United States Department of the Interior

FISH AND WILDLIFE SERVICE
Oregon Fish and Wildlife Office
2600 SE 98th Avenue, Suite 100
Portland, Oregon 97266
Phone: (503) 231-6179 FAX: (503) 231-6195

Reply To: 01EOFW00-2016-F-0225
File Name: WeyCoSHA Final BiOp (1).doc
TS Number: 16-355
TAILS: 01EOFW00-2016-F-0225)
Doc Type: Final

MAY 24 2016

Memorandum

To: Manager, Division of Conservation Planning and Decision Support
Pacific Regional Office, Portland, Oregon

From: for State Supervisor, Oregon Fish and Wildlife Office
Portland, Oregon

Jody L. Caicco

Subject: Proposed Safe Harbor Agreement for the Threatened Northern Spotted Owl

At the request of the Division of Conservation Planning please find the attached Formal Biological Opinion addressing the proposed issuance of an Endangered Species Act Enhancement of Survival Permit for a Safe Harbor Agreement for the Northern Spotted Owl between Weyerhaeuser Company and the U.S. Fish and Wildlife Service.

If you have any questions, please contact Jody Caicco at (503) 231-6179.

Attachments:

Printed on 100 percent chlorine-free/100 percent post-consumer content recycled paper

Biological Opinion
addressing
the Proposed Issuance of an Endangered Species Act Enhancement of Survival Permit
for a
Safe Harbor Agreement
for the
Northern Spotted Owl
Between
Weyerhaeuser Company
and the
U.S. Fish and Wildlife Service

(FWS Reference Number OIEOFW00-2016-F-0225)

Prepared by the Oregon Fish and Wildlife Office
U.S. Fish and Wildlife Service
Portland, Oregon

Prepared for
Pacific Regional Office
U.S. Fish and Wildlife Service
Ecological Services
Division of Conservation Planning and Decision Support

for Paul Henson, Ph.D., State Supervisor

May 24, 2016
Date

TABLE OF CONTENTS

INTRODUCTION 2
CONSULTATION HISTORY 3
1.0 Description of the Proposed Action 3
1.1 Proposed Activities 3
1.2 Action Area 5
2.0 Analytical Framework for Jeopardy Determination 7
3.0 Status of the Northern Spotted Owl 8
4.0 Environmental Baseline 9
4.1 Environmental Baseline in the Action Area 9
4.2 Physiographic Provinces in the Action Area 10
4.3 Recovery Plan for the Northern Spotted Owl 10
5.0 Effects of the Action 11
6.0 Effects of the Action Relative to the Recovery Plan for Northern Spotted Owl 15
7.0 Effects of the Action Relative to the Northern Spotted Owl Population at the Provincial Scale 15
8.0 Cumulative Effects 17
9.0 Conclusion 17
10.0 Amount or Extent of Take 18
11.0 Reasonable and Prudent Measures and Terms and Conditions 18
12.0 Conservation Recommendations 18
13.0 Reinitiation – Closing Statement 19

LIST OF TABLES

Table 1. Enrolled Lands For 7
Table 2. Baseline Spotted Owl Sites For Weyerhaeuser Safe Harbor Agreement. 16
Table 3. Spotted owl sites that are not baseline sites 7

LIST OF APPENDICES

Appendix A Detailed status of the species 22
Ap[pendix B Glossary 57
Appendix C References 60

Memorandum

From: State Supervisor, Oregon Fish and Wildlife Office
Portland, Oregon

To: Manager, Division of Conservation Planning and Decision Support
Pacific Regional Office
Portland, Oregon

Subject: Proposed Safe Harbor Agreement for the Threatened Northern Spotted Owl

INTRODUCTION

This document transmits the U.S. Fish and Wildlife Service's (Service or USFWS) Biological Opinion (BO) on the Service's proposed issuance of an Enhancement of Survival Permit (Permit) based on our review of the proposed Safe Harbor Agreement (SHA) for the threatened northern spotted owl (*Strix occidentalis caurina*) (spotted owl) between the Weyerhaeuser Company (Weyerhaeuser) (Applicant), and the USFWS. No spotted owl critical habitat will be affected by the proposed action. This document was prepared in accordance with section 7 of the Endangered Species Act (Act or ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*).

This BO is based on the following major sources of information: the January 2016, Final Draft SHA for the Spotted Owl between Weyerhaeuser and the USFWS; the Final Environmental Assessment for the Weyerhaeuser SHA and Permit; the Biological Assessment for the Service's Barred Owl Removal Experiment (BA); the Final EIS for the Experimental Removal of Barred Owls to Benefit the Threatened Northern Spotted Owl (Barred Owl Removal Experiment); the Final BO addressing the Barred Owl Removal Experiment; Forest Ecosystem Management: an Ecological, Economic, and Social Assessment (FEMAT) (Thomas and Raphael 1993); the Northwest Forest Plan (NWFP) (USDA and USDI 1994a); the 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 (USDA and USDI 1994b) (FSEIS); the Service's BO on the NWFP (USFWS 1994a); Status and Trends in Demography of Northern Spotted Owls, 1985-2003 (Anthony et al. 2006); Population Demography of Northern Spotted Owls: 1985–2008 (Forsman et al. 2011); Scientific Evaluation of the Status of the Northern Spotted Owl (Courtney et al. 2004); and the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a). A complete decision record of this consultation is on file at the Service's Oregon Fish and Wildlife Office.

CONSULTATION HISTORY

The Service's Pacific Regional Office requested formal consultation on the proposed Permit action via an Intra-Service Section 7 Evaluation Form, dated January 12, 2016.

BIOLOGICAL OPINION

1.0 Description of the Proposed Action

The proposed Federal action is the issuance of a Permit by the USFWS, under 50 CFR 17.32(c)(1), authorizing the incidental take of spotted owls in conjunction with a return to baseline conditions established for the SHA between Weyerhaeuser and the USFWS in the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment in Lane County, Oregon. Under this SHA, the USFWS is providing assurances to Weyerhaeuser that, in allowing the USFWS to survey for and remove barred owls (*Strix varia*) from Weyerhaeuser lands as part of the Barred Owl Removal Experiment, Weyerhaeuser will not be subject to additional regulatory requirements under the Act that may affect the management of their covered lands if spotted owls reoccupy currently unoccupied sites or areas above the agreed upon baseline condition for the covered area.

The USFWS is conducting the Barred Owl Removal Experiment to determine the benefits of implementing Recovery Action 29 of the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) on the spotted owl. The experiment will be conducted on two study areas in Oregon, one in the Oregon Coast Ranges west of Eugene, Oregon, and one in the forest lands around Canyonville, Oregon. While the experiment is focused on Federal lands, the Oregon Coast Ranges Study Area (Study Area) contains significant tracts of interspersed private lands, including 7,489 acres of lands owned by Weyerhaeuser. Through this SHA, Weyerhaeuser will contribute to implementation of the experiment on the Study Area by allowing researchers access to and through Weyerhaeuser lands in the Study Area for both barred owl survey and subsequent removal work. This access is crucial to efficient and effective implementation of this experiment. Information from this experiment is critical to the development of a long-term management strategy to address the barred owl threat to the spotted owl (USFWS, 2013b).

1.1 Proposed Activities

The Act is intended to protect and conserve species listed as endangered or threatened, and to conserve the habitats and ecosystems upon which they depend. The Act also mandates that all Federal agencies shall utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of listed species.

Section 9 of the Act prohibits the "take" of Federally-listed endangered and threatened species unless authorized under the provisions of Sections 7, 10(a), or 4(d) of the Act. Section 3 of the Act defines take as "to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Section 10 of the Act, its implementing regulations, and

Service policy allow the USFWS to enter into a SHA. Section 2 of the Act encourages interested non-Federal parties to develop and maintain conservation programs through Federal financial assistance that reflects a system of incentives that are key to safeguarding the Nation's heritage in fish, wildlife, and plants. Section 7(a)(1) of the Act requires the USFWS to review programs it administers and to use such programs to further the conservation purposes of the Act. Section 7(a)(2) of the Act requires all Federal agencies to insure that actions they authorize, fund, or otherwise carry out do not jeopardize listed species or destroy or adversely modify designated critical habitat.

A SHA entered into under Section 10(a)(1) of the Act, is a voluntary agreement between the USFWS and a non-Federal landowner whose land management actions provide a net conservation benefit to species listed under Section 4 of the Act. In exchange for complying with the SHA and Permit conditions that are reasonably expected to provide a net conservation benefit to the covered listed species, the landowner is assured that the USFWS will not require additional management activities without their consent. In addition, under a SHA, landowners may return their lands to mutually agreed baseline conditions, as described in the SHA. If that return to the agreed upon baseline conditions involves the incidental take of listed species, the authorization for such take is provided under a permit issued by the Service under Section 10(a)(1)(A) of the Act.

The Permit associated with this SHA would authorize incidental take of the spotted owl that may occur as a result of the Applicants forest management activities on covered lands and that may become occupied as a result of the Barred Owl Removal Experiment through August 31, 2025. The Permit would authorize incidental take of the spotted owl during implementation of the SHA for conducting forest management activities consistent with current State regulations that constitute a return to the agreed upon baseline conditions for this SHA.

The purpose of Weyerhaeuser's participation in the SHA is to demonstrate good faith cooperation with the USFWS to implement this recovery action on their covered lands while maintaining their current level of not otherwise needing regulatory compliance under the Act because their covered lands are not occupied by the spotted owl. Under the SHA, Weyerhaeuser will:

- Provide access and permission for USGS and USFWS biologists and their contactors? to access Weyerhaeuser lands to survey barred owls throughout the Study Area.

- Provide access to Weyerhaeuser roads and permission for USGS and USFWS biologists and their contractors to remove barred owls located on Weyerhaeuser lands within the treatment portion of the Study Area.

- Provide permission for USGS and USFWS biologists and their contractors to use roads owned or managed by Weyerhaeuser to access sites for the removal of barred owls located on Federal lands, and any other lands for which we have landowner permission to remove barred owls within the treatment area of the experiment.

- Maintain habitat in the nest stand to support nesting spotted owls that may reoccupy non-baseline sites during the nesting and rearing season (March 1 to September 30 of the year). Actual habitat to be maintained will be determined by mutual agreement of the USFWS and Weyerhaeuser. At any time that biologists determine the pair is no longer nesting, this seasonal restriction would no longer be in effect.

In addition to the lands owned by Weyerhaeuser, the covered lands under the SHA include lands for which Weyerhaeuser hold easements and agreements that allow them to access the covered lands for timber haul and management. These easements and agreements allow for a variety of activities, including but not limited to road use, road construction, road maintenance and the normal management activities associated with managing private forestland for timber production. These activities could, depending on the specific circumstances, result in the disturbance of nesting spotted owls or the loss of some spotted owl-occupied habitat.

The enrolled lands listed in Table 1 have been surveyed for spotted owls under the Spotted Owl Demography Study protocol. The information from these surveys was used to define the 9 currently occupied baseline sites for which no take would be authorized under this SHA and the 16 non-baseline sites with no evidence of spotted owl occupancy for at least the last three years. With the removal of barred owls, these currently unoccupied sites may be reoccupied by spotted owls. The Permit would authorize incidental take of the spotted owls that may reoccupy the non-baseline sites during implementation of the SHA by forest management activities consistent with current State regulations that constitute a return to the agreed upon baseline conditions for this SHA.

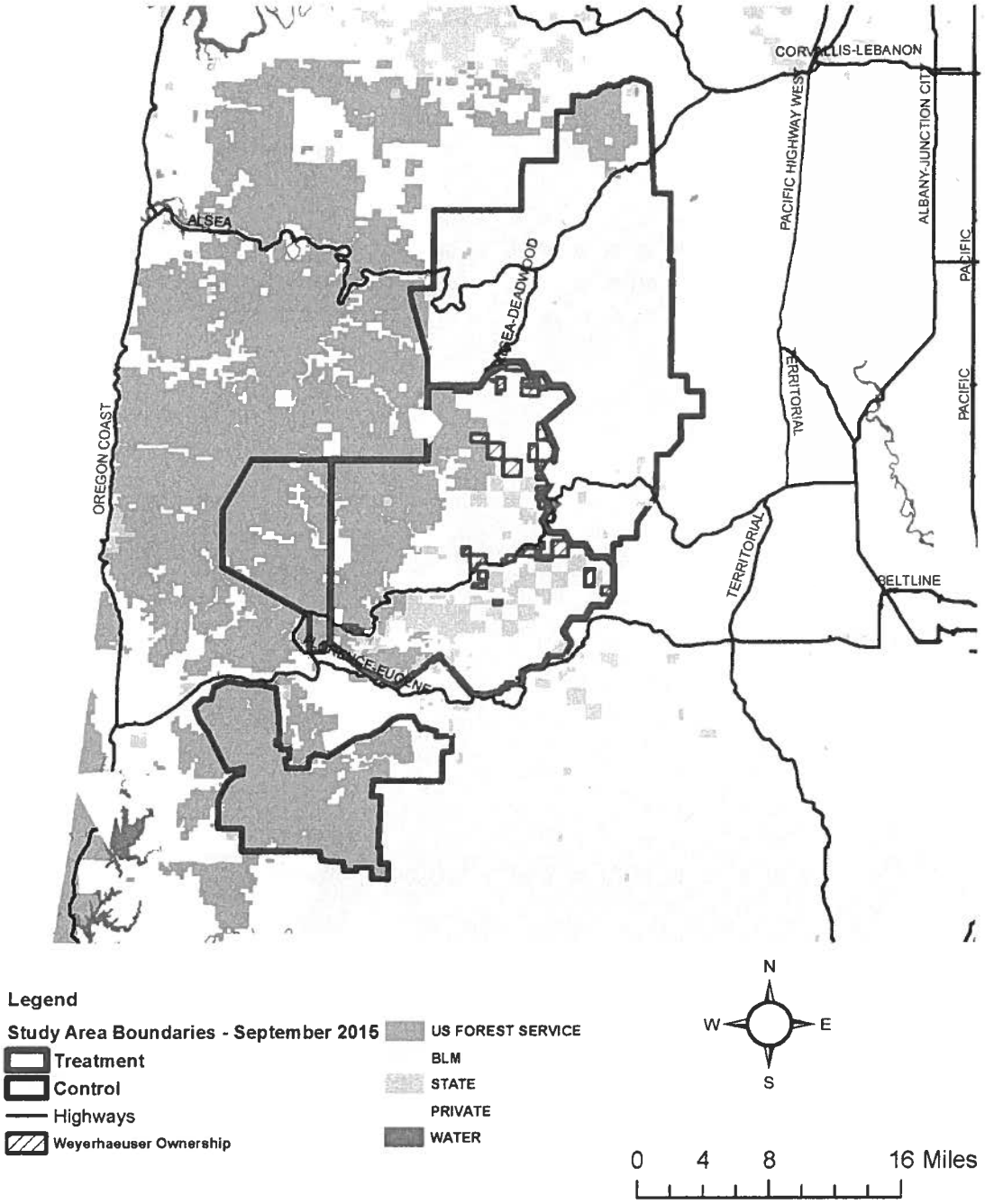
1.2 Action Area

The action area is defined in the implementing regulations for section 7 at 50 CFR 402 as, "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." For this consultation, the action area is equivalent to the "covered area" and is located in the Coast Range Mountains of western Oregon, west of Eugene and south of Highway 20 in Lincoln, Benton, Douglas, and Lane Counties within the Study Area for the Barred Owl Removal Experiment (Map 1). The Study Area includes a total of 418,000 acres. Barred owl removal would occur on approximately 150,000 acres of the Study Area. This area is one of eight, long-term spotted owl demography study areas selected as part of Northwest Forest Plan Effectiveness Monitoring Program.

The Study Area consists of a mixture of Federal, State, and privately owned lands. The Siuslaw National Forest and the Salem and Eugene Districts of the BLM administer approximately 67 percent of the Study Area. The Oregon Department of Forestry includes 5 percent of the study area. Weyerhaeuser owns or manages 10 percent of the study area. The remaining 18 percent of the study area is in private ownership.

Map 1. Land ownership within the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment, including treatment and control areas, with Weyerhaeuser lands identified.

Land Ownership - Oregon Coast Ranges Study Area



The barred owl treatment portion of the Study Area includes lands managed by the Siuslaw National Forest and the Salem and Eugene Districts of the BLM, Oregon Department of Forestry, Weyerhaeuser, and other private landowners. Federal lands represent 57 percent of the treatment area, State lands 12 percent, Weyerhaeuser lands 5 percent, and other private lands 26 percent.

Weyerhaeuser owns approximately 7,489 acres of forest lands within the treatment portion of the Oregon Coast Ranges Study Area in Lane County, Oregon (Map 1). All Weyerhaeuser lands within the sections listed in Table 1 are covered in the SHA at issue herein.

The action area also includes the SHA-covered lands on which Weyerhaeuser hold easements and agreements that allow them to access their covered lands for timber haul and management, and authorization to conduct operational activities on those lands that are also covered under the proposed SHA (Table 1).

Table 1. Sections within the treatment portion of the Study Area where Weyerhaeuser owns and manages lands and sections where Weyerhaeuser has easements and agreements allowing access and operational activities. These represent the covered areas for the safe harbor agreement.

Location			
Township	Range	Sections with Weyerhaeuser Ownership	Sections with potential operational activities where Weyerhaeuser has easements or agreements
15S	7W	7, 30, 32	17, 18, 19, 31
15S	8W	2, 8, 10, 12, 28, 34, 36	1, 3,11, 13, 14, 15, 16, 17, 22, 24, 25, 27, 35
16S	7W	6, 7, 18, 31, 32, 34	19, 33
16S	8W	2, 32, 36	1, 3, 10, 11, 28, 33, 34, 35
17S	7W	10, 14	3, 5, 6, 7, 9, 15, 17, 30
17S	8W	2, 4, 9, 15	1, 3, 5, 6, 17
17S	9W	29, 30	none

2.0 Analytical Framework for Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this BO relies on four components: (1) the *Status of the Species*, which evaluates the spotted owl's range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the spotted owl in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the spotted owl; (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 spotted owl; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the spotted owl.

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 spotted owl's current status, taking into account 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 the spotted owl in the wild.

The jeopardy analysis in this Biological Opinion places an emphasis on consideration of the range-wide survival and recovery needs of the spotted owl and the role of the action area in the survival and recovery of the spotted owl as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

3.0 Status of the Northern Spotted Owl

The northern spotted owl (spotted owl) was listed as a threatened species in 1990 because of widespread loss of suitable habitat across the species range and the inadequacy of existing regulatory mechanisms to conserve the species (55 FR 26114 [June 26, 1990]). Many populations of spotted owls continue to decline, especially in the northern parts of the species' range, where populations have declined by as much as 80 percent since 1990. While past and current habitat loss continues to threaten spotted owl populations, even though loss of habitat due to timber harvest has been greatly reduced on Federal lands for the past 2 decades (USFWS 2011, p. vi), increasing competition from the non-native barred owl (*Strix varia)* is now a significant threat to the continued existence of the northern spotted owl (USFWS 2004, USFWS 2011).

There are no current estimates of the total population size of spotted owls because many areas across the range of the species remain unsurveyed (USFWS 2011, p. A-2). Spotted owl demography studies use estimates of fecundity (reproduction) and apparent survival to determine if populations within 11discrete study areas in California (3), Oregon (5), and Washington (3) are increasing, stationary, or decreasing. Spotted owl populations declined range-wide at an estimated rate of 3.8 percent per year from 1985 to 2013 (Dugger et al. 2015, p. 57). The rates of population decline vary by study area, with the greatest rates of decline occurring in Washington and northern Oregon (Dugger et al. 2015, p. 70). 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 (Forsman et al. 2011, pp. 67-72, Dugger et al. 2015, pp. 93-99). An overall decline in apparent survival rates (the probability that an owl will survive from one year to the next) is the most significant factor driving the declining population trends across the range of the species (Forsman et al. 2011, pp. 63-64). There is now strong evidence that barred owls have negatively affected spotted owl populations, primarily by decreasing apparent survival and increasing rates of local territory abandonment (Dugger et al. 2015, p. 58).

The loss of nesting, roosting, and foraging habitat was a major cause of the spotted owl's decline over the past century. Habitat loss is still considered to be a threat to the spotted owl, as habitat

continues to be lost to wildfires, timber harvest, and other natural disturbances (Davis et al. 2015, p. 45). Although under the Northwest Forest Plan, an extensive number of Late Successional Reserves have been established and are being managed to maintain, enhance, or restore NRF habitat conditions over the range of the spotted owl, the impacts of past habitat loss and degradation within these areas will require many more decades to once again support high quality spotted owl NRF habitat (insert citation(s)). Monitoring of spotted owl habitat in the Northwest Forest Plan area from 1993 to 2012 indicated nesting/roosting habitat declined from 9.09 million acres to 8.95 million acres on Federal lands during the monitoring period, a loss of about 1.5 percent (Davis et al. 2015, p. 22). Across all lands (Federal and non-federal), habitat declined from approximately 12.5 million acres to 12.1 million acres, a loss of 3.4 percent (Davis et al. 2015, p. 21). Wildfire has been the major cause of habitat loss on Federal lands, while timber harvest is the primary cause of habitat loss on non-federal lands. Although the maintenance, enhancement and restoration of NRF habitat is a key element in the conservation of spotted owls, it may no longer be the primary factor affecting population stability in either the short or long term due to the rapidly increasing trend of barred owl populations (Davis et al. 2011, p. 18). Barred owls compete with and displace spotted owls (insert citation(s).

The 2011 Revised Recovery Plan for the Northern Spotted Owl (Recovery Plan)(USFWS 2011, entire) identified past and ongoing habitat loss and competition from barred owls as the primary threats to the survival and recovery of spotted owls at this time. The Recovery Plan includes Recovery Actions specific to addressing barred owl competition and habitat loss. For barred owl competition, Recovery Actions include the implementation of a barred owl removal experiment, management to reduce the effect of barred owls on spotted owls, and the retention and restoration of high quality spotted owl habitat to buffer the effects of barred owl competition in the short term (USFWS 2011, p. III-65, 67), While long-term maintenance and restoration of additional habitat on Federal lands, as envisioned under the Northwest Forest Plan, remains essential to the spotted owl's recovery (USFWS 2011, pp. III-41), additional conservation measures addressing competition from barred owls that were not envisioned under the Northwest Forest Plan may ultimately be needed to recover the species in the face of the barred owl expansion into the Pacific Northwest (Dugger et al. 2011, p. 99, USFWS 2011, p. III-65).

A complete discussion of the current status of the northern spotted owl is contained in Appendix A. This includes a discussion of the 1) legal status of the northern spotted owl; 2) the state of our current knowledge of the spotted owl's life history including range, habitat, and population trends; 3) threats to the spotted owl including the threat of competition from the non-native barred owl; 4) the conservation needs of the spotted owls, including Federal and non-federal contributions to recovery; and 5) the current condition of the spotted owl on a range-wide and recovery unit basis.

4.0 Environmental Baseline

4.1 Environmental Baseline in the Action Area

The environmental baseline is defined as "the past and present impacts of all Federal, state or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section

7 consultation, and the impact of State and private actions which are contemporaneous with the consultation in process [50 CFR 402.02]." Such activities include, but are not limited to, previous timber harvests and other land management activities, including the adoption of a late-successional forest management strategy known as the Northwest Forest Plan (USDA and USDI 1994a, 1994b). The Forest Ecosystem Management Assessment Team (FEMAT), the 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 (USDA and USDI 1994a), and the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl (USDA and USDI 1994b) are relevant to addressing the environmental baseline for this action (USDA and USDI 1994a, b).

The Action Area lies within the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment and adjacent lands up to 0.5 miles around the action area where project-related noise may occur are included in this baseline.

The Study Area includes lands within the Oregon Coast Ranges long-term Spotted Owl Demographic Study Area, east of Eugene Oregon (Map 1). The Study Area consists of a mixture of Federal, State, and privately owned lands. The Siuslaw National Forest and the Salem and Eugene Districts of the BLM administer approximately 67 percent of the Study Area. The Oregon Department of Forestry includes 5 percent of the study area. Weyerhaeuser owns or manages 10 percent of the study area. The remaining 18 percent of the study area is in private ownership. This area is well surveyed for spotted owls. There are 48 historic and current known spotted owl sites on the treatment portion of the Oregon Coast Ranges Study Area of the Barred Owl Removal Experiment.

4.2 Physiographic Provinces in the Action Area

Oregon Coast Range

The Oregon Coast Physiographic Province is located on the Oregon Coast and provides links with the Oregon Western Cascades, and Klamath Mountains Physiographic Provinces. Washington Western Lowlands are to the north of this province; however, the Columbia River may be a barrier of possible dispersal of spotted owls to the Washington Western Lowlands Physiographic Province. The 2006/7 evaluation baseline (USFWS 2011a) was 607,800 acres of suitable spotted owl habitat on Federal lands within the Oregon Coast Physiographic Province. As of June 24, 2013, proposed management activities and natural events have resulted in the baseline being reduced by 1,021 acres of suitable spotted owl habitat resulting in a decrease of 0.17 percent of the 2006/7 provincial baseline (Appendix A, Table 3).

4.3 Recovery Plan for the Northern Spotted Owl

The 2011 Revised Recovery Plan for the Northern Spotted Owl includes Recovery Action 29 – the design and implementation of a large-scale barred owl removal experiments to assess the

effects of barred owl removal on spotted owl site occupancy, reproduction, and survival. The Barred Owl Removal Experiment is the implementation of this Recovery Action.

4.4 Role of the Action Area in the Survival and Recovery of the Spotted Owl

The action area occurs on private, non-federal lands. Under the conservation strategy set forth in the NWFP and the Spotted Owl Recovery Plan, the non-federal land likely plays a minor role in supporting spotted owls including in the action area.

5.0 Effects of the Action

Effects of the action refer to the permanent or temporary direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated and interdependent with that action that will be added to the environmental baseline. Indirect effects are those that are caused by the proposed action, occur later in time, but are still reasonably certain to occur.

The proposed activities may impact northern spotted owls in a variety of ways, and at differing levels, depending on where and when the activity occurs. According to the Endangered Species Act Consultation Handbook (USFWS and NMFS 1998), a "may affect" determination is required when a proposed action may pose any effects to listed species or designated critical habitat. When any adverse effects to listed species or critical habitat may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, a "likely to adversely affect" determination is appropriate. However, when effects to listed species or critical habitat are expected to be discountable, insignificant, or entirely beneficial, "is not likely to adversely affect" is the appropriate conclusion. Insignificant effects relate to the size of the impact and should never reach the level where take would occur. Discountable effects are those unlikely to occur. Based on best judgment, a person would not: (1) be able to meaningfully measure, detect or evaluate insignificant effects; or (2) expect discountable effects to occur. Analysis of potential effects for spotted owl was made using the following information and according to the reasoning described below.

In Oregon, the Forest Practices Act (ORS 527.610) identifies forest practices as any operation conducted on or pertaining to forestland, including but not limited to: (a) reforestation of forestland; (b) road construction and maintenance; (c) harvesting of forest tree species; (d) application of chemicals; (e) disposal of slash; and (f) removal of woody biomass. The rules specifically state that compliance with the forest practices rules does not substitute for or ensure compliance with the ESA and nothing in the rules imposes any state requirement to comply with the ESA. Landowners and operators are advised that Federal law prohibits a person from taking certain threatened or endangered species, which are protected under the ESA.

There are a total of 113 current and historic spotted owl territories in the Oregon Coast Ranges Study Area, of which 25 directly overlap some portion of Weyerhaeuser lands and operation base in the treatment portion of the Study Area (Map 2). The nine currently occupied sites listed

in Table 2 are part of the occupied baseline for the Agreement. Incidental take will not be authorized for these spotted owl sites through the permit. The experimental removal of barred owls from the treatment areas are likely to result in some currently unoccupied (non-baseline) sites or lands outside of historic sites becoming reoccupied by spotted owls. Spotted owls that reoccupy these16 non-baseline sites (Table 3) or lands located outside of Thiessen polygons could be taken as part of Weyerhaeuser's ongoing forest operations and management activities. It is highly unlikely these sites would be re-occupied by spotted owls without the experimental removal of barred owls. It is also likely that these sites will become unoccupied again once the experiment ends and barred owls are allowed to expand back into the treatment area.

Incidental take of spotted owls under this Safe Harbor Agreement would likely be in the form of harm from forest operation activities that result in habitat degradation, or harassment from forest management activities that cause disturbance to spotted owls. USFWS has concluded that noise disturbance from barred owl removal on the treatment area does not rise to the level of take (USFWS 2013a). Incidental take in the form of harassment by disturbance is most likely to occur near former spotted owl nest sites if they become reoccupied. Harm and harassment could occur during timber operations and management that will continue during the permit term. Weyerhaeuser will perform routine harvest, road maintenance and construction activities, including rock pit development, spraying and fertilization that may disturb spotted owls. The permit terms and conditions of incidental take are described in Section 5.

If currently unoccupied spotted owl sites in the Study Area are re-occupied by spotted owl pairs and those pairs initiate nesting, Weyerhaeuser will alter harvest unit configurations and potentially harvest scheduling necessary to maintain sufficient habitat in a 70-acre core, designated based on the "nearest, best most contiguous habitat", which in all cases will include the nest trees or activity center either on or adjacent to Weyerhaeuser lands only during the nesting and rearing season (March 1 to September 30 of the year). Actual habitat to be maintained will be determined by mutual agreement of the USFWS and Weyerhaeuser. The intent is to allow spotted owls that initiate nesting to complete their nesting and fledge young, so that these young may contribute to the spotted owl population. At any time that biologists determine the pair is no longer nesting, this seasonal restriction will no longer be in effect.

Beyond nesting spotted owl pairs, Weyerhaeuser may continue to conduct their normal forest operations and management activities, including removal of spotted owl habitat within the non-baseline spotted owl sites. The permit authorizes the incidental take, via habitat removal or harassment of spotted owls, of spotted owls that may occupy the 16 non-baseline sites (as defined by the Thiessen polygons) listed in Table 3. Take may occur throughout the term of the permit.

The potential effect of the removal of spotted owl habitat under this Safe Harbor Agreement on the experiment depends on the amount of habitat lost relative to the available habitat. The 16 non-baseline sites in the treatment area (Table 3) where take is authorized under this Safe Harbor Agreement include varying amounts of Weyerhaeuser lands. There is a total of 817 acres of nesting-roosting habitat on Weyerhaeuser lands on the 16 non-baseline sites. Weyerhaeuser is a minor owner on 7 of these Thiessen polygons with less than 10 percent of the land ownership and less than 5 percent of the remaining suitable habitat on these sites. On the remaining 9

Map 2. Baseline and non-baseline spotted owl sites, showing coverage of Thiessen polygons, in the treatment portion of the Oregon Coast Ranges Study Area.

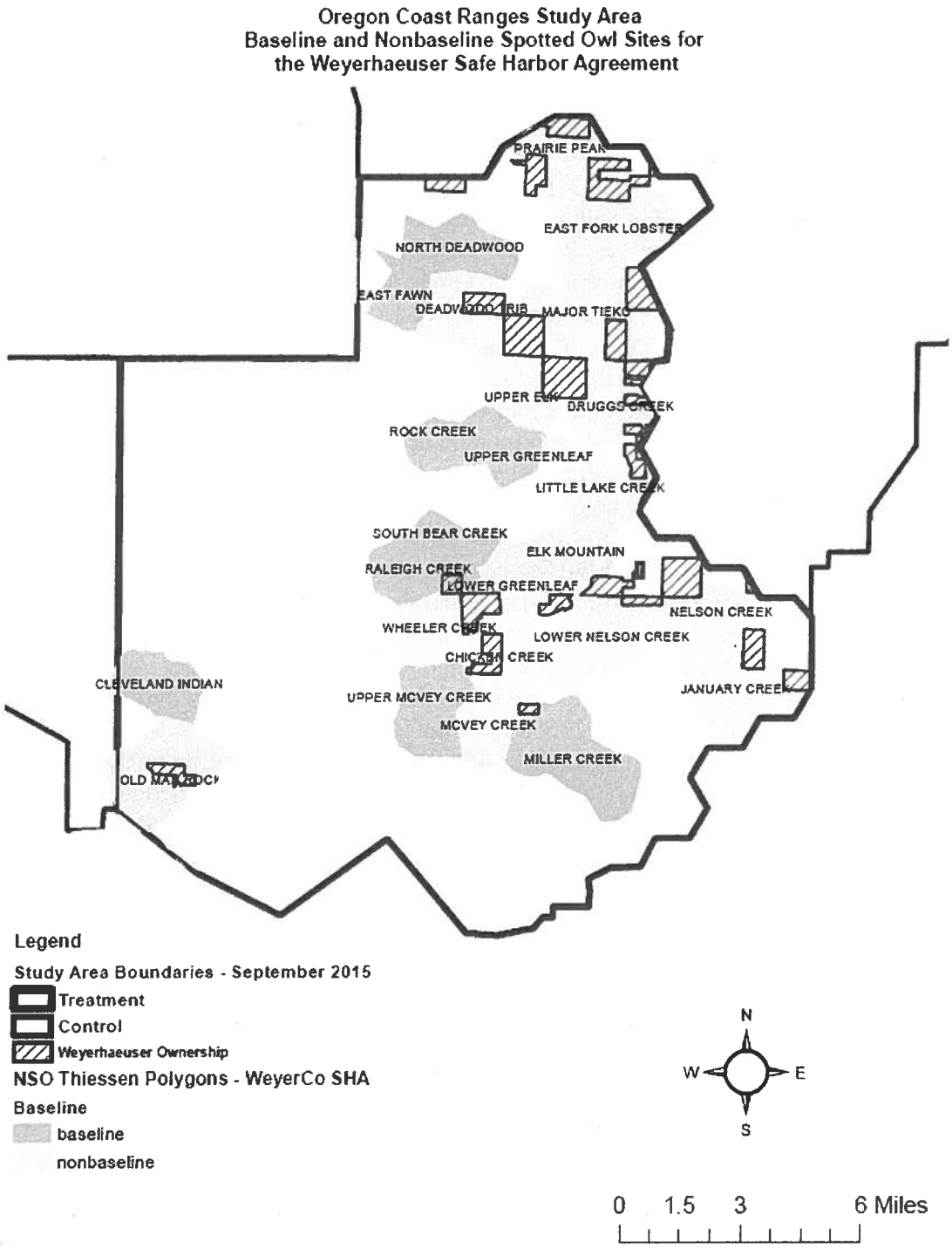


Table 2. Baseline spotted owl sites for Weyerhaeuser Safe Harbor Agreement, Oregon Coast Ranges Study Area.

BASELINE SPOTTED OWL SITES	
Master Site #	**Spotted Owl Site Name**
0765	Cleveland Indian
1761	East Fawn
0160	Miller Creek
1760	North Deadwood
3553	Raleigh Creek
2721	Rock Creek
3913	South Bear Creek
4680	Upper Greenleaf
4474	Upper McVey Creek

Table 3. Spotted owl sites that are not baseline sites.

NON-BASELINE SPOTTED OWL SITES		
Master Site #	**Spotted Owl Site Name**	**Last Year With Spotted Owl Response**
4491	Chicken Creek	2010
0087	Deadwood Trib	2010
2543	Druggs Creek	2008
0183	East Fork Lobster	2012
0524	Elk Mountain	2011
2549	January Creek	2012
2552	Little Lake Creek	2007
2313	Lower Greenleaf	2010
4492	Lower Nelson	2011
4651	Major Tieko	2008
4088	McVey Creek	2012
3554	Nelson Creek	2003
0814	Old Man Rock Canyon	2009
0188	Prairie Peak	2002
0086	Upper Elk	2010
2722	Wheeler Creek	2011

non-baseline sites (Table 3), Weyerhaeuser owns between 10 and 29 percent of the land within the Thiessen polygon. However, on 6 of 9 sites, Weyerhaeuser owns less than 7 percent of the remaining suitable habitat and less than 10 percent on all sites Again, Federal lands make up a significant portion of one of these sites, and contain the majority of remaining suitable habitat on all of these 9 sites.

Some additional, minor loss of suitable spotted owl habitat may occur on lands adjacent to Weyerhaeuser ownership for the construction of spur roads to access and facilitate the harvest and removal of timber from Weyerhaeuser lands where the companies have easements and agreements that allow such activity. These linear spur roads are likely to be relatively short and the road prism narrow and as such it is not expected to account for loss of suitable spotted owl habitat.

6.0 Effects of the Action Relative to the Recovery Plan for Northern Spotted Owl

Within the action area, the 2011 Revised Recovery Plan for the Northern Spotted Owl recommends designing and implementing large-scale control experiments to assess the effects of barred owl removal on spotted owl site occupancy, reproduction, and survival (Recovery Action 29). The proposed action implements Recovery Action 29 within the action area. Therefore, although there may be some adverse effects to individual spotted owls in the short-term with implementation of the proposed action, it is expected to benefit the long-term survival and recovery of the spotted owl population by helping to address the major threat that barred owls represent to the continued existence of the spotted owl.

7.0 Effects of the Action Relative to the Northern Spotted Owl Population at the Provincial Scale

Oregon Coast Range

The effect of the proposed action to the spotted owl population in the affected Physiographic Province is potential disturbance or harm to individual spotted owls that may re-occupy 16 currently unoccupied sites (i.e., non-baseline areas) as a result of the removal of barred owls within 113 current and historic spotted owl sites within the Oregon Coast Ranges Study Area, of which 48 lie within the treatment area. Nine spotted owl sites are currently occupied by spotted owls and are therefore baseline sites not subject to take authorization on Weyerhaeuser. Under the Permit, Weyerhaeuser could remove approximately 817 acres of suitable spotted owl habitat in conjunction with the return to the agreed upon baseline of spotted owl unoccupied habitat. This effect represents 0.135% of the estimated 606,800 acres of suitable spotted owl habitat in the Oregon Coast Ranges Physiographic Province, which represents one of the 12 identified recovery units for the northern spotted owl. This level of impact is not likely to significantly affect or compromise the capability of this recovery unit to provide a sufficient quantity and quality of suitable spotted owl habitat to support successful reproduction of spotted owls to an extent needed for a persistent population in the long-term.

Weyerhaeuser owns 2 percent or less of the spotted owl nesting/roosting habitat on 6 of the 16 sites, 5 percent or less on 10 of the 16 sites, and less than 10 percent all of the 16 sites. Given the small amount of suitable spotted owl habitat owned by Weyerhaeuser within the action area and several of the individual Thiessen polygons, some adult spotted owls on some sites may survive the effects of proposed activities under the SHA. However, as we cannot determine exactly where and how many spotted owl may be affected, we assumed all would be taken for the purposes of this analysis.

The Permit would allow the incidental take of spotted owls that may reoccupy sites where extensive surveys have not detected resident spotted owls for at least three years. It is unlikely that these sites would become re-occupied if barred owls in the SHA-covered area are not removed. And once the experiment is complete, barred owl removal on this area will cease. The USFWS anticipates that barred owls will re-invade the area and re-establish their population within three to five years post-removal. Thus, any spotted owls taken/displaced under this Permit would likely have been displaced within the term of the Permit even without the habitat loss.

In the absence of the SHA, the Applicant would have the incentive to remove the subject habitat immediately, as harvest of these areas are currently not restricted because Service-approved protocol surveys have confirmed they are not currently occupied by the spotted owl. Alternatively, the landowners could simply accept the risk that the sites would not become re-occupied due to the presence of remaining barred owls on their property.

The primary conservation value of the Barred Owl Removal Experiment and of this SHA, which supports that Experiment, is the information the USFWS will gain about the feasibility and efficiency of lethal removal as a tool for barred owl management. The SHA will allow scientists to conduct a more complete removal, resulting in stronger and timelier results. Failure to access these roads and lands would result in pockets of barred owls within the treatment area, effectively reducing the effect of the removal. This, in turn, could extend the time required to reach scientifically-credible results, and potentially delaying the development and implementation of any future barred owl management strategy.

Under the Barred Owl Removal Experiment, and this SHA and Permit that supports that Experiment, current spotted owl populations will continue to be supported, and may benefit from the experiment, as it will likely reduce competitive pressure from barred owls for the remaining spotted owls. These territorial spotted owls are more likely to maintain their territories due to the removal of competing barred owls, and therefore breed and contribute to future spotted owl populations. Thus the Permit is not likely to reduce the current territorial population of spotted owls in the treatment area and may, in fact, protect these sites from incursions by expanding barred owl populations during the removal period. The loss of spotted owls on sites that would only be temporarily occupied is offset by the value of the information gained from the study, including the areas that would be accessed as a result of the SHA, that will directly inform a more timely and effective implementation of a barred owl management strategy.

Based on consideration of the above findings, the Service concludes that implementation of the proposed Permit and SHA is likely to provide a net conservation benefit to the spotted owl.

8.0 Cumulative Effects

Cumulative effects include the effects of future State, Tribal, local or private actions that are reasonably certain to occur within the action area considered in this BO. 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 Act.

The action area of the SHA is an actively managed landscape with frequent presence of humans, vehicles, heavy truck and heavy equipment, machinery, etc. It is likely that spotted owls are currently and are likely to be exposed in the future to the continued effects of ongoing timber harvest and road maintenance and building within the action area. Fortunately, given the protections afforded to the spotted owl and its habitat on Federal lands and the potential benefits of implementing a future barred owl removal program informed by the results of this Experiment, the effects of the above cumulative effects within the action area are not likely to be significant at a spotted owl population scale (provincial or range-wide).

9.0 Conclusion

After reviewing the current status of the spotted owl, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the proposed issuance of the Permit is *not likely to jeopardize the continued existence* of the spotted owl. The Service reached this conclusion because the potential adverse impacts caused by the proposed action are likely to be minimal at a population and recovery unit scale, will not appreciably impair or preclude the capability of the affected spotted owl recovery unit to provide for the intended survival and recovery function assigned it, and are likely to be more than offset by the potential for the large scale implementation of an effective barred owl management strategy should the Experiment, to which the proposed action will contribute, be successful.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act 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 attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2) of the Act, take that is incidental to and not

intended as part of the agency action is not considered to be a prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

10.0 Amount or Extent of Take

For the reasons set forth above under the "Effects of the Action" section of this document, the Service anticipates that the proposed action is likely to cause the incidental take of the spotted owl in the form of harm or harass at 16 currently unoccupied sites if they become re-occupied after barred owls are removed under the Experiment, and the applicant subsequently conducts forest management activities that are likely to result in adverse effects to spotted owls occupying these areas.

The estimation of the number of spotted owls affected by this project relied on data on the number and distribution of owl locations from spotted owl demographic study surveys and other agency owl survey data sets. These data are extensive and cover at least 25 years of intensive work, thus we have complete data on the past and current presence of spotted owls in this area. Whether take will occur or not depends on the on the re-occupation of the sites by spotted owls as a result of the removal of barred owls, and the level of habitat removal. However, as the SHA and Permit allow for a return to an agreed upon baseline condition (9 currently occupied spotted owl sites). In this case, such assurances could involve the incidental take of spotted owls at up to 16 currently unoccupied sites that may become re-occupied after barred owls are removed under the Experiment.

11.0 Reasonable and Prudent Measures and Terms and Conditions

The SHA and its associated documents anticipated impacts to spotted owls that are likely to result from the proposed Permit action, and the measures that are necessary and appropriate to minimize those impacts. All conservation measures described in the SHA and the proposed Permit, are hereby incorporated by reference as reasonable and prudent measures and terms and conditions of this Incidental Take Statement. Such terms and conditions are non-discretionary, and must be undertaken for the exemptions under section 10(a)(1)(A) and section 7(o)(2) of the ESA to apply. If the permittee fails to adhere to these terms and conditions, the protective coverage of the section 10(a)(1)(A) permit and section 7(o)(2) may lapse. The amount or extent of incidental take anticipated under the SHA, associated reporting requirements, and provisions for disposition of dead or injured animals are as described in the SHA and its accompanying section 10(a)(1)(A) permit.

12.0 Conservation Recommendations

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by implementing conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities designed to

minimize or avoid adverse effects of a proposed action on listed species or designated critical habitat, to assist in the implementation of recovery plans or to obtain information.

The Service believes the following conservation recommendation will reduce the impact of the proposed action on nesting spotted owls within the action area:

1. As described in the SHA, if spotted owls that may re-occupy the currently unoccupied sites or areas are found to be nesting, the permittees should maintain suitable spotted owl habitat to support the nesting activity during the nesting season (March 1 to September 30).

13.0 Reinitiation – Closing Statement

This concludes formal consultation on the proposed action outlined in your Biological Assessment (i.e., Intra-Service Section 7 Evaluation Form for the proposed Permit). 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 maintained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agencies' action that may affect listed species or critical habitat in a manner or to an extent not considered in this BO; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this BO; or (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 re-initiation of formal consultation.

Appendix A – Detailed Status of the Species

A.0 Status of the Northern Spotted Owl

A.1 Legal Status

The spotted owl was listed as threatened on June 26, 1990 due to widespread loss and adverse modification of suitable habitat across the owl's entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (USDI FWS 1990a, p. 26114). The spotted owl was listed as threatened on June 26, 1990 due to widespread loss and adverse modification of suitable habitat across the owl's entire range and the inadequacy of existing regulatory mechanisms to conserve the owl (USDI FWS 1990a, p. 26114). The northern 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 (USDI FWS 2004, p. 55). Priority numbers are assigned on a scale of 1C (highest) to 18 (lowest). This number reflects a high degree of threat, a low potential for recovery, and the owl's taxonomic status as a subspecies (USDI FWS 1983b, p. 51895). The "C" reflects conflict with development, construction, or other economic activity (USDI FWS 1983a, p. 43104). The most recent five year status review was completed on September 29, 2011, and did not propose changes to the listing status or introduce any new threats (USDI FWS 2011a). In 2012, the Service was petitioned to uplist the northern spotted owl from threatened to endangered under the Endangered Species Act. In April 2015, the Service determined that petition presented substantial information indicating that the listing may be warranted due to a number of listing factors (80 FR pp.19259-19263).

A.2 Life History

A.2.1 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 (Gutiérrez et al. 1995, p. 2), and biogeographic information (Barrowclough and Gutiérrez 1990, p.741-742). The distribution of the Mexican subspecies (*S. o. lucida*) is separate from those of the northern and California (*S. o. occidentalis*) subspecies (Gutiérrez et al. 1995, p.2). Recent studies analyzing mitochondrial DNA sequences (Haig et al. 2004, p. 1354; Chi et al. 2004, p. 3; Barrowclough et al. 2005, p. 1117) and microsatellites (Henke et al., unpubl. data, 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).

Funk et al. (2008, pp. 1-11) tested the validity of the three current recognized subspecies of spotted owls and found them to be valid. During this genetics study, bi-directional hybridization and dispersal between northern spotted owls and California spotted owls centered in southern

Oregon and northern California was discovered. In addition, a discovery of intro-regression of Mexican spotted owls into the northernmost parts of the northern spotted owl populations in Washington was made, indicating long-distance dispersal of Mexican spotted owls into the northern spotted owl range (Funk et al. 2008, pp. 1-11). Some hybridization of northern spotted owls with barred owls has been recorded (Hamer et al. 1994, pp. 487-491; Dark et al. 1998, pp. 50-56; Kelly 2001, pp. 33, 38). *A.2.2 Physical Description*

The northern spotted owl is a medium-sized owl and is the largest of the three subspecies of spotted owls (Gutiérrez et al. 1995, p. 2). It is approximately 46 to 48 centimeters (18 inches to 19 inches) long and the sexes are dimorphic, with males averaging about 13 percent smaller than females. The mean mass of 971 males taken during 1,108 captures was 580.4 grams (1.28 pounds) (out of a range 430.0 to 690.0 grams) (0.95 pound to 1.52 pounds), and the mean mass of 874 females taken during 1,016 captures was 664.5 grams (1.46 pounds) (out of a range 490.0 to 885.0 grams) (1.1 pounds to 1.95 pounds) (P. Loschl and E. Forsman, pers. comm. cited in USDI FWS 2011b, p. A-1). The northern spotted owl is dark brown with a barred tail and white spots on its head and breast, and it has dark brown eyes surrounded by prominent facial disks. Four age classes can be distinguished on the basis of plumage characteristics (Forsman 1981; Moen et al. 1991, p. 493). The northern spotted owl superficially resembles the barred owl, a species with which it occasionally hybridizes (Kelly and Forsman 2004, p. 807). Hybrids exhibit physical and vocal characteristics of both species (Hamer et al. 1994, p. 488).

A.2.3 Current and Historical Range

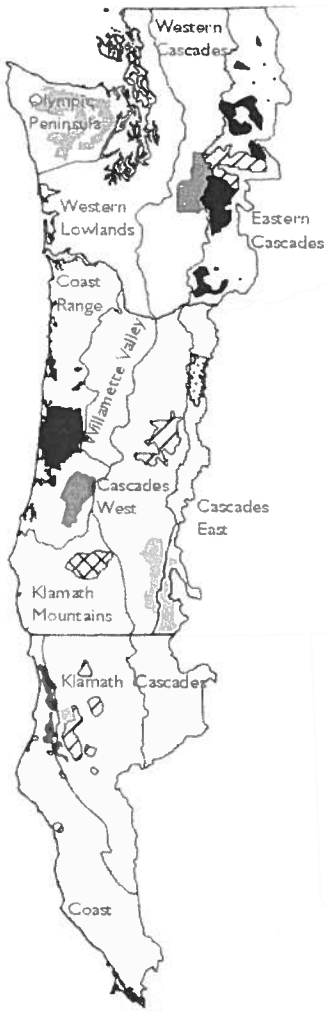
The current range of the spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (USDI FWS 1990a, p. 26115). The range of the spotted owl is partitioned into 12 physiographic provinces (see Figure 1) based on recognized landscape subdivisions exhibiting different physical and environmental features (; Thomas et al. 1993, USDI FWS 2011b, p. III-1). These provinces are distributed across the species' 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 is extirpated or uncommon in certain areas such as southwestern Washington and British Columbia. Timber harvest activities have eliminated, reduced or fragmented spotted owl habitat sufficiently to decrease overall population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (Thomas and Raphael 1993, USDI FWS 2011b, pp. B-1 to B-4;).



	Demographic Study Area	Land Ownership	# Owls Banded	Fecundity	Apparent Survival	λ_{RJS}	Population Trend Based on $\Delta\lambda$
	Washington						
	Wenatchee (WEN)	Private	1,200	Stable	Declining	0.917	Declining
	Rainer (RAI)	USFS	217	Stable	Declining	0.896	Declining
	Olympic (OLY)	NPS & USFS	985	Stable	Declining	0.956	Declining
	Cle Elum (CLE)	USFS	724	Declining[1]	Declining?[2]	0.938	Declining
	Oregon						
	Oregon Coast Range (COA)	USFS & BLM	1,025	Declining?[1]	Stable	0.968	Declining
	Tyee (TYE)	BLM & Private	1,032	Increasing	Stable	1.005	Stationary
	South Oregon Cascades (CAS)	USFS & BLM	881	Declining	Stable	0.974	Stationary
	H.J. Andrews (HJA)	USFS	1,095	Stable?[3]	Stable	0.978	Declining
	Klamath (KLA)	BLM & Private	1,147	Stable	Stable	0.997	Stationary
	Warm Springs (WSR)	Tribal	381	Stable	Stable	0.908	Declining
	California						
	Marin (MAR)	NPS	96	Stable	Stable	NA	NA
	Simpson (SIM)	Private	1,344	Declining[1]	Stable	0.970	Declining
	Hoopa (HUP)	Tribal	279	Increasing	Stable	0.980	Stationary
	NW California (NWC)	USFS	1,026	Declining	Declining	0.985	Declining?[4]

[1] Best model included age and even-odd year effects, but a competing model had a negative time effect on productivity.
[2] Variable among years, but with a declining trend.
[3] Decreasing in early years, increase in last 5 years, stable overall.
[4] Gradual declines in fecundity and apparent survival, plus estimates of realized population change suggest a decline in last 8 years.

Figure 1. Physiographic provinces, northern spotted owl demographic study areas, and demographic trends (Anthony et al. 2006).

A.2.4 Behavior

Northern spotted owls are primarily nocturnal (Forsman et al. 1984, pp. 51-52) and spend virtually their entire lives beneath the forest canopy (Courtney et al. 2004, p. 2-5). They are adapted to maneuverability beneath the forest canopy rather than strong, sustained flight (Gutiérrez et al. 1995, p. 9). They forage between dusk and dawn and sleep during the day with peak activity occurring during the two hours after sunset and the two hours prior to sunrise (Gutiérrez et al. 1995, p. 5; Delaney et al. 1999, p. 44). They will sometimes take advantage of vulnerable prey near their roosts during the day (Layman 1991, pp. 138-140; Sovern et al. 1994, p. 202).

Northern spotted owls seek sheltered roosts to avoid inclement weather, summer heat, and predation (Forsman 1975, pp. 105-106; Barrows and Barrows 1978; Barrows 1981; Forsman et al. 1984, pp. 29-30). Northern spotted owls become stressed at temperatures above 28°C, but there is no evidence to indicate that they have been directly killed by temperature because of their ability to thermoregulate by seeking out shady roosts in the forest understory on hot days (Barrows and Barrows 1978; Forsman et al. 1984, pp. 29-30, 54; Weathers et al. 2001, pp. 678, 684). During warm weather, spotted owls seek roosts in shady recesses of understory trees and occasionally will even roost on the ground (Barrows and Barrows 1978, pp. 3, 7-8; Barrows 1981, pp. 302-306, 308; Forsman et al. 1984, pp. 29-30, 54; Gutiérrez et al. 1995, p. 7). Glenn et al. (2010, p. 2549) found that population growth was negatively associated with hot summer temperatures at their southernmost study area in the southern Oregon Cascades, indicating that warm temperatures may still have an effect on the species. Both adults and juveniles have been observed drinking water, primarily during the summer, which is thought to be associated with thermoregulation (Gutiérrez et al. 1995, p. 7).

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. They will actively defend their nests and young from predators (Forsman 1975, p. 15; Gutiérrez et al. 1995, p. 11). 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 (Gutiérrez 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 (Gutiérrez 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 (Gutiérrez et al. 1995, p. 10).

A.2.5 Habitat Relationships

A.2.5.1 Home Range

Home-range sizes vary geographically, generally increasing from south to north, which is likely

a response to differences in habitat quality (USDI FWS 1990a, p. 26117). Estimates of median size of their annual home range (the area traversed by an individual or pair during their normal activities (Thomas and Raphael 1993, pp. IX-15)) vary by province and range from 2,955 acres in the Oregon Cascades (Thomas et al. 1990, p. 194) to 14,211 acres on the Olympic Peninsula (USDI FWS 1994a, p. 3). 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 (approximately 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 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).

A.2.5.2 Habitat Use and Selection

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).

Spotted owls generally rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging. Features that support nesting and roosting typically include a moderate to high canopy closure (60 to 90 percent); a multi-layered, multi-species canopy with large overstory trees (with diameter at breast height [dbh] of greater than 30 inches); a high incidence of large trees with various deformities (large cavities, broken tops, mistletoe infections, and other evidence of decadence); large snags; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas et al. 1990, p. 19). Forested stands with high canopy closure also provide thermal cover (Weathers et al. 2001, p. 686) and protection from predators (Franklin et al. 2000, p. 578).

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 (Folliard 1993, p. 40; Buchanan et al. 1995, p. 1402; Hershey et al. 1998, p. 1404).

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.

Foraging habitat is the most variable of all habitats used by territorial spotted owls (Thomas et al. 1990; USDI FWS 2011b, p. G-2). 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 (Gutiérrez 1996, p. 5). Foraging habitat for northern 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 (Irwin et al. 2000, p. 180; Courtney et al. 2004, pp. 5-15), snag volume, density of snags greater than 20 in (50 cm) dbh (North et al. 1999, p. 524; Irwin et al. 2000, pp. 179-180; Courtney et al. 2004, pp. 5-15), 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. 2004, 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 northern 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 (USDI FWS 2011b, p. G-1). 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 (USDI FWS 2011b, p. G-1). Forsman et al. (2002, p. 22) found that spotted owls could disperse through highly fragmented forest landscapes. In a study of the natal dispersal of northern spotted owls, Sovern and others (2015, pp. 257-260) found the majority of roosts were in forested habitats with at least some large (>50 cm dbh) trees and they selected stands with high canopy cover (>70%) at the landscape scale. These authors suggested the concept of 'dispersal' habitat as a lower quality type of habitat may be inappropriate. 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 (Thomas et al. 1990, p. 158; Diller

and Thome 1999, p. 275). 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 Cascades, spotted owls roosted in mature forests dominated by trees greater than 50 centimeters (19.7 inches) dbh with greater than 60 percent canopy closure more often than expected for roosting during the non-breeding season. Spotted owls also used young forest (trees of 20 to 50 centimeters (7.9 inches to 19.7 inches) dbh with greater than 60 percent canopy closure) less often than expected based on this habitat's 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 (Forsman et al. 1984, pp. 24-25; Carey et al. 1990, pp. 14-15; Thomas et al. 1990; 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 that while owls selected the oldest forest available to them, they showed 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 with lower variance in prey densities (that is, where the occurrence of prey was more predictable) within older forests and near ecotones of old forest and brush seral stages. Zabel et al. (1995, p. 436) showed that spotted owl home ranges are larger where flying squirrels (*Glaucomys sabrinus*) are the predominant prey and smaller where wood rats (*Neotoma* spp.) are the predominant prey.

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 (Zabel et al. 2003, p. 1038; Franklin et al. 2000, pp. 573-579; Meyer et al. 1998, p. 43). In 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. In a large-scale demography modeling study, Forsman et al. (2011, pp. 1-2) found a positive correlation between the amount of suitable habitat and recruitment of young.

A.2.6 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 (Forsman et al. 1984; Gutiérrez 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 (Miller et al. 1985, p. 93; Franklin 1992, p. 821; Forsman et al. 2002, p. 17). 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 (USDI FWS 1990b; Forsman et al. 1984, pp. 32-34; Anthony et al. 2006, p. 28), and re-nesting after a failed nesting attempt is rare (Gutiérrez 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 (Gutiérrez 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 (USDI FWS 1990a; 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 (Haig et al. 2001, p. 35; Forsman et al. 2002, p. 18). Hybridization of northern spotted owls with California spotted owls and barred owls has been confirmed through genetic research (Hamer et al. 1994, pp. 487-492; Gutiérrez et al. 1995, pp. 2-3; Dark et al. 1998, p. 52; Kelly 2001, pp. 33-35; Funk et al. 2008, pp. 161-171).

A.2.7 Dispersal Biology

Natal dispersal of spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Miller et al. 1997; 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 (USDI FWS 1990a; Miller 1989, pp. 32-41). Known or suspected causes of mortality during dispersal include starvation, predation, and accidents (Miller 1989, pp. 41-44; USDI FWS 1990a; Forsman et al. 2002, pp. 18-19). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Hoberg

et al. 1989, p. 247; Gutiérrez 1989, pp. 616-617; Forsman et al. 2002, pp. 18-19). 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 water bodies rather than cross them (Forsman et al. 2002, p. 22). Analysis of the genetic structure of spotted owl populations suggests that gene flow may have been adequate between the Olympic Mountains and the Washington Cascades, and between the Olympic Mountains and the Oregon Coast Range (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 are apparently random in direction (Forsman et al. 2002, pp. 21-22). In California spotted owls, a similar subspecies, the probability for dispersal was higher in younger owls, single owls, paired owls that lost mates, owls at low quality sites, and owls that failed to reproduce in the preceding year (Blakesley et al. 2006, p.77). Both males and females dispersed at near equal distances (Blakesley et al. 2006, p. 76). In 72 percent of observed cases of dispersal, dispersal resulted in increased habitat quality (Blakesley et al. 2006, p. 77).

Dispersal can also be described as having two phases: transience and colonization (Courtney et al 2004, p. 5-13). Fragmented forest landscapes are more likely to be used by owls in the transience phase as a means to move rapidly between denser forest areas (Courtney et al 2004, p. 5-13; USDI FWS 2012, p. 14086). Movements through mature and old growth forests occur during the colonization phase when birds are looking to become established in an area (Miller et al 1997, p. 144; Courtney et al 2004, p. 5-13). Transient dispersers use a wider variety of forest conditions for movements than colonizing dispersers, who require habitats resembling nesting/roosting/foraging habitats used by breeding birds (USDI FWS 2012, p. 14086). Dispersal success is likely highest in mature and old growth forest stands where there is more likely to be adequate cover and food supply (USDI FWS 2012, p. 14086).

A.2.8 Food Habits

Spotted owls are mostly nocturnal, although they also forage opportunistically during the day (Forsman et al. 1984, p. 51; 2004, pp. 222-223; 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) 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; 2004, p. 218; Ward et al. 1998, p. 84; Hamer et al. 2001, p. 224). 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; 2004, p. 218; Ward et al. 1998; p. 84; Hamer et al. 2001, p.224).

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 (reviewed by Courtney et al. 2004, pp. 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 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; 2004, pp. 218-219). In the southern portion of their range, where woodrats are a major component of their diet, northern spotted owls are more likely to use a variety of stands, including younger stands, brushy openings in older stands, and edges between forest types in response to higher prey density in some of these areas (Forsman et al. 1984, pp. 24-29).

A.2.9 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 (Forsman et al. 1984; Gutiérrez et al. 1995, 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).

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, p.81 *In*: Forsman et al. 1996) and fluctuation in prey abundance (Zabel et al. 1996, pp.437-438).

A variety of factors may influence 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). Recent findings suggest that competition with barred owls is an important stressor on spotted owl populations, but habitat availability and climatic patterns also appear to influence survival, occupancy, recruitment, and, to a lesser extent, fecundity (Wiens et al. 2014, entire; Dugger et al. 2016, entire).

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). Recently, the variable influences of different covariates for particular demographic parameters across study areas were noted by Dugger et al., 2016 (entire). Authors noted that the control areas in Green Diamond Study Area (GDR-C), Washington Study Areas, and the Oregon Coast Study Area (COA) had the highest annual rates of population decline.

A.3 Threats

A.3.1 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" (USDI FWS 1990a, p. 26114). More specifically, threats to the spotted owl included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of provinces, predation and competition, lack of coordinated conservation measures, and vulnerability to natural disturbance (USDI FWS 1992a, pp. 33-41). These threats were characterized for each province as severe, moderate, low, or unknown (USDI FWS 1992a, pp. 33-41). Declining habitat was recognized as a severe or moderate threat to the spotted owl throughout its range, isolation of populations was identified as a severe or moderate threat in 11 provinces, and a decline in population was a severe or moderate threat in 10 provinces. Together, these three factors represented the greatest concerns about range-wide conservation of the spotted owl. Limited habitat was considered a severe or moderate threat in nine provinces, and low populations were a severe or moderate concern in eight provinces, suggesting that these factors were also a concern throughout the majority of the spotted owl's 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.

A.3.2 New Threats

The Service conducted a 5-year review of the spotted owl in 1994 (USDI FWS 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 and Gutiérrez 2004, pp.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 and Gutiérrez 2004, pp.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 and Gutiérrez 2004, pp. 11-8).

Threats, as identified in the 2011 Revised Recovery Plan for the Northern Spotted Owl, continue to emphasize that habitat loss and barred owls are the main threats to northern spotted owl recovery (USDI FWS 2011b, Appendix B).

A.3.2.1 Barred Owls (*Strix varia*)

Barred owls currently appear to be the primary threat to northern spotted owls. With its range expansion to as far south as Marin County, California (Gutiérrez et al. 2004, pp. 7-12 to 7-13; Steger et al. 2006, p.226), the barred owl's range now completely overlaps that of the northern spotted owl. Barred owls compete with spotted owls for prey (Hamer et al. 2001, p.226, Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319,Wiens et al., 2014, pp. 24 and 33) or habitat (Hamer et al. 1989, p.55; Dunbar et al. 1991, p. 467; Herter and Hicks 2000, p. 285; Pearson and Livezey 2003, p. 274). In addition, barred owls have been documented to 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). And finally, the growing body of evidence that barred owls are causing significant negative demographic effects based on retrospective examination of long-term data collected on spotted

owls (Kelly et al. 2003, p. 46; Pearson and Livezey 2003, p. 267; Olson et al. 2005, p. 921, Forsman et al., 2011, pp. 41-43, 69-70, Wiens et al. 2014, pp. 35-37; Dugger et al., 20162016, pp. 70-96).

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 et al 1989, 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; Gremel 2005, Schmidt 2006, p. 1; Singleton et al. 2010, pp. 290-292). In Western Oregon, Wiens and others (2011, p. 537) found the overall occupancy probability of barred owls was high (.89) in an intensively managed forest landscape, representing an increase in barred owl occurrence in that region over the past 30 years (citing Taylor and Forsman 1976). In this Western Oregon study, barred owls were non-randomly distributed, with a highest proportion of public ownership containing a structurally diverse mixture of mature and old forests (p.537). 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 two species of owls share similar habitats and are likely competing for food resources (Hamer et al. 2001, p. 226, Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319, Wiens et al., 2014, pp. 24 and 33). Hamer found a strong diet overlap (76 percent) between northern spotted and barred owl diets (pp. 221, 226). Barred owl diets are more diverse than northern spotted owl diets and include species associated with riparian and other moist habitats (e.g. fish, invertebrates, frogs, and crayfish), along with more terrestrial and diurnal species (Smith et al. 1983; Hamer et al. 2001; Gronau 2005, Wiens et al., 2014, p. 24). Even though barred owls appear to be generalists, northern spotted owls may be affected by a sufficient reduction in the density of these prey when they co-exist in an area, leading to a depletion of prey to the extent that the northern spotted owl cannot find an adequate amount of food to sustain maintenance or reproduction (Gutiérrez et al. 2007, p. 187; Livezey and Fleming 2007, p. 319).

There is consensus in the literature on the negative influence barred owls are having on northern spotted owl detectability, site occupancy, reproduction, and survival The occupancy of historical territories by spotted owls in Washington and Oregon was found to be significantly lower ($p < 0.001$) after barred owls were detected within 0.8 kilometer (0.5 miles) of the territory center but was "only marginally lower" ($p = 0.06$) if barred owls were located more than 0.8 kilometer (0.5 miles) 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 miles) ($p = 0.001$), 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. In contrast, Bailey et al.

(2009, p. 2983), when using a two-species occupancy model, showed no evidence that barred owls excluded northern spotted owls from territories in Oregon. Preliminary results from a barred owl and northern spotted owl radio-telemetry study in Washington reported two northern spotted owls fleeing their territories and traveling six and 15 miles, believed to be as a result of frequent direct encounters with barred owls (Irwin et al. 2010, pp. 3-4). Both northern spotted owls were subsequently found dead (Irwin and Rock. 2010, p. 4). Yackulic and others (2014) modeled the occupancy dynamics of coexisting barred and spotted owls and found the competitive effects lead to a weaker relationship between habitat and northern spotted owl occupancy (Yackulic et al., 2014, pp. 271-273). Regarding territory occupancy dynamics, the most recent demographic meta-analysis found a consistent strong positive association between the territory extinction rates of spotted owls and the presence of barred owls and in all 11 study areas. Occupancy rates declined as follows (Dugger et al., 2016, p. 74):

- Washington - 56–100 percent% in 1995 to 11–26% in 2013;
- Oregon - 61–88% in 1995 to 28–48% in 2013;
- California - 75% to 38% in NWC and from 79% to 47% in HUP between 1995 and 2013
- In the control areas in the GDR study area, occupancy rates declined from 92% in 1999 to
- 55% in 2013.

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 (E. Forsman, pers. comm., cited in USDI FWS 2011b, p. B-11). Wiens and others (2014, pp. 35-37) found barred owl demographic variables favoring barred owls. Survival and fecundity was higher in barred owls, with the barred owls producing on average 4.4 times the number of young. Dugger et al., 2016 found barred owls and habitat covariates explained little of the temporal variation in fecundity in most study areas and models suggested fecundity was partially influenced by additive effects of regional and annual time variation the amount of suitable core area habitat, barred owl presence, and the amount of edge habitat. Substantial annual variation in fecundity among study areas, with support for declining trends in eight areas (CLE, COA, HJA,TYE, KLA, NWC, HUP, and GDR; (Dugger et al., p.91).

Barred owls are also influencing the survival, extinction, and colonization of spotted owls. 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. Dugger et al. (2011, pp. 2463-2467) confirmed the synergistic effects of barred owls and territory habitat characteristics on extinction and colonization rates of territories by northern spotted owls in Oregon. Some northern spotted owl pairs retained their territories and continued to survive and successfully reproduce during their study even when barred owls were present, but that the effects of reduced old growth forest in the core habitat areas were compounded when barred owls were present - extinction rates of northern spotted owl territories nearly tripled when barred owls were detected. Yackulic and others documented similar

findings; the effects of interspecific competition was likely to negatively affect spotted owls, both through its immediate effects on local extinction and by indirectly lowering colonization (Yackulic et al., 2014, pp. 271-273).

Most recently, the key vital rates barred owls most influencing spotted owl populations appear to be apparent survival and local extinction rates (Dugger et al., 2016, p. 93-98). Additionally, these authors found a *positive* association between barred owl *removals* and spotted owl vital rates. Regional climate cycles were found to be strongly associated with apparent survival across all study areas. These recent results suggested that apparent annual survival rates were declining in eight of eleven study areas, and that declines were most strongly associated with increased detections of barred owls in seven areas. Because adult survival is a critical vital rate influencing the rate of population change in long-lived birds, authors expressed concern that continued trends as found in this study could threaten the continued persistence of the subspecies.

Monitoring and management of northern spotted owls has become more complicated due to their possible reduced detectability when barred owls are present (Kelly et al. 2003, pp. 51-52; Courtney et al. 2004, p. 7-16 ; Olson et al. 2005, p. 929; Crozier et al. 2006, p.766-767). 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. In a study evaluating the response behavior and barred owl detection probabilities using spotted owl and barred owl (conspecific) calling, Wiens and others (2011) found that response behavior and detection probabilities of barred owls varied between the types of surveys. These authors found that per-visit barred owl detection probabilities were higher for conspecific surveys. On average, response rates of barred owls were 10 percent lower and single visit detection probabilities were 18 percent lower during surveys for spotted owls compared to conspecific surveys, suggesting that barred owl occurrence is likely higher than what is generally was recognized by spotted owl monitoring programs (pp.535-536). Evidence that northern spotted owls were responding less frequently during surveys led the Service and its many research partners to include updates to the northern spotted owl survey protocol, which were based on the probability of detecting northern spotted owls when barred owls are present (USDI Fish and Wildlife Service, 2011).

Hybridization with barred owls may also negatively influence spotted owls, but the overall rangewide impact may not be significant. In an 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).

Due to the evidence suggesting that barred owls are exacerbating the spotted owl population decline, the Service initiated an experimental barred owl removal study beginning in 2013. The goal of this experiment is to test the feasibility of barred owl removal to determine whether it improves conditions for spotted owls on a small scale. Barred owls will be removed on less than one twentieth of one percent of the range of the barred owl. If the experimental removal of barred owls results in improved spotted owl populations, wider scale treatments as part of a barred owl management strategy may be proposed (USDI 2015). In 2004 it was noted that 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 northern spotted owls have been already fully realized" (Gutiérrez et al. 2004, pp. 7-38). This situation to date does not appear to have changed.

A.3.2.2 Wildfire

Fire is often considered a primary threat to spotted owls because of its potential to alter habitat rapidly (Bond et al. 2009, p. 1116) and is a major cause of habitat loss on Federal lands (Courtney et al. 2004, executive summary) particularly in the California Klamath Province (Davis et al., 2015, p. 17-22. At the time of listing there was recognition that large-scale wildfire posed a threat to the spotted owl and its habitat (USDI FWS 1990a, p. 26183). Information since suggests fire may be more of a threat than previously thought. The most recent Northwest Forest Plan Habitat Monitoring Report indicates that range-wide, the nesting/roosting habitat lost from fire (505,800 acres) represents about 31 percent of the total habitat loss. The rate of habitat loss in the relatively dry East Cascades and Klamath provinces is proportionally higher, comprising about 68 percent of nesting/roosting habitats on federal and non-federal lands lost from fire (Table 7, Davis et al., 2015). This is particularly concerning as most of these acres are located in reserved lands (Table 5, Davis et al., 2015).

It may be possible to influence through forest management how fire prone forests will burn and the extent of the fire when it occurs. Forest fuels are currently being managed 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 and debated in the literature (Courtney et al. 2004, pp. 12-11, Omi and Martenson 2002, pp. 19-27 Irwin et al., 2004, p. 21; Spies et al 2006p. 359-361; Hanson et al., 2009, pp.3-6; Spies et al., 2009, pp. 331-332; Ager et al., 2012, p.282; Odion et al 2014 pp. 10-12, Spies et al., 2012, pp. 10-12; Odion 2014, pp. 46-49)). The 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 and the critical habitat network may help mitigate the risks associated with large-scale fire (Lint 2005, p. 77). Fire is a disturbance factor spotted owls have evolved with; however, studies indicate that the effects of wildfire on spotted owls and their habitat are variable, depending on site-specific fire intensity, severity, size, and the availability and distribution of suitable habitat (See review of literature in Appendix B). Within the fire-adapted forests of the spotted owl's range, spotted owls likely have adapted to withstand fires of variable sizes and severities, but these adaptations evolved under a different habitat baseline and different threats than those recognized currently. More research is needed to understand further the relationship between fire and spotted owl habitat use. Overall, we can conclude that fires are a change agent for northern spotted owl habitat, but there are still many unknowns regarding how much fire benefits or adversely affects northern spotted owl habitat (USDI FWS 2011b, p. III-31).

A.3.2.4 West Nile Virus

West Nile virus (WNV), caused by a virus in the family Flaviviridae, has killed millions of wild

birds in North America since it arrived in 1999 (McLean et al. 2001; Caffrey 2003; Caffrey and Peterson 2003, pp. 7-8; 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; Komar et al. 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died.

Health officials expect that WNV will eventually spread throughout the range of the spotted owl (Courtney et al. 2004; Blakesley et al. 2004, pp. 8-31), but it is unknown how WNV will ultimately affect spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley et al. 2004, pp. 8-33), but most owls appear to be quite susceptible. For example, breeding Eastern screech owls (*Megascops asio*) in Ohio experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley et al. 2004, pp. 8-33). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley et al. 2004, pp. 8-34). Some level of innate resistance may occur (Fitzgerald et al. 2003), which could explain observations in several species of markedly lower mortality in the second year of exposure to WNV (Caffrey and Peterson 2003). Wild birds also develop resistance to WNV through immune responses (Deubel et al. 2001). The effects of WNV on bird populations at a regional scale have not been large, even for susceptible species (Caffrey and Peterson 2003), perhaps due to the short-term and patchy distribution of mortality (K. McGowan, pers. comm., cited in Courtney et al. 2004) or annual changes in vector abundance and distribution.

Blakesley et al. (2004, pp. 8-35) offer competing propositions for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions due to WNV, because spotted owl populations are widely distributed and number in the several hundreds to thousands. 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. Thus far, no mortality in wild, northern spotted owls has been recorded; however, WNV is a potential threat of uncertain magnitude and effect (Blakesley et al. 2004, pp. 8-34).

A.3.2.5 Sudden Oak Death

Sudden oak death was recently identified as a potential threat to the spotted owl (Courtney et al. 2004). This disease is caused by the fungus-like pathogen, *Phytopthora ramorum* that was recently introduced from Europe and is rapidly spreading. The disease is now known to extend over 650 km from south of Big Sur, California to Curry County, Oregon (Rizzo and Garbelotto 2003, p. 198), and has reached epidemic proportions in oak (Quercus spp.) and tanoak (*Lithocarpus densiflorus*) forests along approximately 300 kilometers of the central and northern California coast (Rizzo et al. 2002, p. 733). 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 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 800 m. During a study completed between 2001 and 2003 in California, one-third to one-half of the hiker's present in the study area carried infected soil on their shoes (Davidson et al. 2005, p. 587), creating the potential for rapid spread of the disease. 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, pp. 11-8).

A.3.2.6 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). 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, pp. 11-9). A 2004 study (Harestad et al. 2004, p. 13) indicates that the Canadian breeding population was estimated to be less than 33 pairs and annual population decline may be as high as 35 percent. In 2007, a recommendation was made by the Spotted Owl Population Enhancement Team to remove northern spotted owls from the wild in British Columbia (USDI FWS 2012, p. 14078). This recommendation resulted in the eventual capture of the remaining 16 wild northern spotted owls in British Columbia for a captive breeding program (USDI FWS 2012, p. 14078). 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. Hybridization of northern spotted owls with California spotted owls, Mexican spotted owls, and barred owls has been confirmed through genetic research (Funk et al. 2008, p. 1; Hamer et al. 1994, p. 487; Gutiérrez et al. 1995, p. 3; Dark et al. 1998, p. 50; Kelly 2001, pp. 33-35).

A.3.2.7 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 2011a, 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 (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). Most recently, the relationships between spotted owl populations and climate was complex and variable, but rangewide, Dugger et al. (2016, pp. 91-98) suggested that survival of young spotted owls and their ability to become part of the breeding population increased when winters were drier. This may become a factor in population numbers in the future, given climate change predictions for the Pacific Northwest include warmer, wetter winters.

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.

A.3.2.8 Disturbance

Northern 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; Saplosky 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 northern 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 northern spotted owl core areas (Wasser et al. 1997, p.1021; Tempel and Gutiérrez 2004, p. 544).

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 Skagan 1998, 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.

Information specific to behavioral responses of spotted owls to disturbance is limited, research indicates that recreational activity can cause Mexican spotted owls (*S. o. lucida*) to vacate otherwise suitable habitat (Swarthout and Steidl 2001, p. 314) and helicopter overflights can reduce prey delivery rates to nests (Delaney et al. 1999, p. 70). Additional effects from disturbance, including altered foraging behavior and decreases in nest attendance and reproductive success, have been reported for other raptors (White and Thurow 1985, p. 14; Andersen et al. 1989, p. 296; McGarigal et al. 1991, p. 5).

Although it has not been conclusively demonstrated, it is anticipated that nesting spotted owls may be disturbed by heat and smoke as a result of burning activities during the breeding season.

A.4 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) needs:

A.4.1 Habitat-specific Needs

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

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

3. Suitable habitat distributed across a variety of ecological conditions within the northern 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 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.

A.4.2 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 understand better the risk that WNV and sudden oak death pose to spotted owls and, for WNV, research into methods that may reduce the likelihood or severity of outbreaks in spotted owl populations.

A.4.3 Conservation Strategy

Since 1990, various efforts have addressed the conservation needs of the northern spotted owl and attempted to formulate wide-ranging strategies based upon these needs. These efforts began with the ISC's Conservation Strategy (Thomas et al. 1990); they continued with the designation of critical habitat (USDI FWS 1992a), the Draft Recovery Plan (USDI FWS 1992b), and the Scientific Analysis Team report (Thomas et al. 1993), report of the Forest Ecosystem Management Assessment Team (Thomas and Raphael 1993); the NWFP (USDA FS and USDI BLM 1994a), and they culminated with the Revised Recovery Plan (USDI FWS 2011) and the revised final critical habitat designation (USDI FWS 2011). Each of these strategies were based upon the reserve design principles first articulated in the ISC'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.

- High quality 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.

A.4.4 Federal Contribution to Recovery

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 (USDA FS and USDI BLM 1994a, 1994b). 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. Land management under the NWFP was expected to provide for the long term conservation of the spotted owl by including land use allocations which would sustain population clusters of northern spotted owls (i.e., demographic support) and maintain connectivity between populations. Certain land use allocations in the plan contribute to supporting population clusters: 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. To ensure a predictable and sustainable level of timber sales, "matrix" areas were designated to support timber production while also retaining some connectivity and biological legacy components important to old-growth obligate species (in 100-acre owl cores, 15 percent late-successional provision, etc. (USDA FS and USDI BLM 1994a, USDI FWS 1994b) which would persist into future managed timber stands.

One of the overall goals of the NWFP was to protect and enhance habitat for the NSO on federal lands. The NWFP predicted that over time, the rate of habitat losses would be reduced and the spotted owl population would decline in the Matrix land use allocation, while the population would stabilize and eventually increase within LSRs as habitat conditions improved over the next 50 to 100 years (Thomas and Raphael 1993, p. II-31; USDA FS and USDI BLM 1994a, 1994b, p.3&4-229).

Periodic assessments monitoring changes in NSO habitat on federal and non-federal lands within its geographic range in the United States have been published every five years since 2005 (Lint 2005, Davis et al., 2011; Forsman et al., 2011, Davis et al., 2015). These assessments evaluate assumptions made during development of the NWFP; including the assumption that habitat would not decline faster than five percent per decade. Key points of the 2015 NWFP Monitoring Report (Davis et al., 2015, pp. 20, 36-39):

- Reductions in habitat range-wide have not exceeded expectations. During its first two decades, range wide losses of nesting/roosting habitat on federal lands were estimated at total range wide loss of 7.2 percent (5.2 percent (474,300 ac) from wildfire, 1.3 percent (116,100 ac) from timber harvesting, and 0.7 percent (59,800 ac) from insects, disease, or other natural disturbances)
- Range-wide there has been a gross loss of about 650,200 ac of nesting/roosting habitat on federal lands or about 7.2 percent of what was present right before the NWFP was established.
- Most of the losses (73 percent) occurred within the federally reserved land use allocations, or a loss of about 7.5 percent of the habitat reserved by the NWFP.
- Non-reserved federal land use allocations experienced a 6.4 percent range-wide loss of habitat that existed in 1993.
- Wildfires were the primary cause of habitat loss since 1993, accounting for about 82

percent of the loss in reserved allocations and about half of the loss in non-reserved allocations

- Some areas are affected by NR habitat loss disproportionally particularly within the Oregon and California Klamath provinces - 56 percent of the range-wide habitat loss on federal lands occurred in these two provinces
- Oregon and California Klamath physiographic provinces experienced the largest amounts (132,000 to 199,800 ac respectively) and double digit percentage losses (13.2 and 10.7 percent respectively) since the plan was implemented.
- Some habitat growth/recruitment is occurring in portions of the range and appears to have begun beginning to help offset losses
- These authors project that if localized habitat losses continue at the current rates within some provinces in the reserved land allocations, the effectiveness of the Plan to maintain the distributed and connected NSO populations across the range is in question (Davis et al., 2011, p. 54).

Similar to the periodic assessments monitoring changes in NSO habitat on federal and non-federal lands, population trends are also monitored on eleven study sites in Washington, Oregon, and California. The most recent meta-analysis has determined a mean annual decline of 3.8 percent decline range-wide (Dugger et al., 2016), an increase in the2.8 percent decline reported in 2011. Refer to Population Dynamics and Barred Owl sections for more information pertaining to recent findings.

On June 28, 2011, the Service published the Revised Recovery Plan for the Northern Spotted Owl (USDI FWS 2011b). The recovery plan identifies threats from competition with barred owls, ongoing loss of northern spotted owl habitat as a result of timber harvest, loss or modification of northern spotted owl habitat from uncharacteristic wildfire, and loss of amount and distribution of northern spotted owl habitat as a result of past activities and disturbances (USDI FWS 2011b, p. II-2 and Appendix B). To address these threats, the current recovery strategy identifies five main steps: 1) development of a range-wide habitat modeling framework; 2) barred owl management; 3) monitoring and research; 4) adaptive management; and 5) habitat conservation and active forest restoration (USDI FWS 2011b, p. II-2). The recovery plan lists recovery actions that address each of these items, some of which were retained from the 2008 recovery plan. The Managed Owl Conservation Areas and Conservation Support Areas recommended in the 2008 recovery plan are not a part of the recovery strategy outlined in the revised recovery plan. The Service completed a range-wide, multi-step habitat modeling process to help evaluate and inform management decisions and critical habitat development (USDI FWS 2011b, Appendix C).

The revised recovery plan (USDI FWS 2011b) recommended implementing a robust monitoring and research program for the spotted owl. The recovery plan encourages these efforts by laying out the following primary elements to evaluate progress toward meeting recovery criteria: monitoring spotted owl population trends, comprehensive barred owl research and monitoring, continued habitat monitoring; inventory of spotted owl distribution, and; explicit consideration for climate change mitigation goals consistent with recovery actions (USDI FWS 2011b, p. II-5). The revised recovery plan also strongly encourages land managers to be aggressive in the implementation of recovery actions. In other words, land managers should not be so

conservative that, to avoid risk, they forego actions that are necessary to conserve the forest ecosystems that are necessary to the long-term conservation of the spotted owl. But they should also not be so aggressive that they subject spotted owls and their habitat to treatments where the long-term benefits do not clearly outweigh the short-term risks. Finding the appropriate balance to this dichotomy will remain an ongoing challenge for all who are engaged in spotted owl conservation (USDI FWS 2011b, p. II-12). The revised recovery plan estimates that recovery of the spotted owl could be achieved in approximately 30 years (USDI FWS 2011b, p. II-3).

A.4.5 Conservation Efforts on Non-Federal Lands

In the report from the Interagency Scientific Committee (Thomas et al. 1990, p. 3, p. 272), the draft recovery plan (USDI FWS 1992b), and the report from the Forest Ecosystem Management Assessment Team (Thomas and Raphael 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 U.S. Fish and Wildlife 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 and ongoing conservation plans (CPs) including Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) that have incidental take permits issued for northern spotted owls—eight in Washington, three in Oregon, and six in California (USDI FWS 2011b, p. A-15). The CPs range in size from 76 acres to more than 1.8 million acres, although not all acres are included in the mitigation for northern spotted owls. In total, the CPs cover approximately 3 million acres (9.4 percent) of the 32 million acres of non-Federal forest lands in the range of the northern spotted owl. The period of time that the HCPs will be in place ranges from 20 to 100 years. While each CP 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 nesting habitat
- Forest harvest that maintains or develops foraging 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 (Washington Forest Practices Board 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 (Hanson et al. 1993, pp. 11-15; Buchanan et al. 1994, p. ii). The 1996 rule package was developed by a stakeholder policy group and then reviewed and

approved by the Forest Practices Board (Buchanan and Swedeen 2005, p. 9). Spotted owl-related HCPs in Washington generally were intended to provide demographic or connectivity support (USDI FWS 1992b, p. 272). There are over 2.1 million acres of land in six HCPs and two SHAs (USDI FWS 2011b, p. A-15). Some of these CPs focus on providing nesting/roosting habitat throughout the area or in strategic locations; while others focus on providing connectivity through foraging habitat and/or dispersal habitat. In addition, there is a long term habitat management agreement covering 13,000 acres in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange (USDI FWS 2011b, p. A-15).

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 (Oregon Department of Forestry 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 (USDI FWS 2011b, p. A-16). On July 27, 2010, the Service completed a programmatic SHA with the Oregon Department of Forestry that will enroll up to 50,000 acres of non-federal lands within the State over 50 years. The primary intent of this programmatic SHA is to increase time between harvests and to lightly to moderately thin younger forest stands that are currently not habitat to increase tree diameter and stand diversity (USDI FWS 2011b, p. A-16).

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 (California Department of Forestry and Fire Protection 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 (California Department of Forestry and Fire Protection [CALFIRE] 2007, pp. 85-87). Currently CALFIRE reviews all timber harvest plans to ensure that take was is not likely to occur. Two industrial timberland owners operate under spotted owl management plans that have been reviewed by the U.S. Fish and Wildlife Service and that specify basic measures for spotted owl protection. Four HCPs and two SHAs authorizing take of spotted owls have been approved; these HCPs cover more than 622,000 acres of non-Federal lands. Implementation of these plans is intended to provide for spotted owl demographic and connectivity support to NWFP lands (USDI FWS 2011b, p. A-16).

A.5 Current Condition of the Spotted Owl

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

A.5.1 Range-wide Habitat and Population Trends

A.5.1.1 Range-wide Habitat Baseline

The Service has used information provided by the USFS, BLM, and National Park Service to update the habitat baseline conditions by tracking relative habitat changes over time on Federal lands for northern spotted owls on several occasions, since the northern spotted owl was listed in 1990 (USDA and USDI 1994b, USDI 2001, Lint 2005, Davis et al. 2011). The estimate of 7.4 million acres used for the NWFP in 1994 (USDA and USDI 1994b) was believed to be representative of the general amount of northern spotted owl habitat on NWFP lands at that time. Periodic range-wide evaluations of habitat, as compared to the Final Supplemental Environmental Impact Statement (FSEIS; USDA and USDI 1994b), are necessary to determine if the rate of potential change to northern spotted owl habitat is consistent with the change anticipated in the NWFP: a reduction in suitable habitat of approximately 2.5 percent per decade (USDA and USDI 1994a, p. 46). The most recent mapping effort estimates a range-wide gross loss of about 650,200 ac of nesting/roosting habitat on federal lands, amounting to about 7.2 percent of what was present in 1993. Most of the losses (73 percent) occurred within the federally reserved land use allocations, or a loss of about 7.5 percent of the habitat reserved by the NWFP. The primary cause of habitat loss since 1993 were wildfires, accounting for about 82 percent of the range-wide loss in reserved allocations (388,500 acres) and about half of the loss in non-reserved allocations (85,900 ac) (Davis et al. 2015, p. 17).

Although the spatial resolution of this new habitat map currently makes it unsuitable for tracking habitat effects at the scale of individual projects, it is informative for tracking provincial and range-wide habitat trends and now considers these data as the best available information on the distribution and abundance of extant spotted owl habitat within its range as of 2006 for Oregon and Washington, and 2007 for California (when the base imagery was collected).

April 13, 2004, marked the start of the second decade of the NWFP. Decade-specific baselines and summaries of effects by State, physiographic province and land use function from proposed management activities and natural events are not provided here, but are consistent with expected habitat changes under the NWFP. In February 2013, the Service adopted the 2006/07 satellite imagery data on spotted owl habitat as the range-wide habitat baseline for Federal lands which effectively resets the timeframe for establishing changes in the distribution and abundance of spotted owl habitat. On that basis, the assessment of local, provincial and range-wide spotted owl habitat status in this and future Opinions as well as Biological Assessments will rely on these 2006/07 habitat data to characterize changes in the status of spotted owl habitat. Note that tables in this database have not yet been updated to reflect the adjusted values estimated by Davis and others (2015).

A.5.1.2 Service's Consultation Database

In general, the analytical framework of these section 7 consultations focuses on the reserve and connectivity goals established by the NWFP land-use allocations (USDA FS and USDI BLM 1994a), with effects expressed in terms of changes in suitable northern spotted owl habitat within those land-use allocations. To update information considered in 2001 (USDI 2001), the Service

designed the Consultation Effects Tracking System database in 2002, which recorded impacts to northern spotted owls and their habitat at different spatial and temporal scales. In 2011, the Service replaced the Consultation Effects Tracking System with the Consulted on Effects Database located in the Service's Environmental Conservation Online System (ECOS). The ECOS Database corrected technical issues with the Consultation Effects Tracking System. Data are currently entered into the ECOS Database under various categories including; land management agency, land-use allocation, physiographic province, and type of habitat affected.

A.5.1.3 Range-wide Consultation Effects: 1994 to December 7, 2015

The Service updated the ECOS Database to reflect the 2006/2007 habitat baseline developed for the NWFP 15-year monitoring report (Davis et al. 2011, Appendix D, Table D) but at the time of this writing, this had not been updated to reflect the data within the 2015 NWFP 20-year report. Between 1994 and December 7, 2015, the Service has consulted on the proposed removal/downgrade of approximately 207,070 acres (Table A1) or 2.3 percent of the 8.854 million acres of northern spotted owl nesting/roosting habitat estimated by Davis et al. (2011) to have occurred on Federal lands (Table A2). These changes in suitable northern spotted owl habitat are consistent with the expectations for implementation of the NWFP, which anticipated a rate of habitat harvested at 2.5 percent per decade (USDA FS and USDI BLM 1994a).

The Service tracks habitat changes on non-NWFP lands 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 522,431 acres (about 6 percent) habitat on non-NWFP lands. Most of these losses have yet to be realized because they are part of large-scale, long-term Habitat Conservation Plans.

Table A1. **Range-wide Aggregate of Changes to NRF[1] Habitat Acres From Activities Subject to Section 7 Consultations and Other Causes. NWFP Timeframe - 1994 to Present:**

Land Ownership	Consulted On Habitat Changes[2]		Other Habitat Changes[3]	
	Removed/ Downgraded	Maintained/ Improved	Removed/ Downgraded	Maintained/ Improved
NWFP (FS,BLM,NPS)	**207,070**	**549,778**	**262,620**	**54,673**
Bureau of Indian Affairs / Tribes	**113,926**	**28,372**	**2,398**	**0**
Habitat Conservation Plans/Safe Harbor Agreements	**339,692**	**14,539**	**N/A**	**N/A**
Other Federal, State, County, Private Lands	**68,813**	**28,447**	**2,392**	**0**
Total Changes	**729,501**	**621,136**	**267,410**	**54,673**

Table A2. **Summary of northern spotted owl suitable habitat (NRF)[1] acres removed or downgraded on Federal lands within the Northwest Forest Plan area through timber harvest, natural disturbance, or other management actions as documented through section 7 consultation and technical assistance. Range-wide changes by land-use function from 2006 to present.**

Suitable Habitat (NRF) Effects	Reserves (LSR, MLSA, CRA)[3]	Non-reserves (AWA, AMA, Matrix)[3]	Totals
Evaluation Baseline (2006/2007)[2]	**5,961,000**	**2,594,200**	**8,555,200**
Removed/Downgraded (timber harvest only)[4]	**8,514**	**40,763**	**49,277**
Removed/Downgraded (other management activities)[5]	**3,660**	**2,575**	**6,235**
Subtotal	**12,174**	**43,338**	**55,512**
Removed/Downgraded (natural disturbance)[6]	**38,015**	**29,789**	**67,804**
Total Net Change	**50,189**	**73,127**	**123,316**
Baseline Balance	**5,910,811**	**2,521,073**	**8,431,884**
Habitat Maintained[7]	**53,338**	**64,390**	**117,728**

Notes:

1. Nesting, roosting, foraging (NRF) habitat. In California, suitable habitat is divided into two components; nesting - roosting (NR) habitat, and foraging (F) habitat. The NR component most closely resembles NRF habitat in Oregon and Washington. Due to differences in reporting methods, effects to suitable habitat compiled in this, and all subsequent tables include effects for nesting, roosting, and foraging (NRF) for 1994-6/26/2001. After 6/26/2001 suitable habitat includes NRF for Washington and Oregon but only nesting and roosting (NR) for California.
2. Includes both effects reported in USFWS 2001 and subsequent effects reported in the Northern Spotted Owl Consultation Effects Tracking System (web application and database.). Note consulted on effects to NSO habitat (NR and F) for Fruit Growers' HCP is included in these totals, but has not yet been entered into the web application database.
3. Includes effects to suitable NRF habitat (as generally documented through technical assistance, etc.) resulting from wildfires (not from suppression efforts), insect and disease outbreaks, and other natural causes, private timber harvest, and land exchanges not associated with consultation.

A.5.1.4 Range-wide Consultation Effects: 2006/2007 to November 23, 2015

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 effects to current owl habitat at provincial and range-wide scales.

Table A3 summarizes the habitat impacts on Federal lands that have occurred since 2006/2007 through November 23, 2015. Note these data reflect data provided through the section 7 consultation efforts and may not reflect the same data displayed in Davis et al., 2015. The rangewide effects from 2014 or 2015 fires were not available for the preparation of this biological opinion. This database reports an estimated 123,316 acres of nesting, roosting, and foraging habitat has been lost from Federal lands since 2006/2007 due to land management activities and natural events. When overall habitat loss is evaluated as a proportion of provincial baselines, the Oregon Cascades and the California Klamath provinces have proportional losses

greater than the loss of habitat across all provinces (51 percent of rangewide loss). While variable among the individual provinces, most of the impacts are due to management-related actions and are concentrated within the 'Non-Reserves' land-use allocations (about 73,000 acres in non-reserve land allocations and about 50,000 acres reported). When habitat loss is evaluated as a proportion of the affected acres range-wide from management activites, Oregon reports the highest proportion, with almost 48,000 acres removed (about 86 of rangewide loss from management activities). Washington reports about 6,500 acres (12 percent) and California about 1,010 acres removed (about two percent). Wildland fires have resulted in considerable loss of NRF habitat within the California Klamath Province (about 40 percent of total lost habitat range-wide).

Table A3. Summary of northern 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.

State	Physiographic Province[2]	Evaluation Baseline (2006/2007)[3]			Habitat Removed/Downgraded[4]							% Provincial Baseline Affected	% Range-wide Effects
					Land Management Effects			Habitat Loss from Natural Events			Total NRF removed/ downgraded		
		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	5.38
	Olympic Peninsula	729,000	33,400	762,400	6	0	6	0	1	1	7	0	0.01
	Western Cascades	1,031,600	246,600	1,278,200	779	834	1,613	3	0	3	1,616	0.13	1.31
	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	2,434	10,073	20,566	5.46	16.68
	Cascades West	1,275,200	939,600	2,214,800	1,587	25,029	26,616	761	1,531	2,292	28,908	1.31	23.44
	Coast Range	494,400	113,400	607,800	750	1,623	2,373	0	0	0	2,373	0.39	1.92
	Klamath Mountains	549,400	334,900	884,300	2,999	5,464	8,463	3,427	3,816	7,243	15,706	1.78	12.74
	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	0.27
	Coast	132,900	10,100	143,000	274	1	275	0	175	175	450	0.31	0.36
	Klamath	910,900	501,200	1,412,100	75	649	724	24,301	21,700	46,001	46,725	3.31	37.89
Total		5,961,000	2,594,200	8,555,200	12,174	43,338	55,512	38,015	29,789	67,804	123,316	1.44	100

Notes:

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.

Defined in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) as Recovery Units as depicted on page A-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 (Not updated for 20-Year Monitoring Report.

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.

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.

A.5.1 *Spotted Owl Population Trends and Distribution*

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 (USDI FWS 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 (USDI FWS 1990a, p. 26114). 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 1992a, p. 31). The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

Population estimates are difficult to achieve on wide-ranging species such as the Northern spotted owl. As of July 1, 1994, there were 5,431 known site-centers of spotted owl pairs or resident singles: 851 sites (16 percent) in Washington, 2,893 sites (53 percent) in Oregon, and 1,687 sites (31 percent) in California (USDI FWS 1995, p. 9495). The totals above represent the cumulative number of locations recorded in the three states, not population estimates. Estimated populations were modeled during the 2012 critical habitat designation which projected a steady-state range-wide population size of roughly 3,400 female NSOs. Population sizes varied regionally from low in the north, especially the northwest (e.g., about 100 in the North Coast Olympics and West Cascades North modeling regions), to high in parts of southern Oregon and northern California (e.g. about 750 each in the Inner California Coast, Klamath East, Klamath West, Redwood Coast, and West Cascades South modeling regions) (Dunk et al., 2012, p. 64). These estimates likely over represent the numbers of females as this modeling effort was based on 2008 NSO data and do not reflect subsequent declines over the last seven years. Additionally, the actual number of currently occupied spotted owl locations across the range is unknown because many areas remain unsurveyed (USFWS 2011b, p. A-2) and many historical sites are no longer occupied because spotted owls have been displaced by barred owls, timber harvest, or severe fires. Additionally it is possible that some new sites have been established due to reduced timber harvest on Federal lands since 1994.

Because the existing survey coverage and effort are insufficient to produce reliable range-wide estimates of population size, demographic data are used to evaluate trends in spotted owl populations. Analysis of demographic data can provide an estimate of the finite rate of population change (λ), which provides information on the direction and magnitude of population change. A λ of 1.0 indicates a stationary population, meaning the population is neither increasing nor decreasing. A λ of less than 1.0 indicates a decreasing population, and a λ of greater than 1.0 indicates a growing population. Demographic data are analyzed periodically to estimate trends in the populations of the spotted owl.

As described above, after the implementation of the NWFP, populations were expected to decline in the short term, and then stabilize or increase after 50–100 years (Thomas et al. 1990, Lint et al. 1999). Previous demographic analyses suggested that populations confirmed this

projection, but the rates of decline began to taper through 2009 (Dugger et al., 2016,Table 26, p.97); however, these rates have varied among study areas (Franklin et al. 1999, Anthony et al. 2006, Forsman et al. 2011).

The most recent meta-analysis results suggest that the rates of decline have now increased range-wide, as summarized below (Dugger et al., 2016, entire). Estimated declines in annual rates of population change and occupancy rates were found to continue from past reports in all parts of their range. That rate of decline was increasing in many areas, including southern Oregon and Northern California (Dugger et al., 2016, p. 91)(Table A4).

Table A4. Summary of spotted owl population trends from in demographic study areas (Dugger et al., 2016, Table 25, p.97).

Study Area	Fecundity	Apparent Survival*	Occupancy Rates	Mean Population change / population change	% Population Change[1]
Cle Elum	**Declining**	**Declining**	**Declining**	.916/No trend	-77%
Rainier	No trend	**Declining**	**Declining**	.953/No trend	-61%
Olympic	No trend	No trend	**Declining**	.961/No trend	-59%
Coast Ranges	**Declining**	No trend	**Declining**	.949/**Declining**	-64%
HJ Andrews	**Declining**	**Declining**	**Declining**	.965/**Declining**	-47%
Tyee	**Declining**	**Declining**	**Declining**	.976/**Declining**	-31%
Klamath	**Declining**	No trend	**Declining**	.972/**Declining**	-34%
Southern Cascades	No trend	**Declining**	**Declining**	.963/No trend	-44%
NW California	**Declining**	**Declining**	**Declining**	.970/**Declining**	-55%
Hoopa	**Declining**	**Declining**	**Declining**	.977/**Declining**	-32%
Green Diam. - CB	**Declining**	**Declining**	**Declining**	.988/**Declining**	-31%
Green Diam. - TB	**Declining**	**Declining**	**Declining**	.961/**Declining**	-26%
Green Diam. - CA	**	**	**Declining**	.878/**	-41%
Green Diam. - TA	**	**	N/A[2]	1.030/**	-9%-

[1] With the exception of the Green Diamond study area, percent population change was based on estimates of *realized population change* in 2011, the last year for which an estimate of population change could be generated.
[2] Data used for occupancy modeling in the GDR study area excluded treatment areas after Barred Owl removals began in 2009.
** Too few years since Barred Owl removal to evaluate a trend.
CB = control before barred owl removal; TB=treatment before removal; CA=control after removal; TA= treatment after removal

Individual study area *annual rates of population change* (λ) were based on capture histories for 5,992 territorial owls from all age classes. Almost all study areas showed declining population trends, with strong evidence of declines in all of Washington study areas, the coastal and HJ Andrews study areas in Oregon and three California study areas. Less of a decline was found in Tyee, Klamath, and Cascades study areas of Oregon. The only study area indication an increasing population was observed in Green Diamond treatment areas after barred owl removals

began in 2009 (GDR-TA). The rates of decline were variable across the range; the highest were in Green Diamond control areas (GDR-CA) after 2009 (12.0% annual decline). the Washington CleElum study area (8.4 percent) and the lowest was in the Green Diamond before barred owl removals began in treatment areas in 2009 (1.2 percent annual decline. The weighted mean population change for all study areas (excluding GDR-TB) was an estimated decline of 3.8 percent per year from 1985-2013 (Dugger et al., 2016, p.70-71). This is an increase from 2.8 percent reported by Forsman et al., 2011).

Recent estimates of *realized population change* (change in populations since studies were initiated) showed sharper declines in the northern portion of the range. Populations in Washington declined by 55–77 percent; sites in Oregon ranged from 31 percent in TYE to 68 percent in COA, with two cases more uncertain (KLA and TYE). The 95% confidence intervals in these sites widely overlapped 1.0 for most or all of the last several years. Declines in California, ranged from 32 – 55 percent, with exceptions in HUP and treatment areas of GDR (GDR T where confidence limits overlapped 1.0 in many years, indicating uncertainty about annual rates of population change in these areas.

Decreases in adult apparent survival rates were an important factor contributing to decreasing population trends. Dugger et al., 2016 (p.58) found strong evidence that barred owls negatively affected spotted owl populations, largely from increasing local territory extinction rates and decreasing apparent survival. The amount of suitable habitat, local weather, and regional climatic patterns also were related to survival, occupancy (via colonization rate), and recruitment. Associated effects to fecundity were weaker.. Five of the 11 study areas included either a negative linear or log-linear time trend on 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 2011b, 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.

A.5.2 Spotted Owl Recovery Units

The 2011 Final Revised Recovery Plan for the Northern Spotted Owl determined that the 12 existing physiographic provinces meet the criteria for use as recovery units (USDI FWS 2011b, p. III 1-2). The proposed project is within the Eastern Oregon Cascades Physiographic Province. Recovery criteria, as described in the 2011 Final Revised Recovery Plan (p. 11-3), are measurable and achievable goals that are believed to result through implementation of the recovery actions described in the recovery plan. Achievement of the recovery criteria will take time and are intended to be measured over the life of the plan, not on a short-term basis. The criteria are the same for all 12 identified recovery units. The four recovery criterion are: 1) stable population trend, 2) adequate population distribution, 3) continued maintenance and recruitment of northern spotted owl habitat, and 4) post-delisting monitoring (USDI FWS 2011b, p III-3).

As discussed in the Section A.5.1, demographic data are used to evaluate trends in northern spotted owl populations. The Southern Oregon Cascades Demographic Study Area, which overlaps a portion of the Eastern Oregon Cascades Physiographic Province, is one of five demographic study areas in Oregon that are part of the Effectiveness Monitoring Program for Spotted Owls in the Northwest Forest Plan. A workshop was conducted to analyze range-wide demographic data of northern spotted owls in January 2004 and fecundity, apparent survival, and population trend were estimated for the Southern Oregon Cascades Study Area during the workshop for a period of 1985 to 2003 (Anthony et al. 2008, pp.23-24). Anthony et al. (2008, p. 24) found that apparent survival estimated from the model that "best fit" the data indicated that there were no sex related differences but that subadult (first and second year combined) survival differed from adult owls. Anthony et al. (2006) also found that the "best fit" model of fecundity incorporated a three-age-class effect, an odd-even year effect, and linear time trend. The model indicated that fecundity for the southern Cascades was possibly decreasing for the period of study. Results from this study also suggest that the population was stationary (neither increasing nor decreasing) during the period of the study. Similarly, Forsman et al. (2011) indicate that fecundity (young produced) within the Southern Oregon Cascades Study Area is declining. At the population scale, Forsman et al. (2011) indicate that the population in the Southern Oregon Cascades Study Area may be stable; however, the precision of the estimates (95 percent confidence interval) may not be sufficient to detect declines in this population (Forsman et al. 2011).

Appendix B - Glossary

The proposed SHA and Permit activities were analyzed, in part, using the following terms:

B.2.1 General Definitions

B.2.1.1 *Suitable Spotted Owl Habitat*: Forest stands with sufficient structure (large trees, snags, and downed wood) to provide opportunities for spotted owl nesting and roosting (Davis et al. 2015). Generally, these conditions are associated with conifer-dominated stands that are 80 years old or older, are multi-storied in structure, have trees greater than or equal to 18 inches mean diameter at breast height (dbh), and have canopy closure that generally exceeds 60 percent. Stands are defined as suitable spotted owl habitat at a larger scale (i.e., the province scale) based on age (80 yrs or older) and/or size (dbh >18inches). A biologist with expertise on spotted owl habitat evaluates all covered areas to make a final determination of the extent of suitable spotted owl habitat within a covered area based on the structural complexity known to be associated with functional spotted owl nesting, roosting, and foraging habitat.

B.2.1.2 *Spotted Owl Dispersal Habitat*: Refers to the subset of forested habitat used by dispersing spotted owls that does not contain suitable habitat. These stands provide protection from avian predators and at least minimal foraging opportunities for spotted owls during dispersal. At a minimum, dispersal habitat is comprised of conifer and mixed mature conifer-hardwood habitats with a canopy cover greater than or equal to 40 percent and conifer trees greater than or equal to 11 inches average dbh but less than the habitat characteristics described above for suitable spotted owl habitat. Generally, spotted owls use younger stands to move between blocks of suitable habitat, and to roost, forage, and survive until they can establish a nesting territory. Juvenile spotted owls also use dispersal habitat to move from natal areas.

B.2.1.3 *Spotted Owl Breeding Period*: March 1 through September 30. The critical breeding period for the spotted owl is March 1 through July 7.

B.2.1.4 *Known Spotted Owl Site*: A site that was or is occupied by a pair of or a resident single (1990 to present) spotted owl as defined by the Service's survey protocol for the spotted owl (USFWS 2010). A specific site location is determined by a spotted owl biologist based on the best and/or most recent information.

B.2.1.5 *Spotted Owl Nest Patch (or Stand)*: A 300-meter radius circle around a known spotted owl site where a spotted owl would be likely to select a nesting tree (Miller 1989).

B.2.1.6 *Spotted Owl Core Area*: A 0.5-mile radius circle around a known spotted owl site, which delineates the area most heavily used by spotted owls during the nesting season (Glenn et al. 2004).

B.2.1.7 *Spotted Owl Home Range*: An estimated area of habitat use by a spotted owl pair. For the Oregon Coast, this estimated area is a 1.5-mile radius circle around a known spotted owl site (Thomas et al. 1990 and Foresman et al. 1984).

B.2.2 Spotted Owl Disturbance/Disruption Distances

B.2.2.1 *Disturbance Distance*: The distance from a project boundary within which a stressor caused by the project would likely cause a spotted owl, if one was present, to be distracted from its normal activity (Table 1).

A spotted owl biologist is responsible for ensuring that the correct effects determination is made for each project. The biologist may increase or decrease these disturbance distances based on best available scientific information and site-specific conditions. If a known spotted owl site is surveyed to protocol and the spotted owl(s) are determined to be non-nesting, the biologist may determine that no disturbance to or disruption of the spotted owl(s) is likely to occur and lift the associated restrictions on activities within the disruption distances determined for the site during the year of survey.

B.2.2.2 *Disruption Distance*: The distance from a project boundary within which a stressor caused by the project would likely cause a spotted owl, if one was present, to be distracted from its normal activity to such an extent as to significantly impact its normal behavior and create the likelihood of injury (i.e., be taken in the form of harass). The disruption distance is a subset of the disturbance distance (Table B1).

A spotted owl biologist is responsible for insuring that the correct effect determination is made for each project with respect to spotted owl disruption. The biologist may increase or decrease these disruption distances based on best available information and site-specific information. If a known spotted owl site is surveyed to Service (2010) protocol and the spotted owl(s) are determined to be non-nesting, the biologist may determine that no disruption is likely to occur and lift the associated restrictions on activities within the disruption distances determined for the site during the year of survey.

Table B1. Disturbance and disruption distances for northern spotted owls during the breeding period (March 1 – September 30). When the nest tree location is not currently known, distance is measured from the edge of the nest patch.

DISTURBANCE SOURCE	DISTURBANCE DISTANCES DURING THE BREEDING PERIOD[1] (MAR 1 – SEP 30)	DISRUPTION DISTANCES DURING THE CRITICAL BREEDING PERIOD[1] (MAR 1 – JUL 7)	DISRUPTION DISTANCES DURING THE LATE BREEDING PERIOD[1] (JUL 8 – SEP 30)
Road brushing and maintenance on all roads	440 yards (0.25 mile)	0 yards	0 yards
Hauling on open roads	440 yards (0.25 mile)	0 yards	0 yards
Use of chainsaws	440 yards (0.25 mile)	65 yards	0 yards
Heavy equipment	440 yards (0.25 mile)	35 yards	0 yards
Tree climbing	440 yards (0.25 mile)	35 yards	0 yards
Burning	440 yards (0.25 mile)	440 yards (0.25 mile)	0 yards

Use of Type I helicopter [2]	880 yards (0.5 mile)	440 yards (0.25 mile)	440 yards (0.25 mile)
Use of Type II, III or IV helicopter [3]	440 yards (0.25 mile)	120 yards	0 yards
Use of fixed-wing aircraft	440 yards (0.25 mile)	120 yards	0 yards
Pile driving	440 yards (0.25 mile)	60 yards	0 yards
Rock crushing	440 yards (0.25 mile)	180 yards	0 yards

[1] Noise disturbance and disruption distances were developed from a sound threshold (USFWS 2003). Smoke disturbance and disruption distances are based on a FWS white paper (USFWS 2008b).

[2] Type I helicopters seat at least 16 people and have a minimum capacity of 5,000 lbs. Both a CH-47 (Chinook) and UH-60 (Blackhawk) are Type I helicopters. Kmax helicopters are considered "other" for the purposes of disturbance. Sound readings from Kmax helicopter logging on the Olympic NF registered 86 dB at 150 yards (Piper 2006).

[3] All other helicopters (including Kmax).

Appendix B - Glossary

Anderson, D.R. and K.P. Burnham. 1992. Demographic analysis of Northern Spotted Owl populations. Recovery Plan for Northern Spotted Owl, Appendix C. U.S. Fish and Wildlife Service, Portland, Oregon.

Andersen, D. E., O.J. Rongstad, and W. R. Mytton. 1989. Response of nesting red-tailed hawks to helicopter overflights. The Condor 91:296-299.

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. Unpublished report, OCWRU, Oregon State University, Corvallis, Oregon. 29pp.

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 Monograph No. 163. XX pp.

Bailey, L.L., J.A. Reid, E.D. Forsman, and J.D. Nichols. 2009. Modeling co-occurrence of northern spotted and barred owls: accounting for detection probability differences. Biological Conservation. 142: 2983-2989.

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

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

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. 1981. Roost selection by Spotted Owls: an adaptation to heat stress. Condor 83: 302-309.

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

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.

Bigley, R. and J. Franklin. 2004. Habitat trends.Pages 6-1 – 6-35 *In*: Courtney, S.P., J.A. Blakesley, R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, L. Sztukowski. . Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute. Portland, Oregon. September 2004. 508 pp.

Bingham, B.B, and B.R. Noon. 1997. Mitigation of habitat "take": application to habitat conservation planning. Conservation. Biology. 11(1): 127-139.

Blakesley, J.A., W. LaHaye, J.M.M. Marzluff, B.R. Noon, and S. Courtney. 2004. Demography. Pages 8-1 – 8-46 *in*: Courtney, S.P., J.A. Blakesley, R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, L. Sztukowski. 2004. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute. Portland, Oregon. September 2004. Pp 211-257.

Blakesley, J.A., D.R. Anderson, and B.R. Noon. 2006. Breeding dispersal in the California spotted owl. The Condor. 108(1): 71-81.

Bond, M.L., R.J. Gutierrez, 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.

Bond, M.L., D.E. Lee, R.B. Siegel, and J.P. Ward, Jr. 2009. Habitat use and selection by spotted owls in a postfire landscape. Journal of Wildlife Management 73(7):1116-1124.

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

Buchanan, J., 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, Washington.

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 59:301-310.

Buchanan, J.B. and P. Swedeen. 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. 84pp.

Burnham, K.P., D.R. Anderson, and G.C. White. 1994. Estimation of vital rates of the northern spotted owl. Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, Colorado, USA.

Caffrey, C. 2003. Determining impacts of West Nile Virus on crows and other birds. American Birds (103rd Count) 57:14-21.

Caffrey, C. and C.C. Peterson. 2003. West Nile Virus may not be a conservation issue in northeastern United States. American Birds (103rd Count) 57:14-21.

Campbell, N. A. 1990. Biology. The Benjamin/Cummings Publishing Company, Inc. Redwood City, California.

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 54:11–17.

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) pp. 223-250.

Carsia, R. V., and S. Harvey. 2000. Adrenals. Chapter 19 *in* G. C. Whittow, editor. Sturkie's Avian Physiology. Academic Press, San Diego, CA.

Chi, T., A. Henke, J. Smith, and C. Brinegar. 2004. Spotted owl mitochondrial DNA haplotyping. San Jose State University. Unpublished results submitted to U.S. Fish and Wildlife Service.

CDFFP (California Department of Forestry and Fire Protection). 2007. California Forest Practices Rules: 2001. Title 14, California Code of Regulations, Chapters 4, 4.5, and 10. Sacramento, California.

Chutter, M.J., I. Blackburn, D. Bonin, J. 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. British Columbia Ministry of Environment, Victoria. 74pp.

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

Courtney, S.P. and R.J. Gutiérrez. 2004. Scientific evaluation of the status of the northern spotted owl – threats. In: Courtney, S.P., J.A. Blakesley, R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, L. Sztukowski. 2004. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute. Portland, Oregon. September 2004.

Crozier, M.L., M.E. Seamans, R.J. Gutiérrez, P.J. Loschl, R.B. Horn, S.G. Sovern, and E.D. Forsman. 2006. Does the presence of barred owls suppress the calling behavior or spotted owls? The Condor. 108: 760-769.

Dark, S.J., R.J. Gutiérrez, and G.I. Gould, Jr. 1998. The barred owl (*Strix varia*) invasion in California. The Auk. 115(1): 50-56.

Davidson, J.M., A.C. Wickland, H.A. Patterson, K.R. Falk, and D.M. Rizzo. 2005. Transmission of *Phytophthora ramorum* in mixed-evergreen forest in California. Ecology and Epidemiology. 95(5)587-596.

Davis, Raymond J.; Dugger, Katie M.; Mohoric, Shawne; Evers, Louisa; Aney, William C. 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.

Davis, R.J., Hollen, B., Hobson, J., Gower, J.E. and Keenum, D. 2015. Northwest Forest Plan-The first 20 years (1994-2013): Status and trends of Northern Spotted Owl habitats. USDA Forest Service General Technical Report PNW-GTR-000. p.51.

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.

Deubel, V., L. Fiette, P. Gounon, M.T. Drouet, H. Khun, M. Huerre, C. Banet, M. Malkinson and P. Despres. 2001. Variations in biological features of West Nile viruses. Annals of the New York Academy of Sciences 951:195-206.

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: 275–286.

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

Dugger, K.M., Forsman, E.D., Franklin, A.B., Davis, R.J., White, G.C., Schwarz, C.J., Burnham, K.P., Nichols, J.D., Hines, J.E., Yackulic, C.B. and Doherty Jr, P.F. 2015. The effects of habitat, climate, and Barred Owls on long-term demography of Northern Spotted Owls. The Condor, 118(1), pp.57-116.

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. The Condor 107:863-878.

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.

Folliard, L. 1993. Nest site characteristics of northern spotted owls in managed forest of northwest California. M.S. Thesis. University of Idaho, Moscow, Idaho.

Forsman, E. D. 1983. Methods and materials for locating and studying Spotted Owls. Gen. Tech. Rep. PNW-162. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 8 pp.

Forsman, E.D. 1981. Molt of the spotted owl. Auk 98:735-742

Forsman, E.D. 1975. A preliminary investigation of the spotted owl in Oregon. M.S. thesis, Oregon State University, Corvallis. 127pp.

Forsman, E.D., R.G. Anthony, K.M. Dugger, E.M. Glenn, A.B. Franklin, G.C. White, C.J. Schwarz, K.P. Burnham, 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. Schaberl, T.J. Snetsinger, and S.G. Sovern. 2011. Population demography of northern spotted owls: 1985–2008. Studies in Avian Biology. Cooper Ornithological Society.

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., 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.

Forsman, E.D., S. DeStefano, M.G. Raphael, and R.J. Gutierrez, (editors). 1996. Demography of the northern spotted owl. Studies in Avian Biology No. 17. Cooper Ornithology Society.

Forsman, E.D., T.J. Kaminski, J.C. Lewis, K.J. Maurice, S.G. Sovern, C. Ferland, and E.M. Glenn. 2005. Home range and habitat use of northern spotted owls on the Olympic Peninsula, Washington. Journal of Raptor Research 39(4):365-377.

Forsman, E.D., E.C. Meslow, and H.M. Wight. 1984. Distribution and biology of the spotted owl in Oregon. Wildlife Monographs 87:1-64.

Franklin, A.B. 1992. Population regulation in northern spotted owls: theoretical implications for management. Pp 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. Gutiérrez, 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, R.J. Anthony, E.D. Forsman, C. Sanchez, J.D. Nicols and J. Hines. 1999. Range-wide status and trends in northern spotted owl populations. Colorado Coop. Fish and Wildl. Res. Unit, Fort Collins, Colorado and Oregon Coop. Fish and Wildl. Res. Unit, Corvallis, Oregon. Unpublished report.

Funk, W.C., E.D. Forsman, T.D. Mullins, and S.M. Haig. 2008. Introregression and dispersal among spotted owl (Strix occidentalis) subspecies. Evolutionary Applications. 1: 161-171.

Gaines, W.L., 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 Dr. J.M. Greenlee, ed. 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, ID.

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 38:3110-3111.

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

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.

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 86:441.

Gremel, S. 2005. Factors controlling distribution and demography of northern spotted owls in a reserved landscape. M.S. thesis, University of Washington, Seattle. 49pp.

Gronau, C.W. 2005. Evidence of an unusual prey item in a barred owl pellet. Wildlife Afield. 2(2):81-82.

Gutiérrez, R.J. 1989. Hematozoa from the spotted owl. Journal of Wildlife Diseases 24:614–618.

Gutiérrez, R.J. 1996. Biology and distribution of the northern spotted owl. Pages 2-5 in E.D. Forsman et al., editors. Demography of the northern spotted owl. Studies in Avian Biology No. 17. Cooper Ornithological Society.

Gutiérrez, R. J., M. Cody, S. Courtney, and A. Franklin. 2007. The Invasion of Barred Owls and its Potential Effect on the Spotted Owl: a Conservation Conundrum. Biological Invasions 9:181-196.

Gutiérrez, R. J., M. Cody, S. Courtney, and D. Kennedy. 2004. Assessment of the potential threat of the northern barred owl. In: Courtney, S.P., J.A. Blakesley, R.E. Bigley, M.L. Cody, J.P. Dumbacher, R.C. Fleischer, A.B. Franklin, J.F. Franklin, R.J. Gutiérrez, J.M. Marzluff, L. Sztukowski. 2004. Scientific evaluation of the status of the northern spotted owl. Sustainable Ecosystems Institute. Portland, Oregon. September 2004.

Gutiérrez, R.J., A.B. Franklin, and W.S. LaHaye. 1995. Spotted owl (*Strix occidentalis*) *in*: A. Poole and F. Gill, editors. The birds of North America, No. 179. The Academy of Natural Sciences and The American Ornithologists' Union, Washington, D.C. 28pp.

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

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., 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., 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, Washington.

Hanson, E., D. Hays, L. Hicks, L. Young, and J. Buchanan. 1993. Spotted Owl Habitat in Washington: A Report to the Washington Forest Practices Board. Washington Forest Practices Board, Spotted owl Advisory Group. Final Report: December 20, 1993. Olympia, Washington. 116pp.

Harestad, A., J. Hobbs, and I. Blackburn. 2004. Précis of the Northern Spotted Owl in British Columbia. Pages. 12-14 *in* Zimmerman, K., K. Welstead, E. Williams, J. Turner, (editors). Northern Spotted Owl Workshop Proceedings. Forrex Series (online No. 14), Vancouver, British Columbia, Canada.

Henke, A.L., T.Y. Chi, J. Smith, C. Brinegar. *Unpublished Draft.* Microsatellite Analysis of Northern and California Spotted Owls in California. Conservation Genetics Laboratory, Department of Biological Sciences, San Jose State University, San Jose, California.

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*). Journal of Wildlife Diseases 25:246–251.

Irwin, L., D. Rock, and S. Rock. 2010. Spotted owl and barred owl resource selection in southwestern Washington, Progress Report, February 2010. Unpublished Report.

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? M.S. Thesis, Western Washington University, Bellingham, Washington.

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. M.S. Thesis, Oregon State University, Corvallis, Oregon.

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 and Merchant and Marine Fisheries Committees of the U.S. House of Representative. Scientific Panel on Late Successional Forest Ecosystems, Washington, D.C.

Kelly, E.G. 2001. The Range Expansion of the Northern Barred Owl: An Evaluation of the Impact on Spotted Owls. M.S. Thesis. Oregon State University, Corvallis, Oregon. 92 pp.

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 121:806-810.

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

King, G.M., K.R. Bevis, M.A. Rowe, E.E. Hanson. 1998. Spotted owls use of habitat impacted by 1994 fires on the Yakama Indian Reservation: three years post fire. Unpub. report.

Knight, R.L., and S.K. Skagen. 1988. Effects of recreational disturbance on birds of prey: a review. Pages 355-359 in R.L. Glinski et al., editors. Proceedings of the Southwest

Raptor Management Symposium and Workshop, National Wildlife Federation, Washington, D.C.

Komar, N., N.A. Panella, J.E. Burns, S.W. Dusza, T.M. Mascarenhas, and T.O. Talbot. 2001. Serologic evidence for West Nile virus infection in birds in the New York City vicinity during an outbreak in 1999. Emerging Infectious Diseases 7(4):621-5.

LaHaye, W.S., R.J. Guiterrez, 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 association of Barred Owls and Great Horned Owls in southern New Jersey. Journal of Raptor Research 29:151–157.

Laymon, S.A. 1991. Diurnal foraging by spotted owls. Wilson Bulletin 103(1):138-140.

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

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.

Lint, J., technical coordinator. 2005. Northwest Forest Plan – the first 10 years (1994-2003): status and trends of northern spotted owl populations and habitat. PNW-GTR-648, USDA Forest Service, Pacific Northwest Research Station, Portland, Oregon.

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.

Livezey, K.B. and T.L. Fleming. 2007. Effects of barred owls on spotted owls: the need for more than incidental detections and correlational analyses. Journal of Raptor Research. 41(4): 319-325.

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. Issacs. 1991. Interactions of humans and bald eagles on the Columbia River estuary. Wildlife Monographs 115:1-47.

McLean, R.G., S.R. Ubico, S.E. Docherty, W.R. Hansen, L. Sileo and T.S. McNamara. 2001. West Nile Virus and transmission and ecology in birds. Annals of the New York Academy of Sciences 951:54-57.

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. 1989. Dispersal of juvenile northern spotted owls in western Oregon. Thesis, Oregon State University, Corvallis, USA.

Miller, G.S., S.K. Nelson, and W.C. Wright. 1985. Two-year-old female spotted owl breeds successfully. Western Birds 16:69-73.

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. Henstrom, J.R. Martin, J. Alegria, J. Browning, J. Cissel, W.B. Cohen, T.E. Demeo, S. Healey, R. Warbington. 2005. Northwest Forest Plan–The first 10 years (1994-2003): status and trend of late-successional and old-growth forest. Gen. Tech. Rep. PNW-GTR-646. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 142pp.

Mote P.W. and E.P. Salathé. 2010. Future climate in the Pacific Northwest, Chap 1. In: The Washington climate change impacts assessment: evaluating Washington's future in a changing climate, climate impacts group. University of Washington, Seattle, Washington.

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

North, M.P., J.F. Franklin, A.B. Carey, E.D. Forsman, and T. Hamer. 1999. Forest 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.

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.

ODF (Oregon Department of Forestry). 2007. Forest Practices Administrative Rules and Forest Practices Act. Salem, Oregon.

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.

Pierce, D.J., J.B. Buchanan, B.L. Cosentino, and S. Snyder. 2005. An assessment of spotted owl habitat on non-federal lands in Washington between 1996 and 2004. Wildlife Department of Wildlife Research Report.

Piper, Susan. 2006. Kmax Sound Reading, Olympic National Forest. Preliminary unpublished report. Olympic National Forest.

Rizzo, D.M. and M. Garbelotto. 2003. Sudden oak death: endangering California and Oregon forest ecosystems. Frontiers in Ecology and the Environment 1(4):197-204.

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. Can. J. Zool. 70:161-166.

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.

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.

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 Reviews 21:55-89.

Schmidt, K. 2006. Northern spotted owl monitoring and inventory, Redwood National and State Parks, 2005 annual report. Redwood National and State Parks, Orick, California.

Singleton, P., J.F. Lehmkuhl, W.L. Gaines, and S.A. Graham. 2010. Barred owl space use and habitat selection in the eastern Cascades, Washington. Journal of Wildlife Management. 74(2): 285-294.

Singleton, P., S. Graham, W. Gaines, and J. Lehmkuhl. 2005. The ecology of barred owls in fire-prone forests. USDA PNW December 2005 Progress Report; Wenatchee, Washington.

Sisco, C.L. 1990. Seasonal home range and habitat ecology of spotted owls in northwestern California. M.S. Thesis. Humboldt State University, Arcata, California.

Smith, D., A. Devine, and D. Devine. 1983. Observations of fishing by a barred owl. Journal of Field Ornithology 54:88-89.

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.

Steger, G. N., Werner, L. R., and Munton, T. E. 2006. First documented record of the Barred Owl in the southern Sierra Nevada. W. Birds 37:106–109.

Swarthout, E.C. and Steidl, R.J. 2001. Flush responses of Mexican spotted owls to recreationists. J. Wildl. Manage. 65(2):312-317.

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 18:538-547.

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. Unpublished interagency document. 458pp.

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 20:277–287.

Thomas, J.W., and M.G. Raphael (Eds.). 1993. Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Report of the Forest Ecosystem Management Assessment Team (FEMAT). July 1993. Portland, OR: USDA Forest Service and the USDI Bureau of Land Management.

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 63:44–59.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of Interior). 1994a. 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. USDA Forest Service and USDI Bureau of Land Management. Portland, Oregon.

USDA (U.S. Department of Agriculture) and USDI (U.S. Department of Interior). 1994b. 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. USDA Forest Service and USDI Bureau of Land Management. Portland, Oregon. Two vols. and appendices.

USFWS (U.S. Fish and Wildlife Service) and USDC NMFS (U.S. Department of Commerce, National Marine Fisheries Service). 1998. Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act.

USFWS (U.S. Fish and Wildlife Service). 1989. The northern spotted owl; a status review supplement. U.S. Fish and Wildlife Service, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1990. The 1990 status review: northern spotted owl: *Strix occidentalis caurina*. Report to the U.S. Fish and Wildlife Service, Portland, Oregon. 95 pages.

USFWS (U.S. Fish and Wildlife Service). 1992. Draft final recovery plan for the northern spotted owl. U.S. Fish and Wildlife Service. 2 Volumes. Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service). 1994a. Final biological opinion for the preferred alternative of the 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. *In*: USDA Forest Service, and USDI Bureau of Land Management. 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: Appendix G. Portland, Oregon, USA.

USFWS (U.S. Fish and Wildlife Service). 1994b. Letter from D.C. Frederick (USFWS) to J. Belcher (Washington Department of Natural Resources) dated February 1, 1994, regarding correction to spotted owl home-range data for the Olympic Peninsula. USFWS, Olympia, Washington.

USFWS (U.S. Fish and Wildlife Service). 2001. A rangewide baseline summary and evaluation of data collected through section 7 consultation for the northern spotted owl and its critical habitat: 1994-2001. Portland, Oregon. Unpublished document. 41pp.

USFWS (U.S. Fish and Wildlife Service). 2003. Estimates of distances at which incidental take of murrelets and spotted owls due to harassment are anticipated from sound-generating, forest-management activities in Olympia National Forest. Lacey, WA.

USFWS (U.S. Fish and Wildlife Service). 2004. Northern Spotted Owl: Five Year Review Summary and Evaluation. U.S. Fish and Wildlife Service, Portland, Oregon. 73pp.

USFWS (U.S. Fish and Wildlife Service). 2006. Endangered and threatened wildlife and plants; Designation of Critical Habitat for the Marbled Murrelet; Proposed Rule. September 12, 2006. Federal Register 71(176): 53837-53951.

USFWS (U.S. Fish and Wildlife Service). 2007. Draft: What are the Effects of Habitat Thinning on Northern Spotted Owls? Literature Summarized through 2005. Portland, OR. 17pp.

USFWS (U.S. Fish and Wildlife Service). 2008a. Final: Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). U.S. Fish and Wildlife Service, Portland, Oregon. xii + 142pp.

USFWS (U.S. Fish and Wildlife Service). 2010. Protocol for surveying proposed management activities that may impact northern spotted owls. February 18, 2010. 40pp.

USFWS (U.S. Fish and Wildlife Service). 2011a. Revised recovery plan for the northern spotted owl, *(Strix occidentalis caurina*). U.S. Fish and Wildlife Service, Portland, Oregon. xii + 163pp.

USFWS (U.S. Fish and Wildlife Service). 2011b. Northern Spotted Owl: Five Year Review Short Form Summary. U.S. Fish and Wildlife Service, Portland, Oregon. 6pp.

USFWS (U.S. Fish and Wildlife Service). 2012. Revised Critical Habitat for the Northern Spotted Owl (*Strix occidentalis caurina*); Proposed Rule. Fed. Reg. Vol. 77. 46: 14062-14165.

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: Forsman, E.D., S. DeStefano, M.G. Raphael, and R.J. Gutierrez, (editors). 1996. Demography of the northern spotted owl. Studies in Avian Biology No. 17. Cooper Ornithology Society.

Ward, J. W. Jr. 1990. Spotted owl reproduction, diet and prey abundance in northwest California. M.S. Thesis. Humboldt State University, Arcata, California.

Ward, J. W. Jr., 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.

Washington Forest Practices Board. 1996. Permanent rules for the northern spotted owl. Washington Department of Natural Resources, Olympia, WA.

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

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.

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

Whitworth, D. L., S. K. Nelson, S. H. Newman, G. B. Van Vliet, and W. P. Smith. 2000. Foraging distances of radio-marked Marbled Murrelets from inland areas in southeast Alaska. Condor 102:452-456.

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 et al., editors. Demography of the northern spotted owl. Studies in Avian Biology No. 17. Cooper Ornithology Society.

Appendix A

Demographic Study Area	Land Ownership	# Owls Banded	Fecundity	Apparent Survival	λ_{RJS}	Population Trend Based on $\Delta\lambda$
Washington						
Wenatchee (WEN)	Private	1,200	Stable	Declining	0.917	Declining
Rainer (RAI)	USFS	217	Stable	Declining	0.896	Declining
Olympic (OLY)	NPS & USFS	985	Stable	Declining	0.956	Declining
Cle Elum (CLE)	USFS	724	Declining[1]	Declining?[2]	0.938	Declining
Oregon						
Oregon Coast Range (COA)	USFS & BLM	1,025	Declining?[1]	Stable	0.968	Declining
Tyee (TYE)	BLM & Private	1,032	Increasing	Stable	1.005	Stationary
South Oregon Cascades (CAS)	USFS & BLM	881	Declining	Stable	0.974	Stationary
H.J. Andrews (HJA)	USFS	1,095	Stable?[3]	Stable	0.978	Declining
Klamath (KLA)	BLM & Private	1,147	Stable	Stable	0.997	Stationary
Warm Springs (WSR)	Tribal	381	Stable	Stable	0.908	Declining
California						
Marin (MAR)	NPS	96	Stable	Stable	NA	NA
Simpson (SIM)	Private	1,344	Declining[1]	Stable	0.970	Declining
Hoopa (HUP)	Tribal	279	Increasing	Stable	0.980	Stationary
NW California (NWC)	USFS	1,026	Declining	Declining	0.985	Declining?[4]

[1] Best model included age and even-odd year effects, but a competing model had a negative time effect on productivity.
[2] Variable among years, but with a declining trend.
[3] Decreasing in early years, increase in last 5 years, stable overall.
[4] Gradual declines in fecundity and apparent survival, plus estimates of realized population change suggest a decline in last 8 years.

Figure 1. Physiographic provinces, northern spotted owl demographic study areas, and demographic trends (Anthony et al. 2006).