Northern Spotted Owl (*Strix occidentalis caurina*)

Species Status Report

Oregon Fish and Wildlife Office

U.S. Fish and Wildlife Service, Region 1

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Introduction

The U.S. Fish and Wildlife Service (Service) was petitioned to reclassify the Northern Spotted Owl (*Strix occidentalis caurina*) from threatened to endangered on August 21, 2012 (EPIC 2012). On April 10, 2015, we published a 90-day finding that the petition presented substantial information indicating the listing of the species as endangered under the Endangered Species Act of 1973, as amended (Act), may be warranted; this finding initiated a status review of the species (80 FR 56423). We have prepared this summary document to help inform that status review. Here we present a review of the biological status of the northern spotted owl, including species abundance, distribution, and population trends; stressors that may affect the northern spotted owl; and conservation measures or regulations that may ameliorate those stressors. We reviewed a large number of references to compile this report; however, for the discussion of population status and trend, we primarily draw upon a thorough and recent peer-reviewed report published by the Cooper Ornithological Society, *The effects of habitat, climate, and barred owls on long-term demography of Northern Spotted Owls* (Dugger *et al.* 2016).

This document is not intended to be an exhaustive review of all published scientific literature relevant to the northern spotted owl; rather, it is intended to capture and summarize the key points from the best scientific and commercial data available relevant to our evaluation of the current and future conservation status of the species.

This species status report was prepared by the staff of the Service as follows: Oregon Fish and Wildlife Office, Portland, Oregon; Pacific Regional Office, Portland, Oregon; Klamath Falls Fish and Wildlife Office, Klamath Falls, Oregon; Headquarters, Falls Church, Virginia; Washington Fish and Wildlife Office, Lacey, Washington; Central Washington Field Office, Wenatchee, Washington; Yreka Fish and Wildlife Office, Yreka, California; and Arcata Fish and Wildlife Office, Arcata, California.

EXECUTIVE SUMMARY

The northern spotted owl has declined across large portions of its range since the time of listing, with the most severe declines occurring in the northern portion of the species range where non-native barred owls (*Strix varia*) have been established for the longest period of time. The rate of population decline has continued to increase since the "2011 5-year Review for the Northern Spotted Owl" was published. The current rate of decline raises concerns about the long-term persistence of the northern spotted owl throughout the Pacific Northwest.

The northern spotted owl was listed as threatened throughout its range "due to loss and adverse modification of northern spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (55 FR 26114). Loss of northern spotted owl habitat on Federal lands since the 1990s has occurred at a rate less than what was anticipated under the Northwest Forest Plan (NWFP or the Plan), and timber harvest has been reduced on Federal lands over the past two decades. Wildfire is currently the primary cause of habitat loss on Federal lands, and the rate and intensity of wildfire in portions of the range of the northern spotted owl are expected to increase in the future under projected climate change scenarios. Northern spotted owl habitat on private lands has continued to decline since the time of listing and has declined at a higher rate than on Federal lands; thus Federal and State lands will continue to provide the majority of habitat for northern spotted owls for the foreseeable future. With the exception of some areas in northern California, northern spotted owls are unlikely to persist in areas without Federal lands.

The NWFP predicted continued declines in populations of northern spotted owls in the short term following implementation of the Plan that allowed for continued but more carefully managed timber harvest. However, the northern spotted owl faces a new significant and complex threat in the form of competition from the barred owl, a species not native to the Pacific Northwest, and a future threat from the effects of climate change. Currently, competition with barred owls may be the primary cause of northern spotted owl population declines across their range. Declines in apparent survival and increased local extinction rates of northern spotted owls have been observed in sites where barred owls were present, as well as an increase in northern spotted owl vital rates on the study areas where barred owl removal had been conducted from 2009-2013. Without implementation of management that can effectively reduce the impact of barred owls on northern spotted owl population performance, northern spotted owl populations will likely continue to decline at an accelerated rate across the range of the species. The Service has implemented a number of recovery actions that were developed to address the impact of barred owls on northern spotted owls, including the implementation of a barred owl removal experiment to evaluate the effectiveness of removing barred owls as a strategy for conserving and recovering northern spotted owls. Preliminary results from the Service's ongoing barred owl removal experiment are encouraging in terms of occupancy and survival, but do not yet demonstrate a significant improvement in spotted owl population trends. Additional years of removal may decrease the uncertainty in these results (Wiens *et al.* 2019, p. 12-13). Projected changes in climate for the Pacific Northwest are also predicted to result in increased risks to northern spotted owls from increases in forest pathogens (insects and other disease outbreaks), and changes in forest structure, extent, and species composition. Climate change may also affect northern spotted owl survival and reproduction, both directly (adult survival rates) and indirectly (changes in prey species distributions and abundance).

The most recent observed 3.8 percent annual rate of decline of the northern spotted owl indicates that this species is in severe decline and the extinction risk for this species has increased since the time of listing. Spotted owl populations in long-term study areas have declined 32-77 percent since the early 1990s. If this rate continues into the future, the species will likely decline to extirpation in the northern portion of its range in the near future where populations declines have been greatest (59-77 percent). Additionally, northern spotted owl population simulations indicated that without a reduction in barred owl impacts on northern spotted owls, northern spotted owl populations had a greater than 50 percent probability of extirpation in Washington and the Oregon Coast Ranges. The most recent range-wide northern spotted owl demographic study indicated that barred owls are currently the factor with the largest negative impact on northern spotted owls. Habitat loss continues to occur although to a lesser degree than prior to implementation of the NWFP and several additional studies indicate that climate change has the potential to add additional stressors on spotted owls. The NWFP has conserved and developed northern spotted owl habitat on Federal lands; however, the amount of northern spotted owl habitat on non-Federal lands has decreased considerably over the past two decades.

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1.0 BACKGROUND

The northern spotted owl inhabits structurally complex forests from southwestern British Columbia through Washington and Oregon to northern California. The northern spotted owl is one of three subspecies of spotted owls currently recognized by the American Ornithologists' Union, along with the Mexican spotted owl (*S. o. lucida*) and the California spotted owl (*S. o. occidentalis*). The California Spotted Owl is recognized as a Species of Special Concern by the California Department of Fish and Wildlife (CDFW 2017). The Mexican spotted owl is listed as a threatened species in the United States (58 FR 14248). It is also classified as threatened by the states of Colorado and Utah and by the Navajo Nation and is currently a species of concern in Arizona and New Mexico.

In 1990, the northern spotted owl was listed under the Endangered Species Act of 1973, as amended (Act) as a threatened species due to loss and adverse modification of northern spotted owl habitat resulting from timber harvest, and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms (55 FR 26114; June 26, 1990). Threats to the northern spotted owl at the time included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of populations, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms and vulnerability to natural disturbance. On January 15, 1992, the Service published a final rule designating critical habitat for the northern spotted owl on 6,887,000 acres (ac) (2,787,000 hectares (ha)) of Federal lands in Washington, Oregon, and California (57 FR 1796). The critical habitat was revised on August 13, 2008 (73 FR 47326), and again on December 4, 2012, with a final designation of 9,577,969 ac (3,876,064 ha) in 11 units and 60 subunits in Washington, Oregon, and California (77 FR 71876).

Controversy over conservation of the northern spotted owl and harvest of old-growth forests led to sweeping changes in management of Federal forests in western Washington and Oregon and northwest California. These changes were prompted by a series of lawsuits in the late 1980s and early 1990s, which effectively shut down most Federal timber harvest in the Pacific Northwest. In response, President Clinton convened a summit in Portland, Oregon, in 1993, where he issued a mandate for Federal land management and regulatory agencies to work together to develop a plan to resolve the conflict. This plan became the NWFP. Immediately after the summit, a team of scientists and technical experts was convened to conduct an assessment of options. This assessment, the *1993 Forest Ecosystem Management: An Ecological, Economic, and Social Assessment* (FEMAT) (Thomas and Raphael 1993), provided the scientific basis for the Environmental Impact Statement and Record of Decision (ROD) (USDA and USDI 1994a) to amend Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl.

The ROD put in place a new approach to Federal land management. A key component of the Plan was a new set of land use allocations to conserve habitat for species dependent on old growth forests including the northern spotted owl; the allocations included reserved lands and non-reserved lands. Reserved lands include late-successional reserves (LSRs) where timber harvest is not allowed, managed LSRs (MLSR) that function as LSRs but allow some timber harvest/silvicultural treatments for the prevention of wildfires and disease/insect outbreaks, as well as congressionally reserved, administratively withdrawn, adaptive management areas, and riparian reserves (RRs). Most LSRs were designated in areas that had enough suitable forest cover to support multiple pairs of northern spotted owls and were distributed to facilitate movement of spotted owls across their range. Reserves varied in habitat composition, containing some measure of nesting/roosting habitat, foraging habitat, dispersal habitat, and/or younger forest expected to grow into northern spotted owl habitat. Many LSRs contained late successional old-growth forest but some of them were designated in fragmented landscapes with younger forest, under the assumption that these areas would provide dispersal for northern spotted owls and eventually develop into suitable nesting/roosting habitat for the species. In many of the fire-prone areas, larger Federal reserves were delineated so that the habitat could handle disturbances without breaking function (USDA and USDI 1994b, p. J3:8-9; Davis *et al.* 2016, p. 35). Nonreserved lands included matrix lands, and adaptive management areas (AMAs); timber harvest is allowed on nonreserved lands. The Plan assumed that RRs, remaining habitat in the matrix, and administratively withdrawn areas would also provide for dispersal of northern spotted owls between the LSRs. Of the over 24 million ac (ha) in the planning area of the NWFP, approximately 30 percent were congressionally reserved, 30 percent LSRs, 6 percent adaptive management areas, 1 percent MLSRs, 6 percent administratively withdrawn areas, 11 percent RRs, and 16 percent matrix (USDA and USDI 1994a , p. 2). The NWFP standards and guidelines provided specific management direction regarding how these land use allocations were to be managed (USDA and USDI 1994a). In addition, the NWFP put in place a variety of strategies and processes to be implemented including adaptive management, an aquatic conservation strategy, LSR and watershed assessments, a survey and manage program, an interagency organization, social and economic mitigation initiatives, and monitoring.

The Record of Decision for the NWFP projected approximately 2.5 percent of northern spotted owl habitat on Federal lands would be harvested per decade (USDA and USDI 1994a, p. 46), primarily in the non-reserved matrix areas. The Plan did not provide a projection on the amount of northern spotted owl habitat that may be lost per decade due to wildfire, but the U.S. Forest Service (USFS) has used in their monitoring reports a figure found in FEMAT as a measure of expected loss. The USFS's 10-year monitoring report on the NWFP describes that although losses from catastrophic events such as fire or windthrow were anticipated, they could find "only one quantitative estimate of expected rates for such events: FEMAT (1993, IV-55), in conducting simulation studies to estimate forest development, assumed that 2.5 percent of reserved areas (on average over the Plan area) would be subject to severe disturbance per decade" (Raphael 2006, p. 121). This 2.5 percent rate of loss per decade has been used by USFS as a projected measure of wildfire related loss of northern spotted owl nesting/roosting habitat (Raphael 2006, p. 123; Davis *et al.* 2016, p. 34). Habitat trends recently described in the USFS monitoring report, The Northwest Forest Plan—the First 20 Years (1994-2013) (Davis *et al.* 2016, entire), represent the best available current range-wide synthesis of nesting/roosting habitat status and trends data.

Since 1994, the NWFP has served as an important landscape-level plan that has contributed to the conservation of the northern spotted owl and late-successional forests on Federal lands across the range of the species (Thomas *et al.* 2006, p. 278–284). The Federal forest lands outside the LSRs have been managed to allow dispersal of northern spotted owls between the LSRs through riparian reserves and other land allocations. By providing for late successional/old growth over the long term, the NWFP was designed to arrest the downward trends in spotted owl populations by maintaining and restoring the habitat conditions necessary to support viable owl populations on federally administered lands throughout the range of the owl. With the implementation of the NWFP's reserve system, it was predicted that even with habitat conservation, northern spotted owl populations would continue to decline for several decades, due to ongoing timber harvest in non-reserved (matrix) areas and the consequence of lag effects of past timber harvest (delay in observable species response) at both individual and population levels. It was expected that after an initial period of continued decline in the first 40 to 50 years, populations on Federal lands would stabilize and begin increasing as habitat recovery exceeds losses (Raphael *et al.* 1994, p. 6-8; Raphael 2006, p. 119). The NWFP estimated the population would stabilize at a lower population number than existed historically; while an increase is some reserves or habitat conservation areas was expected, there was no expectation of an increase in range-wide population (Davis 2017, pers. comm.). Thomas *et al.* (1990, p. 5) predicted "… even with this conservation strategy fully implemented, a short-term loss of a significant portion of the existing population of northern spotted owls is likely… but we believe the subspecies can withstand a reduction provided our strategy is followed." The potential effect of competition from the barred owl on northern spotted owl abundance was acknowledged but not fully understood when the NWFP was developed.

On May 21, 2008, the Service released the Recovery Plan for the Northern Spotted Owl (73 FR 29471) and then released a Revised Recovery Plan for the Northern Spotted Owl on July 1, 2011 (76 FR 38575). The Revised Recovery Plan identified the most significant range-wide threats to the northern spotted owl as competition with the congeneric (referring to a member of the same genus) non-native barred owl (*Strix varia*), ongoing loss of northern spotted owl habitat as a result of timber harvest, loss or modification of habitat from uncharacteristic wildfire, and loss of amount and distribution of northern spotted owl habitat as a result of past activities and disturbances (76 FR 38575). To address these threats, the recovery strategy included five basic 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 (USFWS 2011a, p. vii).

The U.S. Fish and Wildlife Service (Service) conducted a 5-year review of the spotted owl in 2004 (USFWS 2004), based in part on the content of an independent scientific evaluation of the status of the spotted owl (Courtney *et al.* 2004) performed under contract with the Service. For that evaluation, an assessment was conducted of how the threats described in 1990 might have changed by 2004. Some of the key findings were: (1) "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" (Courtney and Gutiérrez 2004, p. 11–7); (2) "Currently the primary source of habitat loss is catastrophic wildfire, although the total amount of habitat affected by wildfires has been small" (Courtney and Gutiérrez 2004, p. 11–8); and (3) "We are convinced that Barred Owls are having a negative impact on Spotted Owls at least in some areas" (Gutiérrez *et al.* 2004, pp. 7–43) 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).

The Service conducted another 5-year review of the spotted owl in 2011 (USFWS 2011b). This review noted that between 2004 and 2011, additional scientific research indicated that northern spotted owl populations continued to decline at a rate of 2.7 percent per year, and declines were associated with past and current habitat loss and barred owl presence (Forsman *et al.* 2011, entire). The 2011 status review concluded that the overall condition of the northern spotted owl was worse than at the time of the last 2004 review, and observed population declines indicated an increased possibility for this subspecies to become endangered in the future. But the 2011 review expressed uncertainty regarding the outcome of barred owl and spotted owl competition because, although barred owls generally have a greater negative impact on northern spotted owls in the northern parts of the range of northern spotted owl, the relationship between the two species appeared to be variable across its range. It noted that although populations were declining, spotted owls were still present across the majority of the subspecies' range. Given the declining population trends, ongoing habitat loss, and the known level of threat from barred owls at that time, the 2011 status review concluded that the northern spotted owl continued to meet the definition of a threatened species.

On August 21, 2012, the Service received a petition from the Environmental Protection Information Center to list the northern spotted owl as endangered (EPIC 2012, entire). The Service found that the petition provided substantial information on the present or threatened destruction, modification or curtailment of the species' habitat or range, habitat loss and the decline of preferred prey species, competition with and predation by barred owls, disease, the inadequacy of existing regulatory mechanisms, and range-wide population declines (USFWS 2015, entire).

In 2013, the Service began implementation of the Experimental Removal of Barred Owls to Benefit Threatened Northern Spotted Owls (Barred Owl Removal Experiment) to test one of the potential tools for managing barred owl's impacts on northern spotted owls (USFWS 2013 and 78 FR 57171). The Service intends to use the results of the Barred Owl Removal Experiment, along with information from all other relevant sources, including public input, to develop a barred owl management strategy.

2.0 SPECIES INFORMATION

2.1 Taxonomy

The taxonomic separation of the northern spotted owl, the California spotted owl, and the Mexican spotted owl 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 is separate from those of the northern and California subspecies (Gutiérrez *et al.* 1995, p. 2). Studies analyzing mitochondrial DNA sequences (Haig *et al.* 2004, p. 1354; Chi *et al.* 2004, p. 3; Barrowclough *et al.* 2005, p. 1117) 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 by analyzing 394 spotted owls at 10 microsatellite loci. In addition, the authors tested whether northern and California spotted owls hybridize as suggested by previous mitochondrial DNA studies. The study found the recognition of the three current subspecies to be valid and also revealed bi-directional hybridization and dispersal between northern spotted owls and California spotted owls centered in southern Oregon and northern California. In addition, evidence of Mexican spotted owl genes within northern spotted owl populations in northern Washington has been reported, which may indicate long-distance dispersal of Mexican spotted owls into the northern spotted owl range (Funk *et al.* 2008, pp. 1-11).

2.2 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 18 to 19 inches (in) (46 to 48 centimeters (cm)) 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 1.28 pounds (lbs) (580.4 grams (g) (out of a range 0.95 to 1.52 lbs) (430 to 690 g), and the mean mass of 874 females taken during 1,016 captures was 1.46 lbs (664.5 g) (out of a range 1.1 to 1.95 lbs (490.0 to 885.0 grams)) (P. Loschl and E. Forsman pers. comm. 2006, as cited in USFWS 2011a, 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 (juvenile, 1st year subadult, 2nd year subadult, adult) can be distinguished on the basis of plumage characteristics (Forsman 1981, p. 736; Moen *et al.* 1991, p. 493). The average life span of northern spotted owls is relatively long, with banded owls in the wild documented living up to 20 years (Courtney *et al*. 2004, p. 11-3). The northern spotted owl superficially resembles the barred owl, though it can be easily differentiated by visual and auditory cues (Kelly and Forsman 2004, p. 807).

2.3 Historical and Current Range

Forsman *et al.* (1984, pp. 15-16) documented northern spotted owl use of the following forest types: Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), grand fir (*Abies grandis*), white fir (*A. concolor*), ponderosa pine (*Pinus ponderosa*), Shasta red fir (*A. magnifica shastensis*), mixed evergreen, mixed conifer hardwood (Klamath montane), and coast redwood (*Sequoia sempervirens*). The upper elevation limit at which northern 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). The historical range of the northern spotted owl extended in these forest types from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and northern California, as far south as Marin County (55 FR 26114). The eastern edge of the range was largely defined by the extent of mature forest on the eastern slopes of the Cascade and Klamath mountains, and the western edge by the extent of mature forest along the Pacific Coast. Northern spotted owls are believed to have inhabited most old growth forests or stands throughout the Pacific Northwest, including northwestern California, prior to beginning of modern settlement in the mid-1800s (USFWS 1989, p. 2.17; 55 FR 26114). There are no estimates of the size of the northern spotted owl population prior to settlement by Europeans.

The current range of the northern spotted owl is smaller than the historical range as the northern spotted owl is extirpated or very uncommon in certain areas such as southwestern Washington and British Columbia. The major reduction in historical range is largely the result of timber harvest activities that eliminated, reduced or fragmented northern spotted owl habitat sufficiently to decrease overall population densities across its range, particularly within the coastal provinces where habitat reduction had been concentrated (Thomas and Raphael 1993; USFWS 2011a, pp. B-1 to B-4). The current range of the northern spotted owl is found in 12 physiographic provinces (Figure 1), which are based on recognized landscape subdivisions exhibiting different physical and environmental features (Thomas *et al.* 1990, p. 61; USFWS 2011a, 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.

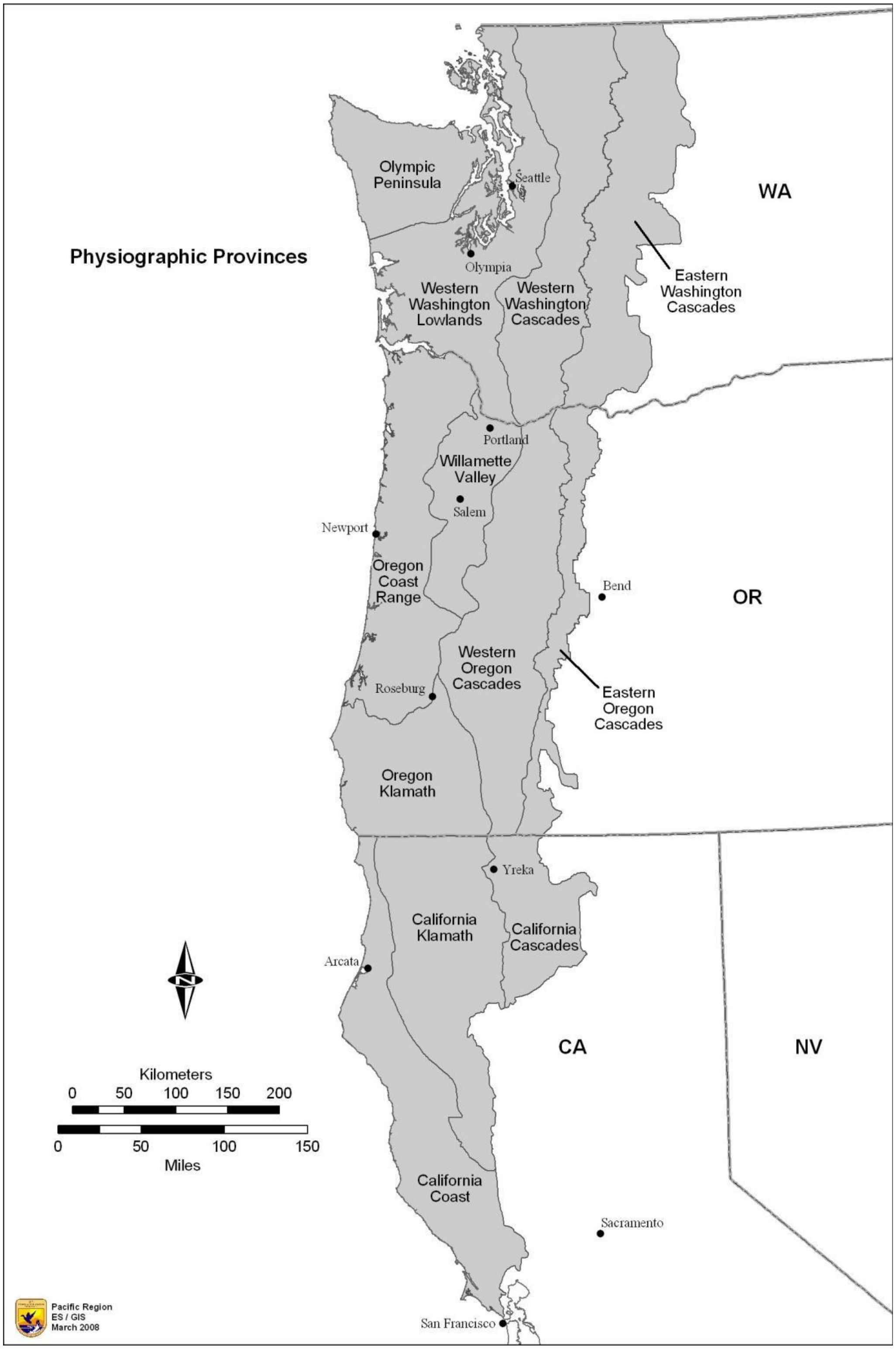


Figure 1. Physiographic provinces within the range of the northern spotted owl in the United States.

British Columbia has a small population of northern spotted owls. This population has declined at least 49 percent since 1992 (Courtney *et al.* 2004, p. 8-14), and by as much as 90 percent since European settlement (Chutter *et al.* 2004, p. 6) to a 2004 breeding population estimated at about 23 birds (SLFD & WCWC 2005, p. 16) on 15 sites (Chutter *et al.* 2004, p. 26). Chutter *et al.* (2004, p. 30) suggested immediate action was required to improve the likelihood of recovering the northern spotted owl population in British Columbia. In 2007, the Northern Spotted Owl Population Enhancement Team recommended to remove northern spotted owls from the wild in British Columbia (Fenger *et al.* 2007, p. 15). Personnel in British Columbia captured and brought into captivity 18 (mostly juvenile) wild northern spotted owls (Ian Blackburn 2019 pers. comm.). They received an additional 3 spotted owls from the U.S. Prior to initiating the captive-breeding program, the population of northern spotted owls in Canada was declining by as much as 10.4 percent per year, or an overall decline of 67 percent from 1992 to 2002 (COSEWIC 2008, p. 6).

2.4 Reproductive Biology

The northern spotted owl is relatively long-lived, has a long reproductive life span (6-9 years, Loschl 2008, p. 107), invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman *et al.* 1984, entire; Gutiérrez *et al.* 1995, p. 5). Northern 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 northern spotted owl pairs do not nest every year, nor are nesting pairs successful every year (55 FR 26114; 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 northern spotted owls depend on their parents until they are able to fly and hunt on their own. Parental care continues after fledging into September (55 FR 26114; 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).

2.5 Food Habits

Northern spotted owl diets vary across owl territories, years, seasons, geographical regions, and forest type (Forsman *et al.* 2001, pp. 146–148; 2004, pp. 217–220). Northern spotted owls forage opportunistically during the day; however, they are primarily nocturnal and their diets are dominated by four to six species of nocturnal mammals (Forsman *et al.* 1984, p. 51; 2004, pp. 218, 222-223; Sovern *et al.* 1994, p. 202). Generally, northern flying squirrels

(*Glaucomys sabrinus*) are the most prominent prey for northern spotted owls in Douglas-fir and western hemlock forests in Washington and Oregon, while dusky-footed wood rats (*Neotoma fuscipes*) are a major part of the diet in the Oregon Klamath, California Klamath, and California Coastal provinces (Forsman *et al.* 1984, pp. 40-42; Forsman *et al.* 2004, p. 218; Ward *et al.* 1998, p. 84; Hamer *et al.* 2001, p. 224). Depending on location, other important prey include deer mice (*Peromyscus maniculatus*), red 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 northern 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). Rosenberg *et al.* (2003, p. 1720) showed a strong correlation between annual reproductive success of northern spotted owls (number of young per territory) and abundance of deer mice (*Peromyscus maniculatus*) (r^2 = 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, while nesting male northern spotted owls hunt for larger prey items to deliver to the nest they probably eat smaller food items to reduce foraging energy costs, highlighting the potential importance of smaller prey items, like deer mice, in the northern spotted owl diet (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, Irwin *et al.* 2011, p. 7-8).

Northern flying squirrels are positively associated with late-successional forests with high densities of large trees and snags (Holloway and Smith 2011, p. 671). Northern flying squirrels typically use cavities in large snags as den and natal sites, but may also use cavities in live trees, hollow branches of fallen trees, crevices in large stumps, stick nests of other species, and lichen and twig nests they construct (Carey 1995, p. 658), as well as mistletoe brooms when snags are not abundant (Carey 1995, p. 593). Mycorrhizal and epigeous fungi (*e.g.* truffles) are prominent in their diet; however, seeds, fruits, nuts, vegetation matter, insects, and lichens may also represent a significant proportion of their diet (summarized in Courtney *et al.* 2004, App. 4, p. 3-12). Northern flying squirrel densities tend to be higher in older forest stands with shrubs such as Pacific rhododendron (*Rhododendron macrophyllum*) and an abundance of large snags (Carey 1995, p. 654), and higher tree canopy cover (Lehmkuhl *et al.* 2006a, p. 591) likely because these forests produce a higher forage biomass. Wilson (2010, pp. i-ii) reported that dense mid-story canopy conditions can also be a limiting factor for northern flying squirrel abundance. Northern flying squirrel density tends to increase with stand age (Carey 1995, pp. 653–654; Carey 2000, p. 252), although managed and second-growth stands sometimes also show high densities of squirrels, especially when canopy cover is high (*e.g.*, Rosenberg and Anthony 1992, p. 163; Lehmkuhl *et al.* 2006a, pp. 589–591). The main factors that may limit northern flying squirrel densities are the availability of den structures and food, especially hypogeous (below ground) fungi or truffles (Gomez *et al.* 2005, pp. 1677–1678), as well as protective cover from predators (Wilson 2010, p. 115).

For northern spotted owls in Oregon, both dusky-footed and bushy-tailed woodrats are important prey items (Forsman *et al.* 2004, pp. 226–227), whereas in Washington owls rely primarily on the bushy-tailed woodrat (Forsman *et al.* 2001, p. 144). Habitats that support bushy-tailed woodrats usually include early-seral mixed-conifer/mixed-evergreen forests close to water (Carey *et al.* 1999, p. 77). Bushy-tailed woodrats reach high densities in both old forests with openings and closed-canopy young forests (Sakai and Noon 1993, pp. 376–378; Carey *et al.* 1999, p. 73), and use hardwood stands in mixed-evergreen forests (Carey *et al.* 1999, p. 73). Bushy-tailed woodrats are important prey species south of the Columbia River and may be more limited by abiotic features, such as the availability of suitable rocky areas for den sites (Smith 1997, p. 4) or the presence of streams (Carey *et al.* 1992, p. 234; 1999, p. 72). Dense woodrat populations in shrubby areas are likely a source of colonists to surrounding forested areas (Sakai and Noon 1997, p. 347); therefore, forested areas with nearby open, shrubby vegetation generally support high numbers of woodrats.

The diet of northern spotted owls in California is varied and appears to be dominated by dusky-footed woodrats, northern flying squirrels, deer mice, and red tree voles. Studies determined that larger prey items were found in higher proportion of the diets of reproductively successful pairs (Barrows 1987, p. 96; White 1996, p. 235). Factors that may limit woodrats are access to stable, brushy environments that provide food, cover from predation, materials for nest construction, dispersal ability, and appropriate climatic conditions (Carey *et al.* 1999, p. 78), and arboreal and terrestrial cover in the form of large snags, mistletoe, and soft logs (Lehmkuhl *et al.* 2006b, p. 376).

2.6 Habitat Relationships

2.6.1 Home Range

Annual home range is the area traversed by a resident individual northern spotted owl or pair during their normal activities (Thomas and Raphael 1993, pp. IX-15). Home-range sizes of the northern spotted owl vary geographically, generally increasing from south to north, which is likely a response to differences in habitat quality including structural complexity of forest conditions and availability of prey (USFWS 2011a, p. G-2). Estimates of median size of a pair's annual home range vary by province and range from 2,955 ac (1,196 ha) in the Oregon Cascades (Thomas *et al.* 1990, p. 194) to 14,211 ac (5,751 ha) on the Olympic Peninsula (USFWS 1994, p. 3). Zabel *et al.* (1995, p. 436) showed that these provincial home ranges are larger where northern 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; Glenn *et al.* 2004, p. 41; Wiens *et al.* 2014, p. 19), suggesting that the defended area is a subset of the area used for foraging. Northern spotted owls' home ranges are typically smaller during the breeding season and often dramatically increase in size during fall and winter (Forsman *et al.* 1984, pp. 21-22; Sisco 1990, p. iii, Glenn *et al.* 2004, p. 41, Schilling *et al.* 2013, p. 8; Forsman *et al.* 2015). Forsman *et al.* (2015) reported that home range sizes in Washington were on average three times larger than breeding season ranges. Within the home range there is often a smaller area of concentrated activity (approximately 20 percent of the home range), often referred to as the core area (Bingham and Noon 1997, pp. 133-135). Northern spotted owl core areas vary in size geographically and with local habitat conditions, 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).

2.6.2 Habitat Use and Selection

Northern spotted owls rely on older forested habitats because such forests contain the structures and characteristics required for nesting, roosting, and foraging. As mentioned above, forest types vary throughout the range and include Douglas-fir, western hemlock, grand fir, white fir, ponderosa pine (the moist end of this forest type), Shasta red fir, mixed evergreen, mixed conifer hardwood, and coast redwood. General features that support nesting and roosting typically include a moderate to high canopy cover (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 (in) (76 centimeters (cm)); 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 northern spotted owls to fly (Thomas *et al.* 1990, p. 19; 77 FR 71876). Forested stands with high canopy cover also provide thermal cover (Weathers *et al.* 2001, p. 686), protection form adverse weather conditions, protection from predators, and greater densities of flying squirrels (Weathers *et al.* 2001, p. 686; Franklin *et al.* 2000, p. 578; Holloway and Smith 2011, p. 668). For the purposes of monitoring changes in northern spotted owl habitat and evaluating the potential effects of land management actions, researchers and managers have traditionally broken northern spotted owl habitat into several categories: nesting/roosting habitat, foraging habitat, and dispersal habitat or cover types[1]. These categories are described in detail in the Designation of Revised Critical Habitat for the Northern Spotted Owl (73 FR 47326) and are summarized below.

Habitat requirements for nesting and roosting are nearly identical. However, nesting habitat is specifically associated with a high incidence of large trees with various deformities or large snags suitable for nest placement. Patches of nesting habitat, in combination with roosting habitat, must be sufficiently large and contiguous to maintain northern spotted owl core areas and home ranges, and must be proximate to foraging habitat. Typically, nesting habitat also functions as roosting, foraging, and dispersal habitat. Roosting habitat is essential to provide for thermoregulation, shelter, and cover to reduce predation risk while resting or foraging. As noted above, the same habitat generally serves for both nesting and roosting functions; technically "roosting habitat'' differs from nesting habitat only in that it need not contain those specific structural features used for nesting (cavities, broken tops, and mistletoe platforms). In practice,

[1] This report uses the descriptions of habitat conditions, consistent with the northern spotted owl recovery plan and critical habitat, although cover type may be a better description of the stand level conditions (Dugger *et al.* 2016, pp. 65,87, Glenn *et al.* 2016, p. 567). Stand level habitat/cover type does not work in isolation to support northern spotted owls. Habitat to support northern spotted owl has a spatial scale that is larger than the local stand condition. Development of models to assess habitat at the landscape level may include abiotic factors (*e.g.* slope, elevation) and biotic factors (*e.g.* forest structure, age and composition). Additionally, scale of analysis influences the model. These differences in modeling result in differences in acreage and spatial arrangement of mapped habitat. Habitat modeling versus a cover type map allows better identification of the landscape features where viable territories or dispersal may occur.

however, roosting habitat is often not segregated from nesting habitat. Nesting and roosting habitat also functions as foraging and dispersal habitat.

Foraging habitat is essential to provide a food supply for survival and reproduction. Foraging habitat is the most variable of all habitats used by territorial northern spotted owls, and is closely tied to the prey base, as described below. Nesting and roosting habitat always provides for foraging, but in some cases owls also use more open and fragmented forests, especially in the southern portion of the range where some younger stands may have high prey abundance and structural attributes similar to those of older forests, such as moderate tree density, subcanopy perches at multiple levels, multilayered vegetation, or residual older trees. Foraging habitat generally has attributes similar to those of nesting and roosting habitat, but foraging habitat may not always support successfully nesting pairs (USFWS 1992, pp. Vol. 1-24, Vol. 2-189). Foraging habitat can also function as dispersal habitat.

Because northern spotted owls show a clear geographical pattern in diet, and different prey species prefer different forest types, prey distribution contributes to differences in northern spotted owl foraging habitat selection across the range. In the northern portion of their range, northern spotted owls forage heavily in older forests or forests with similar complex structure that support northern flying squirrels (Carey *et al.* 1992, p. 233; Rosenberg and Anthony 1992, p. 165). 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 (Solis 1983, pp. 89–90; Sakai and Noon 1993, pp. 376–378; Sakai and Noon 1997, p. 347; Carey *et al.* 1999, p. 73; Franklin *et al.* 2000, p. 579). Both the amount and distribution of foraging habitat (including the abundance of prey species) within the home range influence the survival and reproduction of northern spotted owls.

Dispersal habitat is essential to maintaining stable populations by providing connectivity for owls filling territorial vacancies when resident northern spotted owls die or leave their territories, and by providing adequate gene flow across the range of the species. Due to lack of data, the definition of dispersal habitat is based on professional judgment but, at a minimum, dispersal habitat consists of stands with adequate tree size (greater than 11 in (28 cm) dbh) and canopy cover (30 to 40 percent in dry and moist forests, respectively) to provide protection from avian predators and at least minimal foraging opportunities (USFWS 2011a, p. G-1, Thomas *et al.* 1990, P. 310). Dispersal habitat may include younger and less diverse forest stands than foraging habitat, such as even-aged, pole-sized stands, but such stands should contain some roosting structures and foraging habitat to allow for temporary resting and feeding for dispersing juveniles (USFWS 2011a, p. G-1). In a study of the natal dispersal of northern spotted owls, Sovern *et al.* (2015, pp. 257-260) found the majority of roosts were in forest stands with at least some large (>19 in (50 cm) dbh) trees and they selected stands with high canopy cover (>70 percent). These authors suggested the concept of 'dispersal' habitat as a lower quality type of habitat may be inappropriate. The landscape-level attributes of forests needed to facilitate successful dispersal have not been thoroughly evaluated (Buchanan 2004, p. 1341) and there has not been assessment of the adequacy of conditions in dispersal landscapes (Buchanan 2017, pers. comm.).

Northern spotted owls can utilize forests with the characteristics needed for nesting, roosting, foraging, and dispersal, and likely experience greater survivorship under such conditions. However, dispersing or nonresident individuals may also make use of other forested areas that do not meet the requirements of nesting or roosting habitat on a short-term basis. Forsman *et al.* (2002, p. 22) found that northern spotted owls could disperse through highly fragmented forest landscapes. Such short-term dispersal cover must, at minimum, consist of stands with adequate tree size and canopy cover to provide protection from avian predators and at least minimal foraging opportunities.

Northern 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 northern 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 northern 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, northern spotted owls roosted in mature forests dominated by trees greater than 19.7 in (50 cm) dbh with greater than 60 percent canopy cover more often than expected for roosting during the non-breeding season. Northern spotted owls also used young forest (trees of 7.9 to 19 in (20 to 50 cm) dbh with greater than 60 percent canopy cover) less often than expected based on its availability (Herter *et al.* 2002, p. 437). In the Coast Ranges, Western Oregon Cascades and the Olympic Peninsula, radio-marked northern spotted owls selected 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, p. 149; Forsman *et al.* 2005, pp. 372-373). Glenn *et al.* (2004, pp. 46-47) studied northern spotted owls in young forests in western Oregon and found little preference among age classes of young forest. In mixed conifer forests in California, foraging was associated with patches of forest containing more large trees, hardwoods, presence of understory shrubs, and occurred in close proximity to the nest sites and riparian areas of lower-ordered streams; stands selected for foraging contained patches of trees greater than 66 cm dbh (25.6 in) (Irwin *et al.* 2012, pp. 206-209, Irwin *et al.* 2013 pp. 1032-1033). These authors also observed some winter foraging locations along edges of early-seral shrub cover, noting these riparian and edge cover types support higher densities of key prey species (Irwin *et al.* 2013, p. 1034).

Habitat use is influenced by prey availability. Ward (1990, p. 62) found that northern 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 edges between areas of old forest and brush seral stages. Zabel *et al.* (1995, p. 436) showed that northern spotted owl home ranges are larger where northern flying squirrels are the predominant prey and smaller where woodrats, a larger prey species that provides a higher caloric reward for northern spotted owls, are the predominant prey.

Landscape-level analyses in portions of Oregon Coast and California Klamath provinces suggest that a mosaic of closed-canopy late-successional forest interspersed with other seral conditions may benefit northern 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 2,395 feet (ft) (730 meters (m)). Survival decreased dramatically when the amount of non-habitat (non-forest areas, sapling stands, etc.) exceeded approximately 50 percent of the home range area (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 northern spotted owls. Olson *et al.* (2004, pp. 1050-1051) found that reproductive rates followed a biennial pattern with high reproduction in one year followed by lower reproduction in the subsequent year, and were positively related to the amount of edge between late-seral younger forest 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 northern spotted owls, a mixture of these forest types with younger forest and non-forest may be best for northern spotted owl survival and reproduction in their study area. Similar findings were reported for the Oregon Klamath Province, where home range composition influenced territory success; Schilling *et al.* 2013 (pp. 6-12) found increased forest fragmentation was correlated with decreased survival and increased home-range size. In a large-scale demography modeling study, Forsman *et al.* (2011, pp. 1-2) found a positive correlation between the amount of nesting/roosting habitat and recruitment of young.

2.6.3 Range-wide Habitat Baseline

The NWFP was adopted in 1994 by Federal land managers (primarily the USFS and the BLM) as the primary management plan for the implementation of northern spotted owl conservation on Federal lands (USDA and USDI 1994a). The Service has used information provided by the USFS, BLM, and National Park Service to update the northern spotted owl habitat baseline conditions by tracking relative habitat changes over time on Federal lands. An interagency effectiveness-monitoring framework was implemented in the late 1990s to meet NWFP requirements for tracking the status and trends of late-successional and old-growth forests, northern spotted owl populations and habitat, marbled murrelet (*Brachyramphus marmoratus*) populations and habitat, watershed condition, social and economic conditions, and tribal relationships (Mulder *et al.* 1999). Beginning in 2005, monitoring reports have been published at 5-year intervals and made available at http://www.reo.gov/monitoring/. These periodic range-wide evaluations of northern spotted owl habitat (Lint *et al.* 2005, Davis *et al.* 2011, Davis *et al.* 2016) have been conducted to determine if the rate of potential change to northern spotted owl habitat has been consistent with changes in amount of habitat anticipated under the NWFP and described in the Final Supplemental Environmental Impact Statement (FSEIS; USDA and USDI 1994b). Range-wide habitat baseline updates have occurred on several occasions since the northern spotted owl was listed in 1990, primarily in conjunction with 5-year monitoring reports. Habitat modifications associated with section 7 analyses are tracked against the updated range-wide habitat baseline associated with implementation of the NWFP (USDA and USDI 1994b, USFWS 2001, Lint 2005, Davis *et al.* 2011, Davis *et al.* 2016).

The goal of northern spotted owl monitoring is to evaluate the success of the NWFP in arresting downward trends in northern spotted owl populations and in maintaining and restoring habitat necessary to support viable populations on federally administered forest lands throughout its range. Specific objectives have included the following:

1. Assessing changes in northern spotted owl population trends and demographic rates on Federal lands within its geographic range in the United States; and

2. Assessing changes in the amount and distribution of northern spotted owl habitat on Federal lands.

While the first two monitoring reports (Lint 2005, Davis *et al.* 2011) included chapters addressing both objectives, the most recent report (Davis *et al.* 2016) focused only on the second objective (habitat status and trends) because the status and trends of population and demographic rates were concurrently covered in Dugger *et al.* (2016). Each analysis has used more up-to-date and higher quality data than the previous analyses and new analytical methods have been incorporated over time. While this improved the overall quality of the information provided, it also means that individual reports should not be compared directly without fully understanding the processes used to develop the results. Although new data were incorporated with each analysis, Davis *et al.* (2016) followed similar methods to those described in the second monitoring report (Davis *et al.* 2011).

In addition to forest monitoring conducted under NWFP, the Service developed a range-wide northern spotted owl habitat modeling framework as part of the 2011 Revised Recovery Plan for the Northern Spotted Owl and the 2012 Revised Critical Habitat Rule for the Northern Spotted Owl. To develop this framework, the Service appointed a team of experts to develop and test a modeling framework that can be used in numerous northern spotted owl management decisions. This approach also allowed for the opportunity to integrate new data sets on forest conditions (Davis *et al.* 2011) and northern spotted owl population dynamics (Forsman *et al.* 2011). This spatially explicit modeling effort was designed to allow for a more in-depth evaluation of various habitat features that affect the distribution of northern spotted owl territories and the factors influencing northern spotted owl populations. In addition, it allowed the Service to evaluate different land management scenarios based on their relative potential contribution to northern spotted owl recovery for the purpose of designating critical habitat for the northern spotted owl (73 FR 47326). This modeling approach resulted in a more inclusive definition of northern spotted owl habitat and thereby a greater amount of estimated suitable habitat than what was estimated in the NWFP monitoring reports. The Service's modeling effort is described in detail in Appendix C of the Revised Recovery Plan and in the Modeling Supplement to the 2012 Revised Critical Habitat Rule (USFWS 2012, entire; USFWS 2011, pp. App. C 1-85). Because the 2016 NWFP monitoring report provides data over time from 1993 to 2012, we rely on that information in this Species Status Report to assess trends in levels of suitable northern spotted owl habitat.

The association of mature or late-successional forests for nesting, roosting, and foraging is well described in the literature. The Northwest Forest Plan Habitat Monitoring efforts focus on the structurally-complex nesting/roosting habitat and do not separate out "foraging" habitat. Authors of these monitoring reports acknowledge the complex interaction of available habitats, and that the descriptions of habitat utilizing the combinations of forest attributes may be limited (Lint *et al.* 2005, p. 23-24, Davis *et al.* 2011, p. 38). Recent changes have been made to the Service's internal habitat tracking database to account for impacts to foraging forest cover, which is best accomplished at the field level.

2.7 Dispersal Biology

Successful dispersal of northern spotted owls is essential to maintaining genetic and demographic connections among populations across the range of the species. Landscapes that support movements between larger habitat patches for northern spotted owls act to limit the adverse genetic effects of inbreeding and genetic drift and provide demographic support to declining populations (Thomas *et al.* 1990, pp. 271–272). Dispersing juvenile northern spotted owls experience high mortality rates (more than 70 percent in some studies (Miller 1989, pp. 32–41; Franklin *et al.* 1999, pp. 25, 28; 55 FR 26114 June 26, 1990)) from starvation, predation, and accidents (Miller 1989, pp. 41–44; Forsman *et al.* 2002, pp. 18–19). Juvenile dispersal is thus a highly vulnerable life stage for northern spotted owls, and the survivorship of juveniles during this period could play an important role in the stability of populations of northern spotted owls.

Natal dispersal of northern spotted owls typically occurs in September and October with a few individuals dispersing in November and December (Forsman *et al.* 2002, p. 13). Natal dispersal in Oregon and Washington appears to occur 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 (mi) (16 kilometers (km)) for males and 15.5 mi (25 km) for females (Forsman *et al.* 2002, p. 16). Dispersing juvenile northern spotted owls experience high mortality rates, exceeding 70 percent in some studies (55 FR 26114; Miller 1989, pp. 32-41). At the landscape-scale forest cover types used during natal dispersal in Washington were found to be similar to roosting cover, consisting of high canopy cover and large trees (Sovern *et al.* 2015, pp. 258-260). These authors underscore that previous generalizations of more open, lower quality forests being used for dispersal may discount reliance on higher quality habitats.

Successful juvenile dispersal may depend on locating unoccupied suitable habitat in close proximity to other occupied sites (LaHaye *et al.* 2001, pp. 697–698). Dispersing juveniles are likely attracted to calls of other northern spotted owls, and may look for suitable sites preferentially in the vicinity of occupied territories (Seamans and Gutiérrez 2006, p. 107-108). When all suitable territories are occupied, dispersers may temporarily pursue a nonresident (nonbreeding) strategy; such individuals are sometimes referred to as ''floaters'' (Forsman *et al.* 2002, pp. 15, 26). Floaters prospect for territorial vacancies created when residents die or leave their territories. Floaters contribute to stable or increasing populations of northern spotted owls by quickly filling territorial vacancies. Where nesting roosting and foraging habitat occur, at a spatial scale to support multiple breeding pairs, the opportunities for successful recruitment of dispersers and floaters are enhanced due to the production of potential replacement birds within these large habitat blocks (Thomas *et al.* 1990, pp. 295, 307).

There is little evidence that small openings in the forest influence the dispersal of northern spotted owls, however large, non-forested areas such as the Willamette Valley or forested areas devoid of dispersal-suitable forest cover 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 northern spotted owls move around large water bodies rather than across them (Forsman *et al.* 2002, p. 22). Analysis of the genetic structure of northern spotted owl populations suggests that in the past 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 northern spotted owls; these movements were more frequent among females and individuals whose mates disappeared or moved to another territory (Forsman *et al.* 2002, pp. 20-21). The higher rate of breeding dispersal among females might be attributed to the fact that because the male locates and defends the territory, it may be more difficult for males to switch territories than it is for females to switch mates (Forsman *et al.* 2002, p. 29). 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, 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; Gutiérrez *et al.* 2011, pp. 597-598). 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 territory 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; 77 FR 71876). 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). Colonizing dispersers require nesting/roosting/foraging habitats (77 FR 71876). Transient dispersers use a wider variety of forest conditions for movements than colonizing dispersers, as northern spotted owls will move through lesser quality forest while seeking habitat to establish a territory. Dispersal success is likely highest in mature and old growth forest stands where there is more likely to be adequate cover and food supply (77 FR 71876, Sovern *et al.* 2015, p. 260).

2.8 Population Dynamics

The northern spotted owl is relatively long-lived, has a long reproductive life span (6-11 years, Loschl 2008, p. 107), invests significantly in parental care, and exhibits high adult survivorship relative to other North American owls (Forsman *et al.* 1984, entire; Gutiérrez *et al.* 1995, p. 5). The northern 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). For species such as the northern spotted owl, population growth rate is most sensitive to changes in adult survival and less sensitive to changes in reproduction or juvenile survival (Lande 1988, p. 602; Noon and Biles 1990, p. 25).

Across their range, northern 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, Dugger *et al.* 2016, p. 83). 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) and fluctuation in prey abundance (Zabel *et al.* 1996, pp. 437-438). In coniferous forests, mean fledgling production of the California spotted owl 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.

A variety of factors including amount and quality of habitat, weather, and interspecific competition may influence northern 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 northern 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). Habitat availability and climatic patterns also appear to influence survival, occupancy, recruitment, and, to a lesser extent, fecundity (Glenn 2009, p. 66; Glenn *et al.* 2010, p. 2547; Carroll *et al.* 2010, p. 900-901; Forsman *et al.* 2011, p. 71; Dugger *et al.* 2016, entire).

Olson *et al.* (2005, pp. 930-931) evaluated northern spotted owl territory occupancy using a site occupancy modeling technique (see MacKenzie *et al.* 2006 for details) that (1) accounted for the fact that northern spotted owls are not always detected in surveys, (2) allowed site occupancy to vary across years, and (3) allowed estimation of site extinction and site colonization probabilities. 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. Their results indicated that the probability that a given northern spotted owl territory would be occupied by a pair of northern spotted owls in a given year declined greatly over time on one study area and slightly on the other two areas.

2.9 Natural Causes of Mortality

Known predators of northern spotted owls include great horned owls (Forsman *et al.* 1984, p. 38) and possibly barred owls (Leskiw and Gutiérrez 1998, p. 2). Other suspected predators include northern goshawks, red-tailed hawks, and other raptors (Courtney *et al.* 2004, pp. 2-8). As mentioned earlier, dispersing juvenile northern spotted owls experience high mortality rates (more than 70 percent in some studies (Miller 1989, p. 41; Franklin *et al.* 1999, p. 43-44; 55 FR 26114) from starvation, predation, and accidents (Miller 1989, p. 41; Forsman *et al.* 2002, p. 18). Parasitic infection may contribute to these causes of mortality, but the relationship between parasite loads and survival is poorly understood (Gutiérrez 1989, p. 617; Hoberg *et al.* 1989, p. 247; Forsman *et al.* 2002, p. 18-19).

3.0 ABUNDANCE AND POPULATION TRENDS

3.1 Northern Spotted Owl Population Status—Methods

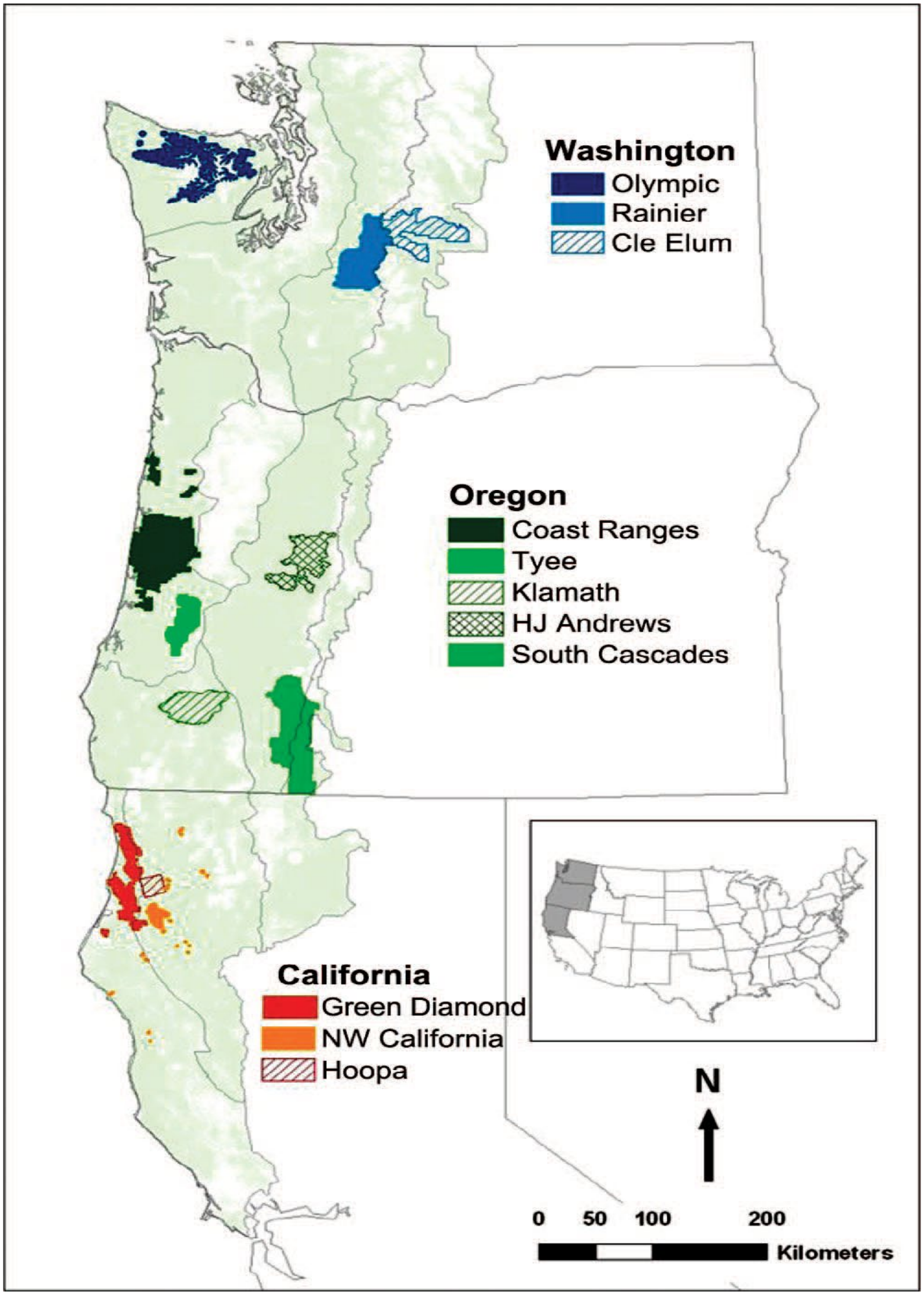
Because existing field survey coverage and effort alone are insufficient to produce reliable range-wide estimates of population size across the range of the northern spotted owl, demographic data from long-term monitoring areas have been used since the early 1990s to evaluate trends in northern spotted owl populations. Consistent monitoring data has been collected through Federal monitoring areas, although demography work was conducted on other study areas before being discontinued. Eight Federal monitoring areas are included in the 1999 Effectiveness Monitoring Program of the Northwest Forest Plan to monitor northern spotted owl population trends and demographic rates (Lint *et al.* 1999, p. 17): Olympic Peninsula (OLY), Cle Elum (CLE), Oregon Coast Ranges (COA), H.J. Andrews Experimental Forest (HJA), Tyee (TYE), Klamath (KLA), South Cascades (CAS), and Northwestern California (NWC). Subsequent to the publication of the NWFP, three additional northern spotted owl monitoring areas were added: Rainier (RAI), Hoopa Tribal Lands (HUP) and Green Diamond (GDR) (Dugger *et al.* 2016, p. 61). Monitoring areas may not entirely represent the range-wide population, as the study areas were not randomly selected and the study areas tended to be established in areas of higher quality habitat. However, they do span the geographic range of the subspecies and encompass the majority of forest types used by northern spotted owls, and therefore are used to assess the status of northern spotted owls across the range of the subspecies. These studies include a large number of individual northern spotted owls and provide one of the most comprehensive demographic datasets for birds of prey in the world. The locations of the 11 Federal monitoring areas are shown below in Figure 2.

Northern spotted owls in these long-term study areas have been monitored by surveying each study area each year to locate and resight previously banded owls, band unmarked owls, and document the number of young produced by each territorial female (Dugger *et al.* 2016, p. 82). Specific protocols used in these surveys have been extensively described in publications produced for each northern spotted owl population analysis (Franklin *et al.* 1996, Lint *et al.* 1999, Reid *et al.* 1999; see summary in Appendix B, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016). The most recent analysis (Dugger *et al.* 2016), was the sixth time that data from these study areas were used to assess the range-wide population status and trends of the northern spotted owl (Anderson and Burnham 1992, Burnham *et al.* 1994, Forsman *et al.* 1996, Franklin *et al.* 1999, Anthony *et al.* 2006, Forsman *et al.* 2011). Each of these analyses has used the cumulative time series of data to estimate trends and demographic rates. Consequently, each new analysis supersedes the prior analyses; however, analytical methods have also evolved since this effort was initiated. We therefore find it important to provide the chronological history of northern spotted owl demographic studies in order to provide a complete assessment of population status.

Researchers have adhered to strict protocols for data preparation and model development for these analyses, and all participants involved in these analyses agreed to follow established protocols (Dugger *et al.* 2016, p. 82). Analysis of demographic data can provide estimates of annual survival rates, fecundity, and the finite rate of population change (λ) (lambda), 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, derived from studies initiated as early as 1985, have been analyzed approximately every 5 years (Anderson and Burnham 1992, Burnham *et al.* 1994, Forsman *et al.* 1996, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016) to estimate population trends and demographic rates of the northern spotted owl.

The six meta-analyses have focused on estimation of several demographic parameters that are key to assessing patterns trends in northern spotted owl population status including annual survival, fecundity, rate of population change (λ), and site occupancy. Apparent annual survival rates for these long-term study areas have been estimated using capture–recapture (resighting) data from banded owls and Cormack-Jolly-Seber open population models (Lebreton *et al.* 1992) to estimate recapture probabilities and annual apparent survival probabilities of nonjuvenile, territorial owls for each of the 6 meta-analyses (Dugger *et al.* 2016, p. 69).

Figure 2. Locations of 11 study areas used in the analysis of vital rates and population trends of Northern Spotted Owls, 1985–2013 (Dugger *et al.* 2016, Figure 1, p. 62).



Fecundity, or the number of female young fledged per territorial female owl have been analyzed using a linear mixed model approach to investigate patterns of variation and hypothesized relationships between covariates and numbers of female young fledged per adult female owl (see Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016 for details).

Starting with Anthony *et al.* (2006), annual rate of population change has been estimated using the reparameterization of the Jolly-Seber capture-recapture model (denoted as λRJS) in program MARK (White and Burnham 1999). This approach was selected to address biases associated with Leslie matrix models, which had been used previously (see Anthony *et al.* 2006 for details). Occupancy modeling was included for the first time in Dugger *et al.* (2016) to address territory occupancy dynamics of both northern spotted owls and barred owls. They modeled the territory occupancy dynamics of northern spotted owls and barred owls in each study using a multi-season extension of 2-species occupancy models (MacKenzie *et al.* 2004, 2006) following Miller *et al.* (2012) and Yackulic *et al.* (2014).

3.2 Northern Spotted Owl Population Status—Summary of Range-wide Results

Of the six meta-analyses of demographic data from the long-term monitoring areas, four were published as peer-reviewed journal articles (Burnham *et al.* 1996, Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016) and two were prepared as agency reports (Anderson and Burnham 1992, Franklin *et al.* 1999). The first analysis included five of the long-term study areas (Northwest California, H.J. Andrews, Klamath, Olympic, and Tyee). Anderson and Burnham (1992, p. 322) reported that populations of resident, territorial females in five study areas had declined significantly at an estimated average rate of 7.5 percent per year during 1985-1991. Annual survival of adult females decreased significantly from 1985-1991.

The second meta-analysis of demographic rates of northern spotted owls was conducted in 1993 and included 11 study areas (Burnham *et al.* 1996, Forsman *et al.* 1996). Three major findings were reported in the second analysis: (1) fecundity rates varied among years and ages of owls, with no increasing or decreasing trend over time, (2) survival rates were dependent on age and there was a decreasing trend in adult female survival, (3) the annual rate of population change based on Leslie matrix models (λPM) was <1.0 for 10 of 11 areas examined, and the estimated average rate of population decline was 4.5 percent per year (Burnham *et al.* 1996, pp. 96-99).

The results from the third meta-analysis conducted on 15 study areas (Franklin *et al.* 1999, pp. 28-29) indicated that annual survival probabilities of adult females varied among years, but did not exhibit a negative trend. This result differed from the 1993 meta-analysis (Burnham *et al.* 1996, p. 96), which found a negative trend in adult female survival. It was unclear whether this change reflected a response to reductions in timber harvest rates on Federal lands. Analyses on individual study areas indicated that three areas in California exhibited significant negative trends in adult female survival. Franklin *et al.* (1999, p. 34) reported that fecundity varied among years with highest reproduction in even-numbered years similar to the results of Burnham *et al.* (1996, p. 97). This analysis produced estimates of the annual rate of population change that indicated a 3.9 percent annual decline in the population of territorial females using Leslie matrix models (λPM). Although the overall analysis indicated a declining population, some individual study areas had estimates that did not differ from 1 (*i.e.*, stationary populations) whereas other studies suggested substantial declines. Franklin *et al.* (1999, pp. 20-23) also examined a newer, alternative method for estimating rate of population change (Pradel 1996), and found that the two approaches differed in their interpretation and each had different biases related to sampling northern spotted owls; Anthony *et al.* 2006, Forsman *et al.* 2011, and Dugger *et al.* 2016 all utilized the newer Pradel model.

Results of the early meta-analyses of northern spotted owl demography were critiqued by Raphael *et al.* (1996) and Boyce *et al.* (2005), who questioned the estimates of annual rate of population change from Leslie matrix models (λPM) used in these earlier analyses, primarily because estimates of juvenile survival from capture-recapture methods were biased by permanent emigration during natal dispersal. In the fourth analysis, Anthony *et al.* (2006) addressed the problems identified by Raphael *et al.* (1996) and Boyce *et al.* (2005) by using the Pradel (1996) model to estimate annual rate of population change (λRJS) as described above. Anthony *et al.* (2006) reported the following trends and patterns in northern spotted owl demography: (1) fecundity was relatively stable among the 14 study areas examined, (2) survival rates were declining on 5 of the 14 areas including four study areas in Washington (Wenatchee, Cle Elum, Rainier, and Olympic) and Northwest California, and (3) populations were declining on 9 of 13 study areas for which there was adequate data to estimate λRJS. The mean λRJS for the 13 areas was 0.963, which indicated that populations were declining 3.7 percent annually during the study (Anthony *et al.* 2006, p. 34). The reasons for declines in northern spotted owl populations in their study were not readily apparent. Therefore, Anthony *et al.* (2006, p. 34) recommended the use of additional covariates in future analyses, to evaluate the possible influence of barred owls, weather, and habitat covariates on vital rates and population trends of northern spotted owls.

The fifth meta-analysis (Forsman *et al.* 2011) included data from 11 study areas. This analysis built on previous efforts by investigating associations between demographic parameters and a suite of covariates hypothesized to be affecting northern spotted owl populations. These covariates included owl gender, owl age, and effects of time as well as the presence of barred owls, amount of suitable owl nesting/roosting cover, seasonal and annual temperature and precipitation, and several long-term climate indices. They found that annual survival was declining on 10 of the 11 study areas, fecundity varied over time, and northern spotted owl populations were declining at a rate of 2.9 percent per year with greater rates of decline in Washington and slower declines in California. They estimated that northern spotted owl populations on four study areas had declined 40-60 percent since the early 1990s (Figure 3). On three study areas, populations declined 20-30 percent and declines of 5-15 percent were observed on the remaining four areas (Figure 3). Increasing numbers of barred owls and loss of nesting/roosting cover were considered partially responsible for declines in demographic rates.

The most recent meta-analysis (Dugger *et al.* 2016) estimated apparent survival, fecundity, recruitment, rate of population change, and local extinction and colonization rates. The analysis included the 11 study areas used in Forsman *et al.* (2011) (Table 1) and reported continued and more pronounced declines in annual survival, rate of population change, and also site occupancy (Table 2). When spotted owl monitoring programs were first established, there were no effective analytical tools for occupancy analyses that allowed for the possibility that a species was present at a site but went undetected (Gutiérrez 2008, p. 794). The subsequent development of these tools enabled researchers in recent years to adapt the spotted owl datasets to include occupancy analyses in the meta-analyses. Estimates of annual rates of population change and occupancy rates from Dugger *et al.* (2016) indicate that northern spotted owls were continuing to decline in all parts of their range (Table 2, Figure 3, Figure 4), and that the annual rate of decline was increasing in many areas, including southern Oregon and northern California.

With the exception of treatment areas in the Green Diamond Study Area (GDR-T) where removal of barred owls was initiated in 2009, Dugger *et al.* (2016, p. 70) reported that the populations in all study areas were declining, including in those study areas that had been relatively stable in earlier analyses. Realized rate of population change for northern spotted owls in Cle Elum and the Olympic Peninsula demographic study areas in Washington showed a 60-70 percent decline over the past 2 decades. The Cle Elum study area had 64 occupied territories in 1992 and in 2016, 14 occupied territories were detected on this study area (Lesmeister *et al.* 2017, p. 12). Similarly, the Olympic study area contained a high of 32 pairs of northern spotted owls in 1992 and in 2016, 3 pairs and two single owls were detected (Lesmeister and Pruett 2017, pp. 3, 8). In the Oregon and California study areas, realized rate of population change has shown a decline of 31-64 percent over the past two decades. While confidence intervals for some of the estimates of rate of population change slightly overlap zero, the results indicated a significant negative trend over time at seven of the eleven study areas (Dugger *et al.* 2016, p. 70). In addition, the annual estimates of rate of population change for most study areas have been less than 1.0 for more than 10 years (Figure 3). These findings indicate that these populations are declining over time and the rate of decline is increasing.

Site occupancy rates have declined from approximately 90 percent occupancy to a range of 25 to 60 percent occupancy over the past two decades. Dugger *et al.* (2016, p. 74) reported that occupancy rates in Washington declined from a range of 56 to100 percent in 1995, to a range of 11 to 26 percent in 2013. During this same time period, occupancy rates in Oregon declined from a range of 61 to 88 percent in 1995, to a range of 28 to 48 percent in 2013. In California, occupancy rates declined from a range of approximately 42 to 92 percent in 1993, to a range of 38 to 55 percent in 2013. This 2016 analysis was the first range-wide assessment of northern spotted owl population status to include estimates of occupancy dynamics (*i.e.* proportion of northern spotted owl territories occupied by a resident single or pair in a given year compared to the total number of territories surveyed), which revealed that territory occupancy of northern spotted owls has declined substantially in all 11 study areas since the early 1990s (Figure 5). The lowest occupancy rates were observed in 2013 (the final year included in this study) in the Oregon Coast Ranges Study Area (28 percent) and at the 3 study areas in Washington (Olympic, Cle Elum, Rainier) (Figure 5).

This most recent meta-analysis also found relationships between climate and demographic rates (Figure 6) for more study areas than previously reported (Forsman *et al.* 2011), and found that recruitment was more strongly associated with climatic factors than the presence of barred owls (Dugger *et al.* 2016, p. 99). These relationships likely reflected the longer time series available for this most recent analysis, rather than new relationships between owl demographics and climate. Given predictions regarding climate change in the Pacific Northwest (warmer, wetter winters), these relationships warrant further exploration. Because rates of population change were a function of both survival and recruitment, lowered survival due to competition with barred owls coupled with reduced recruitment potentially resulting from the predicted future climate trends for the Pacific Northwest could lead to steeper future declines in northern spotted owl populations.

In summary, the northern spotted owl has shown increasing rates of population decline since demographic monitoring was initiated (Dugger *et al.* 2016, entire). Northern spotted owls are a long-lived species, with high, relatively stable adult survival, lower juvenile survival, and highly variable reproduction. For such species, population growth is most sensitive to changes in adult survival and less sensitive to changes in reproduction or juvenile survival (Lande 1988, p. 602; Noon and Biles 1990, p. 25). Long-term demographic monitoring of northern spotted owls has demonstrated declines not only in annual survival, but also in recruitment and site occupancy in most study areas (Dugger *et al*. 2016, p 97). Populations on the long-term demographic monitoring areas have declined 31-77 percent since the early 1990s and on average are declining at a rate of 3.8 percent per year (Table 2). Of particular concern is the decline in annual survival rates. The most recent population analysis (Dugger *et al.* 2016, p. 93) found that annual survival was declining at 8 of the 11 study areas. In addition, territory occupancy was declining at all 11 study areas and recruitment of new individuals into populations has declined at 8 of the 11 areas, with increased barred owl presence being associated with higher rates of unoccupied northern spotted owl territories. Competition with barred owls has been identified as the primary factor associated with the observed population declines; however, habitat loss and environmental factors such as weather and climate have also contributed to the observed declines. The notable declines of 60 to 77 percent found in the northern part of the subspecies' range (where the barred owl has been established for the longest period of time), along with overall declines in survival, fecundity, and occupancy in all portions of the range (Dugger *et al*. 2016, p. 97), provide evidence that this subspecies is at very high risk of extirpation from parts or all of its range. While no one predicted what the rate of decline was expected to be, declines of up to 77 percent are severe and likely much higher than what was expected.

Table 1. Study area descriptions and mark-recapture data used to estimate vital rates of Northern Spotted Owls in Washington, Oregon and California, 1985–2013 (from Dugger *et al.* 2016, p. 63).

Study area	Acronym	Years	Area (km2)	No. owls banded by age class[a] S1	S2	Adult	Total owls	Total encounters[b]	Mean annual precip (cm)
Washington									
Cle Elum	CLE	1989–2013	1,784	5	4	59	228	1,219	136
Rainier	RAI	1992–2013	2,167	1	2	68	191	742	215
Olympic	OLY	1990–2013	2,230	1	9	49	409	1,715	282
Oregon									
Coast Ranges	COA	1990–2013	3,922	3	00	96	659	3,616	212
H.J. Andrews	HJA	1988–2013	1,604	2	30	94	776	3,981	201
Tyee	TYE	1990–2013	1,026	56	28	46	530	2,897	126
Klamath	KLA	1990–2013	1,422	79	52	94	725	3,609	116
South Cascades	CAS	1991–2013	3,377	1	8	57	676	2,856	119
California									
NW California	NWC	1985–2013	460	46	09	15	570	2,935	154
Hoopa	HUP	1992–2013	356	6	7	43	256	1,217	176
Green Diamond Resources	GDR	1990–2013	2,133	62	28	92	982	4,733	187
Totals			20,481	02	,077	,013	6,002	29,520	

[a] Age class codes indicate age when owls were first captured and banded on territories: S1 = 1 yr old, S2 = 2 yrs old, Adult = ≥3yrs old. [b] All captures, recaptures, and resightings, excluding multiple encounters of individuals in the same year.

Figure 3. Estimated mean rates of population change (λ) and 95 percent confidence intervals for Northern Spotted Owls in each of 11 study areas in Washington, Oregon, and California, USA, 1985–2013 presented by Dugger *et al.* (2016, p. 71). Estimates for the GDR study area are presented separately for control and treatment areas before (1990–2008) and after (2009–2013) barred owls were removed (GDR-CB=control before removal, GDR-TB = treatment before removal, GDR-CA= control after removal, GDRTA = treatment after removal). See Table 1 for study area abbreviations.

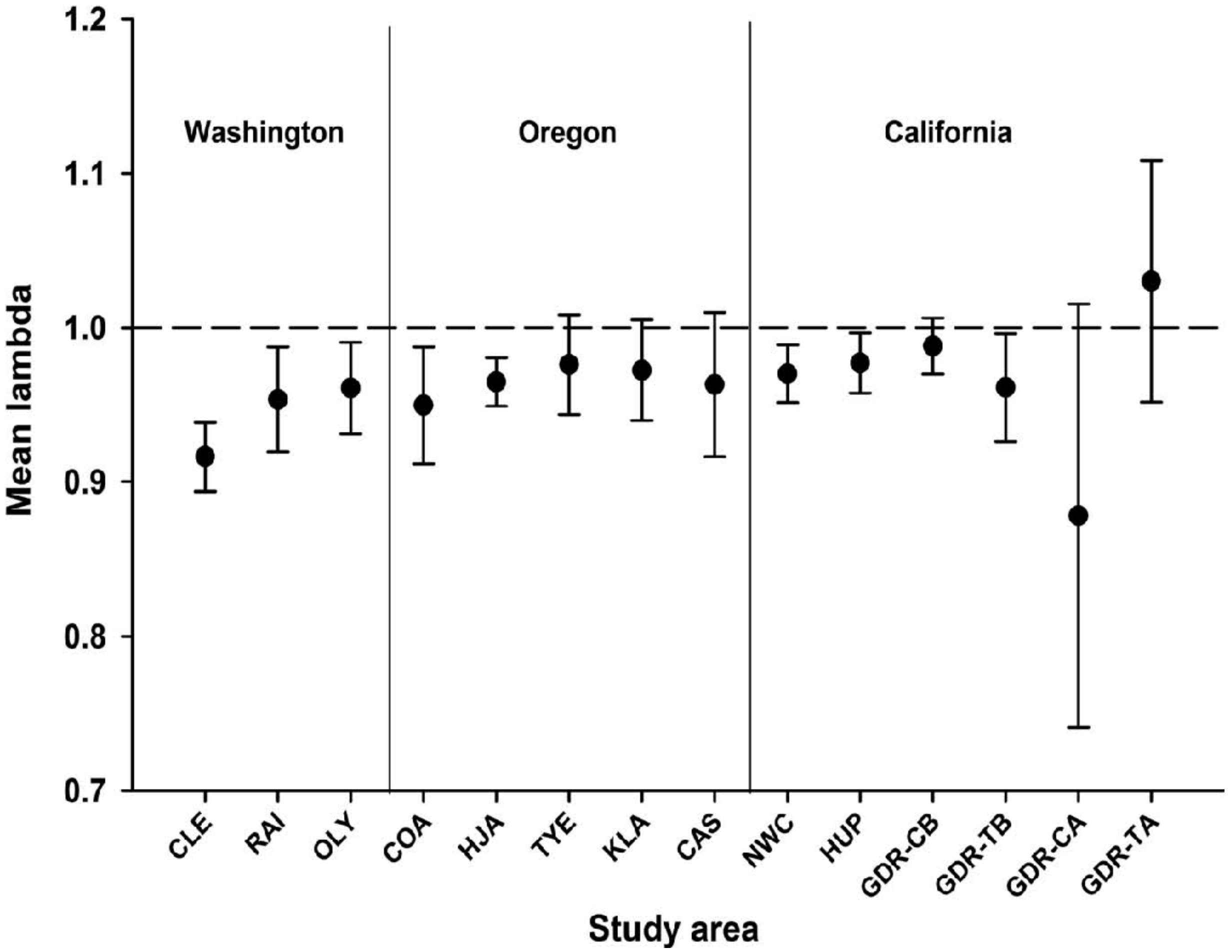


Table 2. Summary of trends in demographic parameters including fecundity, apparent survival (φ), occupancy rates (Ψ), and annual rate of population change (λ) for Northern Spotted Owls from 11 study areas in Washington, Oregon, and California, USA, 1985–2013. Mean annual rate of population change ($\hat{\lambda}$) and percent population change since the start of the monitoring period (%Δ) were based on estimates of realized population change (λ) from the best random effects models with temporal trends on λ are also included. (Dugger *et al.* 2016, p. 97, Table 25)

Study Area[a]	Fecundity	Annual Survival (φ)	Site Occupancy (Ψ)	Rate of Population Change	Annual rate of population change ($\hat{\lambda}$)	Annual change	% population change (%Δ)[b]
Washington							
CLE	Declining	Declining	Declining	No Trend	0.916	−8.4%	-77%
RAI	No Trend	Declining	Declining	No Trend	0.953	−4.7%	-61%
OLY	No Trend	No Trend	Declining	No Trend	0.961	−3.9%	-59%
Oregon							
COA	Declining	No Trend	Declining	Declining	0.949	−5.1%	-64%
HJA	Declining	Declining	Declining	Declining	0.965	−3.5%	-47%
TYE	Declining	Declining	Declining	Declining	0.976	−2.4%	-31%
KLA	Declining	No Trend	Declining	Declining	0.972	−2.8%	-34%
CAS	No Trend	Declining	Declining	No Trend	0.963	−3.7%	-44%
California							
NWC	Declining	Declining	Declining	Declining	0.970	−3.0%	-55%
HUP	Declining	Declining	Declining	Declining	0.977	−2.3%	-32%
GDR-CB	Declining	Declining	Declining	Declining	0.988	−1.2%	-31%
GDR-TB	Declining	Declining	Declining	Declining	0.961	−3.9%	-26%
GDR-CA	**	**	Declining	**	0.878	−12.2%	-41%
GDR-TA	**	**	N/A[c]	**	1.030	3.0%	-9%

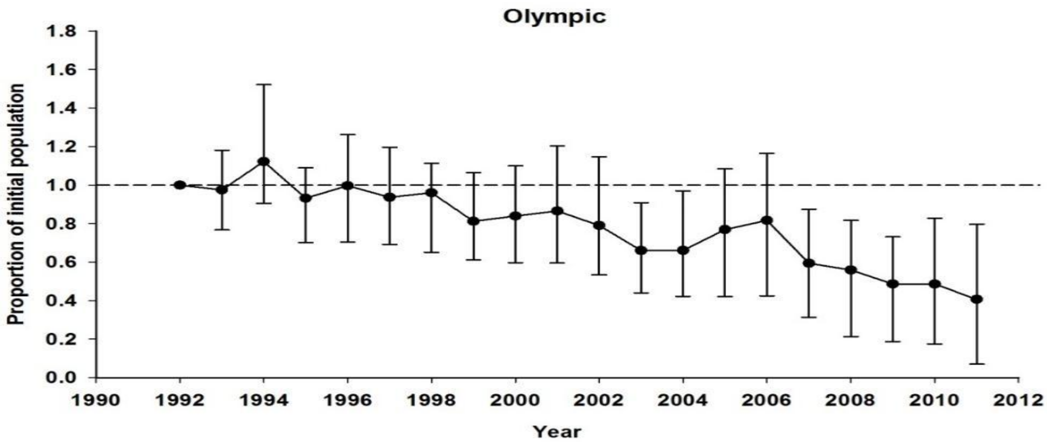
[a] See Table for study area codes. GDR-TB = Green Diamond treatment areas before Barred Owls were removed; GDR-CB = Green Diamond control areas before Barred Owls were removed in treatment areas; GDR-TA = Green Diamond (GRD) treatment areas after Barred Owls were removed (2009–2013); GDR-CA = Green Diamond control areas after Barred Owls were removed in treatment areas (2009–2013).

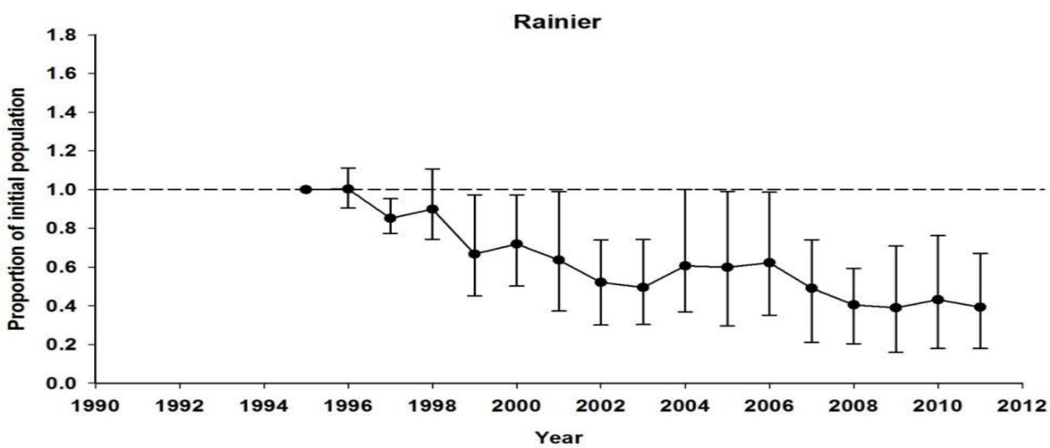
[b] With the exception of the GDR study area, percent population change (%Δ) was based on estimates of λ in 2011, the last year for which an estimate of λ could be generated.

[c] 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.

Figure 4. Annual estimates of realized population change (Δ_t) with 95% confidence intervals) for Northern Spotted Owls at three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C) (from Dugger *et al.* 2016, p. 72-73).





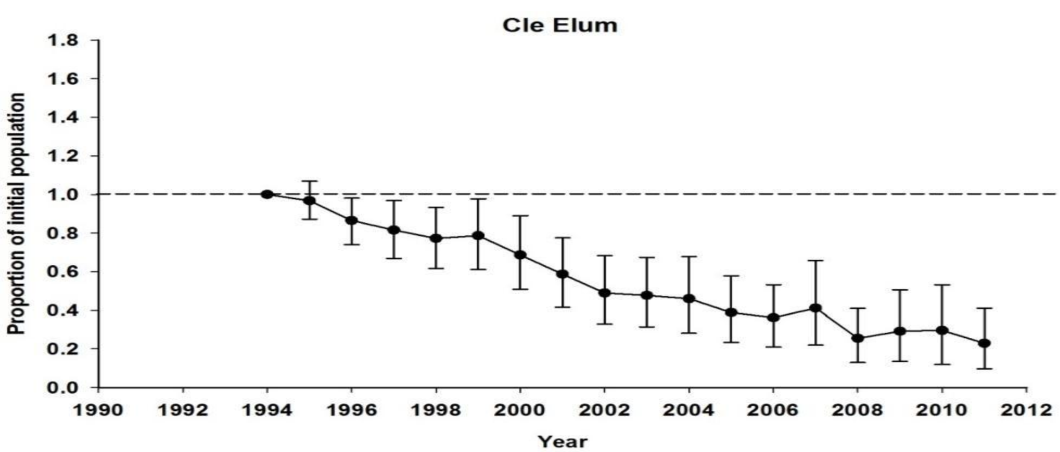


Figure 4 cont. Annual estimates of realized population change (Δ_t) with 95% confidence intervals) for Northern Spotted Owls at three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C) (from Dugger *et al.* 2016, p. 72-73).

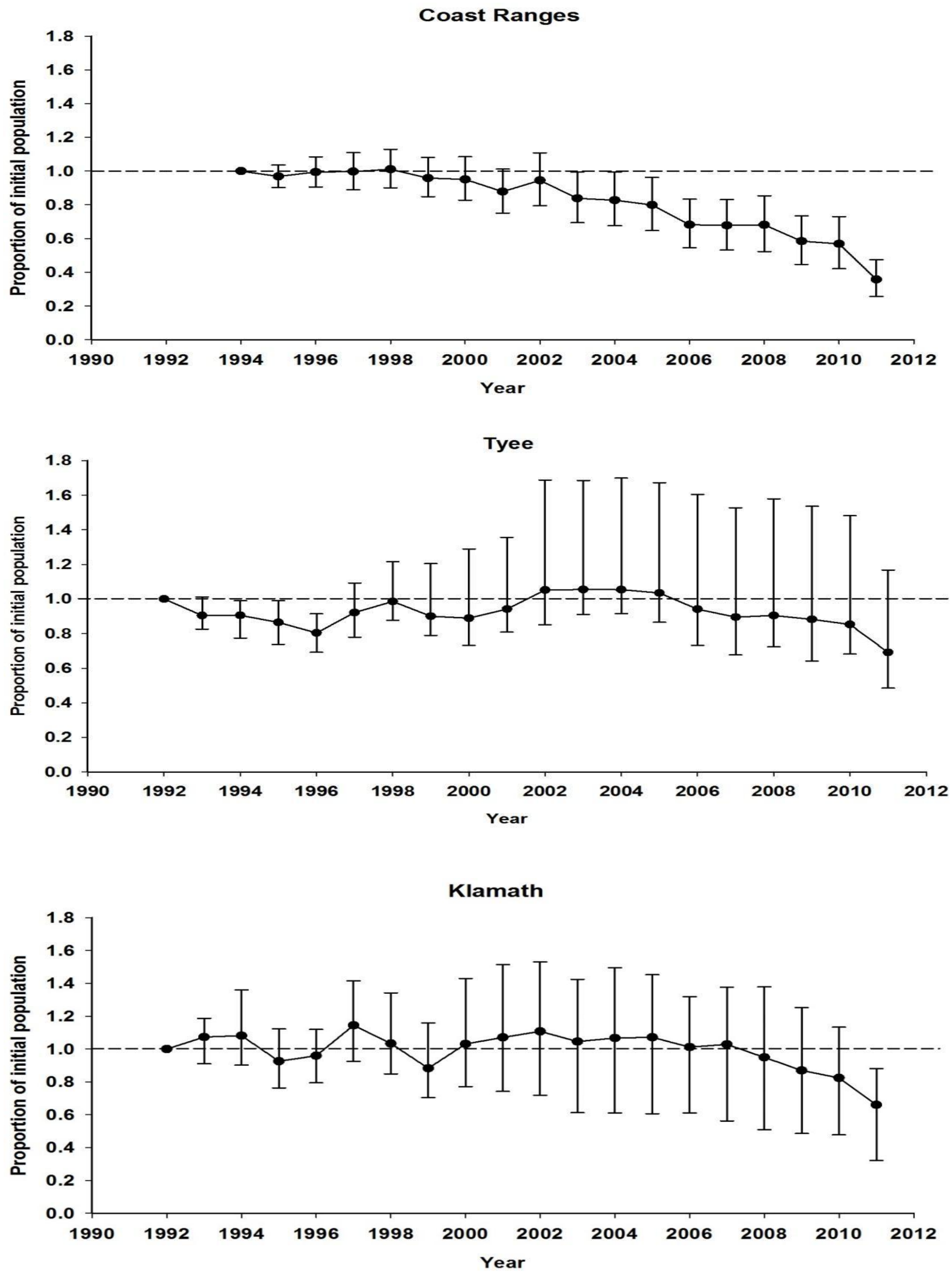
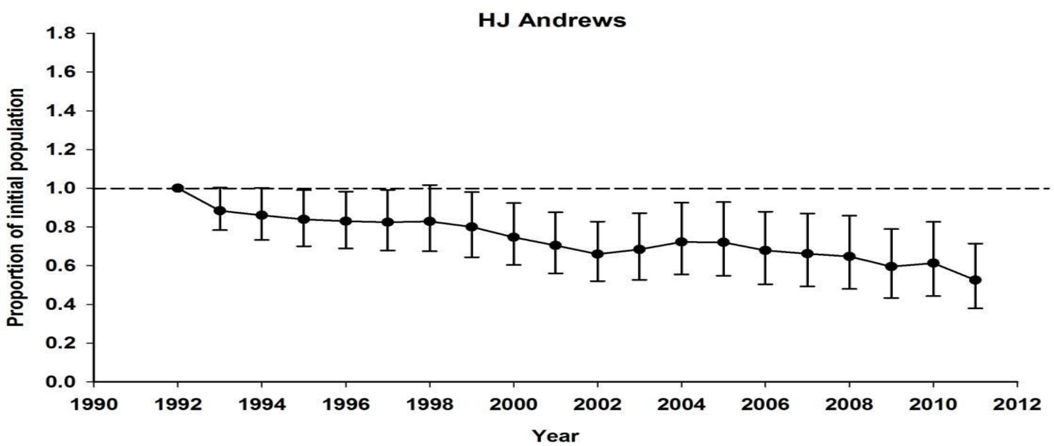
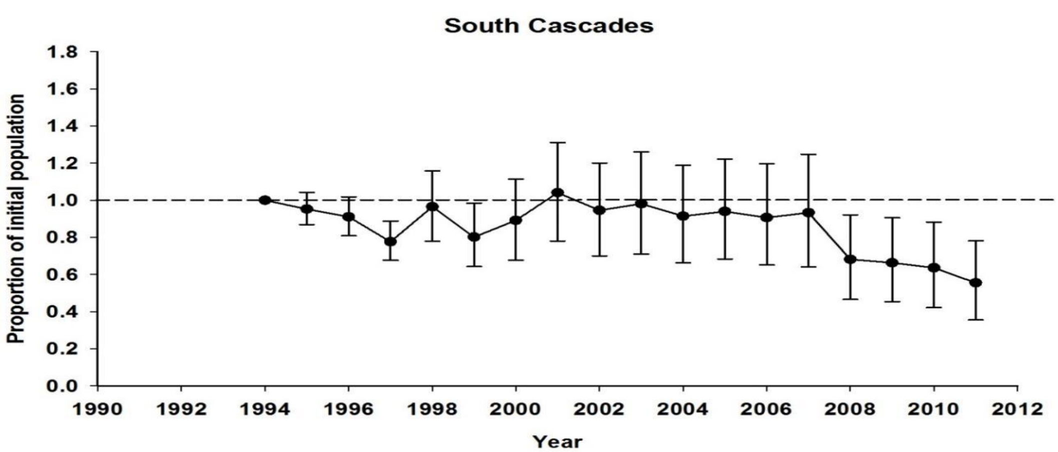


Figure 4 cont. Annual estimates of realized population change (Δ_t) with 95% confidence intervals) for Northern Spotted Owls in three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C) (from Dugger *et al.* 2016, p. 72-73).





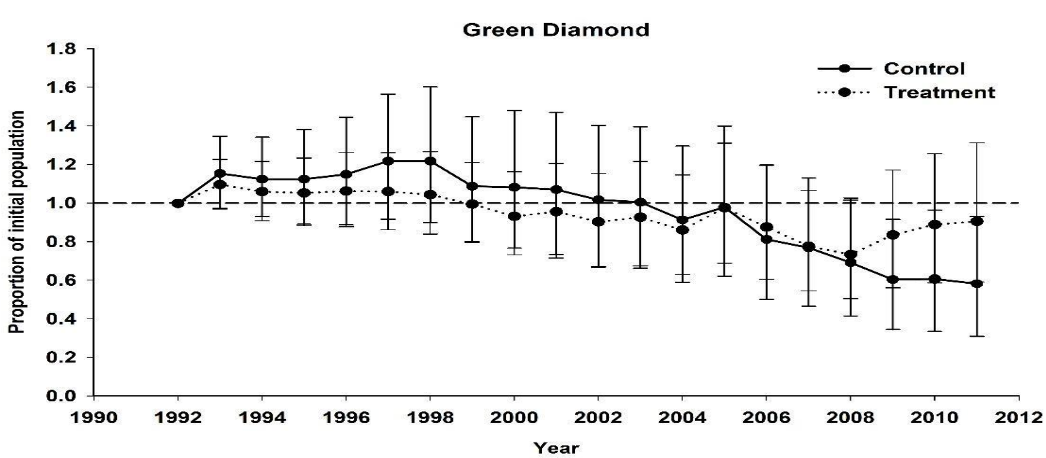
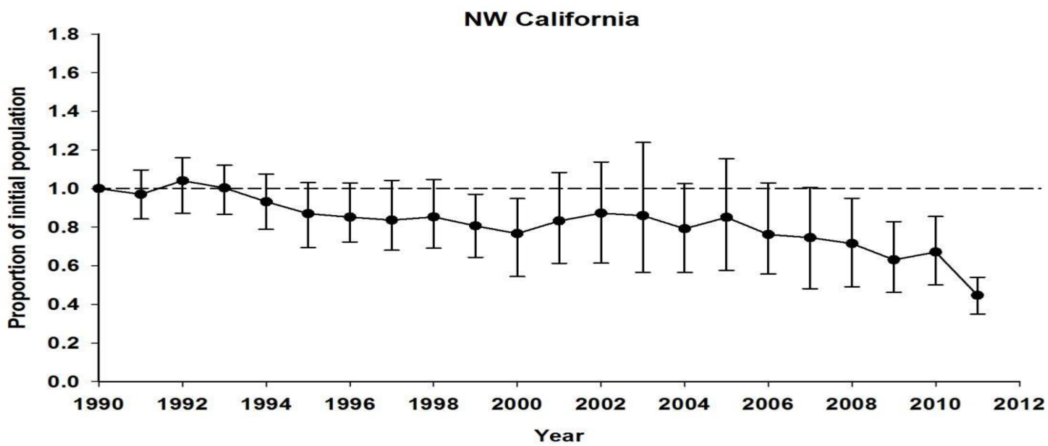


Figure 4 cont. Annual estimates of realized population change (Δ_t) with 95% confidence intervals) for Northern Spotted Owls in three study areas in Washington (A), five study areas in Oregon (B), and three study areas in California (C) (from Dugger *et al.* 2016, p. 72-73).



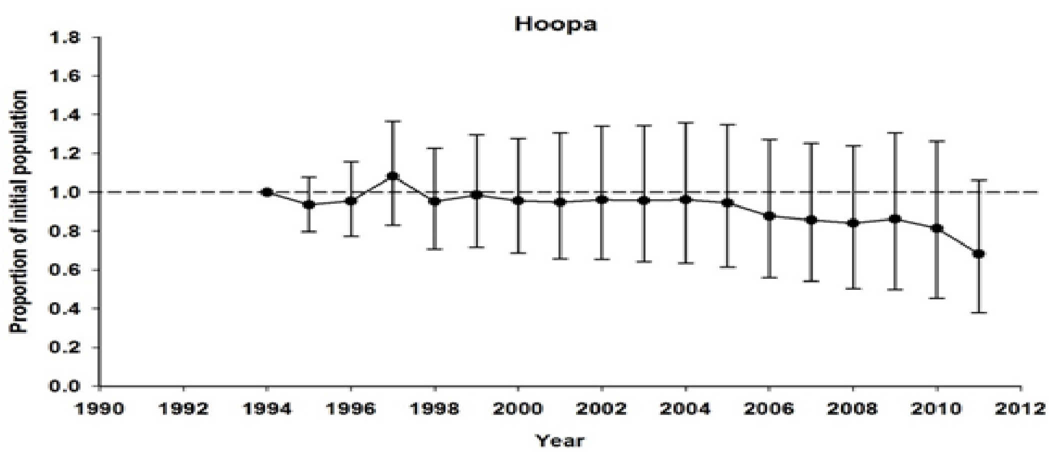


Figure 5. Estimates of the probability of territory occupancy for Northern Spotted Owls in 11 study areas in Washington, Oregon, and California (from Dugger *et al.* 2016, p. 79).

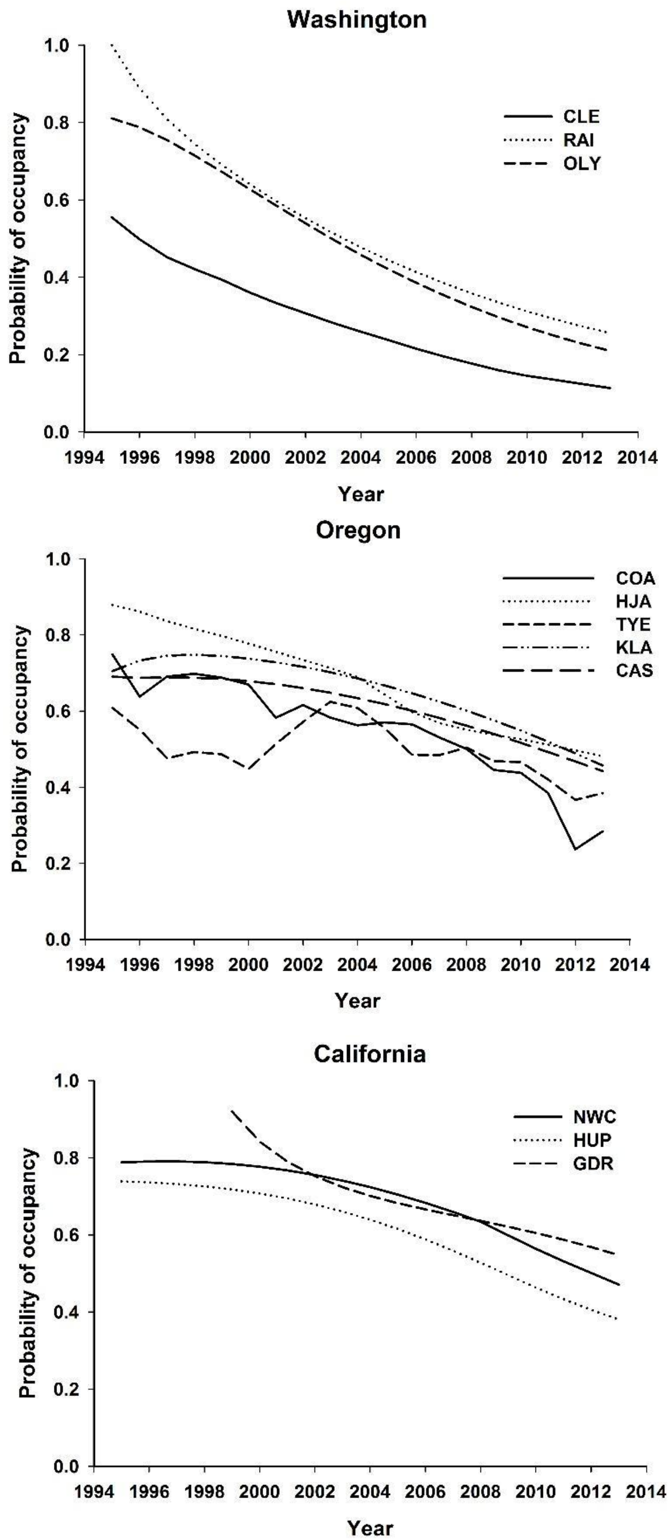
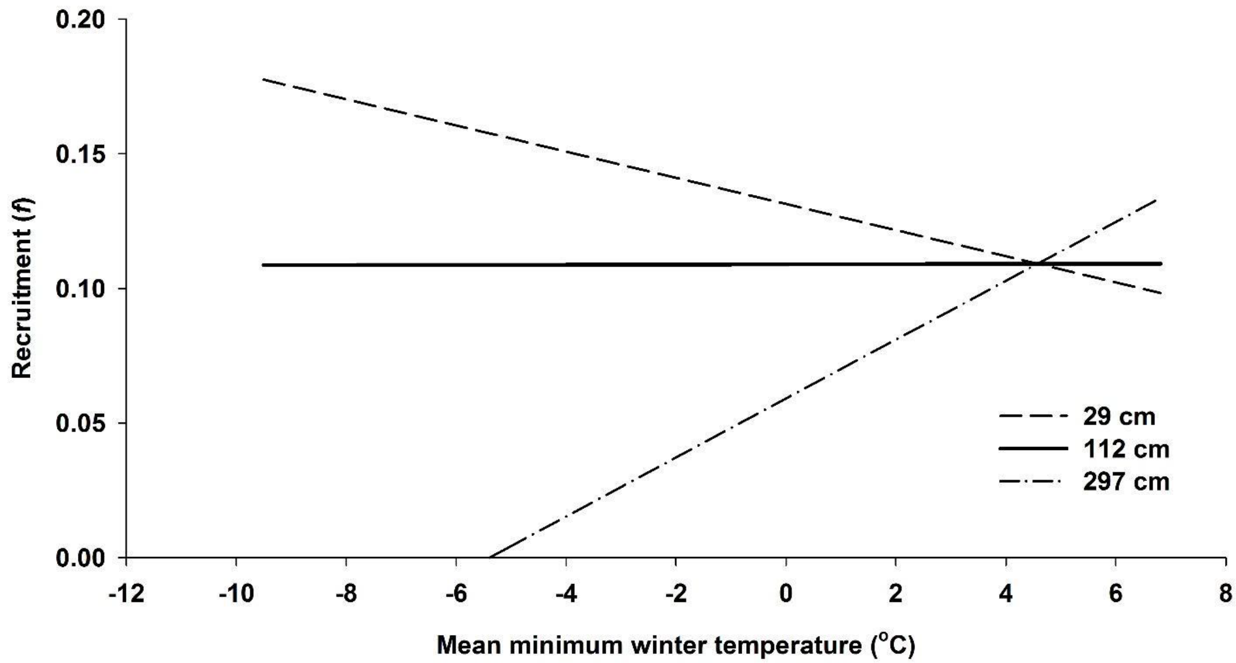


Figure 6. Predicted estimates of recruitment of Northern Spotted Owls[a]. Estimates of recruitment are plotted across the range of mean minimum winter temperatures from the data, for the minimum (29 cm), mean (112 cm) and maximum (297 cm) levels of total precipitation across all study areas and years used in the analysis (from Dugger *et al.* 2016, p. 77).



[a]Results are displayed using the best random effects model from the meta-analysis of lambda using the survival and recruitment parameterization with area and general time effects on , *p*, and *f* [ϕ(Area*t) *p*(Area*t) *f*(Area*t) RE:WP*WMT] from Dugger *et al.* (2016, p. 77)

4.0 POTENTIAL STRESSORS AFFECTING THE STATUS OF NORTHERN SPOTTED OWL

The northern spotted owl was listed in 1990 as threatened throughout its range "due to loss and adverse modification of northern spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and wind storms" (55 FR 26114). Additional threats included low populations, declining populations, limited habitat, declining habitat, inadequate distribution of habitat or populations, isolation of populations within physiographic provinces, predation and competition, lack of coordinated conservation measures, inadequacy of regulatory mechanisms and vulnerability to natural disturbance (USFWS 1992, Section II.B.3). The Service found that the petition from the Environmental Protection Information Center (EPIC 2012) to list the northern spotted owl as endangered provided substantial information on the present or threatened destruction, modification or curtailment of the species' habitat or range, habitat loss and the decline of preferred prey species, competition with and predation by barred owls, disease, the inadequacy of existing regulatory mechanisms, and range-wide population declines (USFWS 2015, entire). In our status review we examined these potential stressors as well as toxicants and the effects of small population size, and found that habitat loss continues to affect the species, although the primary source of habitat loss on Federal lands has shifted from timber harvest to wildfires (Courtney and Gutiérrez 2004, pp. 11-7 through 11-8, Davis *et al.* 2016, p. 42). Furthermore, we now know that the northern spotted owl faces additional stressors beyond habitat loss including a new significant and complex threat in the form of competition from the congeneric, non-native barred owl, as well as effects from climate change. In this document we discuss regulatory mechanisms following the discussion of stressors, in the context of their effectiveness at reducing or ameliorating effects of the stressors on the northern spotted owl.

4.1 Stressors Related to Destruction, Modification or Curtailment of Habitat (Factor A)

4.1.1 Habitat Loss and Fragmentation

Past habitat loss was the primary factor leading to the listing of the northern spotted owl as a threatened species (55 FR 26114). Northern spotted owl habitat is lost and fragmented through disturbance factors such as timber harvest and other silvicultural activities, wildfire, and insect and forest disease outbreaks. Habitat loss through timber harvest and other silvicultural activities continues today but at a much reduced rate from pre-NWFP levels and in fact at a lower rate than what was anticipated in the Plan. The amount of northern spotted owl habitat lost to wildfire has been slightly higher than what was anticipated in the NWFP and the Plan did not predict that the largest areas of loss would be in reserved areas. Insect and disease outbreaks contribute a very minor amount to loss of northern spotted owl habitat. Habitat trends recently described in the 20-Year Northwest Plan Monitoring Report represent the best available current range-wide synthesis of nesting/roosting habitat status and trends data (Davis *et al.* 2016, entire). Proportionally, forest conditions and habitat losses or gains varied by cause, land allocation, and physiographic province. The Record of Decision for the NWFP projected approximately 2.5 percent of northern spotted owl habitat on Federal lands would be harvested per decade (USDA and USDI 1994a, p. 46), primarily in the nonreserved matrix areas.

From 1993 to 2012, the total range-wide gross loss of forest cover types suitable for nesting and roosting by northern spotted owls was over 1.6 million ac (47,497 ha); 40 percent (650,200 ac (263,127 ha)) on Federal lands and 60 percent (960,800 ac (388,822 ha)) on non-Federal lands (Table 3 and Table 4; and Davis *et al.* 2016, pp. 22). After taking into account recruitment of habitat from forest succession, the total net loss of all nesting and roosting habitat across the range of northern spotted owl was 422,000 ac (171,000 ha), or a 3.4 percent decrease since 1993 (Davis *et al.* 2016, p. 22). On Federal lands (both reserved and non-reserved) the total range-wide loss of nesting/roosting habitat from 1993 to 2012 was 7.2 percent, of which 5.2 percent was due to wildfire (474, 000 ac (191,942 ha)), 1.3 percent was due to timber harvest (116,100 ac (46,984 ha)), and 0.7 percent was due to insect and forest disease outbreaks (59,800 ac (24,200 ha)) (Davis *et al.* 2016, p. 42). Although it was projected that habitat loss from timber harvest in non-reserved areas and habitat loss from wildfire in reserved areas would be similar under the NWFP, the majority of losses on Federal lands occurred from wildfire in reserved areas (Table 3 and 4); approximately 388,500 ac (157,220 ha) of nesting/roosting habitat was lost due to wildfire on Federal reserved land or about 60 percent of the total 650,200 ac (263,127 ha) loss of nesting roosting habitat on Federal lands (Davis *et al.* 2016, pp. 20 and 44*)*. Provincially, the Klamath, eastern Cascades, and southern portion of the western Cascades, experienced the highest levels of nesting/roosting habitat loss due to wildfire; most of these losses were in reserved areas (Davis *et al*. 2016, p. 38). The California Klamath province lost the greatest proportion of nesting/roosting habitat due wildfire (199,800 ac (80, 856 ha)) (Davis *et al.* 2016, p. 44).

At the statewide level, nesting/roosting habitat in California declined by approximately 11 percent, while in Washington and Oregon the declines were approximately 5 and 7 percent respectively (Table 3 below; from Davis *et al.* 2016, Table 6, p. 21). The range-wide gross loss of nesting/roosting habitat on Federal lands due to timber harvest since 1993 was 1.3 percent, lower than what was anticipated with the implementation of the NWFP under the NWFP from timber harvest alone on all Federal lands (Davis *et al.* 2016, p. 24). Even though losses from wildfire occurred mainly within the federally reserved allocations, net nesting/roosting habitat losses from wildfire were under 4.0 percent since 1993, less than what was anticipated with the implementation of the NWFP (Davis *et al.* 2016, p. 24). After accounting for recruitment of new habitat, the net loss of nesting/roosting habitat on all Federal lands (both reserved and non-reserved) was just 1.5 percent (Davis *et al.* 2016, p. 42).

In reserved areas, some recruitment of nesting/roosting habitat was noted but overall there was a 4 percent net decrease (Davis *et al.* 2016, p. 20). In non-reserved areas, the recruitment of nesting and roosting habitat led to a net increase of 4.3 percent since 1993 (Davis *et al.* 2016, p. 19). Most of the gains occurred in the moister physiographic provinces (*e.g.*, Coast Ranges and Western Cascades); however, there was also a large gain (13.5 percent) in the Oregon Eastern Cascades. The results of the concurrent late-successional and old-growth forest monitoring estimated a net decrease of 0.8 to 2.8 percent of older forests defined purely by structural attributes (*e.g.*, old-growth structure index) in the Oregon Eastern Cascades (Davis *et al.* 2016, p. 24). However, the net gain in northern spotted owl nesting and roosting habitat may be driven by species composition changes (*e.g.*, understory development) of Douglas-fir and grand fir that in pine stands would lower the percentage of stand basal area composed of pine. Shifts in species compositions in the higher elevations (*e.g.*, silver fir mountain hemlock) could have similar results (Davis *et al.* 2016, p. 37). Habitat recruitment estimates have a higher level of uncertainty than estimates of habitat loss for reasons detailed in the NWFP 15-year monitoring report (Davis *et al.* 2011, pgs. 48 and 49). It is important to note, however, that this loss under the NWFP was anticipated to occur primarily due to harvest within the matrix areas rather than in reserves where much of the loss to wildfire occurred (USDA and USDI 1994a, p. 46; Davis *et al.* 2016, p. 23).

Dispersal habitat has also been reduced. Range-wide on all lands both Federal and non-Federal, there has been an estimated gross loss of about 3,734,100 ac (1,511,136 ha); 789,500 ac (319,499 ha) of which occur on Federal lands (Davis *et al.* 2016, Table 12). In Davis *et al.* (2011, p. 11) dispersal habitat was classified based on a mean conifer dbh ≥11 in and conifer cover ≥40 percent from Gradient Nearest Neighbor maps of forest structure and species composition plus any nesting/roosting habitat that was not already captured. Davis *et al.* (2016, pp. 12-13) also analyzed the larger landscape (15.5 mi (25 km) radius roving circle of all Federal and non-Federal lands) for the ability of dispersal habitat to support landscape level movement of dispersing spotted owls, resulting in a map of a dispersal-capable landscape changes from 1993 to 2012. Davis *et al.* (2016, p. 21) used a threshold of ≥40 percent dispersal habitat within this circle, as this metric of dispersal habitat captured 90 percent of documented northern spotted owl movements from Forsman *et al.* (2002; Davis *et al.* 2016, p. 21). Loss of dispersal-capable landscape area over this time represents a ten percent gross loss of dispersal-capable landscape across the range of the northern spotted owl, mostly around the periphery of the Federal forests (Davis *et al.* 2016, p. 28). This may be due to second-rotation regeneration timber harvesting occurring in dispersal habitats on non-Federal lands that border Federal lands. Large wildfires on Federal lands played a role in this decrease in the eastern Cascade provinces and the Klamath Mountain provinces (Figure 7). A 5 percent gross gain in dispersal-capable landscapes was also noted along the periphery of some Federal forests caused by forest succession in younger forests. Consequently, these gains compensated for some of the dispersal habitat loss, resulting in an overall net decrease in dispersal-capable landscapes of 5 percent since 1993. In general, the dispersal-capable landscape has receded by a few miles into federally managed lands in Washington and Oregon. Some internal losses occurred within large reserves in the Washington Eastern Cascades. Dispersal-capable lands mostly expanded along the coastal regions due to rapid growth of redwood forests. The large reserve network range-wide remains mostly intact for dispersal, in spite of the many large wildfires occurring within some of the reserves. Exceptions are the impacts of the large Biscuit Fire (Oregon Klamath) in 2002 that caused a wide loss of dispersal-capable lands within a large reserve, separating the northern portion of the reserve from the southern portion by about 15 mi (24 km), and the 2014 fires on the Klamath National Forest (California Klamath) that also burned large areas of dispersal (and nesting/roosting) habitats at high severity.

Table 3. Areal estimates of nesting/roosting habitat and net changes from 1993 to 2012 on all Federal lands, assigned causes for losses from LandTrendr disturbance maps (from Davis *et al.* 2016, p. 21).

State and physiographic province	Nesting/roosting habitat estimates from bookend maps: 1993	2012	Net area change	Net percentage change	LandTrendr disturbance assignment for losses: Harvest	Wildfire	Insect	Other	Total explained loss	Percentage loss from 1993
	Acres			*Percent*	*Acres*					*Percent*
Olympic Peninsula	765,800	737,600	-28,200	-3.7	1,700	1,000	800	2,200	5,700	-0.7
Western Lowlands	12,900	12,900	0	0	0	0	0	600	600	-4.7
Western Cascades	1,157,700	1,169,500	11,800	1.0	6,900	2,600	900	3,500	13,900	-1.2
Eastern Cascades	832,700	779,400	-53,300	-6.4	24,400	52,100	34,000	3,100	113,600	-13.6
Total	2,769,100	2,699,400	-69,700	-2.5	33,000	55,700	35,700	9,400	133,800	-4.8
Oregon:										
Coast Range	496,000	506,200	10,200	2.1	7,700	100	200	0	8,000	-1.6
Willamette Valley	7,000	7,500	500	7.1	300	0	0	0	300	-4.3
Western Cascades	2,344,300	2,371,400	27,100	1.2	34,900	63,000	2,500	1,100	101,500	-4.3
Klamath	998,700	932,100	-66,600	-6.7	14,000	132,000	900	200	147,100	-14.7
Eastern Cascades	299,200	339,600	40,400	13.5	8,400	14,700	1,700	300	25,100	-8.4
Total	4,145,200	4,156,800	11,600	0.3	65,300	209,800	5,300	1,600	282,000	-6.8
California:										
Coast Range	113,300	123,800	10,500	9.3	200	1,800	0	500	2,500	-2.2
Klamath	1,860,800	1,764,700	-96,100	-5.2	10,400	199,800	3,300	2,600	216,100	-11.6
Cascades	201,300	209,300	8,000	4.0	7,200	7,200	1,100	300	15,800	-7.8
Total	2,175,400	2,097,800	-77,600	-3.6	17,800	208,800	4,400	3,400	234,400	-10.8
NWFP total	9,089,700	8,954,000	-135,700	-1.5	116,100	474,300	45,400	14,400	650,200	-7.2

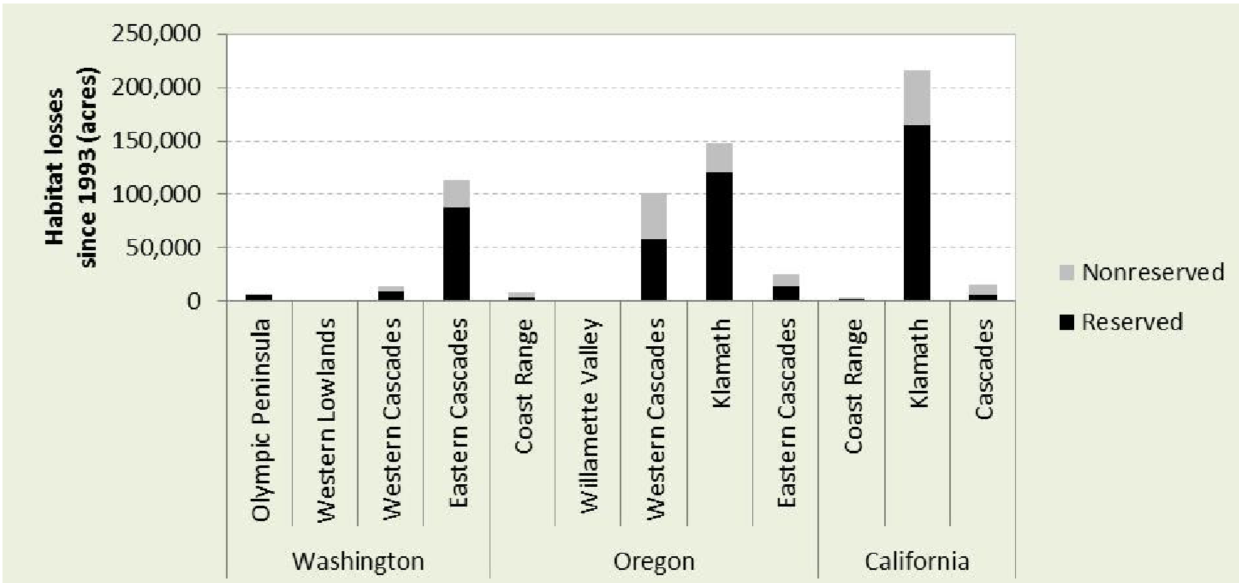
NWFP = Northwest Forest Plan.

Table 4. Areal estimates of nesting/roosting habitat and net changes from 1993 to 2012 on all (Federal and non-Federal) lands, assigned causes for losses from LandTrendr disturbance maps (from Davis *et al.* 2016, p. 22).

State and physiographic province	Nesting/roosting habitat estimates from bookend maps				LandTrendr disturbance assignment for losses					
	1993	2012	Net area change	Net percentage change	Harvest	Wildfire	Insect	Other	Total explained loss	Percentage loss from 1993
	Acres			*Percent*	*Acres*					*Percent*
Washington:										
Olympic Peninsula	936,200	859,600	-76,600	-8.2	41,400	1,000	2,500	2,200	47,100	-5.0
Western Lowlands	184,500	108,900	-75,600	-41.0	81,200	0	1,400	600	83,200	-45.1
Western Cascades	1,391,700	1,350,600	-41,100	-3.0	71,400	2,900	2,000	3,500	79,800	-5.7
Eastern Cascades	1,181,200	1,068,400	-112,800	-9.5	110,100	58,600	40,500	3,100	212,300	-18.0
Total	3,693,600	3,387,500	-306,100	-8.3	304,100	62,500	46,400	9,400	422,400	-11.4
Oregon:										
Coast Range	788,600	696,500	-92,100	-11.7	137,400	400	1,800	0	139,600	-17.7
Willamette Valley	88,400	70,900	-17,500	-19.8	26,700	0	300	0	27,000	-30.5
Western Cascades	2,820,000	2,710,700	-109,300	-3.9	255,100	65,000	5,100	1,100	326,300	-11.6
Klamath	1,238,900	1,175,300	-63,600	-5.1	85,500	134,400	2,200	200	222,300	-17.9
Eastern Cascades	408,500	438,400	29,900	7.3	37,200	19,300	2,900	300	59,700	-14.6
Total	5,344,400	5,091,800	-252,600	-4.7	541,900	219,100	12,300	1,600	774,900	-14.5
California:										
Coast Range	970,700	1,198,500	227,800	23.5	79,500	5,600	2,900	500	88,500	-9.1
Klamath	2,148,500	2,063,400	-85,100	-4.0	50,100	208,100	5,600	2,600	266,400	-12.4
Cascades	368,500	362,500	-6,000	-1.6	44,700	10,500	3,300	300	58,800	-16.0
Total	3,487,700	3,624,400	136,700	3.9	174,300	224,200	11,800	3,400	413,700	-11.9
NWFP total	12,525,700	12,103,700	-422,000	-3.4	1,020,300	505,800	70,500	14,400	1,611,000	-12.9

NWFP = Northwest Forest Plan.

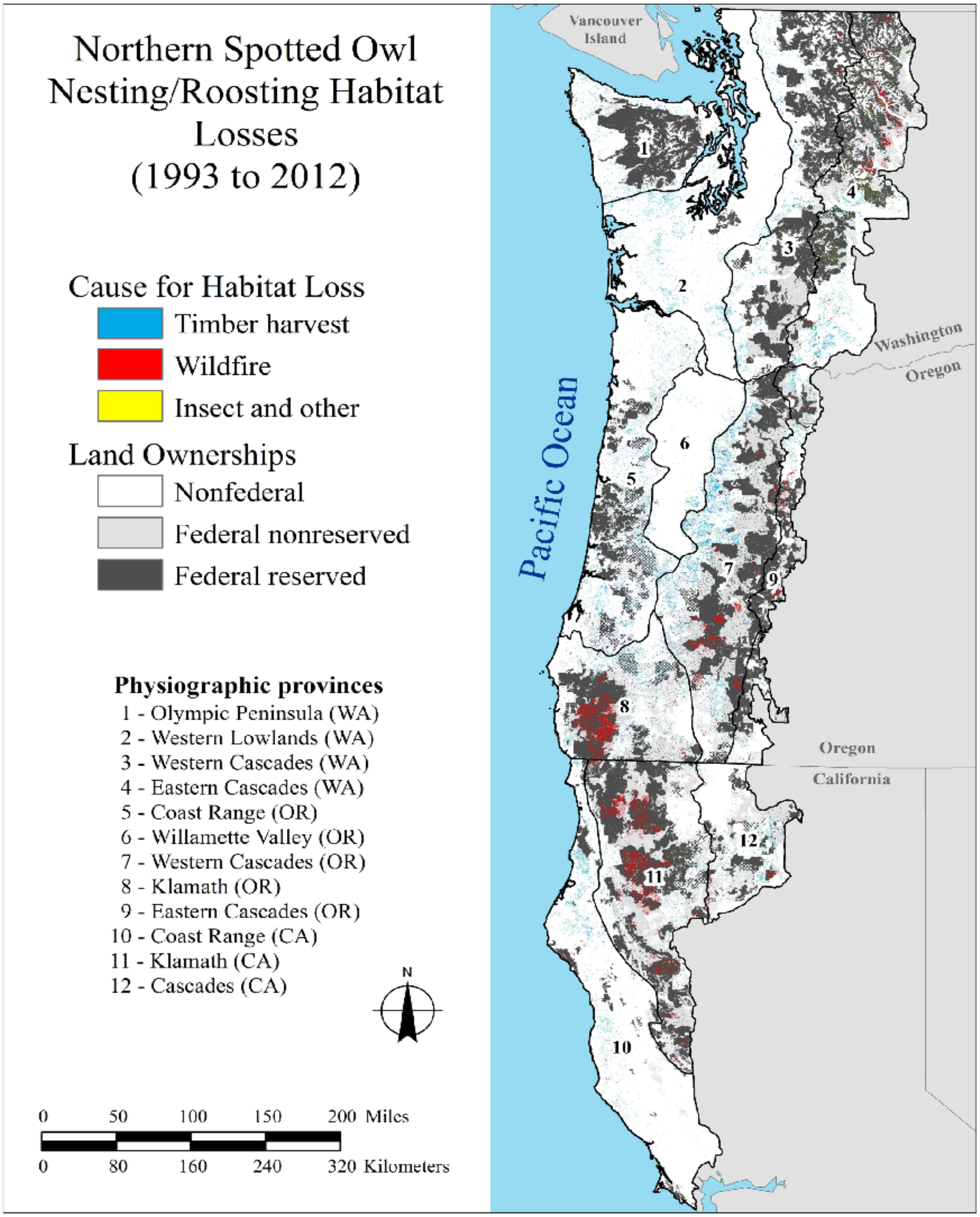
Figure 7. Nesting/roosting habitat losses on Federal lands between 1993 and 2012 by physiographic province (from Davis *et al.* 2016, Figure 6, p. 23).



The spatial context of habitat loss is a consideration when evaluating the impacts to northern spotted owls. Although their home range size is influenced by differences in natural stand characteristics, nesting and roosting and foraging habitat loss and fragmentation may effectively reduce the ability of the remaining habitat within the home range to support residential spotted owls, including negatively impacting northern spotted owl abundance and nesting success (Bart and Forsman 1992, pp. 98-99; Bart 1995, p. 944). Davis *et al.* (2016, p. 24-25) reported that range-wide, nesting/roosting habitats have become slightly more fragmented on all Federal land use allocations, with about a 1.1 percent conversion of core habitat to edge habitat over the past 20 years, however changes in fragmentation varied by physiographic province. Reserved land use allocations in Washington became slightly more contiguous in the distribution of resting/roosting habitat (0.1 to 4.5 percent increase), with the exception of the Eastern Cascades where core/core-edge habitat decreased by 1.7 percent. In Oregon, Federal reserves have generally become slightly more fragmented (0.5 to 2.7) with the highest increase in fragmentation in the Oregon Klamath province (

Figure 8) (see discussion below). The exception was the Oregon Eastern Cascades, where nesting/roosting habitat has become slightly more contiguous (4.9 percent). In California, reserved nesting/roosting habitat has become slightly more contiguous in the Coast Range and Cascades (0.8 to 1.2 percent, respectively), and more fragmented in the Klamath province primarily as a result of wildfire (3.8 percent). Davis *et al.* (2016, p. 28) also noted (1) the loss of dispersal capable landscapes between the Oregon Coast Range and the Oregon Western Cascades, (2) the loss of a connection between the central portion of the Oregon Coast Range physiographic province and its northern end, (3) a widening of the southern connection in the same province, and (4), an increased isolation of the Olympic Peninsula. In non-reserved Federal land use allocations, northern spotted owl nesting/roosting habitat has generally become more fragmented (0.4 to 3.9 percent) on the west side and slightly more contiguous on the east side (2.9 percent). In Oregon, the same pattern was observed with more fragmentation in the moister provinces (1.2 to 4.0) and more contiguous nesting/roosting habitat in the drier provinces (1.7 to 3.1). In California, as in the reserved allocations, non-reserved Federal nesting/roosting habitat became more fragmented in the Klamath province and less in the Coast and Cascades provinces. It should be noted that 20-year monitoring report (Davis *et al.* 2016) focuses change detection at a fine scale rather than through broader landscape-scale characteristics, and may therefore overestimate the habitat value of isolated habitat patches. Ongoing habitat fragmentation may make the actual trend in total available habitat more pessimistic (Carroll 2017, pers. comm.).

Figure 8. Map of nesting/roosting habitat losses on all lands by disturbance agent between 1993 and 2012 in Washington (WA), Oregon (OR), and California (CA). Note wildfires within Federal reserved land use allocations (Davis *et al.* 2016, p. 25).



4.1.1.1 Habitat Loss from Timber Management

Of the total 1.6 million ac (ha) of gross loss of nesting and roosting habitat on all Federal and non-Federal lands in the range of the northern spotted owl, 63 percent (1.2 million ac (485,623 ha)) was lost due to timber harvest (Davis *et al.* 2016, p. 22). The majority of nesting/roosting habitat loss on non-Federal lands was attributed to timber harvest (94 percent or about 904,000 ac (367,050 ha)), compared to only about 18 percent (or 116,100 ac (46,984 ha)) of total habitat loss on Federal lands. Timber harvest removed less than 10,000 ac (4,047 ha) of nesting roosting habitat each year on Federal land (Davis *et al.* 2016, p. 36), accounting for the removal of only 1.3 percent of all nesting/roosting habitat on Federal lands (Davis *et al.* 2016, p. 42), less than the level of habitat loss on Federal land that was anticipated in the NWFP (USDA and USDI 1994a, p. 46) However, the Western Oregon Cascades and the Oregon Coast Ranges experienced the highest habitat losses from harvest (approximately 50 percent) (Davis *et al.* 2016, Table 7). Some recent shifts in timber harvest in Oregon and Washington have been observed; these are general shifts in harvest volume and not directly associated with reported losses in northern spotted owl habitat. Harvest is currently focused in the western Cascades, accounting for about 85 to 90 percent of the annual harvest volume in Oregon and Washington. Additionally, the proportion of harvest on private and Federal lands in Oregon has remained relatively consistent since the implementation of the NWFP, however State lands have become a more substantial contributor to Oregon's harvest in recent years, accounting for 6 to 9 percent of the harvest since 2000 (Simmons *et al.* 2016, p. 7).

Effects from timber management have impacted the amount and distribution of northern spotted owl habitat over the last century. National and global economies strongly influence the rate of timber harvest and market fluctuations within and between states and counties have occurred over time. In general, timber harvesting began in earnest in the early 1900s in Washington, Oregon, and California, peaked in the 1970s and 1980s, and tapered off in the 1990s. Harvest has decreased on Federal lands but otherwise remained relatively stable on non-Federal lands over the last twenty years (Simmons *et al.* 2016, pp. 3-6; ODFW 2017; CBE 2017). Even-aged management (where all or most of the trees are removed, also called clearcutting) was the dominant harvest practice over the last century, leading to the elimination, reduction or fragmentation of northern spotted owl habitat to levels that negatively affect population densities across its range, particularly within the coastal provinces where habitat reduction has been concentrated (Thomas and Raphael 1993, pp. IV-5 through IV-8; USFWS 2011a, pp. B-1 to B-4). More recently, alternative harvest methods focused on thinning have replaced clearcutting as the main method of harvest on Federal lands (Lehmkuhl *et al.* 2015), reducing the intensity of harvest and its effect on northern spotted owl habitat. This change in techniques along with more careful management of old clearcuts to accelerate the development of future habitat is expected to result in significant northern spotted owl habitat recruitment by mid-century (Davis *et al.* 2016, p. 43).

4.1.1.2 Habitat Losses from Wildfire

Of the total 1.6 million ac (647,497 ha) gross loss of nesting/roosting habitat on all Federal and non-Federal lands in the range of the northern spotted owl from 1993 to 2012, 31 percent (505,000 ac (204,366 ha) was due to wildfire (Davis *et al.* 2016, p. 22). The amount of northern spotted owl nesting/roosting habitat lost to wildfire on Federal lands (both reserved and non-reserved) was 474,300 ac (191,942 ha) or a total of 5.2 percent of all nesting/roosting habitat on Federal lands; more habitat was lost from fire than from other disturbance factors (Davis *et al.* 2016, p. 42). Although an estimated 388,500 ac (157,220 ha) (82 percent) of the loss on Federal lands was in reserved allocations, larger Federal reserves were delineated in the historically "fire prone" dry forest portion of the spotted owl's range so that the habitat could handle disturbances without breaking function (Davis *et al.* 2016, p. 35; USDA and USDI 1994b, pp. J3:8-9 and pp. 3-4:46-49). Provincially, the Klamath, eastern Cascades, and southern portion of the western Cascades, experienced the highest proportion of habitat loss due to wildfire. These three areas accounted for 96 percent of the loss of nesting/roosting habitat from wildfire on all Federal lands. The Klamath province accounted for the most loss (331,800 ac, 69 percent), followed by the eastern Cascades (66,800 ac, 14 percent), followed closely by the southern portion of the western Cascades (63,000 ac, 13 percent).

Wildfires vary in frequency, severity and area burned and some portions of the northern spotted owls range are more prone to fire than others. Fires range in severity from low (vegetation lightly scorched, few large trees killed), to moderate (much of the litter is consumed, 40 to 80 percent mortality of trees) to high (tree crowns completely consumed, mortality assumed to be close to 100 percent) (Azuma *et al.* 2004, p. 5). High-severity fire is considered a significant stressor to spotted owls because of its potential to rapidly alter structural components of habitat that support nesting, roosting and foraging (Jones *et al.* 2016, p. 300 and 305), and to significantly reduce large blocks of habitat. The impacts from high-severity fires are a major cause of habitat loss on Federal lands (Courtney *et al.* 2004, executive summary, Davis *et al.* 2011, pp. iv, 46, Davis *et al.* 2016, Table 6, p. 21), and are disproportionately affecting important areas for spotted owl habitat and populations (Davis *et al.* 2011, p. iii, Schumaker *et al.* 2014, pp. 587-588).

Effects of high-severity fires are particularly acute in the Klamath physiographic provinces, the eastern Cascades, and southern portions of the western Cascades, which contain a significant proportion of the nesting/roosting habitat although respective fire regimes and the effect of fire on forest structure, composition, and habitat value differs significantly between the two areas so projected effects and recovery times can vary after fire related habitat loss (Davis *et al.* 2011, p. iii; Carroll 2017, pers. comm.). The 2002 Biscuit Fire in southwestern Oregon (Oregon Klamath physiographic province) burned over 499,000 ac (201,938 ha), 38 percent of which was in reserved land allocations with nesting and roosting cover type. The fire was a mixture of moderate- and high-intensity fire throughout the reserved area (Azuma *et al.* 2004, p. 1 and 12). About 177,000 ac (71,629 ha) of nesting/roosting habitat was lost in just five years in the California and Oregon Klamath Provinces alone, and many of these acres were within patch sizes that exceeded 1,000 ac (405 ha) (Davis *et al.* 2011, p. 42 and Davis *et al.* 2016, p. 22 and 38). A 2018 analysis of fires that impacted 1,000 acres or more on four forests in the California Klamath province found that between the 2008 and 2018 wildfire seasons losses in suitable habitat due to wildfire included a 16 percent loss (72,158 ac) on the Klamath NF, a 7 percent loss (60,307 ac) on the Shasta-Trinity NF, a 2.5 percent loss (9,021 ac) on the Six Rivers NF, and a 14 percent loss (12,662 ac) of nesting/roosting habitat on the Mendocino NF (USFWS 2018, p. 6).

4.1.1.3 Habitat Loss from Insects and Forest Pathogens

Insects, diseases, and other natural disturbances accounted for a minor proportion (0.7 percent) of northern spotted owl habitat loss since 1993 (Table 3). Large area-wide epidemics of forest disease and insect outbreaks may affect suitable habitat if canopy cover is lost and subsequent forest management in response to these disturbances degrade or remove the habitat (Naney *et al.* 2012, p. 36). Large-scale outbreaks of insects and pathogens are typically triggered by drought and have affected wide areas across the western United States (Logan *et al.* 2003, pp. 130-131; Raffa *et al.* 2008, entire; Williams *et al.* 2010, entire; Reilly and Spies 2016, p. 103). Recently, mortality rates in mature and old-growth forests due to insects and disease outbreaks were described as the highest of all age classes within Forest Service lands of Washington and Oregon; additionally, forest types suitable for northern spotted owls were shown to be susceptible to pathogens and/or insects (Reilly and Spies 2016, pp. 105-107). The impacts of most insect and forest disease outbreaks were found to be smaller scale, rather than stand-replacing events (p. 107). Higher levels of forest mortality can result when numerous disturbances interact (Reilly and Spies 2016, pp. 105-106); this in turn can influence habitat quality for northern spotted owls depending on the degree of change to the stands and the scale of this change. Limited information exists on the climatic tolerances of different northern spotted owl habitats, what kind of complex interactions that disease and insects respond to, and how these have influenced northern spotted owl demographics. See Climate Change section for expanded discussion.

Sudden oak death (*Phytophthora ramorum*) specifically has been identified as a potential threat that could affect the availability of northern spotted owl habitat in the future (Courtney *et al.* 2004, p. 6-8). This pathogen spreads aerially by wind and wind-driven rain and moves within forest canopies and tree tops to stems and shrubs and from understory shrubs to overstory trees. It can survive in infected plant material, litter, soil, water, and may move long distances in nursery stock. Sudden oak death has killed hundreds of thousands of oak and tanoak trees along the California coast (from southern Humboldt County to Monterey County) and hundreds of tanoak trees on the southern Oregon coast (southwestern Curry County) (Goheen *et al.* 2006, p. 3). In 2012, the USFS reported an estimated 2 million ac (809,371 ha) were infested in California, heightening concerns about fuel buildups and potential fire severity (USDA 2012, p. 6). Over 130 plant species are known hosts of sudden oak death including native forest species, many of which are components of suitable northern spotted owl habitat such as tanoak, oaks in the red oak group such as California black oak, Douglas-fir, coast redwood, Pacific rhododendron, evergreen huckleberry, and Pacific madrone and laurel (Goheen *et al.* 2006, p. 1). If untreated, infection may result in tree mortality, branch and shoot dieback, and leaf spots depending on host species and location. The majority of the shrub and hardwood components can be killed by the pathogen, thereby shifting species composition or simplifying the stand complexity associated with northern spotted owl habitat.

The impacts of the sudden oak death strain currently affecting northern spotted owl habitat have been somewhat localized and not wide ranging. In the southern portion of the range, losses have been observed but are smaller in scale in Oregon. Due to its potential impact on forest dynamics and alteration of key prey and northern spotted owl habitat components (*e.g.*, hardwood trees, canopy closure, and nest tree mortality), sudden oak death could affect the availability of suitable habitat, especially in the southern portion of the northern spotted owl's range (Courtney *et al.* 2004, pp. 6-26 through 6-28). Insects and pathogens can influence the suitability of suitable owl habitat; however, these impacts are scale dependent. Small-scale changes to forested stands will likely be insignificant to individual owl pairs, but the broadscale ramification to northern spotted owl populations from these stressors and their interactions is uncertain.

4.1.2 Effects to northern spotted owls from habitat disturbance factors

Northern spotted owls are primarily associated with multi-story forests containing large old growth trees and closed canopies (Courtney *et al.* 2004, p. 2-3). Disturbance factors such as timber management, wildfires, insects, and forest pathogens can affect vegetational and structural components that are associated with northern spotted owl habitat (USFWS 2001, p. 23; Courtney *et al.* 2004; Clark *et al.* 2013) at a scale meaningful to northern spotted owls; the removal of any of those components can cause adverse effects to northern spotted owls by:

- Displacing northern spotted owls from nesting, roosting, or foraging areas;
- Concentrating displaced northern spotted owls into smaller, fragmented patches of habitat that may already be occupied;
- Increasing competition for nest sites;
- Decreasing survival of displaced northern spotted owls and their offspring by increasing their exposure to predators and/or limiting the availability of prey;
- Diminishing the future reproductive productivity of displaced nesting pairs that may forgo nesting temporarily following their displacement; and
- Diminishing northern spotted owl population size due to declines in productivity and recruitment.

Generally, the effects of habitat modification and the duration of those effects on spotted owls depend upon the context. The size and intensity of fires or the type of silvicultural prescriptions used, and the location of the harvest relative to habitat will influence the direct and indirect effects. The impacts of either may include the removal or downgrading of habitat and/or altering of habitat by the creation of exposed habitat edges. Harvest prescriptions that remove northern spotted owl habitat and other harvest prescriptions that result in even-aged, monotypic forest stands that would not be suitable for nesting, roosting, or foraging, are likely to adversely affect northern spotted owls by reducing the available amount and quality of habitat. In contrast, treatments that promote multi-aged and multi-storied stands may retain the suitability of habitat within affected stands for northern spotted owls and may increase the quality of that habitat over time (USFWS 2007, p. 12). Likewise, fires that substantially reduce the forest complexity and cover reduce the habitat availability and distribution.

While timber harvest was the major habitat disturbance factor affecting northern spotted owls in the past, the NWFP has been successful at reducing harvest levels in northern spotted owl habitat over time. Therefore, currently wildfire is the biggest habitat disturbance factor for northern spotted owls and is likely to remain so in the future. Fire is a disturbance factor northern spotted owls evolved with and populations must have fluctuated regionally in response to large fires that removed habitat. Studies indicate that the effects of wildfire on spotted owls and their habitat are variable, depending on site-specific fire location, intensity, severity, size, and the availability and distribution of suitable habitat. Within the fire-adapted forests of the northern spotted owl's range, northern spotted owls likely have adapted to withstand fires of variable sizes and severities (Eyes *et al.* 2017, p. 384), but these adaptations evolved under a different habitat baseline, different natural fire regimes, and different threats than those recognized currently. Overall, 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 (USFWS 2011a, p. III-31), especially when combined with current threats. The age structures of Pacific Northwest forests are likely to shift in response to projected climate change; increases in fire frequency and/or severities will likely further reduce the available older structurally complex forests (Wimberly and Liu 2013, p. 273; Wan *et al.* 2019, p. 7), thereby compounding existing trends. Losses from high-severity fires are also compounded by contemporary salvage harvest of burned habitats (particularly on non-Federal lands). All timber sales must follow the normal review process but current state forest practice rules do not require specific environmental review for impacts to northern spotted owls and mixed severity burned northern spotted owl habitat for proposed salvage operations (ODF 2014, CFPR 2017, WDNR 2017).

Many interacting factors influence the effect of fire on spotted owls. Though there are relatively few studies on owl responses to fire, a recent study found that edge type and fire severity were important for explaining owl habitat selection; this suggests that maintaining closed canopy forest within owl home ranges that includes variably sized patches burned at low and moderate fire severity and small patches burned at high severity may be beneficial for owls (Eyes *et al.* 2017, p. 385). However, most studies are constrained by small sample sizes, are short-term in nature, and most often use comparative assumptions to look at post-fire habitat use. Few case studies have been able to compare pre- and post-fire habitat use and these studies are not directly comparable to each other. Large differences in landscapes and high degrees of variability exist between studies. Furthermore, the pre-fire condition and spatial arrangement of suitable habitat, locations of activity centers, burn severities and scales, pre-fire forest management, post-fire forest management, and myriad other factors combine to reduce the certainty or applicability of site-specific results of observational studies to projects being proposed. Comprehensive analyses of the long-term effects of fire on use and occupancy within a landscape are lacking, especially analyses on the small scale effects to pairs or individuals. While the stochastic nature of wildfire make empirically testing hypotheses regarding pre- and post-fire responses of forests and organisms difficult, some trends in spotted owl responses to fire are becoming more clear.

Variable results on spotted owl occupancy in burned landscapes are described in the literature. Some studies of the three subspecies of spotted owls have suggested that there is little or no change in occupancy or other demographic responses by spotted owls after fires, especially those burned at low to moderate severity but also sometimes including high severity burns (Bond *et al.* 2002, pp. 1025–1026; Roberts *et al.* 2011, p. 616; Lee *et al.* 2012, pp. 798–800; Rockweit *et al.* 2017, p. 1579). Other studies have documented reductions in demographic responses in response to high severity fire (Gaines *et al.* 1997, p. 126; Jenness *et al.* 2004; p. 769; Clark 2007, pp. 40–45; Jones *et al.* 2016, pp. 303-305). One recent study in the Klamath Province found a reduction in survival with varying effects on recruitment, including an increase in some territories, after moderate to high severity fires. Although recruitment increased, territory occupancy had a high turnover suggesting post-fire habitat quality was reduced such that it provided only temporary support to owls that emigrated from nearby higher quality habitat (Rockweit *et al.* 2017, pp. 1579-1580). Most recently, the probability of extinction increased when the proportion of owl sites (a circle with radius equal to one-half the mean nearest-neighbor distance - about 1100m) burned at high severity also increased (Jones *et al.* 2016, p. 303). Due to high site fidelity, spotted owls may occupy areas that are not otherwise suitable to meet all of their life requirements and that they occupy these areas despite a reduction in fitness, at least in the short term (Clark 2007, p. 41; Clark *et al.* 2011, pp. 43–44).

Fire patterns and burned patch size appear to influence northern spotted owl use of burned landscapes. Telemetry studies have found patch size of burns can influence foraging patterns, or have demonstrated that spotted owls use and sometimes even nest in areas burned at low or moderate severity (Bond *et al.* 2009, pp. 1120–1122; Clark 2007, pp. 99–116, Eyes 2014, pp. 42-45, Bond *et al.* 2016, pp. 1296-1298). Some owls have been found to shift their core nesting and foraging areas away from higher-severity burned areas (King *et al.* 1998, p. 3, Clark 2007, pp. 40–41). California spotted owls shifted sites particularly when sites burned at more than 50 percent high severity; colonization was attributed to shifts to less-burned sites (Jones *et al.* 2016, p. 303-304). One study found that disturbances that create diffuse edges such as low and mixed severity fire, were favored by foraging northern spotted owls, and that small areas (<3.2 ha) with hard edges were used, especially when surrounded by otherwise intact habitat (Comfort *et al.* 2016, p. 1236)

Additional impacts to northern spotted owls related to fire include forest management that occurs after fires. Post-fire salvage logging typically occurs on the majority of private timberlands, but also occurs on Federal lands to a smaller degree. This type of harvest can directly impact habitat potentially occupied by northern spotted owls and can negatively influence ecological processes, which can impair the long-term development of spotted owl habitat (reviewed in USFWS 2011a, p. III-48). Action agencies, working with the Service, are attempting to influence fire severity by designing projects to reduce fire-suppressed vegetation and mimic the effects of historical fire regimes. The effects of this type of management are uncertain and highly 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.* 2006 p. 359-361; Hanson *et al.* 2009, pp. 1316-1319; Spies *et al.* 2009, pp. 331-332; Ager *et al.* 2012, p. 282; Odion *et al.* 2014a pp. 10-12, Spies *et al.* 2012, pp. 10-12; Odion 2014b, pp. 46-49; Gaines *et al.* 2010, Baker 2015, entire; Baker 2017, entire; Gallagher *et al.* 2018, pp. 10-13).

4.1.2.1 Decline of Preferred Prey Species related to Habitat Loss

Short- and long-term effects of habitat modification from timber management to northern spotted owl prey species has been addressed by a number of researchers (Carey *et al.* 1992, Carey 1995, Rosenberg and Anthony 1992, Waters *et al.* 1994, Waters and Zabel 1995, Ransome and Sullivan 1997; Luoma *et al.* 2003; Gomez *et al.* 2005; Meyer *et al.* 2005; Lehmkuhl *et al.* 2006a and 2006b; Matthews *et al*. 2009; Wilson 2010; Wilson and Forsman 2013, Sollmann *et al.* 2016). Vegetation management can have variable effects on prey depending on the ecology of the prey species, the type of treatments and the forest conditions being treated (as reviewed in Hansen and Dunk 2016, entire). Clearcuts, shelterwoods and heavy commercial thinning operations typically convert habitat for both northern spotted owls and their prey to non-habitat. Silvicultural treatments such as thinning that result in openings or simplify stand structure can influence species abundance (Wilson and Carey 2000, pp. 141-142). Lehmkuhl and others (2006a, p. 596) noted that thinning can reduce the species richness of forest floors thereby negatively influencing prey survival or recruitment of flying squirrels. Additionally, thinning can strongly alter the diversity, composition, and abundance of fungi, which could in turn greatly influence the abundance and distribution of important prey for northern spotted owls (Waters *et al.* 1994, p. 1521; Meyer *et al.* 2005 pp. 1064-1068). Wilson (2010, p. 139) reported most thinning is likely to suppress flying squirrel populations for several decades, but the long-term benefits of variable-density thinning for squirrels could be positive if thinning accelerates the development of the mid-story and late successional characteristics. Manning *et al.* (2012, p. 123) also reported thinning of young Douglas-fir forests had negative impacts on flying squirrel densities for at least 12 years after treatments.

Pre-treatment stand conditions can influence prey abundance and distribution, so the effects of management can have varying impacts. Some studies have found that densities of flying squirrels are highest in old forests (Carey *et al.* 1992, pp. 331-334; Carey 1995, pp. 655-659), whereas others have suggested that the species can utilize early seral stage forests (Rosenberg and Anthony 1992, pp. 163-165; Waters and Zabel 1995, pp. 861-186; Ransome and Sullivan 1997, pp. 541-548). Woodrats in the Klamath or California Coastal Province do not appear to directly benefit from forest thinning or fuels reduction treatments; limited research on the subject suggests depending on the scope and scale of treatments, negative impacts can result (Hamm and Diller 2009, p. 90; Hansen and Dunk 2016, p. 70).

Thinning or associated practices (*e.g.*, burning slash piles) may be detrimental to dusky-footed woodrats if it reduces hardwoods, shrubs or downed wood, yet treatments could ultimately benefit woodrats if they retain coarse wood and result in growth or vertical complexity of shrubs or hardwoods (Williams *et al.* 1992, p. 219; Innes *et al.* 2007, p. 1529). Similar to dusky-footed woodrats, thinning actions that reduce availability of snags, downed wood or mistletoe could negatively impact bushy-tailed woodrat populations (Lehmkuhl *et al.* 2006b, p. 377). Minimizing large gaps or openings, retaining large structural features, overall forest heterogeneity, diversity, and canopy cover can ameliorate effects to prey from forest management (Lehmkuhl *et al.* 2006a, pp. 596-597; Wilson 2010, p. 143; Wilson and Forsman 2013, pp. 84-86; Smith *et al.* 2013, p. 182; Eisinger *et al.* 2014 (abstract); Sollmann *et al.* 2016, p. 106).

Impacts to prey populations from forest disturbance are scale-dependent. Significant changes to vegetative cover at the watershed scale that can result from high-severity wildfires or large-scale timberland management (for example) will negatively influence both northern spotted owls and their prey. Alternatively, within- and between-stand variability in species composition and cover could positively or negatively influence individuals of a prey species population, but not likely at a larger scale. Limited information exists on widescale impacts to northern spotted owl prey species from habitat losses described above; however, smaller-scale studies have described impacts to habitat conditions associated with prey species, so extrapolations can be made if evaluating prey abundance and distribution at a broader scale (see reviews in USFWS 2011a, pp. 111-16-17 and Hansen and Dunk 2016, pp. 7-10, 33-45). Impacts to foraging habitat are assessed at the action area scale during the consultation process with FWS and action agencies, but large-scale, range-wide population evaluations are not conducted.

The range of the red tree vole overlaps with much of the northern spotted owl. They are endemic to and are associated primarily with similar mature/complex habitats in the humid, Douglas-fir dominated conifer and conifer/hardwood forests of western Oregon and northwestern California (Maser 1966, p. 7; Hayes 1996, p. 3, Dunk and Hawley 2009, p. 632, and others - see review in 76 FR 63719; October 13, 2011). Survey data on NWFP lands suggest that red tree voles are widely distributed throughout much of their range in Oregon with the exception of the northern Oregon Coast Range, where they are sparsely distributed (USDA and USDI 2007, pp. 289, 294). Due to the similar habitat associations, threats to tree voles from habitat loss due to high-severity fire and forest management are similar to those of the northern spotted owls. The apparent reduction in tree vole habitat and populations, both range-wide and within the DPS was attributed to past and ongoing habitat loss (76 FR 63719; October 13, 2011). However, there is no information to suggest that a reduction in tree vole populations is currently having a negative effect on northern spotted owl populations.

In terms of both numbers and biomass, woodrats (*Neotoma* spp) and northern flying squirrels (*Glaucomys sabrinus*) comprise much of the northern spotted owl's diet (see Section 2.5). Two woodrat species occur within the range of the northern spotted owl: the dusky-footed woodrat (*N. fuscipes*) and the bushy-tailed woodrat (*N. cinerea*). Population trend data are not available for either woodrat species, nor are they recognized as a Federal or state proposed, candidate, or sensitive species in California, Oregon, or Washington (CDFW 2017; ODFW 2017; WDFW 2017). The flying squirrel is currently not recognized as a Federal or state proposed, candidate, or sensitive species in California, Oregon, or Washington (CDFW 2017; ODFW 2017; WDFW 2017). They occur across northern North America and are associated with mature and late-successional mixed conifer and conifer hardwood forests (see reviews in Carey 1991 and 1995). Population trend data are not available, but similar to the northern spotted owl in the Pacific Northwest, the northern flying squirrel is associated with mature to late-successional forests so threats to this species from habitat losses can be inferred in the above discussions. We have no information to suggest that populations of woodrats and northern flying squirrels are limited to the point of having a negative effect on northern spotted owl populations.

4.1.3 Summary of Stressors Related to Destruction, Modification or Curtailment of Habitat

Every portion of the northern spotted owl range continues to experience some level of habitat loss, although losses on Federal lands are not beyond levels anticipated in the NWFP. Past timber harvest and silvicultural activities eliminated, reduced or fragmented northern spotted owl habitat enough to negatively affect population densities across its range. Timber management activities continue at present, although alternative methods such as thinning have largely replaced high impact clearcutting and so the degree of impact from harvest on northern spotted owl habitat is lower and the potential for future recruitment of habitat through forest succession is higher. The amount of northern spotted owl habitat lost to wildfire on Federal land has exceeded what was lost to timber harvest. The NWFP accurately anticipated that losses from wildfire would most likely occur in the more fire-prone (southern and eastern) portions of the range (USDA and USDI 1994a, p. 3-4:51). Although the Plan did not predict that the largest areas of loss would be in reserved areas, larger reserves were designated in the more fire-prone areas to accommodate for the impacts of wildfire. Insect and disease outbreaks contribute a very minor amount to loss of northern spotted owl habitat. Habitat reduction has been concentrated particularly within the coastal provinces of Oregon and Washington. Dispersal habitat losses were similar to those for nesting and roosting habitat losses, with wildfire being the main cause in reserved allocations. These losses were offset, however, by gains in dispersal habitat on Federal land from forest succession, resulting in a slight net gain of dispersal habitat coverage across the range of the northern spotted owl. The large reserve network range-wide remains mostly intact for dispersal, despite many large wildfires occurring within some of the reserves. Timber harvest continues at a higher rate on non-Federal land than on Federal land; harvest on non-Federal land continues to account for the majority of loss of nesting/roosting habitat.

Nesting and roosting habitats have become slightly more fragmented on all Federal land use allocations; however, changes in fragmentation varied by physiographic province. Fragmentation in the Klamath Provinces increased due to high-severity fires. Habitat connectivity was reduced between the Oregon Coast Range and the Oregon Western Cascades, the loss of a connection between the central and northern portions of the Oregon Coast Range. Additionally, isolation of the Olympic Peninsula was found to have increased. These impacts likely negatively influence key demographic parameters including immigration and emigration within and between populations. The Eastern Oregon Cascades were found to have become slightly more contiguous, likely owing to the corresponding habitat recruitment.

Two decades into the NWFP, Davis *et al.* (2016) reported that nesting and roosting habitat is still declining at the range-wide scale, largely due to fires, but that recruitment is occurring in portions of the range and is beginning to help offset losses. As was anticipated in the NWFP, northern spotted owl habitat on non-Federal land has declined at a higher rate than habitat on Federal lands within the Plan area (Davis *et al.* 2016, p. 22). Federal lands have provided the majority of contribution to northern spotted owl recovery, and in many portions of the range it provides the sole contribution to recovery. While non-Federal lands provide key support for northern spotted owl in some portions of the subspecies' range with little Federal land such as southwestern Washington, northwestern Oregon and northeastern California, these areas are limited within the listed range. Federal lands continue to provide the most habitat to support northern spotted owls and remain the primary focus for recovery of the subspecies.

4.2 Stressors related to Direct Mortality of Northern Spotted Owl (Factor C)

4.2.1 Disease

Disease was identified as a potential threat at time of listing, in the 2004 Status Review (Courtney *et al.* 2004, pp. 2-9, 6-26), and in the 2011 status review. However, anticipated impacts to northern spotted owl populations did not come to pass and at the time of the 2011 review no avian diseases were significantly affecting northern spotted owls and disease was not identified as a stressor to the species (USFWS 2011a, p, III-55). Furthermore, we have not identified any diseases that are significantly affecting northern spotted owls currently. It is unknown whether avian diseases such as West Nile virus (WNV), avian flu, or avian malaria (Ishak *et al.* 2008, p. 1) will significantly affect northern spotted owls. Recently, Lewicki and others (2015, pp. 1724-25) suggested that negative impacts to northern spotted owls could occur in areas of the species overlap as a result of exposure to parasites carried by barred owl and that effects of this can compound those of other existing stressors. Parasitic infection may contribute to mortality in northern spotted owls, 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). Additionally, trichomonosis occurrences in northern spotted owls have coincided with outbreaks in other species, indicating the potential for these diseases to serve as additive stressors to successful northern spotted owl demographics (Rogers *et al.* 2016, pp. 309-310). Recovery Action 17 (USFWS 2011a, p. III-55) calls for action agencies to monitor sudden oak death and avian diseases (*e.g.*, West Nile Virus, avian flu, Plasmodium spp.) and address as necessary. Federal and State agencies keep forest pathogens and avian diseases in mind during forest management activities, and will notify the Service if any forest pathogen or avian disease becomes a threat. If one or more disease causing organism, pathogen, or parasite poses a threat to northern spotted owls or their habitat, specific responses will need to be developed and implemented.

4.2.2 Predation

Predation of northern spotted owls does occur and in some studies has been shown to be a leading cause of mortality of individual northern spotted owls (Forsman *et al.* 1984, p. 38; Wiens *et al*. 2014, p. 26). Predation was identified as a potential stressor for northern spotted owls at the time of listing. The 2004 status review stated that "… predation is not as substantive a threat to northern spotted owl populations as it was considered in 1990, but evidence about this threat is still circumstantial." Predation was not identified as a stressor in the 2011 status review and, although it was noted as a potential stressor in the 2012 EPIC petition, we have no evidence to demonstrate it is a population-level stressor to the subspecies at this time. As mentioned earlier, known predators of northern spotted owls include great horned owls (Forsman *et al.* 1984, p. 38) and possibly barred owls (Leskiw and Gutiérrez 1998, p. 2). Other suspected predators include northern goshawks, red-tailed hawks, and other raptors (Courtney *et al.* 2004, pp. 2-8). Forest fragmentation could increase predation rates on spotted owls by favoring predators that use edges or more open landscapes, such as great horned owls and red-tailed hawks (Wiens *et* al. 2014, p. 36); and competition from barred owls may help push northern spotted owls to these edges where they are more susceptible to predation by these species. Barred owls have been observed preying on smaller owls, so it is possible that they may also prey on northern spotted owls. Northern spotted owl surveyors observed barred owls physically attacking northern spotted owls, and, in one instance, deduced that a barred owl killed a northern spotted owl (Gutiérrez *et al.* 2004, p. 7–25; Leskiw and Gutiérrez 1998, entire). Gutiérrez *et al.* (2004, p. 7-25) also reported that barred owl predation on a juvenile northern spotted owl may have occurred. These are individual occurrences, however, and we have no information to suggest that predation is currently a threat to northern spotted owls on a population level.

4.2.3 Summary of Stressors related to Direct Mortality of Northern Spotted Owl

Though disease and predation of northern spotted owls do occur and cause mortality on an individual basis, we have no evidence to suggest that these factors occur at levels that are impacting northern spotted owls as a subspecies at this time. There are currently no identified population-level stressors related to direct mortality of northern spotted owls.

4.3 Stressors related to other natural or manmade factors affecting the continued existence of northern spotted owl (Factor E)

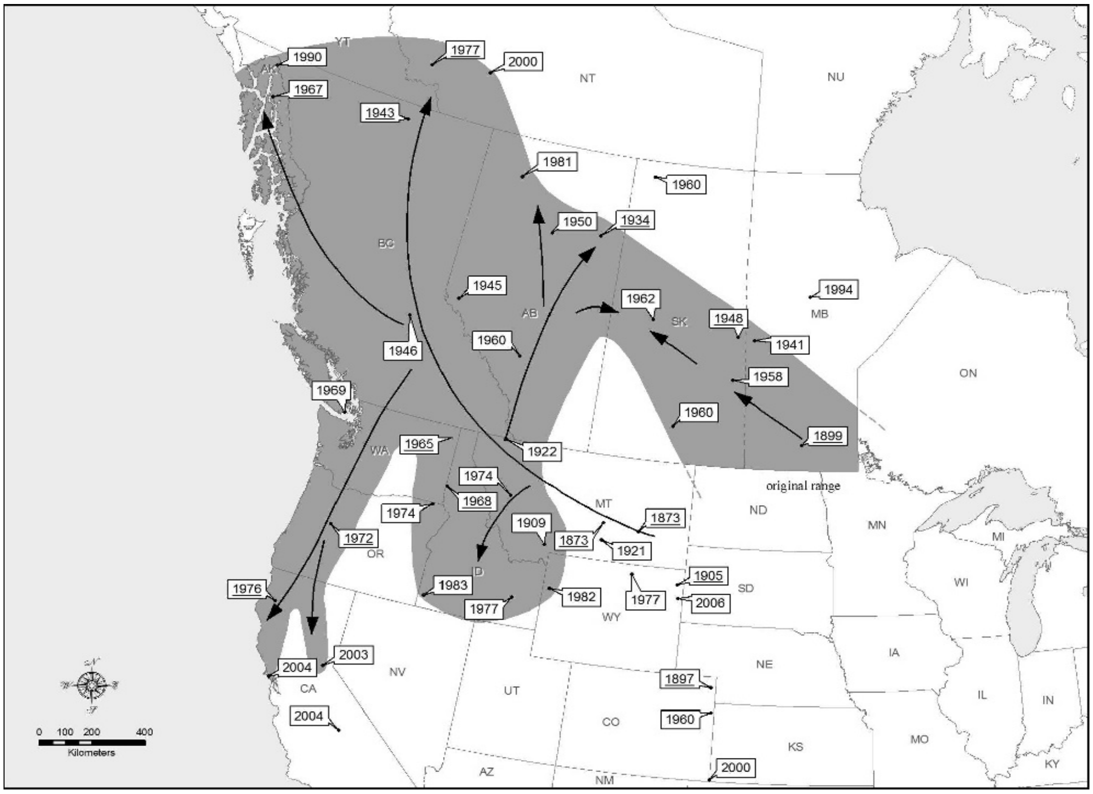
4.3.1 Barred Owl

At the time of listing, the Service stated that the long-term impact of non-native barred owls on the northern spotted owl was unknown but of considerable concern; the Service recommended continued examination of the role and impact of the barred owl as a congeneric intruder in historical spotted owl range and its relationship to habitat fragmentation, as well as examination of the potential for interbreeding (55 FR 26114; June 26, 1990). At the time of the Service's 2004 status review, the Service was convinced of the negative impact of barred owls on northern spotted owls and suggested the full impact of barred owls on the subspecies was yet to come. The 2011 review expressed uncertainty regarding the outcome of competition from barred owl because the relationship between the two species was highly variable across its entire range. It noted that although populations were declining at the time, northern spotted owls were still present across the majority of their range.

During the 20th century, barred owls expanded their range from eastern to western North America, and the range of the barred owl now completely overlaps that of the northern spotted owl (Gutiérrez *et al.* 1995, p. 3; Crozier *et al.* 2006, p. 761). Barred owls compete with northern spotted owls for habitat and resources for breeding, feeding, and sheltering, and the presence of barred owls has significant negative effects on northern spotted owl reproduction, survivorship, and successful occupation of territories. Barred owls first overlapped with the northern spotted owl in British Columbia, then spread into western Washington (Hamer *et al.* 1989, p. 2) (

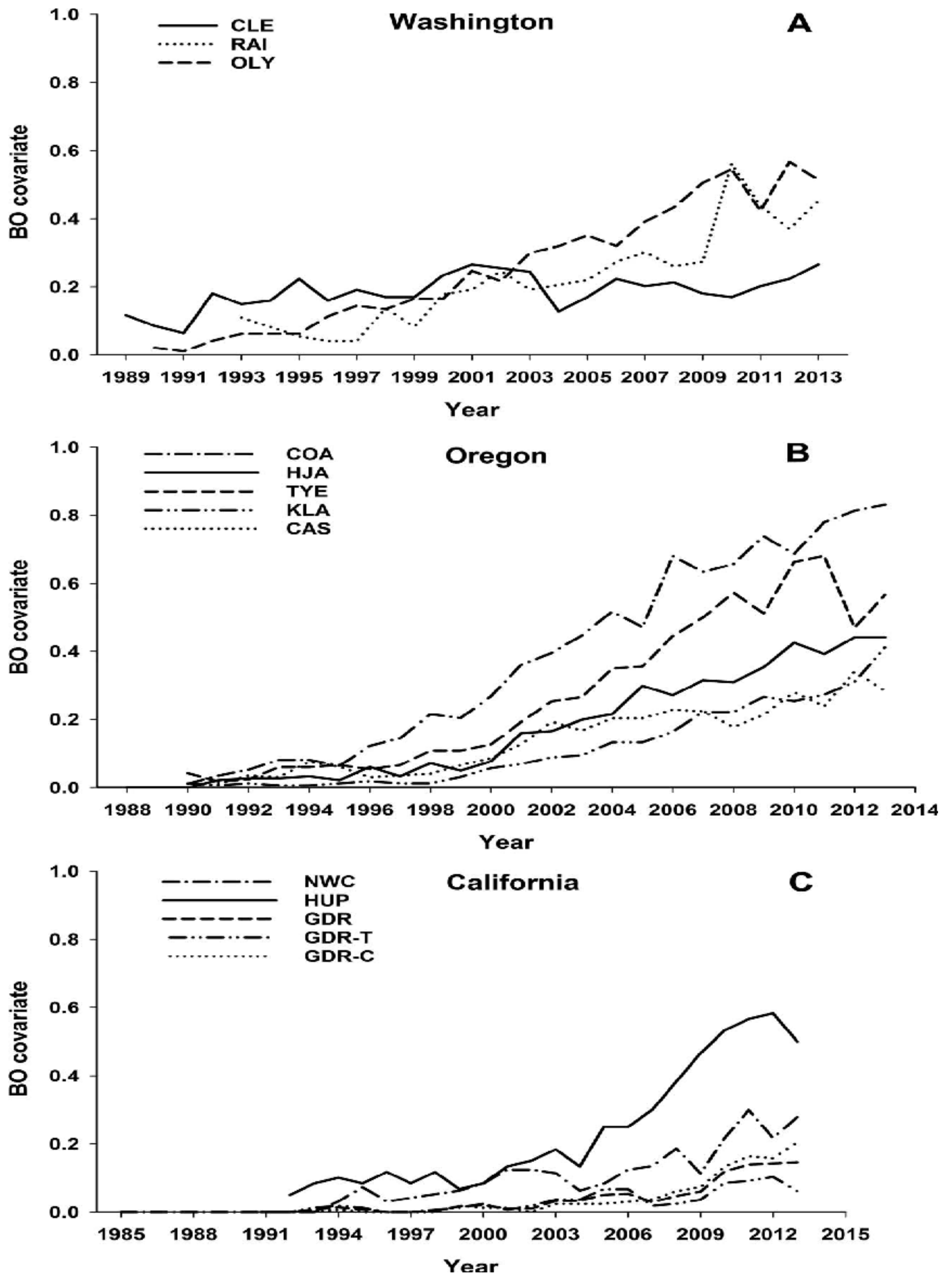
Figure 9). From British Columbia, barred owls expanded south and were first sighted in western Washington in 1973 (Taylor and Forsman 1976, p. 560), Oregon in 1974 (Taylor and Forsman 1976, p. 560), and California in 1976 (Livezey 2009, p. 51), all within the range of the northern spotted owl.

Figure 9. Barred owl range expansion into the Pacific Northwest (Livezey 2009, p. 53, Figure 2).



Our understanding of the barred owl's expansion into the Pacific Northwest is largely based on data gathered incidental to conducting northern spotted owl surveys. Although northern spotted owl surveys were not designed to track barred owl populations, survey results have clearly documented the range expansion of the barred owl and an increase in the density of barred owls observed on landscapes historically occupied by northern spotted owls (Forsman *et al.* 2011, Wiens *et al.* 2014, Dugger *et al.* 2016). Figure 10 (Dugger *et al.* 2016, Appendix C) illustrates increases in the proportion of northern spotted owl territories with one or more barred owl detections from 1985 to 2013 across study areas in Washington, Oregon and northern California, showing an accelerated rate of increase at most areas since the mid-1990s.

Figure 10. Proportion of northern spotted owl territories with barred owl detections (BO Covariate) over time in study areas in Washington, Oregon, and California (Dugger *et al.* 2016, Appendix C, Figure 1.3, p. 107).



Data provided by several areas in California shows both consistent encroachment of barred owls into northern spotted owl sites, and reduced detections of northern spotted owls. Franklin *et al.* (2016, entire) studied northern spotted owls in two areas of northwestern California: a regional study area (RSA) and the Willow Creek Study Area (WCSA). Ninety-five territories previously occupied by northern spotted owls were surveyed on the RSA and WCSA in 2015; northern spotted owls were detected at 32 territories (33.7 percent) (Franklin *et al.* 2016, p. 6-7.). The proportion of surveyed northern spotted owl sites with barred owl detections in 2015 was 0.48, which had increased substantially over the past 3 years (Franklin *et al.* 2016, p. 10). In northwestern California, one national park and three state parks comprise Redwood National and State Parks (RNSP), which are not managed under the Northwest Forest Plan. At RNSP, northern spotted owl detections have declined in in recent years (RNSP 2015, p. 1). Conversely, a study of northern spotted owls in an area of California not yet colonized by barred owls showed that the number of territories occupied by northern spotted owl pairs remained relatively constant over a 25-year period (Kroll *et al*. 2016, p. 1).

With a few exceptions, surveys of historical northern spotted owl sites have resulted in either no owl detections or barred owl only detections (RNSP 2015, p. 1). On lands owned and managed by Green Diamond Resource Company (GDRC), Humboldt County California, GDRC (2017, p. 72) estimated (for year 2016) a minimum of 88 barred owl territories within the density study area and a minimum of 112 barred owl territories within the demographic study area, which is an 18 percent increase since the 2015 reporting period. The number of monitored northern spotted owl sites has declined from 120 sites (year 2000) to 58 sites (year 2016) (GDRC 2017, p. 61). Finally, on lands owned and managed by Humboldt Redwood Company (HRC), Humboldt County, California, barred owl activity in the Habitat Conservation Plan area continues to indicate that there are established barred owl territories that are reproductively active (HRC 2016, p. 10). In 2015, there was an increase in the total number of barred owl detections, with 40 total detections, compared to 27 total detections in 2014 (HRC 2016, p. 10).

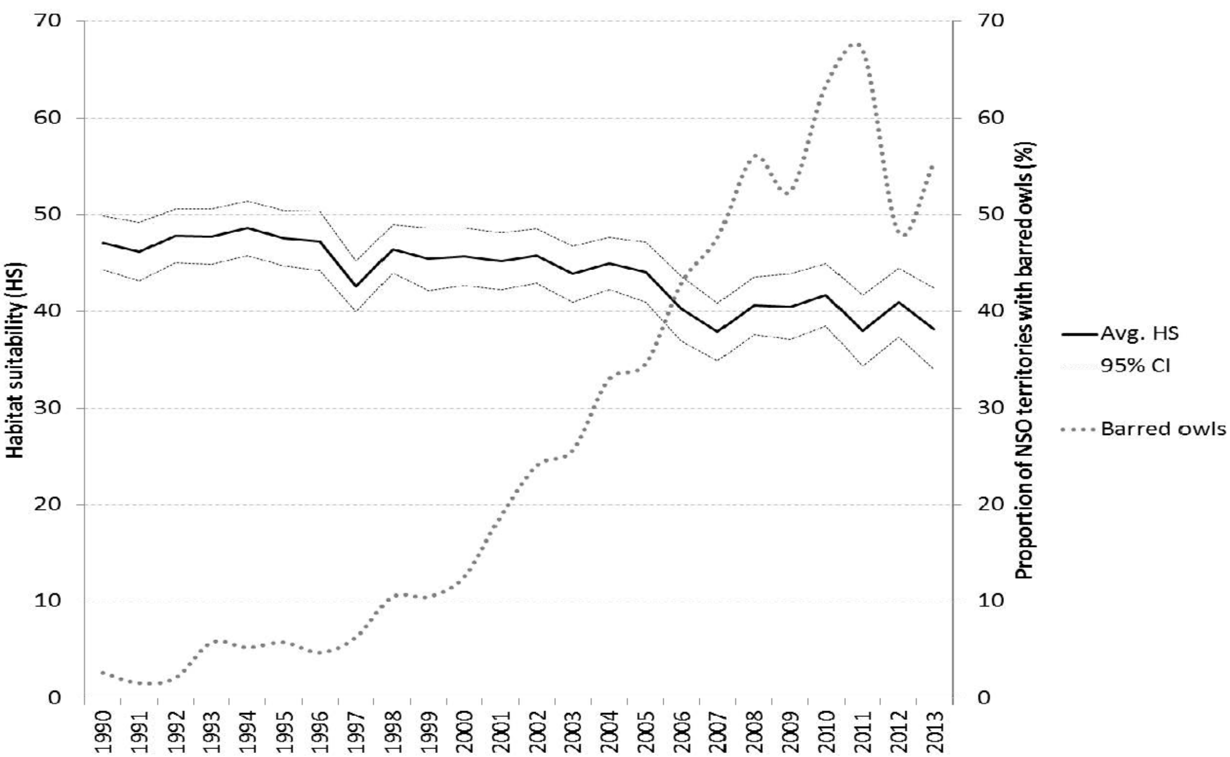
Biologists in the Arcata Fish and Wildlife Office conducted a mapping exercise using data from the California Department of Fish and Wildlife's Natural Diversity Database (CNDDB), to quantify the number and determine the locations of northern spotted owl territories in northern California for which there is at least one associated barred owl detection (AFWO 2016, p. 1-9). In the CNDDB, 28.4 percent of all northern spotted owl territories in California comprised of a pair, nest or young (n = 2,597) had at least one barred owl detection located within the territory (n = 1,683 for Coast Forest District (generally, the coast redwood zone), n = 914 for Northern [or "Interior"] Forest District). Detections of barred owls occurred in a greater proportion of northern spotted owl territory core areas in the Coast Forest District (11.4 percent) than in the Northern Forest District (4.6 percent). The CNDDB report does not include barred owl observations, and thus the analysis represents a minimum of northern spotted owl territories and associated core areas impacted by barred owls.

4.3.1.1 Effects of Barred Owls on Northern Spotted Owls

As noted by Wiens *et al.* (2014, p. 185), the behavioral and life-history traits exhibited by barred owls in addition to the barred owl's slightly larger body size may give them a significant advantage over northern spotted owls when competing for critical resources such as territorial space, nesting and foraging habitat, and food. Evidence of a negative relationship between barred owl occurrence and population characteristics of northern spotted owls has been well documented and includes declines in occupancy rates of historical northern spotted owl territories where barred owls were detected (Kelly *et al.* 2003, p. 51; Olson *et al.* 2005, p. 928;

Kroll *et al.* 2010, p. 1269; Dugger *et al.* 2011, p. 2463); negative relationships between the occurrence of barred owls and apparent survival of northern spotted owls (Anthony *et al.* 2006, pp. 18-19; Forsman *et al.* 2011, p. 38; Glenn *et al.* 2011a, p. 171; Sovern *et al.* 2014, p. 1439; Dugger *et al.* 2016, p. 87); negative relationships between the presence of barred owls and fecundity of northern spotted owls (Olson *et al.* 2004, p. 1048; Forsman *et al.* 2011, p. 24); and steeper declining rates of population change in portions of the northern spotted owl's range where barred owls have been present the longest (Anthony *et al.* 2006, p. 32; Forsman *et al.* 2011, p. 66; Dugger *et al.* 2016, p. 70). Finally, looking at an average measure of habitat suitability at annual northern spotted owl locations, there is a strong negative correlation between the increasing trend in the proportion of northern spotted owl territories with barred owl detections and the average habitat suitability at these sites (Davis *et al.* 2016, p. 14) (Figure 11). In the following sections, we summarize current knowledge regarding the effects barred owls have on northern spotted owl populations in the Pacific Northwest.

Figure 11. Relationship between barred owl presence and northern spotted owl habitat selection. CI = confidence interval (Davis *et al.* 2016, p 18).



4.3.1.2 Hybridization

Hybridization of northern spotted owls with barred owls has been confirmed through genetic research and field observations (Hamer *et al.* 1994, pp. 487-491; Dark *et al.* 1998, p. 52; Kelly 2001, pp. 33-34, Kelly and Forsman 2004, pp. 807-809; Funk *et al.* 2008, pp. 161-171; Wiens 2012, p. 1). Hybrids exhibit physical and vocal characteristics of both species (Hamer *et al.* 1994, p. 488). Reproductive viability has been confirmed in first generation hybrids, though the extent of viability in subsequent generations is uncertain (Kelly and Forsman 2004, p. 808).

Although hybridization between barred owls and northern spotted owls has been documented throughout the range of northern spotted owl, it does not occur frequently (Herter and Hicks 2000, p. 279; Kelly 2001, p. 33; Hamer *et al.* 1994, pp. 487-488). Kelly and Forsman (2004, p. 807) located 47 confirmed cases of hybrids (17 adults and 30 juveniles), including 16 second-generation hybrids. They confirmed six territories where male northern spotted owls were paired with female barred owls, 16 sites where hybrid adults were paired with barred owls, and one site where a hybrid was paired with a northern spotted owl. As with many owls, northern spotted owls and barred owls have reversed sexual dimorphism, *e.g.*, males are smaller than females (Gutiérrez *et al.* 1995, p. 2; Mazur and James 2000, p. 7), which may explain the observations. Pairings of male northern spotted owls and female barred owls would retain the smaller male and larger female pattern, making them more likely to breed, than a male barred owl and female northern spotted owl, which are approximately the same size (Kelly and Forsman 2004, p. 807). Given the hundreds of sites monitored each year during this period, this is a small proportion of hybrid pairs.

Although increasing density of barred owls in northern spotted owl habitat might be assumed to increase the risk of hybridization, it may be that hybridization is more likely when barred owl populations are low. Individual barred owls may have trouble finding a conspecific mate and settle for a closely related northern spotted owl. Kelly and Forsman (2004, p. 808) believe that as barred owl numbers increase and they have more access to barred owl mates, hybridization will decrease. Gutiérrez *et al.* (2007, p. 189) believe that as northern spotted owls continue to become more uncommon relative to barred owls, the incidence of hybridization may again increase.

4.3.1.3 Demographic Differences between Barred Owls and Northern Spotted Owls

Wiens et al. (2014, p. 35) observed that barred owls in the Oregon Coast Ranges had a mean reproductive output that was 4.4 times greater than that of northern spotted owls over a three-year period. While northern spotted owls typically nest every other year, barred owls frequently nest every year. Additionally, barred owls in this study had higher annual survival than northern spotted owls (0.92 and 0.81, respectively). They also reported that increasing proportions of old forest within seasonal home ranges of both species had a positive effect on annual survival of both northern spotted owls and barred owls (Wiens et al. 2014, p. 36). Studies on effects from barred owls in other areas of the northern spotted owl's range are discussed below in the sections 4.3.1.6 and 4.3.1.7.

4.3.1.4 Aggressive Interactions between Barred Owls and Northern Spotted Owls

Barred owls are on average 18 percent larger than northern spotted owls (Hamer *et al.* 1989, p. 58) and may attack and kill northern spotted owls. When interacting with northern spotted owls, barred owls are more likely to assume the dominant role (Van Lanen *et al.* 2011, p. 6). Northern spotted owl surveyors observed barred owls physically attacking northern spotted owls, and, in one instance, found that a barred owl may have killed a northern spotted owl (Gutiérrez *et al.* 2004, pp. 7–25; Leskiw and Gutiérrez 1998, entire). Gutiérrez *et al.* (2004, p. 7-25) reported that barred owls have attacked surveyors imitating northern spotted owls. There is little overlap between adjacent barred owl home ranges, and barred owl territories are small, well defined, and easily defended. These characteristics are consistent with the aggressive territorial behavior reported for barred owls (Singleton *et al.* 2010, p. 291). Barred owls are very aggressive towards other barred owls, even outside their breeding season (Nicholls and Fuller 1987, p. 126). When surveyors record barred owl calls, they often hear barred owls crash through branches of the lower forest canopy, behavior apparently meant to intimidate intruders (Wiens *et al.* 2011, p. 536). Northern spotted owl home ranges, in comparison, tend to overlap more broadly, particularly in areas more distant from the nest site or activity center foraging areas (Hamer *et al.* 2007, p. 763, Glenn *et al.* 2004, p. 41; Wiens *et al.* 2014, p. 18-19). There are relatively few observations of northern spotted owls aggressively chasing or physically attacking a barred owl but those that exist include a nesting northern spotted owl pair aggressively confronting barred owls, a male northern spotted owl in a family group pursuing a barred owl out of an area, and a northern spotted owl pair responding in an agitated manner to a barred owl (Gutiérrez *et al.* 2004, p. 7–25).

4.3.1.5 Competition for Food

As food generalists, barred owls may be more resilient than northern spotted owls to fluctuations in small mammal populations as they are less dependent on these prey items than northern spotted owls. Densities of dusky-footed woodrats, a dominant northern spotted owl prey species in the southern part of its range, can vary from year to year (Forsman *et al.* 2004, p. 222), as well as between and within owl territories (Ward *et al.* 1998, p. 79). Densities of northern flying squirrels can also vary considerably (Carey *et al.* 1992, p. 233; Forsman *et al.* 2004, p. 222). If prey populations are reduced, the limited ability of northern spotted owls, a food specialist, to switch prey would require them to expand their territory in search of their limited food source. As generalists, barred owls can also forage in a wider variety of habitats than northern spotted owls. Barred owls can move into open areas outside of forested habitats to forage (Holt and Bitter 2007, p. 10), and are more apt to forage in meadow and riparian areas than northern spotted owls (Hamer *et al.* 2001, pp. 255–226; Wiens *et al*. 2014, p. 21-22).

In western Montana, the winter diet of barred owls was mostly small mammals with a heavy emphasis (97.6 percent) on vole species more common in open country (Holt and Bitter 2007, p. 7), suggesting the ability to seasonally adapt to food availability. A comparison of prey from the analysis of northern spotted owl and barred owl pellets in western Washington showed that northern spotted owl and barred owl diets overlap by 76 percent, indicating they likely compete for food (Hamer *et al.* 2001, p. 221). Barred owl diets were dominated by terrestrial species and included a high proportion of diurnal prey. Their diets consisted of 74.5 percent mammals (mostly snowshoe hare (45 percent), Douglas' squirrel (14.1 percent), and northern flying squirrel (18.4 percent); 19.4 percent birds; and, 6.1 percent combined fish, amphibians, mollusks, and insects by weight (biomass) (Hamer *et al.* 2001, pp. 225–226). Of the northern spotted owl diet, 98.6 percent (by biomass) comprised mammals; the primary mammal species were northern flying squirrels (58.1 percent), snowshoe hares (13.4 percent), and bushy-tailed woodrats (11.6 percent). For comparison, 74.5 percent of the barred owl diet was mammals (mostly snowshoe hare (45 percent), Douglas' squirrel (14.1 percent), and northern flying squirrel (18.4 percent) (Hamer *et al.* 2001, p. 224). Because northern spotted owls are more specialized in their prey selection, and therefore are at greater risk if their prey populations are low, they may be vulnerable to food limitations. Northern spotted owls populations exhibit behaviors of food stressed populations (*i.e.*, large home range, low and sporadic reproductive rates, low population densities, and nomadic tendencies during the winter), or ones in which even sufficient food resources cannot compensate for high metabolic costs of reproduction (Hamer *et al.* 1989, p. 60; Kroll 2017, pers. comm.).

In a study comparing diets between sympatric northern spotted owls and barred owls in western Oregon in 2007-2009 (Wiens *et al.* 2014, p. 24-25), 1,223 prey items were identified from 15 territories occupied by pairs of northern spotted owls and 4,299 prey items from 24 territories occupied by pairs of barred owls in western Oregon. Diets of both species were dominated by nocturnal mammals; however, barred owl diets included many terrestrial, aquatic, and diurnal prey species that were rare or absent in northern spotted owl diets. Important prey items for both species included northern flying squirrels (*Glaucomys sabrinus*), woodrats (*Neotoma fuscipes*, *N. cinerea*), and lagomorphs (*Lepus americanus*, *Sylvilagus bachmani*), accounting for 81 percent and 49 percent of total dietary biomass for northern spotted owls and barred owls, respectively. Wiens (2012, pp. 37-38) reported that dietary overlap between pairs of spotted and barred owls in adjacent territories ranged from 28-70 percent. Because northern spotted owls have a more limited diet than barred owls, they require a larger territory to support their needs and likely expend more energy covering this larger territory while foraging than barred owls do while foraging.

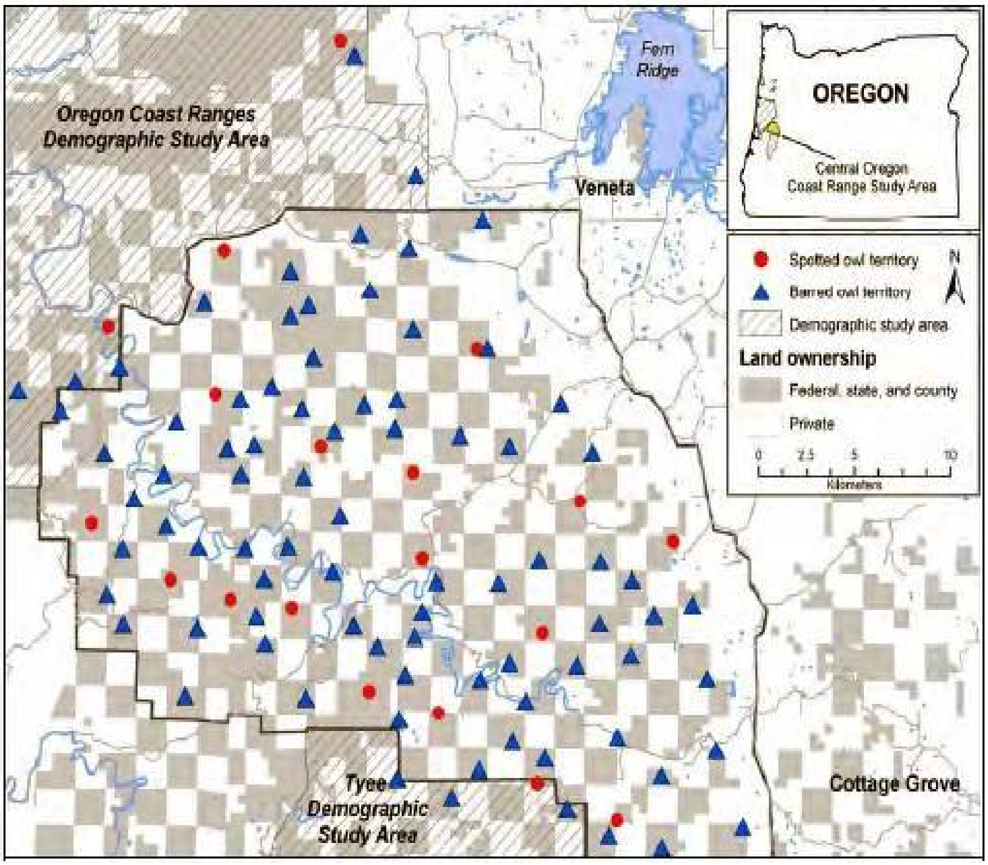
The ability of barred owls to forage on a wider diversity of prey species and in a wider diversity of habitats may explain their reproductive success in comparison with northern spotted owls. In many owls, reproductive success is dependent upon availability or size of principal prey. Prey abundance has a strong effect on fecundity (the number of female offspring produced per adult female owl) in other owl and raptor species (multiple sources cited in Forsman *et al.* 2011, p. 61). Forsman *et al.* (1984, p. 33) suggested that the variation in reproductive behavior of northern spotted owls may be tied to the availability and abundance of preferred prey, but Rosenberg *et al.* (2003, p. 1715) did not find a clear relationship.

4.3.1.6 Competition for Habitat and Territories

Barred owls and northern spotted owls often use the same areas in overlapping territories, although Hamer *et al.* (2007, p. 750) found little overlap of home ranges during the breeding season. Northern spotted owls have home ranges that are three to four times larger than those of barred owls (Hamer *et al.* 2007, p. 750), which suggests that northern spotted owl preference for a relatively narrow range of nocturnal mammals means they must range farther to gather sufficient prey. Conversely, barred owls can forage on a broad range of prey, including diurnal and aquatic species (Hamer *et al.* 2007, p. 750), consistent with their apparent ability to meet their food needs within a smaller range.

Because northern spotted owl habitat can support many more barred owls than northern spotted owls, barred owl densities are higher in these areas (Pearson and Livezey 2003, p. 272). A study near Eugene, Oregon, showed 82 pairs of barred owls and 15 pairs of northern spotted owls on the same landscape (Wiens *et al.* 2014, p. 39) (Figure 12). Considering the dietary overlap between the two species, increased density of barred owls could result in less prey available to northern spotted owls (Gremel 2005, p. 16), and increase the frequency of potentially aggressive interactions (Kelly *et al.* 2003, p. 4-50; Pearson and Livezey 2007, p. 159).

Figure 12. Distribution of northern spotted owl (n=19) and barred owl (n=82) territories within the Veneta Study Area in 2009 (Wiens *et al.* 2009, unpubl. data).



Based on a review of literature on barred owl habitat use in North America, Livezey and Fleming (2007, p. 177) indicated that barred owls prefer old or mature mixed deciduous-coniferous forests with high canopy closure. However, they also use a wider range of forest habitats than northern spotted owls, including suburban woodlots. The relatively open understory and low density of trees in old mixed forests may contribute to the success of barred owls in capturing prey (Nicholls and Warner 1972, p. 222; Mazur *et al.* 1998, p. 752).

In a study in the dry eastern Cascades, radio-tracked barred owls were observed using habitats similar to northern spotted owls in terms of canopy closure and tree size, although the home range sizes of barred owls were smaller and concentrated in gentle slopes in valley bottoms (Singleton *et al.* 2010, p. 285). Buchanan *et al.* (2004, p. 231) also found that, compared to northern spotted owl sites in the eastern Cascades, barred owl nest sites were located on gentle slopes or flat ground, closer to water, and included more hardwoods and a greater richness of tree species. Barred owls nested in black cottonwoods, which are often found in riparian areas and rarely used by northern spotted owls for nesting. Herter and Hicks (2000, p.

279) also noted that in the eastern Cascades, barred owl sites tended to be located more often in mixed riparian stands and in high-elevation moist coniferous forests than did northern spotted owl sites.

In western Washington, northern spotted owl sites tend to be located on steeper slopes and higher elevation areas when barred owls are present compared to when barred owls are absent (Pearson and Livezey 2003, p. 274). Similarly, Gremel (2005, p. 17) found this to be the case in Olympic National Park, where forests had never been logged. Barred owl nests were found in low-elevation forests with relatively level slopes, with some proportion of deciduous trees, with wetlands (Gremel 2005, p. 17), and alongside reservoirs or tributaries (Hamer *et al.* 2007, p. 759). Herter and Hicks (2000, p. 283) found that barred owl sites in central Washington contained more deciduous and young forests than did northern spotted owl sites. While northern spotted owls may occur in landscapes where young forests predominate, they persist there at low densities and generally nest in patches of old forest (Forsman 1988, p. 67).

Wiens *et al.* (2014) investigated spatial relationships, habitat use, diets, survival, and reproduction of northern spotted owls and barred owls on a study area in western Oregon during 2007-2009 with the objective of determining the potential for and possible consequences of competition for space, habitat, and food between these two owl species. They determined that the average size of barred owl home ranges was considerably smaller (581 ha) than home ranges of northern spotted owls (1,843 ha), and while the outer portions of home ranges of the two species overlapped, there was minimal overlap of core use areas within the home ranges. Results from Wiens *et al.* (2014, p. 30) supported the hypothesis that interference competition with barred owls for territorial space can constrain the availability of critical resources required for successful recruitment and reproduction of northern spotted owls. Interference competition is defined as competition where one or more species interact directly with one another to exploit essential resources with a negative effect on fitness-related characteristics of at least one species (Wiens 1989, p. 7). Availability of old forests and associated prey species appeared to be the most strongly limiting factors in the competitive relationship between the two species. They suggested that habitat loss or management actions that reduce prey availability may lead to increases in competitive pressure on northern spotted owls. They reported that variation in northern spotted owl vital rates may arise not only from differences in the quality or abundance of forest habitat among northern spotted owl territories, but also from the spatial distribution of barred owls. Wiens *et al.* (2014, p. 32) also found that northern spotted owls spent more time foraging on steep slopes dominated by old conifers (>120 yr) while barred owls used a broader range of forest types and frequently used flatter, riparian areas with large hardwood and conifer trees. Both species showed strong selection for older conifer forest (Wiens *et al.* 2014, p. 39).

4.3.1.7 Decreases in Northern Spotted Owl Demographic Performance and Site Occupancy

The three meta-analyses of northern spotted owl demographic data completed since 2006 (Anthony *et al.* 2006, Forsman *et al.* 2011, Dugger *et al.* 2016) evaluated effects of barred owls on northern spotted owl demographic performance. Anthony *et al.* (2006, entire) found negative associations between presence of barred owls and northern spotted owl survival at 3 study areas. In addition to a negative association with northern spotted owl survival at six study areas, Forsman *et al.* (2011, entire) found that the presence of barred owls was negatively associated with northern spotted owl recruitment at most study areas, resulting in observed declining population trends. Of all the factors contributing to declines in the demographic rates of northern spotted owls, the presence of barred owls is the strongest and most consistent across study areas (Forsman *et al.* 2011, p. 75). Forsman *et al.* (2011, p. 60) hypothesized that barred owls may be displacing northern spotted owls from their territories causing them to become nonbreeders, and also determined that increased barred owl presence made northern spotted owls more difficult to detect using standard survey methods. They reported that northern spotted owls that remained on their territories continued to breed at historical levels; however, the reduced number of occupied territories produces fewer young northern spotted owls overall resulting in lower reproductive output of northern spotted owl populations included in this study. This explanation is consistent with the fact that observed northern spotted owl fecundity rates are not so different from barred owl rates and yet overall downward trends occur in northern spotted owl populations wherever barred owls are present at densities high enough to displace northern spotted owls from their territories.

In the most recent meta-analysis, Dugger *et al.* (2016, p. 58) observed strong evidence that barred owls negatively affected northern spotted owl populations, primarily by decreasing apparent survival and increasing local territorial extinction rates. They also found that the amount of suitable owl habitat, local weather, and regional climatic patterns were also related to survival, occupancy, recruitment, and fecundity. There was, however, inconsistency regarding which covariates were important for particular demographic parameters and effects differed across study areas. In study areas where habitat was an important source of variation for northern spotted owl demographics, demographic rates were generally positively associated with greater amounts of suitable owl habitat. However, barred owl densities are now high enough across the range of the northern spotted owl that despite the continued management and conservation of suitable owl habitat on Federal lands, the long-term prognosis for the persistence of northern spotted owls may be in question without management to address impacts of barred owls.

One of the first studies to examine effects of barred owls on northern spotted owl territory occupancy was conducted by Kelly *et al.* (2003, entire) who completed a retrospective study to determine if barred owls could be causing declines in northern spotted owl populations observed in the early 2000s. The authors examined northern spotted owl survey data, which included barred owl responses, and demonstrated that the presence of barred owls at historical northern spotted owl sites was associated with reduced northern spotted owl site occupancy (Kelly *et al*. 2003, p. 52). Subsequently, Gremel (2005, entire) analyzed existing data to determine if barred owls affect northern spotted owl site occupancy, location of activity centers, or productivity in the Olympic National Park in western Washington State. The study confirmed that the presence of barred owls appeared to be both reducing northern spotted owl site occupancy at their historical sites, and increasing the detection distance between northern spotted owls and their original site centers. Barred owls were first detected in Olympic National Park (an area that had never been logged) in 1985. From 1992 to 2003, the number of barred owl detections per team day in northern spotted owl sites increased at a rate of 15 percent per year (Gremel 2005, p. 9). During the same period, the rate of northern spotted owl site occupancy where barred owls were present declined overall from a mean of 60.6 to 41.6 percent (Gremel 2005, p. 11). In Olympic National Park, survey results documented that northern spotted owls were located twice as far away from their established activity centers when compared with survey results for northern spotted owl territories without barred owls (Gremel 2005, p. 11), implying that northern spotted owls shifted their activity centers away from the presence of barred owls even if they did not abandon their territories. Northern spotted owl site centers that remained occupied despite the presence of barred owls also tended to be at higher elevations. These findings are consistent with the hypothesis that interference competition may be occurring and that barred owls may be displacing northern spotted owls (Gremel 2005, p. 16). The presence of barred owls may have a greater influence on whether northern spotted owls occupy a territory than whether an area is within a reserve (Pearson and Livezey 2003, p. 274).

Dugger *et al.* (2016) presented the first meta-analysis of northern spotted owl data to examine site occupancy across the range of the species. The most consistent pattern in northern spotted owl territory occupancy dynamics they reported was a strong positive association between the presence of barred owls and territory extinction rates of northern spotted owls in all 11 study areas (Dugger *et al.* 2016, p. 74). Territory extinction rates (probability that a site occupied in one year will become unoccupied by the next year) were higher in all areas when barred owls were present. Dugger *et al.* (2016, p. 75) reported that occupancy rates for northern spotted owls were declining in all study areas. Site occupancy rates in Washington declined from 56-100 percent in 1995 to 11-26 percent in 2013. In Oregon, occupancy rates declined from 61-88 percent in 1995 to 28-48 percent in 2013, and in California, occupancy rates declined from 75 percent to 38 percent at the Northwest California study area and from 79 percent to 47 percent at the Hoopa study area between 1995 and 2013. In the area where barred owl removal did not occur on the Green Diamond study area, occupancy rates declined from 92 percent in 1999 to 55 percent in 2013.

Northern spotted owls have a reduced response rate in the presence of barred owls (Crozier *et al.* 2006, p. 765; Van Lanen *et al.* 2011, p. 5); therefore, barred owls may disrupt certain behaviors important to northern spotted owls. Vocalizations are an important part of the northern spotted owl's territorial behavior. Detection of both barred owls and northern spotted owls was negatively influenced by the presence of other congeneric species, i.e., species belonging to the same genus (Bailey *et al.* 2009, p. 2987). Modeling conducted by Jones and Kroll (2016, p. 10) suggest that declines in spotted owl paired territories could be due to the presence of barred owls, though they found no clear evidence of an effect on spotted owl occupancy with a small sample size of 47 northern spotted owl sites. While the adverse effects of the barred owl on the behavior and demography of the northern spotted owl are well documented, little is known about the immediate and long-term effects that barred owl presence may have on native species composition and ecosystem processes (Holm *et al.* 2016, pp. 1-8). Based on differences between northern spotted owls and barred owls regarding selection for diet and habitat resources, Holm *et al.* (2016, pp. 1-8) suggests that the presence of barred owls in the Pacific Northwest may cause wider trophic effects within predator and prey communities.

Results from Dugger *et al.* (2016) supported the hypothesis that competition with barred owls is an important stressor of northern spotted owl populations; however, nesting and roosting habitat loss and climatic patterns also were related to survival, occupancy, recruitment, and, to a lesser extent, fecundity although relationships with these factors varied across study areas. Their results were consistent with other studies that have found links between habitat and demographic rates of northern spotted owls (Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005, 2011, Forsman *et al.* 2011, Yackulic *et al.* 2014), and provided support for previous recommendations to preserve as much high-quality habitat in late-successional forests as possible across the range of the subspecies (Forsman *et al.* 2011, p. 78). Barred owl densities are now high enough across the range of the northern spotted owl that, despite the continued management and conservation of suitable owl habitat on Federal lands (Davis *et al.* 2011, 2015), the long-term prognosis for the persistence of northern spotted owls may be in question without additional management intervention (Dugger *et al.* 2016, pp. 98-99).

4.3.1.8 Barred Owls – Summary

Barred owls have been found in all areas where surveys have been conducted for northern spotted owls. In addition, barred owls now inhabit all forested areas throughout Washington, Oregon, and northern California where nesting opportunities exist, including areas outside of the specific range of the northern spotted owl (Kelly *et al.* 2003, pp. 50-51; Buchanan 2005, pp. 26-27; Gutiérrez *et al.* 1995, p. 3; Gutiérrez *et al.* 2007, p. 182; Livezey 2009, p. 52). Consequently, the Service estimates that barred owls now occur at some level in all areas used now or in the past by northern spotted owls. Because barred owls compete with northern spotted owls for habitat and resources for breeding, feeding and sheltering, ongoing loss of habitat has the potential to intensify the competition by reducing the total amount of these resources available to the northern spotted owl and bringing barred owls into closer proximity with the northern spotted owl (Weins *et al.* 2014, p. 28, Dugger *et al.* 2011, p. 2467; Forsman *et al.* 2011, pp. 69-70). If the barred owl continues to impact the northern spotted owl at current or increasing levels into the future, it is anticipated that northern spotted owl populations will continue to be negatively affected. The presence of barred owls in the Pacific Northwest may be having effects on ecosystem processes in addition to direct effects upon northern spotted owls (Holm *et al.* 2016, entire). Removal of barred owls is currently being assessed as a possible approach to recover the northern spotted owl (USFWS 2013).

4.3.2 Climate Change

Climate change presents unique challenges to the future of northern spotted owl populations and their habitats. Northern spotted owl distributions (Carroll 2010, p. 1436) and population dynamics (Franklin *et al.* 2000, pp. 576-578; Glenn *et al.* 2010, p. 2551; Glenn *et al.* 2011a, pp. 172-174; Glenn *et al.* 2011b, p. 1291; Peery *et al.* 2012, p. 876) may be directly influenced by changes in temperature and precipitation. In addition, changes in forest composition and structure as well as prey species distributions and abundance resulting from climate change may impact availability of habitat across the historical range of the subspecies. This may in turn exacerbate the loss of connectivity between areas of habitat and ultimately lead to the potential extirpation of some populations (Schumaker *et al*. 2014, p. 587).

Global climate change has the potential to produce new environmental conditions, making predictions about future ecological consequences more challenging. Recent forecasts (Mote *et al.* 2014, entire) indicate that climate change will have long-term and variable impacts on forest habitat at local and regional scales. Locally, this could involve shifts in tree species composition that influence habitat suitability. Frey *et al.* (2016, pp. 1, 6) concluded that old-growth will provide some buffer from impacts of regional warming and/or slow the rate at which some species relying on old-growth must adapt, based on their modeling of the fine-scale spatial distribution, under-canopy air temperatures in mountainous terrain of central Oregon. Similarly, Lesmeister *et al*. (2019, p. 16) concluded that older forest can serve as a buffer to climate change and associated increases in wildfire, as these areas have the highest probability of persisting through fire events even in weather conditions associated with high fire activity. Regionally, there could be losses of habitat availability caused by advances or retreats of entire vegetative communities, and perhaps prey communities as well. Effects of climate change, including fire and pest incidence, will not only affect currently suitable habitat for the northern spotted owl, they will also likely alter or interrupt forest growth and development processes (Karl *et al*. 2008, pp. 15 and 18; Dale *et al*. 2001, entire; Yospin *et al*. 2015, entire) that influence forest turnover rates and the emergence of suitable habitat attributes in new locations. These changes are predicted to be driven by changes in patterns of temperature and precipitation that are projected to occur under climate change scenarios (Mote *et al.* 2014, entire).

4.3.2.1 Temperature and Precipitation

Temperatures increased across the Northwest from 1895 to 2011, with a regionally averaged warming of about 1.3°F (Mote *et al.* 2014, p. 489). All but two years since 1998 have had temperatures above the 20th century average (Dalton *et al.* 2013, p. 28). In the Columbia Basin, which covers portions of the northern spotted owl's range in Washington and Oregon, average temperatures rose by 1.8º F (1º C) between 1950 and 2006, with an average temperature rise of 1.6º F during the entire 20th century (Littell *et al.* 2011, pp. 9–11; Mote 2003, p. 276). In northwestern California, mean temperatures rose by 0.65º F to 1.7º F (0.36º C to 0.92º C) between 1950 and 1999, with a mean temperature increase of 0.3º F (0.18º C) (minimum increase 0.9º F (0.47º C), maximum decrease 0.4º F (0.24º C) during the 20th century (Bonfils *et al.* 2008, pp. 6413-6414; Rapacciuolo *et al.* 2014, Table S-1). Models project average annual temperature increases in Oregon and Washington of between 4.3˚ F (2.4º C) and 5.8˚ F (3.2º C) by the middle of the century (2041 to 2070), and between 3.3˚ F (1.8 ºC) to 9.7˚ F (5.3ºC) by the end of the century (2070 to 2099) (Dalton *et al*. 2013, p. 35; Mote *et al.* 2014, p. 489). The increases are projected to be largest in summer and annual temperatures are expected to continue to warm from 0.2˚ to 1˚ F (0.1˚ to 0.6˚ C) per decade (Mote *et al.* 2014, p. 489; Mote and Salathe 2009, p. 29). In northern California, models project significant temperature increases of between 2.7˚ F (1.5º C) and 8.1˚ F (4.5º C) by the end of the century (Cayan *et al.* 2008, p. S-25). Increases in temperature are projected to be the greatest during the summer months, but are expected for all seasons (Cayan *et al.* 2008, p. S-26).

In the Columbia Basin, precipitation increased by 13 percent during the 20th century, with the greatest increase occurring during the spring at 37 percent (Mote 2003, p. 279). In northern California, trends were varied showing slight increases and decreases (Rapacciuolo *et al.* 2014, Table S-1). Global climate models project an increase of 1 to 2 percent in annual average precipitation, with some models predicting wetter autumns and winters with drier summers (Mote and Salathe 2009, p. 29). In the Columbia Basin, projected changes in precipitation are less certain than temperature projections; however, both the length of dry spells and the number of extremely wet days are likely to increase (Dalton *et al.* 2013, p. 37; Mote *et al.* 2014, p. 489). In northern California total annual precipitation is projected to decrease by up to 18 percent with the greatest decrease in the summer months (Cayan *et al.* 2008, p. S-25). On the cooler, moister west side of the Cascades, the summer water deficit is projected to increase, but more so proportionally in the relatively wet Oregon Coast Range/Olympics, than in western Cascades (Littell pers. comm. 2017; McKenzie and Littell 2017, p. 33). East of the Cascade Crest, the summer water deficit is also expected to increase, but local areas may be impacted to a lesser extent due to greater snow pack at the highest elevations of the Cascades and the snowmelt recharging the deep soil moisture layers (McKenzie and Littell 2017, p. 33; Elsner *et al.* 2010, p. 245). Researchers expect some ecosystems to become more water limited, more sensitive to variability in temperature, and more prone to disturbance. In forests with long-lived dominant tree species, mature individuals can survive these stresses, so direct effects of climate on forest composition and structure would most likely occur over a longer time scale (100 to 500 years) in some areas than disturbances such as wildfire or insect outbreaks (25 to 100 years) (McKenzie *et al.* 2009, pp. 330-331). Seasonality of precipitation may be strongly affected by climate change (Cayan *et al.* 2006, pp. S29-S30). In the next century, winter precipitation across the entire range of the northern spotted owl is forecast to increase by 5 to 15 percent above the amounts for the 1958 through 2008 reference period, with the greatest increases in the Cascade Ranges and Olympic Peninsula. Summer precipitation is predicted to decrease by 10 to 35 percent over the same period, with the greatest change rates also in the Cascades and Olympic Peninsula. Forecasts of spring and fall precipitation show a mixed outcome, with decreases of 5 to 20 percent throughout northern California, and increases of 0 to 15 percent over the remainder of the species' range (Karl *et al*. 2009, p. 31).

These models agree with the global climate models in projecting warmer, drier summers and warmer, wetter autumns and winters for much of the Pacific Northwest, which will likely result in diminished snowpack, earlier snowmelt, and an increase in extreme heat waves and precipitation events. Predicted changes in temperature and precipitation may have direct effects on northern spotted owl habitat selection and demography (see Franklin *et al.* 2000, p. 583; Carroll 2010, pp. 1436-1437; Glenn *et al.* 2010, p. 2548; Glenn *et al.* 2011b, pp. 1288-1289). Various measures of temperature and precipitation during the winter, spring, and summer are important predictor variables in habitat selection models (Carroll 2010, p. 1437; Appendix C in USFWS 2011a; GDRC 2010, entire) and in demographic models (Franklin *et al.* 2000, p. 582; Forsman *et al.* 2011, p. 62; GDRC 2010, entire).

4.3.2.2 Forest Composition

Regional warming and consequent drought stress appear to be the most likely drivers of an increase in the mortality rate of trees in recent decades in the western United States. The increase was evident across regions (Pacific Northwest, California), elevations (*i.e.*, topography), tree size, type of trees, and fire-return-intervals (Van Mantgem *et al.* 2009, p. 521). Climate change forecasts indicate significant effects on the tree species composition of western forests over the next century, with long term implications for the composition and structure of northern spotted owl habitat. There is evidence that the productivity of many high-elevation forests (where low summer temperature and winter snowpack limits the length of the growing season) is increasing in the Pacific Northwest as temperatures rise, potentially increasing the elevation of the tree line (Karl *et al.* 2009, p. 79; Case and Peterson 2007, pp. 71-72). Conversely, productivity and tree growth in many low-elevation Pacific Northwest forests is likely to decrease due to the longer, warmer summers (Case and Peterson 2007, p. 72). This may result in a change in species composition or reduction in the acreage of existing low-elevation forests. The general predicted trend in North American forests is declining occupancy by conifers and displacement by hardwoods (Karl *et al.* 2009, p. 81). In interior northwestern California, Lenihan *et al.* (2008, p. S223) projected sharp declines of 40 to 60 percent in the land area of conifer-dominated forests by 2100, with proportional increases in mixed forests with hardwoods as sub-dominant or dominant species. Lenihan *et al.* (2008, p. S215) also predict a pattern of hardwoods displacing conifers in coastal and interior-coastal areas within the species' range; but they point out that an important predictor of future outcomes is continued public support for fire suppression programs. In simulations without fire suppression they found the same effect in coastal areas, but additionally found displacement of conifer forest by advancing woodland and savannah in the eastern Cascade Ranges.

4.3.2.3 Disturbance Patterns

Climate change is affecting the location, size and intensity of insect outbreaks, which in turn affect fire (frequency, intensity, and extent) and other forest processes (Joyce *et al.* 2008, p. 3-13; Kurz *et al.* 2008, p. 989; Karl *et* al. 2009, p. 82; Littell *et al.* 2010, p. 26; Latta *et al.* 2010, p. 728; Spies *et al.* 2010, p. 5). Warming temperatures have led to mountain pine beetle (*Dendroctonus ponerosae*) outbreaks, with large-scale effects in some western forests, including in the eastern Cascades. In warmer winters more mountain pine beetles survive, which shortens their generation time, resulting in larger and more severe outbreaks. Drought can heighten the susceptibility of host trees to attack (Littell *et al.* 2010, p. 23).

Climate change forecasts of summer and fall warming trends are likely to influence the frequency and extent of wildfires. This can affect northern spotted owl habitat directly by destroying or degrading habitat features, or indirectly by interrupting development in younger forest stands and delaying their development into suitable habitat. Stand-replacing events and disturbances have also been predicted to speed up ecological conversions (*e.g.*, forests to shrublands) (Joyce *et al.* 2008, p. 3-27; Blate *et al.* 2009, p. 58; Littell *et al.* 2010, p. 26). Dry forests are at greater risk to large scale disturbances (Agee and Skinner 2005, p. 94; Mitchell *et al.* 2009, p. 646), but recent research suggests large-scale disturbances will become more likely in west-side forests that have not traditionally been thought of as fire prone (Littell *et al.* 2010, p. 19). Furthermore, the resiliency of forests to wildfire is reduced during periods of high climate variability (Crausbay *et al.* 2017, p. 2).

In the coast redwood forests of northern California, interactions between past timber harvest practices, development, forest fragmentation, fire and climate change are complex, and will likely determine the probabilities of persistence of these forests over time (Koopman *et al.* 2014, pp. 4-5). Thorne *et al.* (2016, p. 3) ranked the Pacific Northwest Conifer Forests (in their report, dominated by coast redwood) as "mid-high" in terms of vulnerability to climate change in the 21st Century. Gardali *et al.* (2012, p. 8/15) assessed climate change vulnerability for 358 avian taxa in California, and based on their ranking criteria, did not find northern spotted owl to be vulnerable to climate change in California.

In its review of the status of the northern spotted owl in California (CDFW 2016, p. 153-155), the California Department of Fish and Wildlife (CDFW) evaluated the possible effects of climate change upon northern spotted owl and the forested habitats on which it depends. In general, CDFW (2016, p. 153-155) determined that climate change is occurring within the northern spotted owl's entire range, including California, with many climate projections forecasting steady changes in the future. They reported that climate change studies predict future conditions that may negatively impact northern spotted owls, such as wet and cold springs, more frequent and severe summer heat waves, decreased fog along the coast, shifts in forest species composition, and increased frequency of severe wildfire events. However, CDFW (2016, p. 153-155) also reported that in some instances predicted future conditions, such as increased frequency of low to moderate severity fires and expansion of suitable owl habitat forest types, may be favorable to the northern spotted owl in the long term. They further reported that in California, current rates of temperature and precipitation change predict hotter and drier conditions in some areas of the northern spotted owl's range, and wetter colder conditions in other areas of the range. They looked at past precipitation and temperature trends, and reported that drying trends across most of the northern spotted owl's range in California, coupled with warmer winters and cooler summers in the interior and cooler winters and warmer summers along the coast, may play a role in both owl and prey population dynamics. CDFW (2016, p. 153-155) recommended that further research is necessary to understand how climate change may be affecting northern spotted owls in California and throughout its range.

4.3.2.4 Effects of Climate on Northern Spotted Owl Population Performance

A number of studies have examined the influence of weather and climate on northern spotted owl demographic performance (Glenn *et al.* 2010, Glenn *et al.* 2011a, Glenn *et al.* 2011b, Forsman *et al.* 2011, Dugger *et al.* 2016, Carrol 2010). Glenn *et al.* (2010, p. 2551) demonstrated that demographic rates of northern spotted owls are associated with local weather and regional climate, although the specific climatic factors most strongly associated with demographic rates, the relative contributions of survival and recruitment to population growth rate, and the amount of variation in demographic rates accounted for by climate varied across the range of the species. They also reported a negative association between barred owl presence and recruitment at four areas and barred owls and survival at two areas. They concluded that variation in climate has the potential to strongly influence population dynamics for northern spotted owls; however, there are numerous factors including habitat, barred owls, and prey that must be considered as well when developing conservation strategies for the northern spotted owl.

In their meta-analysis of rate of population change, Dugger *et al.* (2016, p. 98) found that recruitment of new owls into the population of territorial owls was most affected by the interaction between total winter precipitation and mean monthly minimum temperature during winter, with the lowest levels of recruitment occurring when conditions during the previous winter were cold and wet, and the highest levels of recruitment occurring when the previous winter was cold and dry. These relationships likely reflected direct effects of weather on survival of non-territorial birds (potential recruits) in the previous winter. The survival rate of non-territorial or nonbreeding birds is usually difficult to measure, and when estimated is usually lower than the survival of territorial birds (Lenda *et al.* 2012, p. 395; Dwyer *et al.* 2012, p. 298).

Dugger *et al.* (2016) also recorded evidence of an association between climate and apparent adult survival rates, including both regional climate indices and local weather effects. Their meta-analysis of survival suggested that regional climate cycles (Southern Oscillation Index (SOI), Pacific Decadal Oscillation (PDO)) were strongly associated with apparent survival across all study areas, consistent with previous findings for northern spotted owls (Forsman *et al.* 2011, p. 69) and other raptors (Franke *et al.* 2011, p. 147; Millon *et al.* 2014, pp. 1777-1779). Dugger *et al.* (2016, p. 98) observed higher survival rates when winters were warm (positive association with PDO) and dry (negative association with SOI), rather than higher survival when conditions were warm (positive association with PDO) and wet (positive association with SOI) as observed in a meta-analysis of 6 northern spotted owl study areas by Glenn *et al.* (2011a, p. 174). Regional climate cycles have been associated with vital rates for other birds (*e.g.*, Wright *et al.* 1999, pp. 1644-1645; Sillett *et al.* 2000, p. 2041; LaManna *et al.* 2012, pp. 739-740; Wolfe *et al.* 2015, p. 5), including other raptors (*e.g.*, Franke *et al.* 2011, p. 147; Jonker *et al.* 2014, p. 104), but in most cases a clear understanding of the environmental change that climatic cycles represent (*i.e.* prey densities or habitat conditions) and the causal relationships that link that change to avian demographics are poorly understood.

4.3.2.5 Climate Change—Summary

Glenn *et al.* (2010, p. 2551) noted that the potential consequences of global climate change on Pacific Northwest forests remain somewhat unclear, though there is potential for changes in forest composition and disturbance patterns that could affect northern spotted owl populations. Most models predict warmer, wetter winters and hotter, drier summers for the Pacific Northwest in the first half of the 21st century (Mote *et al.* 2014, p. 489). This may affect northern spotted owl through changes in forest species composition or reduction in the acreage of existing low-elevation forests, and the availability of prey species for northern spotted owl. The general predicted trend in North American forests is declining occupancy by conifers and displacement by hardwoods. Models noted that increased occurrence of drought conditions during the summer has the potential to negatively affect annual survival, recruitment, and population growth rates of northern spotted owls across much of their range. Climate change has the potential to cause fundamentally different patterns in weather which may have unpredictable consequences for northern spotted owl populations. Given that natural resource managers cannot control climate variation and barred owls are likely to persist and increase in the range of the northern spotted owl, both implementing management to reduce the impacts of barred owls on spotted owls and maintaining sufficient high quality habitat on the landscape remain the most important management strategy for the conservation of this subspecies (Glenn *et al.* 2010, p. 2551).

4.3.3 Exposure to Toxicants

Toxicants were not identified as a threat when the northern spotted owl was listed, but a growing body of information suggests exposure to contaminants and other factors associated with marijuana cultivation represent a growing concern for northern spotted owls. New information shows that the scope and scale of exposure to toxicants from illegal cultivation is increasing, and is occurring within different land ownerships in the range of northern spotted owl and many other species.

Numerous forms of toxicants used in marijuana (*Cannabis sativa*) cultivation threaten wildlife. Herbicides and highly toxic, second-generation anticoagulant rodenticides (ARs) are used to prevent grasses and small mammals from damaging the crop (Thompson *et al.* 2013 entire, Gabriel *et al.* 2013, entire). The ARs present short and long-term risks to target and non-target wildlife species, particularly predators of small mammals. These toxicants have been found to affect the abundance local small mammal populations (Brakes *et al.* 2005, p. 121, 124); this in turn could have indirect consequences to the prey availability thus lowered fitness and survival of species like northern spotted owls. Additionally, because small mammals dominate the diet of northern spotted owls, the threat of contamination from secondary effects is a concern. The ARs are acutely toxic and can cause mortality in target and non-target small mammals after a single dose (Handler and Buckle 1992, p. 151).

Sub-lethal (not directly causing mortality) doses of these compounds can potentially have indirect fatal impacts. They persist in the liver and tissues of affected animals, facilitating the exposure to secondary poisoning in predators and scavengers (Eason and Spurr 1995 p. 372). Sub-lethal effects can also affect behavior and fitness in predators by reducing coordination, mobility and escape responses, making the affected animals more vulnerable to predation or other causes of mortality (Cox 1991 and Littin *et al.* 2002, in Brakes *et al.* 2005 p. 121-125).

Known "grow sites" intersect with both subspecies of spotted owl ranges throughout California; 632 trespass grow sites were reported on mixed California ownerships in 2010 (Wengert *et al.* 2015, p. 8). On Forest Service lands in 2014, more than 620,000 marijuana plants on about 1,500 ac (607 ha) were removed from 167 different sites; about 90 percent of which were in California (US Senate press release 2015). There has been a noted increase in exposure to pesticides in fishers (*Pekania pennanti*) in the Sierra Nevada and Northern California that could be related to toxicant use in marijuana cultivation (Gabriel *et al.* 2015, pp. 5-8, 14, Gabriel *et al.* 2017).

Illegal cultivation is a serious issue in the Klamath Physiographic Province, an area recognized as an important area for northern spotted owl populations (Schumaker *et al.* 2014). Drug enforcement data from the Klamath Physiographic Province also illustrate risks to northern spotted owls from illegal cannabis sites. In southwestern Oregon in Jackson and Josephine Counties alone, a multi-agency Drug Task force reported a total of 100 illegal marijuana cultivation sites containing approximately 294,090 plants between 2005-2014 (R. Caruthers, pers. comm. 2017). Many of these sites were located within known spotted owl home ranges, cores, or nest stands (D. Clayton, pers. comm. 2017 May 5 9:42 AM and May 5 6:38 PM). These data represent only sites that were located and eradicated, and not necessarily remediated. Sometimes the toxicants are not removed due to insufficient funding or lack of available hazardous material removal crews (R. Caruthers pers. comm. 2017). Many other undetected grows are assumed to occur and are not reported here. Another dataset of BLM lands within counties intersecting with the range of the NSO outside of Jackson/Josephine Counties, 29 sites containing approximately 62,270 plants were eradicated between 2009 and 2011 (R. Snider, pers. comm. 2017). These data highlight a concern for northern spotted owls in parts of the Oregon Klamath Province.

Recently, high densities of Northern California grow sites were documented in landscape positions associated with northern spotted owls in that part of the range where grow sites were described in forests, in close proximity to streams, and generally in remote or areas with low developed road densities (Butsic and Brenner 2016, pp. 5-7). In the last several years, rural counties in California have reported a wide expansion in the size and numbers of marijuana cultivation sites (DEA 2016, p. 119; CEPA 2017, p. 1). Legal marijuana sales have been increasing significantly. These data suggest these land use trends are not likely to change or will continue to increase (Arcview Market Research 2016, p. 1; DEA p. 125, CBE 2017 p. 1). An estimated 80 percent of illegal marijuana eradicated in California is grown on Federal lands (Smith 2017, p. 4). Data collected for a California study revealed the presence of ARs in northern spotted owls. Of ten northern spotted owl carcasses that were tested for anticoagulant rodenticides, 70 percent tested positive (Gabriel *et al*. 2018, pp. 1, 4). Of 84 barred owls tested in northern spotted owl range, 40 percent had been exposed to anticoagulant rodenticides (Gabriel et al. 2018, pp. 1, 4). However, the owls had various direct causes of mortality (disease, vehicular strike, predation) (Gabriel 2018, p. 4.) and there is no evidence that the level of ARs in their systems led to decreased fitness or the death of any of the individuals owls collected; furthermore we do not know where the owls came in contact with the ARs with respect to the proximity to grow sites.

Anticoagulant rodenticides and other toxicants are applied illegally in known northern spotted owl home ranges and in forested habitats in the range of the northern spotted owl, particularly on Federal land where conservation of the species is expected to occur. Although information suggests that toxicants are having an impact to wildlife in the range of the northern spotted owl and some evidence of exposure to northern spotted owls (Gabriel *et al*. 2018, p. 4), we have no evidence that toxicants are currently causing the decreased fitness or direct mortality of northern spotted owls at a local or population scale. At this time, we do not have information to suggest that toxicants are a stressor on northern spotted owls.

4.3.4 Summary of Stressors Related to Other Natural or Manmade Factors Affecting the Continued Existence of Northern Spotted Owl

Barred owls and climate change are stressors that are currently affecting and will continue to affect northern spotted owls in the future. Since our last status review in 2011, competition from barred owls has become the most significant threat to populations of northern spotted owls. Barred owls have been found in all areas where surveys were conducted for northern spotted owls and they are negatively influencing demographic performances of northern spotted owls. Because barred owls compete with northern spotted owls for habitat and resources for breeding, feeding and sheltering, ongoing loss of habitat has the potential to intensify the competition by reducing the total amount of these resources available to the northern spotted owl and bringing barred owls into closer proximity with the northern spotted owl. If the barred owl continues to impact the northern spotted owl at the current or increasing levels into the future, it is anticipated that northern spotted owl populations will continue to decline precipitously and possibly be extirpated in some areas.

Climate change has the potential to cause fundamentally different patterns in weather which may have unpredictable consequences for northern spotted owl populations. Climate change is already occurring within the northern spotted owl's entire range, with trends showing changes over time in temperature and precipitation; many climate projections forecast steady changes into the future. Projected future changes in climate for the Pacific Northwest are likely to result in increased fire risk; increased risks from forest pathogens; changes in forest structure, extent, and species composition; as well as direct and indirect effects of climate change on northern spotted owl survival and reproduction. Changes in climatic conditions may also influence northern spotted owl population performance through effects to small mammal communities that comprise the diet of the northern spotted owl or through direct effects of weather (*e.g.* increase in storms) on the species. While changes in forest composition and extent are likely to occur as a result of climate change, the rate of that change is uncertain.

Although information suggests that toxicants are having an impact to wildlife in the range of the northern spotted owl and some evidence of exposure to northern spotted owls, we do not have information to suggest that toxicants are a stressor on northern spotted owls.

4.4 Cumulative and Synergistic Effects

Combinations of stressors accumulate and interact to increase the risk of extinction. Any given source of mortality or habitat loss may affect a small proportion of individuals or of the range, but when all sources are added together, the effect may be substantial. Furthermore, some combinations of stressors may act together synergistically to cause effects greater than the sum of the individual effects of each stressor.

4.4.1 Barred owl, Habitat loss, and Climate Change

The combined effects of climate change and past management practices are changing forest ecosystem processes and dynamics, including patterns of wildfires, and insect and forest disease outbreaks, to a greater degree than anticipated in the Northwest Forest Plan (NWFP) (Hessburg *et al.* 2005, pp. 134–135; Carroll *et al.* 2010, p. 899; Spies *et al.* 2010, entire; USFWS 2011a, p. I-8). At the same time, the expansion of non-native barred owl populations is altering the capacity of intact habitat to support northern spotted owls; because barred owls compete with spotted owls for habitat and resources, ongoing loss of habitat can intensify the competition by reducing the total amount of these resources available to the spotted owl and bring barred owls in closer proximity to the spotted owl (USFWS 2011a, p I-9). Projecting the effects of these factors and their interactions into the future leads to even higher levels of uncertainty regarding the response of northern spotted owls and the subspecies ability to persist over time, especially considering how the influences of different threats may vary across the northern spotted owl's large geographical range. It is clear that ecosystem-level changes are occurring within the northern spotted owl's forest habitat. Habitat loss (see Dugger *et al.* 2016, p. 98), competition with barred owls (see Wiens *et al.* 2014, p. 37), and changes in weather patterns predicted to occur in future decades (see Glenn *et al.* 2010, pp. 2549-2551) have independently been demonstrated to have negative effects on northern spotted owl populations. In combination, these factors are likely to interact and have even greater negative consequences for this species.

It has become evident that focusing only on securing habitat will not be effective in achieving the recovery of the northern spotted owl when barred owls are present (USFWS 2011a, p. vi; Dugger *et al.* 2016, p. 98). While conservation of high-quality habitat is essential for the recovery and conservation of the owl, habitat conservation alone is not sufficient to achieve recovery objectives. Given that natural resource managers cannot control climate variation and barred owls are likely to persist and increase in the range of the northern spotted owl, integrating management strategies to reduce the impacts of barred owls on spotted owls while maintaining sufficient high quality habitat on the landscape remains the most important management strategy for the conservation of this subspecies (USFWS 2011a, p. vii; Glenn *et al.* 2010, p. 2551). As stated in the 2011 Revised Recovery Plan, addressing the threats associated with past and current habitat loss must be conducted simultaneously with addressing the threats from barred owls. Addressing the threat from habitat loss is relatively straightforward with predictable results. However, addressing a large-scale threat of one raptor on another, closely related raptor has many uncertainties (USFWS 2011a, p. I-8).

4.4.2 Genetic Effects of Small Population Size

Multiple stressors acting contemporaneously have led to profound population declines of northern spotted owls. These declines in the northern portion of the northern spotted owl's range may be sufficiently severe to increase demographic and genetic threats. In 2004, populations in the northern part of the range were identified as being at increased risk of negative effects from demographic stochasticity (Courtney *et al.* 2004, p. 11-9). Negative genetic effects were not considered a threat to the northern spotted owl population in the United States in 2004, but were identified as a potential future threat. They were also identified as a possibly imminent threat for the small and rapidly declining population of northern spotted owls in British Columbia, Canada (Courtney *et al.* 2004, pp. 3-27 and 11-9).

Since 2004, continued declining population trends in Washington State suggest that Washington populations are becoming critically small. For example, the 1,110 square mile (mi^2) (1,787 square kilometer (km^2)) Cle Elum demographic study area has experienced a decline of over 80 percent in its northern spotted owl population, reducing the number of pairs detected annually from over 50 in the early 1990s to less than 10 in recent years (Lesmeister *et al.* 2017, p. 7). Allele effects (Hutchings 2015, entire) and mortality or reduced fitness due to exposure to stochastic events like wildfires, defoliating insect outbreaks, or blowdowns, may be producing increasingly strong demographic impediments to the persistence and recovery of these small northern spotted owl populations.

While there is currently no empirical evidence of inbreeding depression in spotted owls (as was the case in 2004; Courtney *et al.* 2004, p. 11-9), inbreeding of close relatives has been reported for northern spotted owls (Carlson *et al.* 1998, p. 562) and there is genetic evidence of recent population bottlenecks in northern spotted owls, especially in the Washington Cascades (Funk *et al.* 2009, entire). The circumstantial case for increasing risk of inbreeding depression, genetic isolation, and reduced genetic diversity also has become stronger in the northern portion of the range. In Washington demography study areas, current effective population sizes are on average fewer than 20 individuals (Gremel 2015, pp. 4-5; Herter 2016, p. 8; Lesmeister *et al.* 2017, pp. 3, 12; Lesmeister and Pruett 2017, pp. 3, 7-8). Populations of this size are highly susceptible to loss of genetic variation and fitness due to genetic drift and other factors (Frankham 1996, entire; Frankham *et al.* 2014, entire).

Lifetime reproductive success of individual northern spotted owls show a pattern of variation similar to the highly skewed distribution found in other birds (Newton 1989, pp 283-284; Herman and Colwell 2015, p. 477). During a study on four of the Federal monitoring areas (Oregon Coast Ranges, Tyee, H.J. Andrews, Cle Elum), an estimated 17 percent of female northern spotted owls and 16 percent of males produced more than 50 percent of fledglings, with 39 percent of females and 30 percent of males producing no fledglings (Loschl 2008, pp. 74 and 91). This pattern of variation in reproductive success, coupled with small effective population size, local recruitment, and high site fidelity (Loschl 2008, p. 89), all contribute to increasing the potential for inbreeding among northern spotted owls.

4.4.3 Summary of Cumulative and Synergistic Effects

The combined effects of climate change and past management practices are changing forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks, and disease, to a degree greater than anticipated in the NWFP. At the same time, the expansion of barred owl populations is altering the capacity of intact habitat to support northern spotted owls. Furthermore, there is genetic evidence of recent population bottlenecks in northern spotted owls, especially in the Washington Cascades. Projecting the effects of these factors and their interactions into the future leads to even higher levels of uncertainty, especially considering how the influences of different threats may vary across the owl's large geographical range.

5.0 CONSERVATION MEASURES TO REDUCE STRESSORS

Of the stressors to the northern spotted owl identified and considered here, there is abundant evidence to suggest that the impacts from barred owls and habitat loss (current and historic) have had the strongest effects on northern spotted owls. There is strong evidence to suggest competition with barred owls is currently the primary driving factor behind the observed population declines in and range contraction throughout its distribution. Losses of forest habitat to timber harvest and wildfire remain a concern as do both direct and indirect effects of climate change. Northern spotted owl habitat on Federal lands has been maintained or developed at the rate expected under the NWFP while habitat on non-Federal lands continues to decline. Conservation measures that address potential stressors to the northern spotted owl are presented in the following sections.

5.1 Conservation Measures to Address Habitat Loss and Fragmentation

The 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) contains 14 recovery actions that specifically address northern spotted owl habitat loss and degradation. Two actions of primary importance are recovery actions 10 and 32:

- Recovery Action 10: Conserve northern spotted owl sites and high value northern spotted owl habitat to provide additional demographic support to the northern spotted owl population. This action addresses both nesting/roosting and foraging habitat.
- Recovery Action 32: Because northern spotted owl recovery requires well distributed, older and more structurally complex multi-layered conifer forests on Federal and non-Federal lands across its range, land managers should work with the Service…to maintain and restore such habitat while allowing for other threats, such as fire and insects, to be addressed by restoration management actions. These high-quality northern spotted owl

habitat stands are characterized as having large diameter trees, high amounts of canopy cover, and decadence components such as broken-topped live trees, mistletoe, cavities, large snags, and fallen trees. This action addresses nesting/roosting habitat.

Recovery actions 10 and 32 are implemented on reserved areas by the USFS and BLM through the NWFP and the Resource Management Plans (RMPs); these two regulatory actions are discussed in more detail in Section 6. The large reserve network created under the NWFP and RMPs facilitates implementation of recovery actions 10 and 32 by protection of current nesting/roosting and foraging habitat, protection of spotted owl nest sites, and allowing for recruitment of new northern spotted owl habitat. Through the section 7 consultation process, the Service reviews the management activities implemented under the NWFP and RMPs and provides technical assistance to the USFS and BLM in making activities within or outside of reserves consistent with recovery actions 10 and 32 to the extent consistent with other land management priorities. Nesting/roosting and foraging habitat associated with both recovery actions 10 and 32 may decrease in local areas, but over the larger area and time, habitat that is associated with these recovery actions is increasing and will continue to increase under both the NWFP and RMPs.

Non-Federal lands contributed 3,149,700 ac (1,274,638 ha) to the total 12,103,700 ac (4,898,193 ha) of nesting/roosting habitat available for breeding northern spotted owls in 2012 (Davis *et al.* 2016, pp. 21-22). There are portions of the range where habitat on Federal lands is lacking or of low quality, or where there is little Federal ownership; State and private lands may be important to provide demographic support (pair or cluster protection) and habitat connectivity for northern spotted owl in key areas such as southwestern Washington, northwestern Oregon (potentially including parts of the Tillamook and Clatsop State Forests), and northeastern California (USFWS 2011a, p. III-51). Timber harvest on State and private lands in Washington, Oregon, and California is regulated by each State's forest practice rules. The level of northern spotted owl conservation included in each State's regulations varies. Furthermore, while recovery efforts for the northern spotted owl are primarily focused on Federal land, Recovery actions 14 in the 2011 Revised Recovery Plan centered on seeking partnership with non-Federal landowners to supplement Federal conservation efforts, including voluntary actions like Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs). There are a total of 21 current conservation plans in these states, including 7 HCPs and 3 SHAs located in Washington, 2 HCPs and 5 SHAs in Oregon, and 2 HCPs and one SHA in California, with an additional SHA occurring in both Washington and Oregon.

5.1.1 U.S. Fish and Wildlife Habitat Conservation Plans and Safe Harbor Agreements

The purpose of both the HCP and SHA processes is to provide for the conservation of endangered and threatened species while at the same time authorizing the incidental take of those species. HCPs are required as part of an application for an incidental take permit. They describe the anticipated effects of the proposed taking; how those impacts will be minimized, and mitigated; and how the HCP is to be funded among other things. The Secretary must issue the permit if statutory issuance criteria are met, including that the applicant will minimize and mitigate the effects of the taking to the maximum extent practicable, the taking will not jeopardize the continued existence of the species, and funding to implement the plan is assured. 16 U.S.C. 1539(a)(2)(B). In developing HCPs, people applying for incidental take permits describe measures designed to minimize and mitigate the effects of their actions and receive formal assurances from the Service that if they fulfill the conditions of the HCP, the Service will not require any additional or different management activities by the participants without their consent. SHAs are voluntary agreements between non-Federal property owners and the Service; in exchange for actions that contribute to the recovery of listed species on non-Federal lands, participating property owners may return the enrolled property to the baseline conditions that existed at the beginning of the SHA. Incidental Take Permits that result from both HCPs and SHAs are intended to allow non-Federal entities to undertake actions that incidentally "take" species protected under the Act.

HCPs are not required to have a net benefit and SHAs are designed to have a temporary net gain for northern spotted owls. Under these plans, timber harvest has continued, resulting in the loss of nesting/roosting, foraging, and dispersal habitat; we do not currently have an analysis of habitat loss on lands without conservation plans compared to habitat loss on lands covered by HCPs and SHAs. Although the HCPs do not provide a net conservation benefit to northern spotted owl, they provide mitigation for habitat loss or slow down habitat loss through the required conservation measures. SHAs do provide a net conservation benefit to the northern spotted owl, and both conservation plans eliminate uncertainty with respect to landowners' actions in northern spotted owl habitat, and provide the Service an opportunity to provide technical assistance to landowners in the development of conservation measures included in the agreements. Therefore, in this context, both HCPs and SHAs have contributed to the overall conservation of spotted owls.

In Washington, there are seven northern spotted owl-related HCPs currently in effect covering 2 million ac (80,9371 ha) of non-Federal lands, one of which covers Washington Department of Natural Resources (DNR) lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There are four northern spotted owl-related SHAs in Washington, with one including some lands in Oregon. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. In addition, there is a long-term habitat management agreement covering 13,000 ac (5,261 ha) in which authorization of take was provided through an incidental take statement (section 7) associated with a Federal land exchange (USFWS 2011b, p. A-15). While timber harvest and habitat loss continues on lands covered by these agreements, the plans retain some nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in Washington provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Washington.

In Oregon, there are two northern spotted owl-related HCPs currently in effect covering 210,400 ac (85,146 ha) of non-Federal lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There are two northern spotted owl-related SHAs occurring in Oregon. One SHA is a Washington SHA that covered some Oregon lands. The other SHA is a programmatic SHA with the Oregon Department of Forestry with 13 landowners with 3,484 acres enrolled. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. Strategies employed in the programmatic Oregon Department of Forestry SHA include, maintaining existing suitable habitat, increase time between harvests to allow for habitat development, and to lightly to moderately thin younger forestry stands that are currently not habitat (to increase tree diameter and stand diversity) (USFWS 2011a, p. A-16). There are 4 additional SHAs in Oregon related to the Barred Owl Removal Experiment explained below in the barred owl section. While timber harvest and habitat loss continue on lands covered by these HCPs and SHAs in Oregon, the plans retain some nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in Oregon provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Oregon.

In California, there are two northern spotted owl-related HCPs currently in effect covering 211,765 ac (85,698 ha) of non-Federal lands. These HCPs still allow timber harvest but are designed to retain some nesting habitat and or connectivity over the next few decades. There is one northern spotted owl-related SHA in California. The primary intent of SHAs is to maintain or create potential northern spotted owl habitat. While timber harvest and habitat loss continues on lands covered by these agreements, the plans retain some nesting/roosting habitat throughout the area or in strategic locations, and provide habitat connectivity. Overall, HCPs, and SHAs in California provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in California.

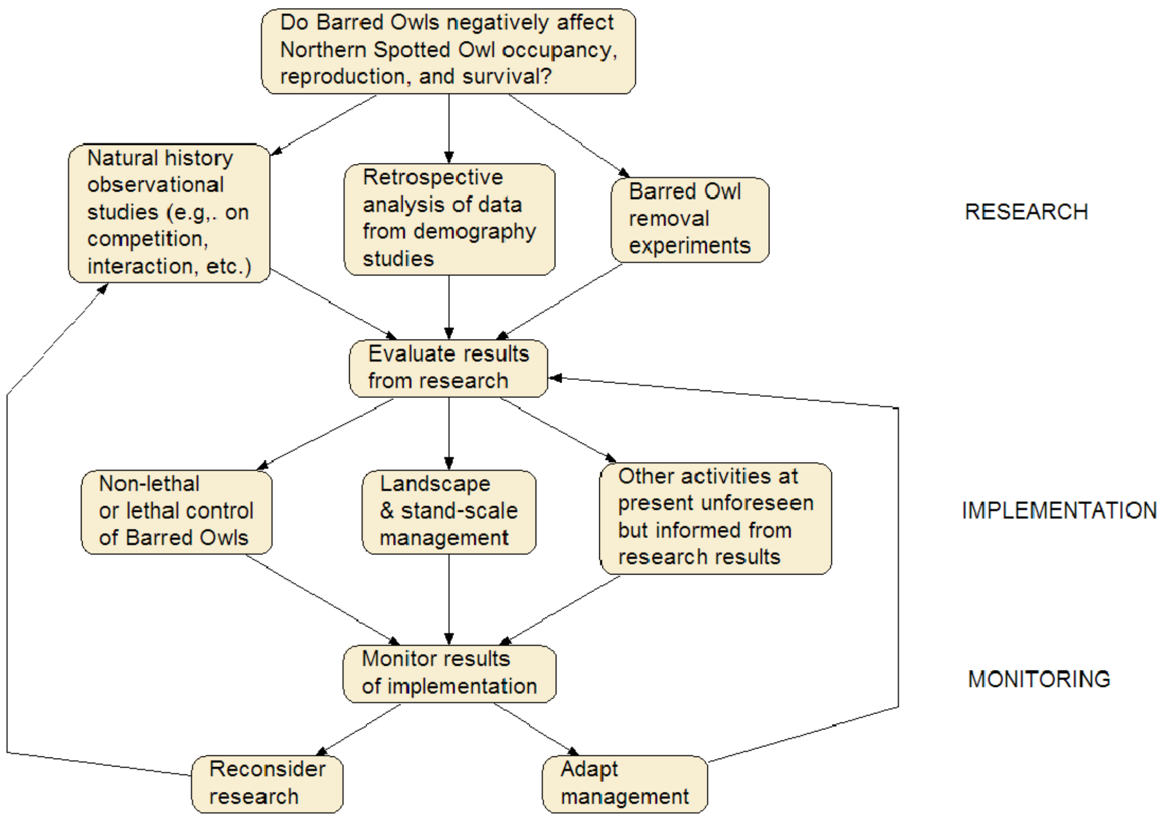
5.2 Conservation Measures to Address Disease and Forest Pathogen Outbreaks

At this time, no avian diseases are significantly affecting northern spotted owls. It is unknown whether avian diseases such as West Nile virus (WNV), avian flu, or avian malaria (Ishak *et al.* 2008, p. 1) will significantly affect northern spotted owls Recovery Action 17 (USFWS 2011a, p. III-55) calls for action agencies to monitor sudden oak death and avian diseases (*e.g.*, West Nile Virus, avian flu, *Plasmodium* spp.) and address as necessary. Federal and State agencies keep forest pathogens and avian diseases in mind during forest management activities, and will notify the Service if any forest pathogen or avian disease becomes a threat. If one or more disease causing organisms, pathogens, or parasites poses a threat to northern spotted owls or their habitat, specific responses would need to be developed and implemented.

5.3 Conservation Measures to Address Barred Owls

The 2011 Revised Recovery Plan for the Northern Spotted Owl contains ten recovery actions specific to addressing the barred owl threat. These include the establishment of protocols to detect barred owls and document barred owl site status and reproduction (Recovery Action 24), and the design and implementation of large-scale control experiments to assess effects of barred owl removal on spotted owl site occupancy, reproduction, and survival (Recovery Action 29). The manner in which this set of ten Recovery Actions is expected to contribute to northern spotted owl recovery is presented in Figure 13

Figure 13. Flowchart of barred owl Recovery Actions (USFWS 2011a, p. III-66, Figure III-1).



Several barred owl recovery actions have been completed, and recovery Action 29 is currently ongoing. The Barred Owl Removal Experiment (USFWS 2013 and 78 FR 57171) was developed based on a pilot project at Green Diamond Resources study area that demonstrated barred owl removal had rapid, positive effects on northern spotted owl survival and the rate of population change (Dugger *et al.* (2016, p. 58). This experiment is currently being implemented under the direction of USGS, the Hoopa Tribe, and the Animal and Plant Health Inspection Service in partnership with the Service. The research program is evaluating the effectiveness of barred owl removal as a potential recovery strategy for northern spotted owls on one study area in Washington, two study areas in Oregon, and one study area in northern California. The barred owl removal experiment was initiated on the California study area in fall/winter 2013-2014, and on the Washington and one of the Oregon study areas in fall/winter 2015-2016. Barred owl removal on the final Oregon study area was initiated in fall of 2016. Removal was scheduled to occur for a minimum of four consecutive years at each study area.

Under the BLM RMPs, the BLM will support barred owl management on their lands as informed by the outcome of the Barred Owl Removal Experiment. In the interim, the BLM is avoiding incidental take of northern spotted owls resulting from timber harvest on their lands. This support is intended to mitigate for the adverse effects associated with timber harvest and other resource programs, and result in a net positive impact on the recovery of northern spotted owls (USFWS 2016, p. 701).

Results from this experiment will provide future management guidance for the recovery of the northern spotted owl. Annual reports on study progress are provided each year, and a final report is anticipated in 2022. While results of the this experiment are not yet fully analyzed, removal has resulted in a substantial increase in the apparent survival of spotted owls on the Hoopa Reservation in California, the longest running of the study areas in the experiment, improving by nearly 10 percent over the apparent survival for the 5 years prior to the initiation of removal (Carlson et. al. 2019, p 9). On the three study areas in Oregon and Washington, the occupancy of spotted owl sites continues to decline on the control areas where no barred owls are removed, but appears to have stabilized or increased slightly on the treatment areas where barred owls are removed. However, the number of spotted owls on these areas is very low. Statistical analysis has not been completed on these areas yet (Wiens *et. al.* 2019, pp 12-13).

5.3.1 Safe Harbor Agreements in Oregon for Barred Owl Experiment

There are currently four SHAs specific to the Service's ongoing Barred Owl Removal Experiment in Oregon. The SHAs were limited to areas managed by landowners that were willing to work with the Service to provide access for survey and removal of barred owls on their lands within the study areas. Agreements were established with Roseburg Resources Company, Oxbow I LLC, Weyerhaeuser Company, and Oregon Department of Forestry to facilitate successful completion of this research project. The Barred Owl Removal Experiment implements Recovery Action 29 of the 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a, p. III-65). The Barred Owl Removal Experiment is being implemented 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 landscapes involved in the study areas include significant interspersed private and state lands. In the Oregon Coast Ranges study area, this includes lands owned by Roseburg Resources Company and Oxbow Timber I, LLC (SHA covers 9,400 ac (3,804 ha) of land total, 308 ac (125 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued); Weyerhaeuser Company (SHA covers 1,072 ac (434 ha) total, 817 ac (331 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued), and lands managed by Oregon Department of Forestry (SHA covers 20,000 ac (8,093 ha) total, 3,345 ac (1,354 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued). In the Union/Myrtle (Klamath) study area in southern Oregon, this includes lands owned by Roseburg Resources Company (SHA covers 45,100 ac (18,251 ha) of land total, 7,080 ac (2865 ha) of currently unoccupied northern spotted owl habitat for which an incidental take permit was issued). Access on these non-Federal lands is important to the effective and efficient completion of the experiment.

Through these four SHAs, Roseburg Resources Company, Oxbow I LLC, Weyerhaeuser Company, and Oregon Department of Forestry will contribute to the conservation of the northern spotted owl by allowing the researchers to survey for barred owls on their lands throughout the Study Area, and remove barred owls from their lands within the removal portion of the experiment. The section 10 permit issued to them as part of the SHA provides these landowners with short-term incidental take authorization through habitat modification for spotted owls that may return to non-baseline northern spotted owl sites (unoccupied by resident spotted owls for the three years prior to the initiation of removal on the area) after the removal of barred owls. However, this information and 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 northern spotted owl.

5.4 Conservation Measures to Address Climate Change

Global climate change will impact northern spotted owl habitat at local, regional, and global scales, and may also indirectly impact northern spotted owl reproduction, prey abundance, and rate of population change. Many of the conservation measures for habitat discussed above have incorporated potential effects of climate change by incorporating uncertainty into assessment of future outcomes. Additionally, various international conservation initiatives developed under the United Nations Framework Convention on Climate Change to address the effects of climate change on national and global scales (UNFCCC 2015) may indirectly help to reduce the effects of climate change on the northern spotted owl. However concrete strategies for specifically addressing how to address or mitigate the effects of climate change on late-successional forest ecosystems in the Pacific Northwest have yet to be established, and no specific actions have been developed to directly address the potential impacts from climate change on northern spotted owl at this time.

Part of the Service-wide priority for responding to climate change is to conduct species and habitat vulnerability assessments, an analytical tool for determining how climate change will affect a species, habitat, or ecosystem and for developing strategies to safeguard these resources (USFWS 2009, entire). Methodologies have been developed in recent years to conduct vulnerability assessments, some of which may be useful for determining appropriate recovery actions, given the climate change effects on the northern spotted owl and its habitat (Stein 2010, video).

The 2011 Revised Recovery Plan for the Northern Spotted Owl recommends that recovery action implementation should where feasible look for opportunities where managing for northern spotted owl habitat also meets other societal priorities concerning climate change. Recovery Action 5 states that the Service will consider, analyze and incorporate as appropriate potential climate change impacts in long-range planning, setting priorities for scientific research and investigations, and/or when making major decisions affecting the northern spotted owl. The highest densities of forest biomass carbon storage in North America occur in the conifer forests of the Pacific Northwest (Sundquist *et al.* 2009, p. 5). Older forests with longer rotations may be more effective at sequestering carbon than younger, more intensively managed tree plantations (Schulze *et al.* 2000, p. 2059; Luyssaert 2008. p. 215), but all forest lands may have value for the purpose of carbon sequestration. Effectiveness in this goal may depend on very specific prescriptions and locales. Preliminary research funded by the Service indicates that forests in Oregon have tremendous potential for carbon sequestration on State forest lands in the Coast Range (Davies *et al.* 2011, p. 32), and nearby lands likely have similar potential. Likewise, managing for carbon sequestration means it is also necessary to manage forest biomass and the risks of stand replacing wildfire (Canadell and Raupach 2008, p. 1457). As of this writing it is unclear what role, if any, Federal and State forest lands will ultimately play in mitigating climate change, but some policy analysts have begun to frame this issue (see Depro *et al.* 2008, entire).

5.5 Summary of Conservation Measures

The 2011 Revised Recovery Plan of for the Northern Spotted Owl contains 14 recovery action that specifically address northern spotted owl habitat loss and degradation, ten recovery actions specifically addressing the barred owl threat, one action specifically addressing the risks from forest disease and insect outbreaks, and one specifically addressing potential effects of climate change. Recovery Actions 10 and 32 are implemented by the USFS and BLM through the NWFP and RMPs. A number of recovery actions were developed to supplement Federal conservation efforts on non-Federal land. These include the state-specific identification of strategic habitat areas, voluntary actions like HCPs and SHAs. There are 21 current and ongoing HCPs and SHAs that have incidental take permits issued for northern spotted owls. Seven HCPs and 3 SHAs are located in Washington, 2 HCPs and 5 SHAs in Oregon, and 2 HCPs and one SHA in California, with an additional SHA occurring in both Washington and Oregon. Timber harvest also continues on non-Federal lands covered under HCPs and SHAs. Although these plans do not provide a net conservation benefit to northern spotted owls, they do provide some site-specific conservation, reduce uncertainty regarding habitat loss on covered lands, and have allowed the Service to be involved in development of conservation measures on those lands. The conservation measures to address habitat loss and degradation may be helping to limit habitat loss. On all lands (both Federal and non-Federal), the overall net decrease of nesting and roosting habitat from 1993 to 2012 was approximately 3.4 percent, still less than the projected loss of 5 percent over two decades anticipated in the NWFP on Federal lands (Davis *et al.* 2016, p. 45).

The Barred Owl Removal Experiment has been underway since 2013. There are encouraging signs of a positive spotted owl response to the removal of barred owls on some study areas. For example, on all study areas the number of occupied sites on the treatment areas (where barred owls are removed) have been maintained while the number of occupied sites on the control area continue to decline. On the Hoopa treatment area, the apparent survival rate of spotted owls has increased by almost 10 percent compared to the period immediately before removal began (Carlson et. al. 2019). However, these results are limited in time and magnitude, the response of spotted owls to date is weak in terms of recruitment and reproduction on most of our study areas, and spotted owl population trends continue to decline. The continued removal of barred owls may improve these trends in the future.

Finally, there are currently no concrete strategies or specific actions to address or mitigate the effects of climate change on late-successional forest ecosystems in the Pacific Northwest or to directly address the potential impacts from climate change on northern spotted owl.

6.0 EXISTING REGULATORY MECHANISMS THAT MAY ADDRESS STRESSORS

6.1 Federal

One of the original reasons for listing the northern spotted owl was the inadequacy of the applicable regulatory mechanisms as they existed in 1990. Although there were regulatory mechanisms in place at the time, they offered variable levels of protection to northern spotted owls and, to a lesser extent, northern spotted owl habitat. Since 1994, the NWFP has been implemented on Federal lands throughout the range of the northern spotted owl, regulating the amount and location of timber harvest and silvicultural activities in northern spotted owl habitat. The Standards and Guidelines for the NWFP (USDA and USDI 1994a) prescribed an ecosystem-based approach to management for the Federal action agencies that manage these lands, and provide guidance for activities conducted on different land use allocations. Actual overall nesting and roosting habitat loss since implementation of the NWFP has been less than the 2.5 percent loss per decade on Federal reserved lands anticipated under the Plan. Nesting and roosting habitat on all Federal lands (both reserved and nonreserved) decreased from approximately 9 million ac (3.6 million ha) in 1993 to approximately 8.9 million ac (ha) in 2012, an overall net decrease of 1.5 percent. On Federal reserved lands, the overall net decrease of nesting and roosting habitat was approximately 4.0 percent, still less than the 5 percent loss over two decades anticipated in the NWFP. Therefore, the NWFP has been relatively successful at limiting habitat loss as intended. The regulations carried out under the NWFP as they pertain to the northern spotted owl have been described in detail above, primarily in sections 1.0 and 4.1. The Service continues to support the implementation of the NWFP and its associated Standards and Guidelines, as a mechanism to limit habitat loss on Federal lands. The 2011 Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) and the 2012 Revised Critical Habitat Rule for the Northern Spotted Owl (73 FR 47326) both recognize the importance of the NWFP as an overarching land management strategy for conservation of the northern spotted owl and other native species associate with late-successional forest.

On August 5, 2016, the BLM signed the Records of Decision for the Resource Management Plans of Western Oregon (RMPs). These plans were the result of a four-year effort by the BLM to use new science, policies, and technology to protect natural resources and support local communities. The Service worked closely with BLM throughout the development of the RMPs to insure that conservation needs for the northern spotted owl were incorporated into the plans. The RMPs maintain strong protections for the northern spotted owl, listed fish species, and water resources, and offers predictable and sustainable outcomes for local communities by increasing job opportunities, tourism and recreation, and timber harvest. In comparison to the NWFP land use allocations, the Late-Successional Reserve designs of the RMPs make similar contributions to the development and spacing of the large habitat blocks needed for northern spotted owl conservation. The RMPs includes approximately 177,000 more acres (71,629 ha) of LSR and RRs than in the NWFP. These land use allocations will be managed for the retention and development of large trees and complex forests across the RMP landscape. The BLM addressed the long-term habitat needs of northern spotted owls through the designation of reserved land. On reserved lands on the BLM portion of the Plan area, the amount of northern spotted owl habitat is expected to increase over the next five decades as a result of BLM's management (BLM 2016, Environmental Baseline section).

6.2 State

The majority of northern spotted owl conservation is expected from Federal lands, but the Service's primary expectations for private lands are for their contributions to demographic support (pair or cluster protection) to Federal lands, or their connectivity with Federal lands. Timber harvest on State and private lands in Washington, Oregon, and California is regulated by each State's forest practice rules. The level of northern spotted owl conservation included in each State's regulations varies Each State's rules are described below (a summary follows in Table 5).

6.2.1 Washington

The northern spotted owl was listed as endangered species in Washington State by the Washington Fish and Wildlife Commission in 1988 to prioritize conservation for the subspecies (WDFW 2017). Timber harvest on State and private lands in Washington is guided by a number of State laws and policies, except for Washington Department of Natural Resources (WDNR) lands that are covered by an HCP. The Washington State Environmental Policy Act (SEPA) requires analysis of environmental impacts and consideration of reasonable alternatives for actions proposed by the State. State timber harvest activities must also comply with the State Forest Practices Act (Chapter 76.09 RCW), which regulates all forest management activities in Washington. The management of State trust lands, specifically, is guided by the Forest Resource Plan, which was adopted by the Board of Natural Resources in 1992. Among other things, the policies of the Plan require the Washington DNR analyze and potentially modify the impacts of its activities on watersheds, wildlife habitat, special ecological features, wetlands, and other natural resources to maintain healthy forests for future generations.

In 1996, the State Forest Practices Board adopted rules (Washington Forest Practices Board 1996) that would contribute to conserving the northern spotted owl and its habitats 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 northern 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). The 1996 rules identified 10 landscapes, or Spotted Owl Special Emphasis Areas (SOSEAs) where owl protections on non-Federal lands would be emphasized. Protections provided under the State Environmental Policy Act for those portions of owl sites located beyond the boundaries of the SOSEAs were largely eliminated (Buchanan and Swedeen 2005, p. 7). The overarching policy goal of the Washington Forest Practices Rules is to complement the conservation strategy on Federal lands, and as such the SOSEAs are adjacent to Federal lands. The SOSEAs are designed to provide a larger landscape for demographic and dispersal support for northern spotted owls with the long-term goal of supporting a viable population of northern spotted owls in Washington.

The Forest Practices Rules for northern spotted owls can be described as containing three basic types of provisions: (1) regulations that apply outside SOSEAs, (2) a circle-based protection scheme for northern spotted owl sites inside SOSEAs (retain all suitable habitat within 0.7 mi (1 km) of site center and retain 40 percent of suitable habitat within 1.8 to 2.7 mi (2.9 to 4.3 km) radius of home range), and (3) landscape-level planning options for inside SOSEAs. To avoid disturbance of nesting northern spotted owls inside SOSEAs, the rules also include timing restrictions from March 1 to August 31 within 0.25 miles of a site center for several potentially disruptive activities (*e.g.*, road construction). Forest practices rules outside the SOSEAs are designed to protect the immediate vicinity of northern spotted owl site centers during the nesting season (March 1 to August 31) by restricting harvest within the best 70 ac (28 ha) of habitat around the site center and requiring additional environmental analysis for permitting (of harvesting, road construction, or aerial application of pesticides), but outside the nesting season there are no owl-related protections outside SOSEAs that constrain harvest of suitable northern spotted owl habitat in spotted owl management circles (Buchanan and Swedeen 2005, p. 14).

Within SOSEAs, the rules were intended to maintain the viability of each northern spotted owl site center by establishing that enough suitable habitat should be maintained to protect the viability of owls associated with each northern spotted owl site center, or to provide for the goals established in Spotted Owl Special Emphasis Areas. Due to extensive timber harvest activities in the decades leading up to listing of the northern spotted owl, most northern spotted owl management circles centered on non-Federal lands have far less habitat than the viability threshold identified (see below) when the rule went into effect. Because the rules do not include provisions for restoration of habitat to achieve the viability threshold at northern spotted owl sites, these circles remain far below those thresholds (Buchanan 2017, pers. comm.). For individual site centers, the habitat considered necessary to maintain viability is as follows: (a) all suitable northern spotted owl habitat within 0.7 mi (1.1 km) of each northern spotted owl site center; (b) at least 5,863 ac (2,373 ha) of suitable northern spotted owl habitat within of 2.7 mi (4.3 km) of a site center in the Hoh-Clearwater Spotted Owl Special Emphasis Area on the western Olympic Peninsula, and (c) at least 2,605 ac (1,054 ha) of suitable northern spotted owl habitat within 1.8 mi (2.9 km) of a site center in all other Spotted Owl Special Emphasis Areas. At all sites within SOSEAs, any proposed harvest of suitable northern spotted owl habitat within a territorial owl circle (status 1, 2, or 3 in the Washington Department of Fish and Wildlife database) would be considered a “Class-IV special” and would trigger State Environmental Policy Act review; such activities would require a Class IV special forest practices permit and an environmental impact statement per the State Environmental Policy Act (Buchanan and Swedeen 2005, p. 15-16).

The Forest Practices Board in Washington has a long-standing relationship with the Service and collaborates extensively on owl conservation. The Service provided extensive technical assistance in the development of the Board's existing owl rules. The Board was recognized in the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011a) for its ongoing owl conservation efforts in Recovery Action 18 encouraged to continue to use its existing processes "to identify areas on non-Federal lands in Washington that can make strategic contributions to northern spotted owl conservation over time. The Service encourages timely completion of the Board's efforts and will be available to assist as necessary." The Board convened the Northern Spotted Owl Implementation Team (NSOIT) in 2010 to develop incentives for landowners to achieve conservation goals for northern spotted owls and to identify the temporal and spatial allocation of conservation efforts on non-Federal lands; a draft product is due to be completed in 2017. The NSOIT conducted a pilot project testing different thinning prescriptions in northern spotted owl habitat but the project has since been discontinued. These efforts underway have evolved over years of collaboration and are designed to change the dynamic away from fear and resistance to partnership and participation. The Service has and is providing funding to support the work of the NSOIT. Overall, State forest practice rules in Washington provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Washington.

6.2.2 Oregon

The northern spotted owl is listed as a threatened species in Oregon (ODFW 2017). The Oregon Fish and Wildlife Commission's long-term goal for species listed as threatened or endangered under the Oregon Endangered Species Act is to manage the species and their habitats so that the status of the species improves to a point where listing is no longer necessary. Timber harvest on non-Federal lands in Oregon is guided by the Forest Practices Act and Forest Practices Rules (ODF 2014). The Oregon Forest Practices Act restricts timber harvest within 70 ac (28 ha) core areas around sites occupied by an adult pair of northern spotted owls capable of breeding (as determined by recent protocol surveys), but it does not provide for protection of northern spotted owl habitat beyond these areas (ODF 2014, pp. 61-62). In general, no large-scale northern spotted owl habitat protection strategy or mechanism currently exists for non-Federal lands in Oregon.

State forests in particular are managed to achieve "greatest permanent value," considering economics, environmental, and cultural goals. Each State Forest has a Forest Management Plan that seeks to implement these ideals. Ultimately, the State's goal is to produce timber revenue and also provide for a range of habitats across ownerships. Specific policies and procedures have been adopted on State lands to protect and conserve the northern spotted owl and its habitat. The State Forests Division has an extensive survey program across all districts as part of annual harvest planning (approximately $1.4 million spent in 2016) and conducts density surveys on two districts. Division policy directs districts to avoid any harvest activity on State lands which results in less than 40% suitable habitat within the provincial home range of an owl or pair (a 1.2-1.5-mi (1.9-2.4 km) radius circle centered on a nest site or activity center). Division policy also directs districts to avoid any harvest activity which results in less than 500 ac (202 ha) of suitable habitat within a 0.7-mi (1.1-km) or 1000 ac (405 ha) radius of a nest site or activity center. In addition, 30 percent of Oregon State forests must be managed for the development of "complex forest structure" and late-seral tree species, which could provide some level of conservation benefit for a number of wildlife species of concern, including the northern spotted owl (IEc 2012). Thirty percent of Oregon State forests must be managed for "complex forest structures" and late-seral tree species, for the benefit of a number of wildlife species. The locations of these managed lands are based in part on locations of northern spotted owl nest sites. Within these areas, a variety of treatments are employed to promote complex habitat and species diversity. Overall, State forest practice rules in Oregon provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in Oregon.

6.2.3 California

The northern spotted owl was listed as an endangered species under the California Endangered Species Act (CESA) in early 2016 (CDFW 2017). The incidental take of state-listed species is prohibited under the California Code of Regulations (783-783.8 and the California Fish and Game Code 2080 (CDFW 2016), unless permitted by an HCP. Forest management and forest practices on private lands in California, including harvesting for forest products or converting land to another use are regulated by the State under Division 4 of the Public Resources Code, and in accordance with the California Forest Practice Rules (CFPR) (California Code of Regulations, (CCR) Title 14, Sections 895-1115; CFPR) (CFPR 2017). The CFPR require surveys for northern spotted owls in nesting/roosting and foraging habitat and restrict timber harvest within 0.7-1.3 mi (1-2 km) of a northern spotted owl activity center. Under this framework, the California Department of Forestry and Fire Protection (CALFIRE) is the designated authority on forest management and forest practices on private lands in California.

All private land timber harvesting in California must be conducted in accordance with a site-specific Timber Harvest Plan (THP, for industrial timberlands) or Nonindustrial Timber Management Plan (NTMP, for non-industrial private timberland owners) that is submitted by the owner and is subject to administrative approval by the CALFIRE. The THP/NTMP must be prepared by a State-registered professional forester, and must contain site-specific details on the quantity of timber involved, where and how it will be harvested, and the steps that will be taken to mitigate potential environmental damage. The THP/NTMP and CALFIRE's review process are recognized as the functional equivalent to the environmental review processes required under the California Environmental Quality Act of 1970 (CEQA). The CFPRs require surveys for northern spotted owls in suitable habitat and to provide protection around activity centers. Under the CFPRs, no THP or NTMP 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.

For private timber lands in California not covered by a HCP or SHA, the policy of the State with regard to the northern spotted owl and timber harvest can be characterized as one of "take avoidance" for which the Service (Arcata and Yreka Fish and Wildlife Offices) has recommended measures to avoid take of northern spotted owls, primarily through recommendations for habitat retention, timing of timber operations and survey procedures for northern spotted owls (described briefly below). The Director of CALFIRE is not authorized to approve any proposed THP or NTMP that would result in take of a federally-listed species, including the northern spotted owl, unless that taking is authorized under a Federal Incidental Take Permit (review process is outlined in 14 CCR 919.9 and 919.10). This latter point creates an incentive for private landowners to enter into HCPs or SHAs, or to implement take avoidance measures recommended by the USFWS.

Prior to 2000, the California Department of Fish and Wildlife (then, California Department of Fish and Game; CDFW) reviewed THPs and NTMPs to ensure that take of northern spotted owls was not likely to occur. From about 2000 until 2010, the Service assumed this role and reviewed THPs and NTMPs (hundreds per year) for northern spotted owl "take avoidance." From 2010, the Service and CALFIRE shared duties for northern spotted owl take avoidance review of THPs and NTMPs. Beginning in 2014, the northern spotted owl was listed as a candidate species for potential listing under the California Endangered Species Act; consequently, in 2014, CDFW began reviewing a small number of THPs and NTMPs annually for northern spotted owl take avoidance. On August 25, 2016, the California Fish and Game Commission recommended that the northern spotted owl be added to the State list of threatened and endangered animals. Regarding timber harvest on private lands in California after 2016, the Service, CALFIRE and CDFW have not formally discussed how the agencies will share reviewing duties for northern spotted owl take avoidance associated with THPs and NTMPs, but recommended habitat retention standards (*i.e.*, Attachments A and B) and survey recommendations remain in effect. California is currently engaged in discussions with the Service addressing northern spotted owl use of post-fire landscapes currently lacking in the California Forest Practice Rules.

For timber harvest activities that occur on non-Federal lands (excluding California State Parks and lands covered under a HCP) within CALFIRE's Coast Forest District (generally, within the range of the coast redwood), the Service (Arcata Fish and Wildlife Office) provided to CALFIRE and foresters a document titled, *Northern Spotted Owl Take Avoidance Analysis and Guidance for California Coast Forest District ("Attachment A")*, dated March 15, 2011. In general, recommended habitat retention guidelines around known active northern spotted owl activity centers in include: (1) delineation of a 100 ac (40 ha) "Core Area" comprised of "nesting/roosting" habitat (defined in Attachment A), in which timber harvest does not occur; (2) retention of at least an additional 100 ac (40 ha) of "nesting/roosting" habitat within 0.7 mi (1.1 km) of an activity center; and (3) retention of at least 300 ac (121 ha) of "foraging" habitat (defined in Attachment A) within 0.7 mi (1.1 km) of an activity center.

For timber harvest activities that occur on non-Federal lands within CALFIRE's Interior Forest District, the Service (Arcata and Yreka Fish and Wildlife Offices) provided to CALFIRE and foresters a document titled, *Attachment B: Take Avoidance Analysis-Interior*, dated February 27, 2008. In general, recommended habitat retention guidelines around known active northern spotted owl activity centers in include: (1) no harvest within 1,000 ft (305 m) of an activity center; (2) within 0.5 mi (0.8 km) radius (502 ac (203 ha) of an activity center, retention of four habitat types (as defined in Attachment B), including at least 100 ac (40 ha) "high quality nesting/roosting" habitat, 150 ac (61 ha) of "nesting/roosting" habitat, 100 ac (40 ha) of "foraging" habitat and 50 ac (20 ha) "low-quality foraging habitat"; and (3) between 0.5 mi (0.8 km) and 1.3 mi (2 km) radius circles on an activity center (2896 ac (1172 ha)), retention of greater than 935 ac (378 ha) of habitat, including at least 655 ac (265 ha) foraging habitat and at least 280 ac (113 ha) low-quality foraging habitat. Overall, State forest practice rules in California provide some protection to northern spotted owls and their habitat. However, nesting/roosting and foraging habitat continue to decline due to timber harvest on non-Federal lands in California.

Table 5. Summary of the forestry rules that provide northern spotted owl (NSO) protections for California, Oregon and Washington (USFWS 2011a, Table III-1, as amended by ODF, pers. comm. 2017).

State	NSO Surveys Required	Habitat Requirements				Noise Disturbance Restrictions			NSO Forest Rules last updated	Exceptions
		Which spotted owl sites	Size-Location	Habitat	Duration	Zone size	Duration	Restricted Disturbance Includes		
California[1]	Yes	All	Within 0.7–1.3 mi (1-2 km) of center	Within 500 ft (152 m) of nest timber operations limited during breeding season and must retain functional nesting habitat[2]	All year as long as determine d by CAL FIRE to be a site	500 ft (152 m)	Breeding season[3]	All timber harvest operations except planting and surveying	2009 – allowed designation of independent biological consultants to fulfill evaluation role for likelihood of take	CFPRs allow for deviations with FWS review and other sec. 7 and 10
				500-1000 ft (152 to 304 m) retain functional roosting habitat[2]						
				500 ac (202 ha) spotted owl habitat in 0.7 -mile radius						
				1336 ac (541 ha) spotted owl habitat in 1.3- mile radius						
Oregon	No	Pair status sites	Operations reviewed within 0.5 mi of nest site4; restrictions within 0.25 mile. of timber operations	70 (28 ha) no cut Core around nest with the outer edge of the Core no less than 300 ft (91 m) distance from the nest	Life of circle	0.25 mi (.4 km)	Critical period[5]	Timber operations except log hauling, reforestation, road maintenance, research and monitoring, ground application of chemicals, aerial applications that do not require multiple passes, and burning	1991	
Washington	No	SOSEA	Within 0.7 mi (1 km) of site center	retain all suitable habitat [6,7]	Life of circle	0.25 mi (.4 km)	Nesting season[8]	Felling and bucking, yarding, slash disposal, prescribed burning, road construction, and other such activities (operation of heavy equipment and blasting)	1996	For landowners whose forest land ownership within the SOSEA is ≤500 ac (202 ha) and where the activity is >0.7 mi (1.1 km) of the NSO site center and sec. 7, 10 and some State planning regulations
			Within home range of 1.8-2.7 mile radius	retain 40% of suitable habitat [6,7]						
		Non-SOSEA	70 ac (28 ha) around known nest site	retain best 70 ac (28 ha)[7]	Nesting season only[8]					

1. California Forest Practice Rules (CFPRs) rely on the Service's Guidelines as presented here.
2. Nest-Roost habitat in California is generally defined as 60-90% canopy closure, multi-layered/species canopy with trees >30 inches diameter, trees with deformities, woody debris on ground and open space below canopy to allow northern spotted owls to fly.
3. Breeding season for Coastal California is defined as February 1-July 30, Interior as February 1-August 31.
4. Nest site or activity center with a pair of northern spotted owls (resident single sites not covered by rules).
5. The critical period in Oregon is defined as March 1 to September 30.
6. Suitable habitat in Washington is defined as: forest stands which meet the description of old forest habitat, sub-mature habitat or young forest marginal habitat per Washington Forest Practices Regulations (Washington Forest Practices Board 1996).
7. These thresholds are used as guidance in SEPA review and do not necessarily preclude harvest.
8. Nesting season in Washington is defined as March 1 to August 31.

6.3 Summary of Regulatory Mechanisms

Both Federal and non-Federal regulatory mechanisms are, to varying degrees, limiting habitat loss and its effect on northern spotted owl across the range of the subspecies; prior to the implementation of the NWFP and northern spotted owl recovery, habitat loss was occurring at greater levels. The NWFP has reduced the threat of current habitat loss on Federal lands through the development of habitat in reserved areas, limitations on harvest in reserved areas, and the managed reduction of suitable habitat in the non-reserved matrix areas. The NWFP has been effective at limiting the rate of habitat loss of northern spotted owl habitat on Federal lands since the 1990s; the rate of actual loss due timber harvest is less than what was anticipated under the NWFP. Since the BLM's RMPs were just finalized in 2016 they have yet to demonstrate results, however the Service believes they will likely result in a net positive impact on the recovery of northern spotted owls. The NWFP did not include mechanisms to deal with the impact of barred owl on northern spotted owl. The BLM's RMPs commit to avoiding activities that would lead to incidental take of northern spotted owls until the barred owl management program is in place.

Though the level of habitat protection varies, the states of Washington, Oregon, and California have all instituted some level of conservation measures for northern spotted owl within their forest practice rules. These measures do help to minimize effects of timber harvest on northern spotted owls, but as a whole the rules have not prevented the continued decline of nesting/roosting and foraging habitat on non-Federal land, especially in areas where nearby Federal lands are lacking and are not available to provide for the long-term conservation of the spotted owl. A number of researchers who evaluated northern spotted owl habitat use in Washington and Oregon (Buchannan 2004, p. 1342; Sovern *et al.* 2015, pp. 259-260; Glenn *et al.* 2004, p. 49), indicated that habitat conservation measures on State and private lands may not be sufficient for maintaining northern spotted owls on these non-Federal landscapes due to factors such as inadequate minimum canopy cover, allowable harvest in core areas, and lack of full protection for areas with documented owl use. Northern spotted owl recovery has been and will continue to be focused on Federal lands, but on all lands (both Federal and non-Federal), the overall net decrease of nesting/roosting habitat from 1993 to 2012 was approximately 3.4 percent, less than the 5 percent that was anticipated over two decades for Federal lands alone under the NWFP (USDA and USDI 1994a, p. 46). Habitat loss remains a stressor to the subspecies due to lag effects of past habitat loss, continued timber harvest, wildfire, and insect and forest disease outbreaks; however, the magnitude of the threat on Federal lands has been substantially reduced since the time of listing, primarily through implementation of the NWFP.

7.0 SUMMARY- STATUS OF THE NORTHERN SPOTTED OWL

We reviewed the best available scientific information regarding northern spotted owl populations and the stressors that affect the species and the forest habitat it utilizes. This information includes over 25 years of demographic monitoring and estimation of population trends at long-term study areas distributed across the range of the species; analysis of changes in amount of forest habitat available to northern spotted owls on Federal and non-Federal lands since the NWFP was established in 1994; research on impacts of the recently established barred owl on northern spotted owl site occupancy, population trends, fecundity, and habitat use; and recent studies that have considered the likely consequences of climate change for northern spotted owls.

The northern spotted owl has declined across large portions of its range since the time of listing, with the most severe declines occurring in the northern portion of the species range where barred owls have been established for the longest period of time. The rate of population decline from the most recent analysis is significant (3.8 percent per year for all areas but as high as 8.4 percent per year in parts of Washington) (Dugger *et al.* 2016, pp. 70-71), and the rate of decline increased noticeably since the 2011 5-year Review for the Northern Spotted Owl (USFWS 2011b, entire). It was expected that after an initial period of continued decline in the first 40 to 50 years of the NWFP, populations would stabilize (at a new lower level) and eventually increase in some areas as habitat recovery exceeded losses (Raphael *et al.* 1994, pp. 6-8; Raphael 2006, p. 119; Davis 2017, pers. comm.). Previous demographic analyses (Anthony *et al.* 2006, entire; Forsman *et al*. 2011, entire) suggested that the rates of decline continued range-wide after the implementation of the NWFP but then began to slow through 2009 (Burnham *et al.* 1996, entire; Dugger *et al.* 2016, p. 97). Additional years of data have since been incorporated into the demographic analyses and the negative impact of barred owls on northern spotted owls has continued to increase. Results from Dugger *et al.* (2016) suggested that rates of decline have increased range-wide since 2011 and that the proximate causes of population declines include both decreased recruitment of new owls into the population and decreased survival of owls currently in the population that were observed across most study areas. The current rate of decline raises concerns about the long-term persistence of the northern spotted owl throughout the Pacific Northwest.

We looked at the potential stressors to northern spotted owl mentioned in our previous status review and the 2012 petition from EPIC, and potential stressors based on new information. We found that the northern spotted owl is currently affected by stressors related to continued habitat loss and fragmentation and stressors related to other natural and manmade factors including barred owls and climate change. We also looked at cumulative and synergistic effects of the stressors and found that the effects of habitat loss compound the effects of barred owls on northern spotted owls, and that genetic effects resulting from small population size may be increasing as the northern spotted owl population continues to decline.

Over the last two decades, the NWFP has reduced the threat of past and current habitat loss on Federal lands through the development of habitat in reserved areas, limitations on harvest in reserved areas, and the managed reduction of suitable habitat in the non-reserved matrix areas. Alternative harvest methods such as thinning have largely replaced high impact clearcutting, therefore the degree of impact from harvest on northern spotted owl habitat is lower than in the past, and the potential for future recruitment of habitat through forest succession is higher. Wildfire is currently the primary cause of habitat loss on Federal lands; the rate and intensity of wildfire in the range of the northern spotted owl (particularly in the fire prone areas (Davis *et al.* 2016, p. 22) is expected to increase in the future under projected climate change scenarios though implementation of conservation measures such as fuels reduction help minimize this risk. Federal lands continue to provide the largest blocks of northern spotted owl habitat for maintaining populations across the range of the subspecies. Habitat loss on Federal lands remains a stressor to the subspecies due to lag effects of past habitat loss, continued timber harvest, wildfire, and insect and forest disease outbreaks, but the magnitude of the threat has been substantially reduced since the time of listing, primarily through implementation of the NWFP over the last two decades. Although intended to be responsive to stochastic events (such as wildfire), the reserve design of the NWFP did not anticipate compounding stressors such as habitat competition from the barred owl and habitat impacts from the effects of climate change.

While recovery efforts for the northern spotted owl are primarily focused on Federal land, there are portions of the range where habitat on Federal lands is lacking or of low quality or where there is little Federal ownership. For this reason, State and private lands are important to the conservation of northern spotted owl in key areas such as southwestern Washington, northwestern Oregon (potentially including parts of the Tillamook and Clatsop State Forests), and northeastern California (USFWS 2011a, p. III-51). Timber harvest on State and private lands is regulated by State forest practice rules in Washington, Oregon, and California; the level of protection provided by these rules varies, and Northern spotted owl habitat on non-Federal lands has continued to decline since the time of listing. Although recovery will continue to be focused on Federal lands, State regulatory mechanisms have not prevented the continued decline of nesting/roosting and foraging habitat on non-Federal land and this will continue to negatively affect the status of the northern spotted owl especially in areas where nearby Federal lands are lacking. Timber harvest continues under the HCPs and SHAs in place on non-Federal land, although these plans do reduce uncertainty regarding habitat loss on covered lands.

The range of the non-native barred owl now completely overlaps that of the northern spotted owl. Dugger *et al.* (2016) concluded that competition with barred owls may be the primary cause of northern spotted owl population declines across their range. They observed declines in apparent survival and increased local extinction rates of northern spotted owls in sites where barred owls were present. Apparent survival and local extinction rates appeared to be the key vital rates through which barred owls influenced northern spotted owl populations. In the Coast Range of Oregon, Wiens *et al.* (2014, p. 35) observed lower survival rates for northern spotted owls compared with barred owls based on telemetry data where fates were known for individuals that co-occurred spatially, and where no permanent emigration of northern spotted owls was observed. In contrast, northern spotted owls that had not been detected in the Green Diamond study area for many years sometimes reappeared in historical territories after the removal of barred owls (Diller *et al.* 2016, pp. 12-13). Given the high densities of barred owls that have been observed across most of the range of the northern spotted owl, Dugger *et al.* (2016, p. 98) concluded that their estimated declines in survival and increased local extinction rates of northern spotted owl territories likely reflected mortality rather than movement although both processes were likely occurring and interacting. Without implementation of management that can effectively reduce the impact of barred owls on northern spotted owl population performance, northern spotted owl populations will likely continue to decline at an accelerated rate across the range of the species. The Service has implemented a number of Recovery Actions that address the impact of barred owls on northern spotted owls, including a barred owl removal experiment to evaluate the effectiveness of removing barred owls as a strategy for conserving and recovering northern spotted owls. A positive association between barred owl removals and northern spotted owl vital rates was reported during a barred owl removal pilot project conducted on Green Diamond lands from 2009-2013 (Dugger *et al.* 2016, p. 58).

Preliminary results from the Service's ongoing barred owl removal experiment are encouraging in terms of occupancy and survival, but do not yet demonstrate a significant improvement in spotted owl population trends. Additional years of removal may decrease the uncertainty in these results. (Wiens *et al.* 2019, p. 12-13). Barred owl removal may be able to slow or reverse northern spotted owl population declines, at least on a localized scale, however it remains unclear at this time whether barred owl removal will be an effective or viable strategy for slowing and reversing declines in spotted owl populations at a larger scale.

Climate change is occurring within the northern spotted owl's entire range, with trends showing changes over time in temperature and precipitation; these changes are starting to affect the habitat of northern spotted owl (USFWS 2017, section 4.3.2). Climate change forecasts indicate significant future effects on the tree species composition of western forests over the next century, with long term implications for the composition and structure of northern spotted owl habitat. Projected changes in climate for the Pacific Northwest are likely to result in the following: increased fire risk; increased risks from forest pathogens; changes in forest structure, extent, and species composition; and northern spotted owl survival and reproduction. Hardwoods are predicted to displace conifer forests, with an expected decline in northwest California landscapes containing conifer-dominated forests of 40 to 60 percent by 2100. Such changes in forest ecosystems in the Pacific Northwest are likely to cause additional habitat stressors for northern spotted owls. A number of northern spotted owl demographic studies also noted associations between northern spotted owl demographic rates, and climate suggesting predicted climate change is likely to have negative consequences for northern spotted owls, although the magnitude of these potential impacts is unknown. Although conservation measures designed to conserve and develop northern spotted owl habitat are being implemented, there are currently no concrete strategies or specific actions to address or mitigate the effects of climate change on late-successional forest ecosystems in the Pacific Northwest or to directly address the potential impacts from climate change on northern spotted owl. The combined effects of climate change and past management practices are changing forest ecosystem processes and dynamics, the expansion of barred owl populations is altering the capacity of intact habitat to support northern spotted owls, and there is genetic evidence of recent population bottlenecks in northern spotted owls. Projecting the effects of these factors and their interactions into the future leads to even higher levels of uncertainty regarding potential impacts on northern spotted owl populations.

Data suggests the widespread use of second-generation anticoagulant rodenticides is causing the indiscriminate mortality of wildlife in forested habitats in the range of the northern spotted owl. Although toxicants are not currently a known stressor on northern spotted owls, cultivation trends appear to be increasing and the exposure risk and potential impact to northern spotted owl populations could be of concern in the future. Furthermore, the combined effects of climate change and past management practices are changing forest ecosystem processes and dynamics, the expansion of barred owl populations is altering the capacity of intact habitat to support northern spotted owls, and there is genetic evidence of recent population bottlenecks in northern spotted owls. Projecting the effects of these factors and their interactions into the future leads to even higher levels of uncertainty regarding potential impacts on northern spotted owl populations.

The most recent estimate of a 3.8 percent rate of decline of the northern spotted owl (Dugger *et al.* 2016, pp. 70-71) suggests an increase in extinction risk for this species. This risk is particularly great in the northern portion of the species' range where barred owls have been present for the longest period and rate of population decline is steepest and in the Oregon Coast Ranges where barred owl densities have increased dramatically over the past decade. If the current 3.8 percent rate of decline observed range wide for northern spotted owls continues into the future, the species will likely decline to extinction in the northern portion of its range in the near future. Additionally, northern spotted owl population simulations developed for the 2012 critical habitat rule (77 FR 71876) indicated that without a reduction in barred owl impacts on northern spotted owls, northern spotted owl populations have more than a fifty percent probability of extirpation in Washington and the Oregon Coast Ranges.

In conclusion, it is clear that northern spotted owl populations are continuing to decline and the rate of decline has increased as barred owls have become established within the range of the northern spotted owl. The current rate of decline is higher than was expected when the NWFP was established in 1994, and northern spotted owl populations on several long-term demographic monitoring areas have declined more than 70 percent since the early 1990s. The most recent range-wide northern spotted owl demographic study (Dugger *et al.* 2016) indicated that barred owls are currently the factor with the largest negative impact on northern spotted owls; however, continued habitat loss is also contributing to population declines, and changing climate may exacerbate these losses. The NWFP has conserved and developed northern spotted owl habitat on Federal lands; however, the amount of northern spotted owl habitat on non-Federal lands has decreased considerably over the past two decades. As noted above, extinction risk for northern spotted owl populations appears to have increased, particularly in Washington and Oregon, as barred owls have become established in the Pacific Northwest.

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8.1.2 Personal Communication and Email

Blackburn, Ian. 2019. July 19 Email to Robin Bown. Subject: Re: help – question. Information on the removal of spotted owls from the wild to initiate the captive breeding population in British Columbia. 1 page.

Buchanan, Joe. 2017. June 16 Email to Ron Vandervort. Subject: RE: Requesting Peer Review of Northern Spotted Owl Species Report. 3 pp. plus two attachments: SKM_C454e17061615090.pdf and CommentsDraftSpeciesStatusReport_WDFW June 2017.docx

Carroll, Carlos. 2017. June 19 Email to Ron Vandervort. Subject: RE: Requesting Peer Review of Northern Spotted Owl Species Report. 3 pp. plus two attachments: Conflict of Interest Disclosure Form_Northern Spotted Owl.pdf and Carrollpeerreview.pdf

Caruthers, Robert. 2017. April 7 telephone conversation with Jan Johnson.1 p.

Clayton, David. 2017. April 12 phone conversation with Jan Johnson. Documented in phone record notes.

Clayton, David. 2017 May 5 9:42 AM email to Jan Johnson. Subject: Larest MJ grow data

Clayton, David. 2017 May 5 6:38 PM email to Jan Johnson. Subject: FW: MjOwls in the 0.5 mile buffer group

Davis, Ray. 2017. June 20 email to Ron Vandervort. Subject: RE: Requesting Peer Review of Northern Spotted Owl Species Report. 4 pp. plus two attachments: NSOdraftSpeciesReport for Peer Review 05182017 RJD review.docx and Davis review of 2017 Status Report.docx

Gabriel, Mourad. 2017. April 10 email to Jan Johnson, Re: Fwd: tox and NSOs/barred owls 1 p. plus one attachment: Gabriel 2017 April 10 attachment.pdf 1 p. with data from Gabriel, M.W. Gabriel, L. Diller, J. Dumbaker, G.M. Wengert, J.M. Higley, R. Poppenga, and S. Mendia. 2017. In review. Exposure to rodenticides in both northern spotted and barred owls on remote forest lands in northwestern California: evidence of prey food web contamination.

Kroll, A.J. 2017. June 20 email to Ron Vandervort. Subject: RE: Requesting Peer Review of Northern Spotted Owl Species Report. 3 pp. plus two attachments: Conflict of Interest Disclosure Form_Northern Spotted Owl.pdf and USFWS NSO comments KROLL.pdf

Littell, Jeremy. 2017. September 18 to Bridgette Tuerler. Subject: Re: seeking assistance on summer water deficits - west Cascades. 2 pp. plus one attachment: McKenzie & Littell 2016 (EA).pdf

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ODF (Oregon Department of Forestry). 2017. February 10 email from Nick Palazzotto to Jody Caicco. Subject: NSO Status Report - courtesy review. Comments from both private and state forest division biologists (Nick Palazzotto and Jenniger Weikel) 2 pp. plus one attachment: NSO Draft Species Report 25Jan2017_ODFComments10Feb2017.docx

Snider, Robin. 2017. April 3, 2017 email to Jan Johnson and David Clayton. Subject: Possible information help for comments for the fisher listing........related to illegal grow sites. 2 pp plus two attachments: MJ Gardens_BLM.xlsx and MJ Cleanup Sites.xlsx

8.1.3 Federal Register Documents

55 FR 26114: Determination of Threatened Status for the Northern Spotted Owl. Final Rule. Published in the Federal Register on January 26, 1990. 26114-26194.

57 FR 1796: Endangered and Threatened Wildlife and Plants; determination of critical habitat for the northern spotted owl. Final Rule. Published in the Federal Register on January 15, 1992. 1796-1838.

58 FR 14248: Final Rule To List the Mexican Spotted Owl as a Threatened Species. Final Rule. Published in the Federal Register on March 16, 1993. 14248-14271.

73 FR 29471: Proposed Revised Designation of Critical Habitat for the Northern Spotted Owl (*Strix occidentalis caurina*). Proposed rule. In addition, this document announced that the Final Recovery Plan for the Northern Spotted Owl is available. Published in the Federal Register on May 21, 2008. 29471-29477.

73 FR 47326: Revised Designation of Critical Habitat for the Northern Spotted Owl; Final Rule. Published in the Federal Register on Federal Register on August 13, 2008. 47326-47522.

76 FR 38575: Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). Notice of document availability: revised recovery plan. Published in the Federal Register on July 1, 2011. 38575-38576.

76 FR 63719: 12-Month Finding on a Petition To List a Distinct Population Segment of the Red Tree Vole as Endangered or Threatened. Proposed Rule. Published in the Federal Register on October 13, 2011. 63720-63762.

77 FR 71876: Designation of Revised Critical Habitat for the Northern Spotted Owl. Final Rule. Published in the Federal Register on December 4, 2012. 71876-72068.

78 FR 57171: Experimental Removal of Barred Owls To Benefit Threatened Northern Spotted Owls; Record of Decision for Final Environmental Impact Statement. Notice of availability September 17, 2013. 57171-57173.

80 FR 19259. 90-Day Findings on 10 Petitions. Notice of petition findings and initiation of status reviews. Published in the Federal Register on April 10, 2015. 19259-72068.