# Draft Environmental Assessment
# Designation of Critical Habitat for the Northern Spotted Owl

**Prepared by the U.S. Fish and Wildlife Service**
**Region 1**
**Portland, Oregon**
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# 1.0 INTRODUCTION

The U.S. Fish and Wildlife Service (Service) is proposing to revise the designated critical habitat for the northern spotted owl (*Strix occidentalis caurina*) (spotted owl), under the Endangered Species Act of 1973, as amended (ESA). The northern spotted owl was originally listed as threatened under the ESA because of loss of its older forest habitat and a declining population (55 FR 26114, June 26, 1990). More recently, competition with barred owls (*Strix varia*) has emerged as a significant additional threat to spotted owl conservation (USFWS, 2011a).

Under section 3(5)(A) of the ESA, critical habitat designation identifies specific areas within the geographical area occupied by the northern spotted owl at the time it is listed that contain the physical or biological features essential to the conservation of the species and that may require special management considerations or protection. Critical habitat may also include areas outside of the geographical area occupied at the time of listing, upon a determination that such areas are essential to the conservation of the species. The current designation of critical habitat was published August 13, 2008 (73 FR 47325) and comprises 5,312, 300 acres (ac)). The Service is currently under a court order to revise critical habitat by November 15, 2012 (see Section 1.1 Purpose of and Need for Proposed Action).

Outside the jurisdiction of the U.S. Court of Appeals for the Tenth Circuit, we do not think there is a requirement to prepare environmental analyses pursuant to the National Environmental Policy Act (NEPA), 42 U.S.C. 4321 *et seq.*, in connection with designating critical habitat under the ESA for the reasons outlined in a notice published in the **Federal Register** on October 25, 1983 (48 FR 49244). This position was upheld by the U.S. Court of Appeals for the Ninth Circuit in a challenge to the first rulemaking designating critical habitat for the northern spotted owl. *Douglas County* v. *Babbitt*, 48 F.3d 1495 (9th Cir. 1995). Nevertheless, the Service decided, as a matter of discretion and not as a legal requirement, to prepare an environmental assessment on this designation prior to making a final decision.

This draft Environmental Assessment (draft EA) presents the purpose of and need for revising critical habitat designation, the proposed action and alternatives, and an evaluation of the direct, indirect, and cumulative effects of the alternatives pursuant to the NEPA of 1969 as implemented by the Council on Environmental Quality (CEQ) regulations (40 CFR 1500, *et seq.*) and according to the U.S. Department of the Interior (USDI) NEPA procedures (43 CFR 46). The final Environmental Assessment will be used by the Service in deciding whether critical habitat will be designated as proposed, if the Proposed Action requires refinement, or if further analyses are needed through preparation of an Environmental Impact Statement (EIS).

## 1.1  Purpose of and Need for the Proposed Action

To help distinguish between the purpose and need, we consider the need of the action as the underlying problem or opportunity we (the Service) must address.  The purposes are the means by which we are trying to address the underlying need for the action.

The need for this action is to designate critical habitat for the threatened northern spotted owl by November 15, 2012, in accordance with a court order in *Carpenters' Industrial Council (CIC) v.* Salazar, Civil Action No. 08-1409 (EGS) (D.D.C. Oct. 12, 2010).

One of the purposes of this action is to designate critical habitat in accordance with the ESA and its implementing regulations, which include the following:

(1) Section 3(5)(A).  This section defines critical habitat as, "the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of this Act, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection.  Section 3(5)(A) goes on to define critical habitat as, "specific areas outside the geographical area occupied by the species at the time is listed in accordance with the provisions of section 4 of this Act, upon determination by the Secretary that such areas are essential for the conservation of the species."  Our regulations also state that the Secretary shall designate areas outside the geographical area presently occupied by a species only when a designation limited to its present range would be inadequate to ensure the conservation of the species (50 C.F.R. 424.12(e)).

(2) Section 4(b)(2).  This section of the ESA states that designation of, and revisions to, critical habitat will be made, "on the basis of the best scientific data available and after taking into consideration the economic impact, the impact on national security, and any other relevant impact, of specifying any particular area as critical habitat." Section 4(b)(2) of the ESA also allows the Secretary of Interior to exclude an area from critical habitat designation if he determines, "the benefits of such exclusion outweigh the benefits of specifying such area as part of the critical habitat, unless he determines, based on the best scientific and commercial data available, that the failure to designate such area as critical habitat will result in the extinction of the species concerned."

(3) Section 4(1)(3)(B).  This section of the ESA states that the Secretary, "shall not designate as critical habitat any lands or other geographical areas owned or controlled by the Department of Defense, or designated for its use, that are subject to an integrated natural resources management plan prepared under section 101 of the Sikes

> Act (16 U.S.C. 670a), if the Secretary determines in writing that such plan provides a benefit to the species for which critical habitat is proposed for designation.”

Within the context of these statutory and regulatory requirements, our purpose is to also designate critical habitat in a way that will achieve the greatest relative conservation and recovery goals for the northern spotted owl but simultaneously minimize effects to other land and resource uses by using an efficient network design. That is, to maximize conservation value to the species while minimizing human use conflicts.

## 1.2 Previous Federal Actions

The northern spotted owl was listed as a threatened species on June 26, 1990 (55 FR 26114). On January 15, 1992, we published a final rule designating 6,887,000 ac of Federal lands in Washington, Oregon, and California as critical habitat for the northern spotted owl (57 FR 1796). Publication of this designation was in compliance with a court order in *Northern Spotted Owl v. Lujan*, 758 F.Supp. 621 (W.D.Wash. 1991).

On January 13, 2003, we entered into a settlement agreement with the American Forest Resources Council, Western Council of Industrial Workers, Swanson Group Inc., and Rough & Ready Lumber Company, to, among other things, consider potential revisions to critical habitat for the northern spotted owl. *Western Council of Industrial Workers (WCIW) v. Secretary of the Interior*, Civ. No. 02-6100-AA (D. Or.). In compliance with the settlement agreement, as amended, we published a final revised rule, which is the current critical habitat designation, on August 13, 2008 (73 FR 47325). The 2008 recovery plan for the northern spotted owl, announced on May 21, 2008 (73 FR 29471), formed the basis for the existing designation of critical habitat, which comprises 5,312,300 ac.

Both the 2008 critical habitat designation and the 2008 recovery plan were challenged in court. *Carpenters’ Industrial Council (CIC) v. Salazar*, 734 F. Supp. 2d 126 (D.D.C. 2010). In addition, on December 15, 2008, the Inspector General of the Department of the Interior issued a report entitled ‘‘Investigative Report of The Endangered Species Act and the Conflict between Science and Policy,’’ which concluded that the integrity of the agency decision-making process for the spotted owl recovery plan was potentially jeopardized by improper political influence. As a result, the Federal Government filed a motion in the *CIC* lawsuit for remand of the 2008 recovery plan and the critical habitat designation that was based on that recovery plan. On September 1, 2010, the Court issued an opinion remanding the 2008 recovery plan to us for issuance of a revised plan. The notice of availability of the final Revised Recovery Plan for the Northern Spotted Owl (hereafter referred to as Revised Recovery Plan) was published in the **Federal Register** on July 1, 2011 (76 FR 38575). On October 12, 2010, the Court remanded the

2008 critical habitat designation and adopted the Service's proposed schedule to issue a final revised critical habitat rule by November 15, 2012.

The Service published the proposed rule for revised critical habitat for the northern spotted owl (proposed revised rule) on March 8, 2012 (77 FR 14062). The Service identified and proposed to designate as critical habitat approximately 13,962,449 ac in 11 units and 63 subunits in California, Oregon, and Washington. In addition, however, the ESA provides the Secretary with the discretion to exclude areas from the final designation after taking into consideration economic impacts, impacts on national security, and any other relevant impacts of specifying any particular area as critical habitat. The alternatives presented in this draft EA are based upon several possible options considered in the proposed rule (labeled "Possible Outcomes" in the rule (77 FR 14067) based on potential exclusions of: (1) private and State lands with active conservation agreements; (2) State Parks and Congressionally reserved natural areas; and (3) all State and private lands. Exclusion of all these areas could bring the final revised designation of critical habitat to 9,390,777 ac.

## 1.3 Northern Spotted Owl

### 1.3.1 Species Description

The northern spotted owl is a medium-sized owl and the largest of the three subspecies of spotted owls currently recognized by the American Ornithologists' Union (Gutiérrez *et al*. 1995). The other two subspecies are the California spotted owl (*S. o. occidentalis*) and the Mexican spotted owl (*S. o. lucida*). The taxonomic separation of these three subspecies is supported by numerous factors (reviewed in Courtney *et al*. 2004), including genetic (Barrowclough and Gutiérrez 1990; Barrowclough *et al*. 1999; Haig *et al*. 2004; Barrowclough *et al*. 2005), morphological (Gutiérrez *et al*. 1995), behavioral (van Gelder 2003), and biogeographical characteristics (Barrowclough *et al*. 1999). The northern spotted owl is dark brown with a barred tail and white spots on the head and breast, and has dark brown eyes that are surrounded by prominent facial disks.

### 1.3.2 Distribution

The current range of the northern spotted owl extends from southwest British Columbia through the Cascade Mountains, coastal ranges, and intervening forested lands in Washington, Oregon, and California, as far south as Marin County (55 FR 26114, June 26, 1990). The spotted owl has become rare in certain areas, such as British Columbia, southwestern Washington, and the northern coastal ranges of Oregon.

For the purposes of developing the proposed revised rule, and based on the Revised Recovery Plan (USFWS 2011a), the range of the northern spotted owl was divided into 11 different regions. These regions were based on regional patterns of climate, topography, forest communities, spotted owl habitat relationships and prey base relationships across the range of the species. These 11 regions were also used as the organizing units for the designation of critical habitat (Figure 1).

### 1.3.3 Habitat

Habitat for northern spotted owls has traditionally been described as consisting of four functional types: nesting, roosting, foraging, and dispersal habitats. Recent studies continue to support the practical value of discussing northern spotted owl habitat usage by classifying it into these functional habitat types (Irwin *et al.* 2000; Zabel *et al.* 2003; Buchanan 2004; Davis and Lint 2005; Forsman *et al.* 2005). Spotted owls generally rely on primarily conifer-forested habitats that contain the structures and characteristics required for nesting, roosting, foraging, and dispersal. Forest characteristics associated with spotted owls usually develop with increasing forest age, but their occurrence may vary by location, past forest practices, and stand type, history, and condition. Although spotted owl habitat is variable over its range, some general attributes are common to the owl's life-history requirements throughout its range. To support northern spotted owl reproduction, a home range requires appropriate amounts of nesting, roosting, and foraging habitat arrayed so that nesting pairs can survive, obtain resources, and breed successfully. In addition, dispersal habitat provides for movement of owls across the landscape to maintain genetic and demographic connections among populations across the range of the species. Both the amount and spatial distribution of nesting, roosting, foraging, and dispersal habitat influence reproductive success and long-term population viability of northern spotted owls. These four habitat functions are described in detail in the revised proposed rule (77 FR 14077, March 8, 2012) and summarized here.

Nesting habitat is essential to provide structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks. Habitat requirements for nesting and roosting are nearly identical. However, nesting habitat is specifically associated with a high incidence of large trees (either live or dead) that contain platforms, cavities, or other structural features suitable for nest placement. Additional features that support nesting and roosting typically include a moderate to high canopy closure; a multilayered, multi-species canopy with large overstory trees; large accumulations of fallen trees and other woody debris on the ground; and sufficient open space below the canopy for spotted owls to fly (Thomas *et al*. 1990).

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), but does contain the remaining forest stand features.

Foraging habitat is essential to provide a food supply that will support survival and reproduction. Foraging habitat is the most variable of all habitats used by territorial spotted owls, and is closely tied to the prey base. Depending on the owl prey species available in a given portion of the range, owls in these areas may use more open and fragmented forests (see Section 1.3.4 Prey). Nesting and roosting habitat always provides for foraging, but foraging habitat may not always support successfully nesting pairs (USDI 1992).

Dispersal habitat provides for the movement of owls across the landscape. Specifically, this supports dispersing juveniles, as well as nonresident subadults and adults that have not yet recruited into the breeding population. Such movement allows genetic and demographic connections among populations across the range of the species. The survivorship of northern spotted owls is likely greatest when dispersal habitat most closely resembles nesting, roosting, and foraging habitat, but owls may use other types of habitat for dispersal on a short-term basis. Dispersal habitat, at a minimum, consists of stands with adequate tree size and canopy closure to provide protection from avian predators and at least minimal foraging opportunities (57 FR 1805, January 15, 1992).

### 1.3.4 Prey

Northern spotted owl diets vary across owl territories, years, seasons, and geographical regions (Forsman *et al.* 2001, 2004). However, four to six species of nocturnal mammals typically dominate their diets (Forsman *et al.* 2004), with northern flying squirrels (*Glaucomys sabrinus*) being a primary prey species in all areas. In Washington, diets are dominated by northern flying squirrels, snowshoe hare (*Lepus americanus*), bushy-tailed woodrats (*Neotoma cinerea*), and boreal red-backed voles (*Clethrionomys gapperi*) (Forsman *et al.* 2001). In Oregon and northern California, northern flying squirrels in combination with dusky-footed woodrats (*Neotoma fuscipes*), bushy-tailed woodrats, red tree voles (*Arborimus longicaudus*), and deer mice (*Peromyscus maniculatus*) comprise the majority of diets (Courtney *et al.* 2004; Forsman *et al.* 2004). Northern spotted owls are also known to prey on insects, other terrestrial mammals, birds, and juveniles of larger mammals (e.g., mountain beaver (*Aplodontia rufa*) (Forsman *et al.* 2001).

Because woodrats and flying squirrels are predominant components of northern spotted owl diets, the habitat limitation for these small mammals are key to understanding spotted owl habitat needs. 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). Flying squirrel densities tend to be higher in older forest stands with ericaceous shrubs (e.g., Pacific rhododendron (*Rhododendron macrophyllum*)) and an abundance of large snags (Carey 1995), and density tends to increase with stand age (Carey 1995, 2000). However, second growth stands may also have high densities of squirrels if suitable structural conditions occur (e.g., Rosenberg and Anthony 1992; Lehmkuhl *et al.* 2006b). The main 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).

### 1.3.5 Life History

Northern spotted owls are a long-lived species with relatively stable and high rates of adult survival, lower rates of juvenile survival, and highly variable reproduction. Franklin *et al.* (2000) suggested that northern spotted owls follow a “bet-hedging” life-history strategy, where natural selection favors individuals that reproduce only during favorable conditions. For northern spotted owls, demographic analyses have indicated declining trends in both adult survival and recruitment across much of the species range (Forsman *et al.* 2011).

Northern spotted owls are highly territorial (Courtney *et al.* 2004), though overlap between the outer portions of the home ranges of adjacent pairs is common (Forsman *et al.* 1984; Solis and Gutiérrez 1990; Forsman *et al.* 2005). Pairs are nonmigratory and remain on their home range throughout the year, although they often increase the area used for foraging during fall and winter (Forsman *et al.* 1984; Sisco 1990), likely in response to potential depletion of prey in the core of their home range (Carey *et al.* 1992; Carey 1995; but see Rosenberg *et al.* 1994). The northern spotted owl shows strong year-round fidelity to its territory, even when not nesting (Solis 1983; Forsman *et al.* 1984) or after natural disturbance alters habitat characteristics within the home range (Bond *et al.* 2002).

### 1.3.6 Threats

Primary threats to northern spotted owl are habitat loss and competition from barred owls (USFWS 2011a). The spotted owl was listed as threatened throughout its range “due to loss and adverse modification of spotted owl habitat as a result of timber harvesting and exacerbated by catastrophic events such as fire, volcanic eruption, and windstorms” (55 FR 26114, June 26, 1990). More specifically, threats to the spotted owl included low and declining populations, limited and 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 (USDI 1992).

In 2006, as part of the development of the Revised Recovery Plan, a panel of scientists with expertise in spotted owl biology and fire ecology identified the current threats facing the spotted owl (USFWS 2011a). Although timber harvest was greatly reduced on Federal lands since the implementation of the Northwest Forest Plan (NWFP) in 1994 (USDA and USDI 1994a), past and current habitat loss and competition from barred owls were identified as the most pressing threats to the spotted owl. In addition, climate change combined with effects of past management practices are likely exacerbating changes in forest ecosystem processes and dynamics, including patterns of wildfires, insect outbreaks and disease, to a degree greater than anticipated in the NWFP (Perry et al. 2011). While a change in forest composition or extent is likely as the result of climate change, the rate of that change is uncertain.

Spotted owl habitat loss on Federal lands rangewide was expected to be about 5 percent per decade (USDA and USDI 1994b) with the implementation of the NWFP. Recent monitoring indicates a rangewide loss of 3.4 percent, leading to the conclusion that habitat is not declining faster than predicted under the Plan (Davis and Dugger 2011). However, some physiographic provinces, particularly those that have experienced large-scale wildfires, have exceeded the 5 percent per decade threshold (Davis and Dugger 2011). The rate of habitat loss on non-federal lands exceeds that of Federal lands. During this same time period, habitat loss on Federal lands comprised 0.6 percent of the available habitat in this ownership, while habitat loss on non-federal lands was 14.9 percent of the available habitat during the same time period (USFWS 2011a).

Spotted owl survivorship and populations have continued to decline, in spite of the reduction in habitat loss (Anthony *et al*. 2006; Forsman *et al*. 2011). Although the reasons for the declines were not clear in earlier owl demographic analyses (Burnham *et al*. 1996; Franklin *et al*. 1999; Anthony *et al*. 2006), Forsman *et al.* (2011) found the presence of barred owls to be the strongest and most consistent factor contributing to declines in demographic rates. Barred owls compete with northern spotted owls for habitat and resources; they select very similar habitat to spotted owls for breeding, feeding, and sheltering. The loss of spotted owl habitat has the potential to exacerbate the situation by intensifying the competition between the two species (Dugger *et al.* 2011). While their results don't demonstrate a cause and effect relationship, Forsman *et al.* (2011) conclude that the invasion of barred owls into the range of the northern spotted owl is at least partly responsible for the continued decline of spotted owls on Federal lands, making it difficult to ensure continued persistence of the spotted owl. Proposing to designate additional critical habitat distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

Projected changes in climate are a more recent, and likely persistent threat to northern spotted owls. Hotter, drier summers and wetter nesting seasons, as predicted for the Pacific northwest, have the potential to negatively affect northern spotted owls (see section 3.4.3 Climate Change). Negative effects can manifest in reductions of nesting habitat through disturbances such as wildfire and insects that are exacerbated by the projected hotter and drier summers. Wetter nesting seasons may also result in decreased productivity through egg and nestling loss.

## 1.4 Endangered Species Act

### 1.4.1 Critical Habitat

"Critical habitat" is defined in section 3 of the ESA as:

> (1) The specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the Act, on which are found those physical or biological features
>
> > (a) Essential to the conservation of the species; and
> >
> > (b) Which may require special management considerations or protection; and
>
> (2) Specific areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species.

"Conservation," as defined under section 3 of the ESA, means to use and the use of all methods and procedures that are necessary to bring an endangered or threatened species to the point at which the measures provided pursuant to the Act are no longer necessary.

Section 4 of the ESA requires that we designate critical habitat on the basis of the best scientific and commercial data available. Under the first prong of the ESA's definition of critical habitat, areas within the geographical area occupied by the species at the time it was listed are included in a critical habitat designation if they contain physical or biological features: (1) which are essential to the conservation of the species, and (2) which may require special management considerations or protection. For these areas, critical habitat designations identify, to the extent known using the best scientific and commercial data available, those physical or biological features that are essential to the conservation of the species (such as space, food, cover, and protected habitat). In identifying those physical and biological features within an area, we focus on the principal biological or physical constituent elements (primary constituent elements (PCEs) such as roost sites, nesting structures, canopy cover, forest type, or prey base) that are essential to the conservation of the species (50 CFR 424.12(b)).

Under the second prong of the ESA's definition of critical habitat, we can designate critical habitat in areas outside the geographical area occupied by the species at the time it is listed, upon a determination that such areas are essential for the conservation of the species. In other words, an area that was not occupied at the time of listing but is nonetheless determined to be essential to the conservation of the species, for example, to support population expansion, may be included in the critical habitat designation. We designate critical habitat in areas outside the geographical area occupied by a species at the time of listing only when a designation limited to its current range would be inadequate to ensure the conservation of the species (50 CFR 424.12(e)).

### 1.4.3 Regulatory Mechanisms associated with Critical Habitat

Critical habitat receives protection under section 7 of the ESA through the requirement that Federal agencies ensure, in consultation with the Service, that any action they authorize, fund, or carry out is not likely to result in the destruction or adverse modification of critical habitat. The designation of critical habitat does not affect land ownership or establish a refuge, wilderness, reserve, preserve, or other conservation area. Such designation does not allow the government or public to access private lands. Such designation does not require implementation of restoration, recovery, or enhancement measures by non-federal landowners. Where a landowner requests Federal agency funding or authorization for an action that may affect a listed species or critical habitat, the consultation requirements of section 7(a)(2) of the ESA would apply, but even in the event of a destruction or adverse modification finding, the obligation of the Federal action agency and the landowner is not to restore or recover the species, but to implement reasonable and prudent alternatives to avoid destruction or adverse modification of critical habitat.

Decisions by the Fifth and Ninth Circuit Courts of Appeals have invalidated our regulatory definition of "destruction or adverse modification" (50 CFR 402.02) (see *Gifford Pinchot Task Force* v. *U.S. Fish and Wildlife Service*, 378 F. 3d 1059 ($9^{th}$ Cir. 2004), and *Sierra Club* v. *U.S. Fish and Wildlife Service*, 245 F.3d 434, 442 ($5^{th}$ Cir. 2001)), and we do not rely on this regulatory definition when analyzing whether an action is likely to destroy or adversely modify critical habitat. Under the statutory provisions of the ESA, we determine destruction or adverse modification on the basis of whether, with implementation of the proposed Federal action, the affected critical habitat would continue to serve its intended conservation role for the species.

If a Federal action may affect a listed species or its critical habitat, the responsible Federal agency (action agency) must enter into consultation with the Service. Examples of actions that are subject to the section 7 consultation process are actions that occur on Federal land or that are implemented by Federal agencies. Additional actions subject to the section 7 consultation process are activities on non-Federal (e.g., State and private) lands that require a Federal permit (e.g., a permit from the U.S. Army Corps of Engineers under section 404 of the Clean Water Act (33 U.S.C. 1251 *et seq*.) or a permit from the Service under section 10 of the ESA) or that involve some other Federal action (e.g., funding from a Federal agency such as the Federal Highway Administration). Federal actions not affecting listed species or critical habitat, and actions on non-federal lands that are not Federally funded or authorized do not require section 7 consultation.

As a result of section 7 consultation, we issue:

(1) A concurrence letter for Federal actions that may affect, but are not likely to adversely affect, listed species or critical habitat; or

(2) A biological opinion for Federal actions that may affect, or are likely to adversely affect, listed species or critical habitat.

When we issue a biological opinion concluding that a project is likely to jeopardize the continued existence of a listed species and/or destroy or adversely modify critical habitat, we provide reasonable and prudent alternatives to the project, if any are identifiable, that would avoid the likelihood of jeopardy and/or destruction or adverse modification of critical habitat. We define "reasonable and prudent alternatives" (at 50 CFR 402.02) as alternative actions identified during consultation that:

(1) Can be implemented in a manner consistent with the intended purpose of the action,

(2) Can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction,

(3) Are economically and technologically feasible, and

(4) Would, in the Director's opinion, avoid the likelihood of jeopardizing the continued existence of the listed species and/or avoid the likelihood of destroying or adversely modifying critical habitat.

Reasonable and prudent alternatives can vary from slight project modifications to extensive redesign or relocation of the project.

While reasonable and prudent alternatives could substantially change a proposed project and affect the economic gains from a timber project, a determination that a project would result in jeopardy or adverse modification with respect to spotted owls is an extremely rare event because: (1) the NWFP generally guides the development of Bureau of Land Management (BLM) and Forest Service actions in a manner that considers the conservation needs of the spotted owl, and (2) the consultation-streamlining procedures in place within the range of the spotted owl are likely to elevate such types of actions for resolution before a formal consultation occurs. Our consultation-streamlining process mandates that the action agency and the Service collaborate on the effects of a proposed action prior to the submission of a biological assessment. As a consequence, impacts that may rise to the level of jeopardy or adverse modification are unlikely to ever be included in a biological assessment or biological opinion under this interagency effort.

Regulations at 50 CFR 402.16 require Federal agencies to reinitiate section 7 consultation on previously reviewed actions in instances where we have listed a new species or subsequently designated critical habitat that may be affected by the action and the Federal agency has retained discretionary involvement or control over the action (or the agency's discretionary involvement or control is authorized by law). Consequently, Federal agencies sometimes may need to request re-initiation of consultation with us on actions for which formal consultation has been completed, if those actions with discretionary involvement or control may affect subsequently listed species or designated critical habitat.

Once finalized, the effect of designation of critical habitat for a listed species is to add an independent requirement that Federal agencies ensure that their actions are not likely to result in the destruction or adverse modification of that critical habitat. Thus, in areas where northern spotted owls occur, which includes most areas within units of the proposed revised critical habitat rule, Federal agencies such as the Forest Service and BLM are already consulting with the Service on the potential effects of their proposed actions, regardless of whether these lands are currently designated as critical habitat. Aside from this requirement specific to Federal agencies, critical habitat designation does not provide additional regulatory protection for a species on non-federal lands unless the activities proposed involve Federal funding or permitting (see above in this section). In other words, designation of private or other non-federal lands as critical habitat has no regulatory impact on the use of that land unless there is such a Federal connection. Identifying non-federal lands that are essential to the conservation of a species may nonetheless be relevant, in that it alerts State and local government agencies and private landowners to the value of the habitat, and may help facilitate voluntary conservation partnerships such as Safe Harbor Agreements (SHAs) and Habitat Conservation Plans (HCPs) that may contribute to the recovery and delisting of the species.

### 1.5 Scoping and Public Participation

In this draft EA we are following CEQ guidance (CEQ 2005, 2012) to focus our analysis on the most salient issue(s) that need to be addressed to make a reasoned choice between or among a "range of reasonable alternatives." The main issue we examine is related to the Purpose and Need, which includes designating critical habitat to meet the conservation and recovery needs of the spotted owl, fulfilling the statutory requirements of the ESA, all while minimizing effects to other land and resource uses by using an efficient network design. This means we have focused on effects to land-use management, wildlife and plant resources, and road and energy projects. Based on internal discussions among Service divisions regionally and nationally, and based on our experience with land-use activities by multiple landowners (Federal and non-federal) that occur within designated critical habitat for northern spotted owls throughout the range, we have assumed that other specific resource issues (such as recreation, water quality, and visual resources) are not primary issues requiring our full treatment or analysis in this draft EA. We think these issues are not likely relevant to the regulatory process of designating critical habitat (any ancillary relevance to these issues is more likely related to the current listed status of the northern spotted owl, which is not the focus of this decision), or are unrelated to the decision, and we are requesting specific public comment on this approach. This draft EA is being made available to the public for a 30-day comment period through July 6, 2012.

# 2 DESCRIPTION OF ALTERNATIVES

Acreage figures used in this analysis were derived from data in the 2012 proposed revised rule. However, as a result of parsing the proposed designation into separate ownerships and land classifications necessary for the analysis in the draft EA, accompanied by the resulting rounding errors associated with recombining the data, the total acreages for the alternatives do not equal the acres listed in Table 1 of the proposed revised rule. These differences are extremely small (less than 0.01 percent). Acres used to describe the potential critical habitat designation found in the rest of this analysis will come from Table 1 of this draft EA.

## 2.1 Alternative A - No Action Alternative

Pursuant to NEPA and its implementing regulations (40 CFR 1502.14), we are required to consider a No Action Alternative. The No Action Alternative, Alternative A, represents the current condition prior to implementation of the proposed action or any of the alternatives considered in this analysis. It is the baseline against which remaining alternatives are compared. This alternative represents the existing environment and conditions that result from the listing of the species in 1990 and the designation of critical habitat in 2008 as it applies to northern spotted owl (Figures 2-4). In 2008, we revised critical habitat for the northern spotted owl, resulting in the current designation of 5,312,300 ac of Federal lands in California, Oregon, and Washington as critical habitat (73 FR 47326, August 13, 2008).

The 2008 designation of critical habitat is limited to Forest Service and BLM lands. Units west of the Cascade Mountains were delineated based on the Managed Owl Conservation Areas (MOCA) described in the 2008 Final Spotted Owl Recovery Plan (USFWS 2008). The 2008 recovery plan did not delineate MOCAs in the Eastern Washington Cascades, Eastern Oregon Cascades, and California Cascades provinces. For these provinces, critical habitat units were based on information developed during the recovery-planning process (USFWS 2007). Further, while the MOCA network of the final 2008 recovery plan included areas of Congressionally reserved lands, such as designated wilderness areas and national parks, the 2008 critical habitat designation does not. However, the 2008 final critical habitat rule states that the contribution of the Congressionally reserved areas should be considered in any evaluation of the sufficiency of the overall habitat network for the recovery of the northern spotted owl (73 FR 47326, August 13, 2008). Current NWFP land-use allocations overlain by the 2008 critical habitat rule comprise 221,300 ac of lands with scheduled timber harvest (that is, Matrix and Adaptive Management Area). The remaining 5,091,000 acres overlay reserve land-use allocations (e.g., Late-Successional Reserve), or allocations not otherwise designated for timber harvest (e.g., Administratively Withdrawn Areas). A more detailed description of these allocations is found in section 3.1.2.2 under the heading, *Federal lands—Other Forest Service and BLM land allocations*.

Within existing critical habitat the northern spotted owl receives protections under section 7 of the ESA by prohibiting Federal agencies from implementing actions that would destroy or adversely modify critical habitat. Both within and outside of currently designated critical habitat, the northern spotted owl receives protections under section 7 of the ESA by prohibiting Federal agencies from implementing actions that would jeopardize the continued existence of the species. In addition, section 9 of the ESA prohibits take of the northern spotted owl on all lands. Finally, section 10 of the ESA would apply on non-federal lands where these landowners may request authorization from the Service for take of a listed species that is incidental to an otherwise lawful activity. These section 7 prohibitions on jeopardizing a listed species and the section 9 protections under the ESA are considered to be part of the baseline in this NEPA analysis.

**Table 1**. Acres of proposed critical habitat designation by land ownership for each alternative. Totals may not sum due to rounding errors.

| Ownership | No Action Alternative | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|---|
| **Federal Total** | **5,312,300** | **12,023,700** | **12,023,700** | **9,391,200** | **9,391,200** |
| USFS | 4,555,600 | 9,527,100 | 9,527,100 | 8,000,000 | 8,000,000 |
| BLM | 756,800 | 1,483,700 | 1,483,700 | 1,376,900 | 1,376,900 |
| NPS | 0 | 998,600 | 998,600 | 0 | 0 |
| DOD[1] | 0 | 14,300 | 14,300 | 14,300 | 14,300 |
| **State Total** | **0** | **671,000** | **446,000** | **281,200** | **0** |
| Washington | | | | | |
| DNR Lands with HCP[2] | 0 | 225,000 | 0 | 0 | 0 |
| State Parks | 0 | 100 | 100 | 0 | 0 |
| Other Washington State lands[3] | 0 | 1,800 | 1,800 | 1,800 | 0 |
| Oregon Department of Forestry | 0 | 228,700 | 228,700 | 228,700 | 0 |
| California | | | | | |
| California State Parks | 0 | 164,700 | 164,700 | 0 | 0 |
| California State Forests | 0 | 50,800 | 50,800 | 50,800 | 0 |
| **Private Total** | **0** | **1,268,900** | **557,100** | **557,100** | **0** |
| Lands in Washington with a conservation agreement | 0 | 46,000 | 0 | 0 | 0 |
| Lands in Washington without a conservation agreement[4] | 0 | 149,900 | 149,900 | 149,900 | 0 |
| Lands in California with a conservation agreement | 0 | 665,800 | 0 | 0 | 0 |
| Lands in California without a conservation agreement[5] | 0 | 407,200 | 407,200 | 407,200 | 0 |
| **Total[6]** | **5,312,300** | **13,963,600** | **13,026,800** | **10,229,500** | **9,391,200** |

[1]DOD lands would not be included in critical habitat designation under any of the action alternatives (B, C, D, or E) if Option 1 is selected, exempting DOD lands from designation. See Section 2.6.

[2]Washington State Department of Natural Resources lands under an existing Habitat Conservation Plan.

[3]Lands managed by Washington Department of Fish and Wildlife.

[4]Includes 16,000 acres of an HCP currently being developed.
[5]Includes 232,600 acres of an HCP currently being developed.
[6]Grand totals not equal to Table 1 of proposed revised rule because of rounding and because acres of non-federal lands from Tables 5 and 6 of the proposed revised rule were used.

## 2.2 Alternative B – Revise critical habitat as described in the proposed rule with no exclusions or exemptions (Proposed Action and Possible Outcome 1 as described in the proposed revised rule)

Alternative B is the critical habitat designation described in the proposed rule published in the Federal Register on March 8, 2012 (77 FR 14062, p. 14067). It is also described on page 14067 of the rule as "Possible Outcome 1." This alternative would result if the Secretary determines, following public comment and consideration of all possible exclusions and exemptions, that all of the areas proposed as revised critical habitat meet the definition of "critical habitat" and no areas are excluded or exempted from the final designation.

Under this alternative, the proposed revised designation of critical habitat for northern spotted owl would be 13,963,600 ac in 11 units and 63 subunits (Table 1, Figures 5-7). Land ownership of the proposed revised critical habitat designation includes Federal, State, and private lands. Of the Federal lands, 3,811,900 ac are in a NWFP land allocation with scheduled timber harvest (that is, Matrix and Adaptive Management Areas); the remaining Forest Service and BLM lands (7,198,900 ac) are in either a reserve allocation such as Late-Successional Reserves, or in allocations not subject to programmed timber harvest (e.g., Administratively Withdrawn Areas). A more detailed description of these allocations is found in section 3.1.2.2 under the heading, Federal lands—Other Forest Service and BLM land allocations.

Under this alternative, private lands would be designated as critical habitat in Washington and California, but not Oregon. Private lands in Oregon were considered for inclusion in the modeling that was done to compare spotted owl population performance under different habitat-reserve networks. Under the scenarios reviewed, spotted owl population performance was not improved when private lands in Oregon were included in reserve networks as compared to networks that did not include private lands in Oregon (USFWS 2011a, Appendix C; Dunk *et al.* 2012). Thus, in an effort to minimize conflicts with human uses of the land, we advanced those scenarios that did not include private lands in Oregon because they still provided similar benefits to the northern spotted owl based on relative population-performance measures.

Under this alternative, private lands are intended to be included in a critical habitat subunit only where private land is identified as a component of critical habitat in the subunit description. Some private lands (e.g., subdivisions, small (typically less than 10 ac) properties owned by individual landowners) may have been inadvertently included on the map as an artifact of both the modeling process and limitations on map resolution and accuracy, but any such private lands are not intended to be included in this alternative and we are asking for public comment to refine these maps. No Indian lands are included in this or any other alternative.

We have tentatively determined that all of the critical habitat units and subunits meet the ESA's definition of being within the geographical area occupied at the time of listing with the exception of one subunit (subunit NCO-3, located on Department of Defense (DOD) lands (Joint Base Lewis-McChord) in Washington, is considered to have been unoccupied at the time of listing but was determined essential for connectivity and additional demographic support). In addition, portions of other units contain a forested mosaic that includes some smaller areas of younger forests that may not have been occupied at the time of listing. We also recognize there may be some uncertainty regarding areas we think were occupied based on the presence of suitable habitat or dispersing owls but for which we do not have survey information. However, the proposed revised rule states that all of these areas are tentatively deemed to be essential to the conservation of the species because they fulfill at least one of two functions essential to the conservation of the species: population connectivity or space for population growth and to provide replacement in the event of disturbances such as wildfires and competition with barred owls.

We have proposed the revised designation of critical habitat for the northern spotted owl to be consistent with the most current assessment of the conservation needs of the species, as described in the 2011 Revised Recovery Plan (USFWS 2011a). The network development and network-evaluation strategy prioritized public lands when identifying lands for inclusion in the critical habitat network. That is, where modeled spotted owl population performance measures showed little difference between scenarios that included public lands only vs. those that included public and non-public lands, we selected the scenario with public lands only. This critical habitat designation approach helps meet the purpose and need (Section 1.1) through advancing northern spotted owl conservation and recovery while minimizing human use conflicts.

### 2.2.1 Primary Constituent Elements

Based on current knowledge of the life history, biology, and ecology of the northern spotted owl and the requirements of the habitat to sustain its essential life-history functions, the primary constituent elements (PCEs) as described in the March 8, 2012 proposed revised rule (77 FR 14062, 14092-14093) are summarized here:

(1) Forest types that are conifer or evergreen dominated and may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range.
(2) Habitat that provides for nesting and roosting. In many cases the same habitat also provide for foraging (PCE (3)). Nesting and roosting habitat provides structural features for nesting, protection from adverse weather conditions, and cover to reduce predation risks for adults and young.
(3) Habitat that provides for foraging, which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes

that influence vegetation structure and prey species distributions. Across most of the owl's range, nesting and roosting habitat is also foraging habitat, but in some regions northern spotted owls may additionally use other habitat types for foraging as well.

(4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs (2) or (3)), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat.

In areas occupied at the time of listing, not all of the proposed revised critical habitat will contain all of the PCEs, because not all life-history functions require all of the PCEs. Some subunits contain all PCEs and support multiple life processes, while some subunits may contain only those PCEs necessary to support the species' particular use of that habitat. However, all of the areas proposed for designation support at least the first PCE described (forest-type), in conjunction with at least one other PCE. Thus PCE (1) must always occur in concert with at least one additional PCE (PCE 2, 3, or 4).

### 2.2.2 Criteria for Defining Essential Habitat

The criteria proposed by the Service to define essential habitat are described in the proposal to designate critical habitat for northern spotted owl (77 FR 14096, March 8, 2012). In summary, in preparing the proposed rule, we assessed what is essential to recovery of the spotted owl by evaluating the relative performance of multiple potential critical habitat scenarios considered against the recovery needs of the owl, as described in the Revised Recovery Plan (USFWS 2011a). We evaluated spotted owl population metrics such as relative population size and trend to assess what is essential to owl conservation, both in terms of where and how much of the physical or biological features are essential and how much unoccupied habitat is essential to meet the recovery objectives for the owl, as defined in the Revised Recovery Plan (USFWS 2011a) and detailed in the supporting documentation (Dunk *et al.* 2012).

To accomplish this, we developed the following rule set to compare and evaluate the potential of various habitat scenarios to meet the recovery objectives and criteria for the northern spotted owl (USFWS 2011a), and thus determine what is proposed as essential habitat for the conservation of the northern spotted owl:

(1) Ensure sufficient habitat to support population viability across the range of the species.
  (a) Habitat can support an increasing or stable population trend, as measured by a population growth rate of 1.0 or greater.
  (b) Habitat will be sufficient to insure a low risk of extinction.
(2) Support demographically stable populations in each recovery unit.

    (a) Habitat can support an increasing or stable population trend in each recovery unit.
    (b) Habitat will be sufficient to insure a low risk of extinction in each recovery unit.
    (c) Conserve or enhance connectivity within and among recovery units.
    (d) Conserve genetic diversity.
    (e) Ensure sufficient spatial redundancy in critical habitat within each recovery unit.
    (f) Accommodate habitat disturbance due to fire, insects, disease, and catastrophic events.
(3) Ensure distribution of spotted owl populations across representative habitats.
    (a) Maintain distribution across the full ecological gradient of the historical range.
(4) Acknowledge uncertainty associated with both future habitat conditions and spotted owl population performance—including influence of barred owls, climate change, fire/disturbance risk, and demographic stochasticity—in assessment of critical habitat design.

In areas that we determined were occupied at the time of listing, our evaluation was focused on determining the distribution and quantity of the necessary physical and biological features that are essential to the conservation of the northern spotted owl. However, we also recognize that there may be some smaller areas of younger forest and some uncertainty regarding areas we think were occupied based on the presence of suitable habitat or dispersing owls but for which we do not have survey information. Therefore, we conclude all of these areas are essential to the conservation of the species to provide for dispersal and connectivity, and to allow space for population growth.

### 2.3 Alternative C - Revise critical habitat as described in the proposed revised rule, excluding all private and State lands with active conservation agreements (Possible Outcome 2 as described in the proposed revised rule)

This alternative would finalize critical habitat as proposed (and as described in Alternative B) with the exclusion of all private and State lands with active conservation agreements (HCPs, SHAs, and other formal agreements) currently in place (Table 2). This scenario is described as "Possible Outcome 2" in the March 8, 2012, revised proposed rule (77 FR 14067). This alternative would result if, following public comment, (1) the Secretary determines that the benefits of excluding private and State lands with formal conservation agreements that support conservation of the northern spotted owl would be greater than the benefits of including those areas in critical habitat, (2) the Secretary determines that exclusion of those areas would not result in the extinction of the species, and (3) the Secretary chooses to exercise his discretion under section 4(b)(2) of the ESA to exclude these areas from designation.

In this alternative, 46,000 ac of private land in Washington, 665,800 ac of private land in

California, and 225,000 ac of State land in Washington would be excluded; a total of 936,800 ac would be excluded, with a final designation of 13,026,800 ac (Table 1, Figures 8-10). Private lands are intended to be included in a critical habitat subunit only where private land is identified as a component of critical habitat in the subunit description. Some private lands (e.g., subdivisions, small (typically less than 10 ac) properties owned by individual landowners) may have been inadvertently included on the map as an artifact of both the modeling process and limitations on map resolution and accuracy, but any such private lands are not intended to be included in this alternative and we are asking for public comment to refine these maps.

The primary constituent elements and the criteria for defining essential habitat remain the same as that described for Alternative B.

Table 2. Lands that would be excluded from proposed critical habitat under Alternative C.

| Name of Agreement | State | Agreement Type |
| --- | --- | --- |
| Port Blakely Tree Farms | WA | Safe Harbor Agreement |
| Cedar River Watershed | WA | Habitat Conservation Plan |
| Green River Water Supply Operations and Watershed Protection | WA | Habitat Conservation Plan |
| Plum Creek Timber Central Cascades I-90 | WA | Habitat Conservation Plan |
| West Fork Timber | WA | Habitat Conservation Plan |
| Scofield Corporation | WA | Habitat Conservation Plan |
| Washington Department of Natural Resources State Lands | WA | Habitat Conservation Plan |
| Forster-Gill, Inc | CA | Safe harbor Agreement |
| Van Eck Forest Foundation | CA | Safe Harbor Agreement |
| Green Diamond Resource Company | CA | Habitat Conservation Plan |
| Humboldt Redwood Company | CA | Habitat Conservation Plan |
| Regli Estates | CA | Habitat Conservation Plan |
| Terra Springs | CA | Habitat Conservation Plan |
| Usal Forest | CA | Other Agreement |
| Big River, Salmon Creek, and Garcia Forests | CA | Other Agreement |

### 2.4 Alternative D - Revise critical habitat as described in the proposed revised rule, excluding all private and State lands with active conservation agreements, all State parks, and all Congressionally reserved natural areas (Possible Outcome 3 as described in the proposed revised rule)

This alternative would finalize critical habitat as proposed with the exclusion of all private and

State lands with active conservation agreements (HCPs, SHAs, and other formal agreements) in place, as in Alternative C, and additionally exclude all State parks, and all Congressionally reserved natural areas (e.g., wilderness areas, national scenic areas, national parks) initially considered for designation under Alternative B (See Appendix A for list of excluded Congressionally reserved natural areas). This scenario is described as “Possible Outcome 3” in the March 8, 2012, revised proposed rule (77 FR 14067). This alternative would result if, following public comment, (1) the Secretary determines that the benefits of excluding private and State lands with formal conservation agreements that support conservation of the northern spotted owl would be greater than the benefits of including those areas in critical habitat, (2) the Secretary determines that exclusion of those areas would not result in the extinction of the species, and (3) the Secretary chooses to exercise his discretion under section 4(b)(2) of the ESA to exclude these areas from designation.

This alternative would exclude the 936,800 ac described in Alternative C (State and private lands with active conservation agreements). In addition, 100 ac and 164,700 ac of State Park land in Washington and California, respectively, would be excluded. Finally, 2,632,500 ac of Congressionally reserved Federal natural areas would be excluded, of which 998,600 ac are National Park Service lands, and the remaining 1,633,900 ac are managed by the Forest Service and BLM. A total of 3,734,100 ac would be excluded under this alternative, with a final designation of 10,229,500 ac (Table 1, Figures 11-13).

Private lands are intended to be included in a critical habitat subunit only where private land is identified as a component of critical habitat in the subunit description. Some private lands (e.g., subdivisions, small (typically less than 10 ac) properties owned by individual landowners) may have been inadvertently included on the map as an artifact of both the modeling process and limitations on map resolution and accuracy, but any such private lands are not intended to be included in this alternative and we are asking for public comment to refine these maps.

The primary constituent elements and the criteria for defining essential habitat remain the same as that described for Alternative B.

### 2.5 Alternative E – Revise critical habitat as described in the proposed rule, excluding all private lands, all State lands, and all Congressionally reserved natural areas (Possible Outcome 4 as described in the proposed revised rule)

This alternative would finalize critical habitat as proposed with the exclusion of all private lands, all State lands, and all Congressionally reserved natural areas. This scenario is described as “Possible Outcome 4” in the March 8, 2012, revised proposed rule (77 FR 14068). This alternative would result if, following public comment, (1) the Secretary determines that the benefits of excluding private and State lands with formal conservation agreements that support conservation of the northern spotted owl would be greater than the benefits of including those areas in critical habitat, (2) the Secretary determines that exclusion of those areas would not result in the extinction of the species, and (3) the Secretary chooses to exercise his discretion under section 4(b)(2) of the ESA to exclude these areas from designation.

This alternative would exclude the 3,734,100 ac described in Alternative D (State and private lands with active conservation agreements, State Parks, and Congressionally reserved natural areas). In addition, all remaining State and private lands would be excluded under this alternative. State lands to be excluded under this alternative are lands managed by the Washington Department of Fish and Wildlife (1,800 ac), Oregon Department of Forestry (228,700 ac), and California State Forests (50,800 ac). Private lands to be excluded under this alternative include 149,900 ac in Washington, and 407,200 ac in California. A total of 4,572,400 ac would be excluded, with a final designation of 9,391,200 ac for this alternative (Table 1, Figures 14-16).

The primary constituent elements and the criteria for defining essential habitat remain the same as that described for Alternative B.

### 2.6 Option 1 – Exempt Department of Defense lands

This option would exempt from designation the 14,300 ac of Department of Defense (DOD) lands at Joint Base Lewis-McChord (JBLM) in Washington that is currently included in the proposed revision of critical habitat. We are considering JBLM for exemption from the designation of critical habitat under section 4(a)(3)(B) of the ESA, which states: "The Secretary shall not designate as critical habitat any lands or other geographical areas owned or controlled by the Department of Defense, or designated for its use, that are subject to an integrated natural resources management plan prepared under section 101 of the Sikes Act (16 U.S.C. 670a), if the Secretary determines in writing that such plan provides a benefit to the species for which critical habitat is proposed for designation." Our determination for exemption is pending our evaluation of JBLM's revised Integrated Natural Resources Management Plan (INRMP), scheduled for completion in 2012. The option to exempt JBLM lands may be applied to any of the action alternatives, (B, C, D, or E). Exemption of DOD lands under section 4(a)(3)(B) of the ESA is a different regulatory process than exclusion of lands under section 4(b)(2). Thus, this exemption is not currently included in any of the action alternatives (C, D, or E) that address various forms of potential exclusions under section 4(b)(2).

### 2.7 Alternatives Considered but Not Fully Evaluated

To identify and map potential critical habitat for the northern spotted owl, we, in part, used a three-step modeling framework developed as part of the Revised Recovery Plan that integrates a spotted-owl-habitat model, a habitat-conservation-planning model, and a population-simulation model. The details of this modeling framework are presented in Appendix C of the Revised Recovery Plan (USFWS 2011a), and a detailed technical description of the modeling and habitat-network-selection process we used in the proposed revised designation of critical habitat is provided in Dunk *et al*. (2012). Each of these three models helped identify an important element of the statutory definition of critical habitat: (1) the identification of physical or biological features needed by the species; (2) the distribution of those features across the geographical range of the species occupied at the time of listing; and (3) the identification of a landscape configuration where these features, as well as any necessary unoccupied areas, are essential to the conservation of the species.

We developed multiple critical habitat scenarios (USFWS 2011a, Appendix C; Dunk *et al*. 2012) and evaluated what is essential to recovery of the spotted owl by examining the performance of these scenarios against the recovery needs of the owl. Specifically, we evaluated spotted owl population metrics such as relative population size and trend to determine what physical and biological features may be essential to owl conservation, and how much unoccupied habitat is essential to conserve the spotted owl, as informed by the Revised Recovery Plan (USFWS 2011a) and detailed in our supporting documentation (Dunk *et al*. 2012). To accomplish this, we developed a rule set for the identification of critical habitat based on the ability of that habitat to meet the recovery objectives and criteria set forth in the Revised Recovery Plan (USFWS 2011a). This rule set is found above in Section 1.4.2 Criteria for Defining Essential Habitat.

In short, modeling enabled us to assess the amount and configuration of habitat essential to the conservation of the northern spotted owl, based on the relative ability of that habitat network to meet the recovery criteria of stable or increasing populations and adequate distribution of viable populations. It also helped us propose an efficient network design (that is, a network that would provide the most habitat value on the smallest land area) and allowed us to maximize reliance on public lands to achieve recovery goals, while still meeting the stated population goals essential for recovery. We consider the various network scenarios assessed in the modeling efforts as alternatives considered but not fully evaluated and include these documents in attached appendices (Dunk *et al*. 2012 is found in Appendix B of this document. Appendix C of USFWS 2011a is found in Appendix C of this document).

# 3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

In this draft EA we will evaluate the direct and indirect effects, and cumulative impacts of this proposed action, and its alternatives. We do this to determine whether the effects of the proposed action, or any of its reasonable alternatives, would have “significant” impacts to the human environment, and hence to determine whether this draft EA supports a Finding of No Significant Impact (FONSI).

“Direct effects” are defined in CEQ regulations as “[e]ffects which are caused by the proposed action and occurring at the same time and place” (40 CFR 1508.8 (a)). The direct effects of this action are to identify those areas on the landscape that provide the physical and biological features essential to the conservation of the northern spotted owl. Any action that may occur or may be required later in time is an indirect result of this action, not a direct effect.

“Indirect effects” are “caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable” (40 CFR 1508.8 (b)). Furthermore, “[i]ndirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems” (40 CFR 1508.8 (b)). Any action that is later triggered or required is an indirect effect of this action, such as an action that that triggers ESA section 7 consultation. These actions would also require NEPA compliance if they occur on Federal lands, require use of Federal funds, or otherwise have a Federal nexus. Thus, other agencies will prepare project or program-level NEPA documents for these subsequent actions. In addition, they will undertake such actions at their discretion subject to the laws and authorities under which they operate. The potential future indirect impacts of this proposed action cannot therefore be predicted in detail, in part because we have no control over these other agency mandates, requirements, and procedures, but also because the indirect effects themselves would depend on institutional reactions and behavior that we cannot precisely gauge at this time. The Service assumes that for these actions, subsequent NEPA documents will address, at the appropriate spatial and temporal scales, the direct, indirect, and cumulative impacts of future actions.

“Cumulative impact” is defined in the CEQ regulations as “[t]he impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time” (40 CFR 1508.7). CEQ guidance on cumulative effects analysis (CEQ 1997, CEQ 2005) indicates that we must only account for any other past (or present) actions that are “relevant” to the action being evaluated—that is, interrelated actions or those with a causal connection to the action. Causal connection has two prongs—the action must affect the outcome of the proposed action, or add to, modify, or mitigate its impacts. Cumulative effects assessment need only include <u>relevant</u> past actions, interrelated present actions, or reasonably foreseeable future actions and their impacts, not <u>all</u> past, present, and potential future actions. (See also 40 CFR 1502.2 regarding acquisition and disclosure of information that is “relevant to reasonably foreseeable significant adverse impacts” and that is “essential to a reasoned choice among alternatives.”)

We describe the direct and indirect effects of this action below (sections 3.1 through 3.4.3). We describe cumulative impacts in section 3.4.4.

## 3.1 Affected Environment and Environmental Consequences –Land-Use Management

This section describes the regulations and policies governing land-use management in the various ownerships overlain by critical habitat. We then describe how designation of critical habitat may alter potential use of the various ownerships. Potential effects of how changes in land use as a result of critical habitat designation may affect specific resources are described in other sections (e.g., sections 3.2 and 3.3).

### 3.1.1 Existing condition

Ownership within the proposed critical habitat units includes a mixture of private, State, and Federal lands. These lands are subject to a multitude of uses, varying by ownership and guided by land-management objectives and the overarching laws and regulations pertaining to land management in general and forest management in particular. Most State and Federal lands are open to public access. Some private industrial timberlands may be available to the public for certain activities or at certain times of years (e.g., access during hunting season). Landowners make management decisions about forest use and timber harvest, recreation use, and access. In this chapter, we are focusing on land-use management related to forest use because it is most relevant to determining the effects of the critical habitat alternatives.

Landowners make land-use decisions at their own discretion pursuant to the laws and authorities under which they operate. Forest management on Federal lands is generally regulated by the relevant agency’s organic act and other applicable statutes (e.g., National Forest Management Act for the Forest Service, Federal Land Management Policy Act and the Oregon and California Railroad and Coos Bay Wagon Road Grant Lands Act for BLM), administrative-unit management plans, and other authorities such as the ESA, Clean Water Act, and Healthy Forests Restoration Act. Natural resources on Department of Defense lands are managed in accordance with plans developed pursuant to the Sikes Act (16 U.S.C. § 670a). Washington, Oregon, and California all have forest practice rules regulating the management of most non-federal forest lands, providing varying degrees of protection for spotted owls from timber harvest and management (ODF 2008; CAL FIRE 2012; WA DNR 2012). Most State forests with managed forest resources have forest-resource-management plans that guide timber management (e.g., ODF 2001). The laws and regulations that govern land-use management can vary by ownership and by State. Below we describe the different authorities by ownership.

#### *3.1.1.1 Federal Lands (Forest Service, BLM, and National Park Service)*

There are 24,733,000 ac of Forest Service, BLM, and National Park Service lands within the range of the northern spotted owl. As many as 12,009,400 ac may be included in this critical habitat proposal (Table 1). The Forest Service and BLM manage their lands under the Northwest Forest Plan (NWFP), which was implemented in 1994 through Records of Decisions (RODs) amending their land and resource management plans (LRMPs) and resource management plans (RMPs), respectively (USDA and USDI 1994a, 1994b).

The NWFP established reserved areas (e.g., Late-Successional Reserves (LSRs), Managed Late-Successional Areas) intended to provide for conservation of late-successional associated species, including the northern spotted owl. Land allocations where programmed timber harvest is expected to occur are the Matrix and Adaptive Management Areas (AMA). In the Matrix allocation, standards and guidelines require retention of structural components (e.g., down wood, snags, and green trees) in timber sale units. Retention levels vary by area, but example quantities include leaving 120 to 240 linear feet of down logs (greater than or equal to 20 inches in diameter) per acre, and retaining 15 percent of the area associated with each cutting unit to provide green-tree structure (USDA and USDI 1994a). The AMAs were designated to, "encourage the development and testing of technical and social approaches to achieving desired ecological, economic, and other social objectives" (USDA and USDI 1994a, p. D-1). Ten AMAs were identified, each with a specific management emphasis. While timber harvest is programmed in AMAs, Matrix standards and guidelines do not apply; the intent of Matrix standards and guidelines, however, should be met, consistent with the management emphasis identified for the individual AMA (USDA and USDI 1994a).

Remaining allocations under the NWFP are areas where timber harvest is not programmed (e.g., Administratively Withdrawn Areas); these areas incorporate a wide variety of uses, from recreation and visual areas, to backcountry and other areas where management precludes scheduled timber harvest (USDA and USDI 1994a). Riparian Reserves, which are protection buffers along waterbodies, overlay all of the above land allocations.

The Revised Recovery Plan for the northern spotted owl (USFWS 2011a) recommends restoration-focused management in reserve and non-reserve areas to accommodate climate change and dynamic ecosystem processes, with the goal of maintaining or restoring forest ecosystem structure, composition, and processes so they are sustainable and resilient under current and future climate conditions. In addition, the plan recommends extra protections for older habitat and spotted owls sites in non-reserved areas (USFWS 2011a). Recovery actions recommended by recovery plans are not regulatory and are implemented at the landowner's discretion.

The current guidelines for managing the large reserves of the NWFP are aimed at creating and maintaining the habitat characteristics required by the northern spotted owl and, thus, are consistent with the objectives of the proposed critical habitat designation (USDA and USDI 1994a, b). In allocations programmed for timber harvest (Matrix and Adaptive Management Areas), the NWFP affords fewer protections to the northern spotted owl and its habitat per the NWFP than in reserve lands. The Revised Recovery Plan recommends implementing additional conservation measures, such as retaining high-quality habitat and conserving spotted owl sites, to promote spotted owl conservation and recovery (USFWS 20012). While these are discretionary actions for the Forest Service and BLM, the agencies have been implementing some of these conservation measures as part of their timber sales. For example, the agencies have been identifying and retaining high-quality habitat, which is a recovery action (Recovery Action 32) originally included in the 2008 recovery plan (USFWS 2008) that was carried forward into the current Revised Recovery Plan (USFWS 2011a) (e.g., Chapman *et al.* 2008; North Coast Planning Province Interagency Level 1 Team 2010; USDA FS and USDI BLM 2010; BLM undated). Agencies are also incorporating conservation of spotted owl sites (Recovery Action 10, USFWS 2011a), (e.g., BLM unpublished data; USFWS 2011b) although it is too early in the plan implementation to know the extent to which this measure will be applied across the range of the northern spotted owl. The Revised Recovery Plan also recommends implementing ecological forestry techniques to restore and develop structurally complex forests to benefit the spotted owl (USFWS 2011a). BLM units in southwest Oregon are developing pilot projects to test these actions. In addition, the BLM is revising its resource management plans for its western Oregon districts in part because of new science related to forest resiliency that was brought forth in the Revised Recovery Plan. Thus, Federal agencies seem to be starting to implement discretionary measures described in the Revised Recovery Plan, but it is too early to foresee the extent to which these recommendations will be applied.

Under the NWFP, post-fire salvage can occur in the Matrix, AMAs, and, to a much more limited extent, in LSRs (USDA and USDI 1994a, b). In areas where management is focused on development of spotted owl habitat (e.g., critical habitat), the Revised Recovery Plan (Recovery Action 12) recommends managing post-fire areas for, "conserving and restoring habitat elements that take a long time to develop (e.g., large trees, medium and large snags, downed wood)" (USFWS 2011a, p. III-49). Again, it is too early in the implementation of the recovery plan to know the extent to which this recommendation will be applied by the agencies.

In Congressionally Reserved areas (e.g., National Parks, wilderness areas, and national scenic areas) there is no timber harvest unless specified under the Congressional designation of these lands. Current management practices in these lands are more conservative than may be implemented in other areas designated as critical habitat. Management in some areas may include removal of hazard trees, road maintenance, as well as fire-management activities including let-burn approaches.

#### *3.1.1.2 Other Federal Lands (Department of Defense)*

Joint Base Lewis-McChord (JBLM) is an 86,500-ac U.S. Army military reservation in western Washington. This installation contains one of the largest remaining intact forest areas in the Puget Sound basin. The primary mission of the JBLM forest is to provide a variety of forested environments for military training. JBLM has a history of applying an ecosystem-management strategy to its forests to provide for multiple conservation goals, which have included promoting native biological diversity, maintaining and restoring unique plant communities, and developing late-successional (older) forest structure (INRMP 2007).

Currently, JBLM is the one unoccupied subunit of proposed revised critical habitat. This is the only substantial Federal ownership in this region of Washington and is the largest contiguous block of forest in this area as well. This subunit is expected to primarily provide connectivity between the Olympic Peninsula and the Washington Cascades; the subunit may also provide some limited demographic support. To date, JBLM has managed its forest lands with the objective of developing spotted owl habitat characteristics to provide for nesting, roosting, foraging, and dispersal habitat (INRMP 2007). The base is currently in the process of revising their INRMP. The Service has not yet seen a draft of this revision so we can't compare the revision with the current INRMP regarding any conservation benefits it may have on northern spotted owls. The Service can neither yet determine whether DOD would be exempted under section 4(a)(3)(B) of the ESA. The proposed revised rule proposes designation of 14,300 ac of critical habitat on JBLM lands (Table 1).

#### *3.1.1.3 Non-Federal Lands (primarily State and private)*

There are roughly 3,053,800 ac of State-managed lands within the range of the northern spotted owl, 671,000 ac of which were included in the proposed revised rule (Alternative B) (Table 1). Lands owned by the States under consideration for critical habitat designation are primarily managed as State Forests or State Parks, with some additional lands managed by the Washington Department of Fish and Wildlife. Of the 29,072,419 ac of private lands within the range of the northern spotted owl, as much as 1,268,900 ac were included in the proposed revised rule (Table 1). Ownership of these lands varies from individuals to industrial businesses and corporations.

Timber harvest on state and private lands is guided by a number of State laws and policies. Land-management policies, by state, for private and State-owned lands are described in depth in the draft economic analysis for the revised proposed critical habitat rule (IEc 2012) and are summarized below.

*Washington State lands*

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. Management of State Trust lands are guided by the Forest Resource Plan, which requires the Washington Department of Natural Resources (DNR) to analyze and potentially modify the effects of activities on watersheds, wildlife habitat, wetlands, and other natural resources to maintain healthy forests for future generations (IEc 2012). In addition, all Washington DNR lands included in the proposed critical habitat designation are covered by an HCP designed to provide habitat for a number of species, including the northern spotted owl (see Appendix D).

The Washington Department of Fish and Wildlife also maintains a land base where commercial timber harvest does not occur, and all harvest activities are limited to thinning. Commercial timber harvest does not occur within Washington State Parks either. Washington Department of Fish and Wildlife is currently developing an HCP for their lands that would provide conservation measures for multiple species, including the northern spotted owl.

*Oregon State lands*

Timber harvest on State lands in Oregon is guided by the Forest Practices Act and Forest Practices Rules (ODF 2008). 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. In addition, thirty 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, including the northern spotted owl (IEc 2012)

*California State lands*

The California Department of Forestry and Fire Protection (CAL FIRE) manages State forestland for research purposes and to demonstrate different forest-management techniques, including demonstrating timber harvests. Harvests are regulated by the California Forest Practices Rules

(CAL FIRE 2012). The Forest Practice Rules contain specific provisions for the protection of the northern spotted owl. California State Parks are managed by the California Department of Parks and Recreation to "administer, protect, provide for recreational opportunity, and develop the State Park System." (California State Parks 2001, p. 9).

*Private lands in Washington*

The Washington State Forest Practices Rules (Washington Administrative Code (WAC) Title 222), which guide State and private timber harvest, are administered by the Washington DNR through the Forest Practices Act of 1974 (Revised Code of Washington (RCW) Chapter 76.09). The Rules that implement the purposes and policies of the Forest Practices Act are adopted by a 13-member, multi-stakeholder Forest Practices Board (RCW 76.09.030).

The Forest Practices Board has established rules related to protection of the northern spotted owl, which included establishment of Spotted Owl Special Emphasis Areas (SOSEAs) and designation of "critical habitat (state)" for the species. Within each SOSEA, these rules establish "median home range" circles around identified owl "site centers." The ultimate goal of these management rules is to maintain the highest-quality 40 percent of habitat within each circle as such. Outside of the SOSEAs, rules are focused on protecting the habitat around identified site centers during the nesting season (IEc 2012).

Spotted owl habitat identified around owl site centers in SOSEAs is considered to be "critical habitat (state)." Timber harvest on lands identified as critical habitat state requires a "Class IV – Special" application, which triggers the State Environmental Policy Act (SEPA) (WAC 222-16-050(1)(b)), which requires an environmental review of proposed activities. All activities requiring SEPA review are considered carefully by Washington DNR prior to issuance of a timber-harvest permit. Landowners holding less than 500 ac are exempt from the requirement to submit a Class IV Special application (i.e., their land is not considered to be "critical habitat (state)") to harvest timber as long as the proposed activity will not occur within 0.7 miles of an identified spotted owl site center (IEc 2012).

*Private lands in Oregon*

Because the proposed revised rule does not include private lands in Oregon, we do not describe the regulations and policies governing land-use management on private lands in Oregon.

*Private lands in California*

Timber operations on private lands, including timber harvesting for forest products or converting land to another use other than growing and harvesting timber, are also regulated by the State in accordance with the California Forest Practice Rules and other applicable laws and regulations (IEc 2012). In order to obtain approval to harvest, landowners generally hire a registered professional forester (RFP) to prepare a Timber Harvesting Plan (THP). THPs are environmental-review documents that outline what timber will be harvested, how it will be harvested, and the steps that will be taken to prevent damage to the environment. CAL FIRE reviews THPs under the California Environmental Quality Act (CEQA). As a result of its review, CAL FIRE may recommend changes to the THP so that significant impacts to natural resources, or "take" of Federally listed species, will be avoided or mitigated (IEc 2012).

The California Forest Practice Rules prohibit CAL FIRE from approving any permit resulting in the "take" of northern spotted owl, unless such take is covered under a State or Federal incidental take permit. Project proponents may obtain an incidental take permit (ITP) from the Service, which includes developing and implementing an HCP, to satisfy the State requirements. For harvests not covered by an HCP, the California Forest Practice Rules outline procedures for avoiding spotted owl "take" and the criteria by which the potential for "take" will be evaluated. The Forest Practice Rules define "take" in terms of harm or harassment if feeding, nesting, or sheltering sites are affected. These procedures apply to actions within a Northern Spotted Owl Evaluation Area or within 1.3 miles of a known northern spotted owl activity center outside of a Northern Spotted Owl Evaluation Area. This area is generally synonymous with the range of the northern spotted owl in California and encompasses the areas proposed for critical habitat designation in California (IEc 2012, Exhibit 4-4). However, there are approximately 25,431 proposed ac of private land along the border of Sonoma and Napa Counties that fall outside the State's Northern Spotted Owl Evaluation Area. Activities on these lands are not subject to an existing HCP or conservation easement. However, given the presence of the spotted owl in these areas, these lands are likely to be subject to the northern spotted owl protections provided by the California Forest Practice Rules even though they fall outside the boundaries of the Northern Spotted Owl Evaluation Area (IEc 2012).

#### *3.1.1.4 Section 7 of the Endangered Species Act*

*Federal Actions*

In addition to the authorities and regulations in place for specific landowners described above, Federal actions that may affect the northern spotted owl or its existing designated critical habitat are analyzed individually during the section 7 consultation process (see section 1.4.3 Regulatory Mechanisms Associated with Critical Habitat). Individuals, organizations, local governments, States, and other non-federal agencies are potentially affected by this requirement only if their actions occur on Federal lands, require a Federal permit or license, or involve Federal funding (e.g., section 404 Clean Water Act permits from the U.S. Army Corps of Engineers or funding of activities by the Natural Resource Conservation Service). Designation of critical habitat does not regulate land use. It does not amend Federal or State land-management plans. It does not impose broad rules or restrictions on land use, nor does it prohibit any land-use activity. The only statutory requirement of critical habitat designation is for Federal agencies to ensure that their actions are not likely to result in the "destruction or adverse modification" of critical habitat, as that term is used in its statutory context, after consultation with the Service.

The majority of spotted owl consultations under section 7 of the ESA are between the Service and either the Forest Service or the BLM, or both agencies; the vast majority of these consultations are timber sales or timber-management projects developed under the NWFP. The Service also consults on transportation projects on State and Federal lands where there is a Federal nexus (e.g., Federal Highway Administration funding). In addition, the Service consults on energy-transmission projects and their associated rights-of-way where they may affect northern spotted owls or their designated critical habitat. These energy projects include natural-gas pipelines and electricity-transmission power lines, all of which require the complete removal of forest structure within their rights-of-way (see section 3.3 Affected Environment and Environmental Consequences – Linear Road Maintenance/Repair and Energy Transmission Projects).

In the range of the northern spotted owl, the Service has entered into a streamlined consultation agreement with the BLM and Forest Service that provides for detailed discussions prior to their submittal of a biological assessment for purposes of conducting section 7 consultation under the ESA. In this pre-consultation process the Service provides, for the action agency's consideration, advice and technical assistance for minimizing effects of the action on spotted owls and critical habitat. The final project design and implementation is at the discretion of the action agency, subject to its statutory and regulatory authorities.

*Non-Federal actions*

Currently there is no critical habitat on non-federal lands; as a result, barring any action with a Federal nexus that may affect the northern spotted owl and thus require section 7 consultation to determine whether it is likely to jeopardize the species, these landowners are subject only to the regulations under Section 9 of the act, which prohibits taking of a listed species. If landowners anticipate take of a northern spotted owl, they may obtain an incidental take permit from the Service pursuant to section 10 of the ESA. The action of issuing the permit by the Service is subject to intra-Service consultation under section 7 of the ESA, wherein the Service must consult internally over the issuance of the permit.

Incidental take permits under section 10 of the ESA have been granted to State and private landowners covering lands overlain by proposed critical habitat units; to receive these permits, these landowners have either submitted HCPs under Section 10(a)(1)(B) of the ESA, or have entered into a SHA with the Service under Section 10(a)(1)(A) (Table 2). Actions that the landowner must take or refrain from taking to either benefit the species, as in an SHA, or to minimize and mitigate take, as in an HCP, are specific to the individual SHAs and HCPs. These are summarized in the proposed revised rule (77 FR 14135-14140); the conservation benefits that these agreements provide for the northern spotted owl are described in Appendix D.

There are other non-federal lands within the boundary of proposed critical habitat units that operate under other formal agreements (e.g., conservation easements or deed restrictions) that may benefit northern spotted owl habitat. These agreements are briefly described in the proposed revised critical habitat rule (77 FR 14141-14142).

### 3.1.2 Environmental Consequences

For each of the alternatives, we describe potential effects of critical habitat designation on implementing management actions on all ownerships. Potential effects related to specific land uses as a result of critical habitat designation are described in other sections (e.g., sections 3.2 and 3.3).

#### *3.1.2.1 Alternative A (No Action)*

Under Alternative A, the No Action Alternative, 5,312,300 ac of land would remain designated as critical habitat for the northern spotted owl under the existing 2008 rule, and no additional critical habitat would be designated for this species under the ESA (Table 1). Because this is the status quo, no changes to existing land-use management would occur. Current designation of critical habitat is limited to Federal lands; most of this existing designation overlays NWFP land allocations that are reserve lands, but there are 221,300 ac of Matrix and AMA (areas allocated for timber harvest) within the 2008 designation of critical habitat. This acreage figure includes Riparian Reserves that overlay these allocations; thus, the actual area available for timber harvest is reduced from this number.

Section 7 consultations would continue for proposed actions with a Federal connection for actions that may affect the northern spotted owl as well as those that may affect designated critical habitat. While it is difficult to predict how or if specific actions would be changed to avoid adverse modification, such changes generally would be limited to those NWFP land allocations where timber harvest is programmed (221,300 ac). However, voluntary implementation of Revised Recovery Plan conservation measures may result in as little as 99,400 ac (IEc 2012, unpublished data) being subject to additional project modifications as a result of critical habitat. These acreages include Riparian Reserves that overlay these allocations, so the actual area available for timber harvest is reduced from this number. Management of these lands is described in Section 3.1.2.2 under the subheading Federal Lands—Other Forest Service and

BLM land allocations. In short, the effects on land-use management as a result of critical habitat designation under this alternative ranges from 99,400 acres if the Federal agencies choose to implement recovery actions from the Revised Recovery Plan on all of their projects, to 221,300 ac if the agencies choose not to implement the Revised Recovery Plan on any of their projects.

Because critical habitat is currently designated only on Federal lands, Alternative A does not affect non-federal lands. All landowners (Federal and non-federal) make land-use decisions at their own discretion pursuant to the laws and authorities under which they operate. On non-federal lands where the northern spotted owl itself may be affected by an activity authorized, funded, or permitted by the Federal government, section 7 of the ESA would apply. For activities on non-federal lands without a Federal nexus, section 9 would continue to apply and section 10 permits from the Service would continue to be needed if those activities may incidentally take northern spotted owls. Non-federal landowners would also continue to be subject to their respective state laws and regulations with respect to managing forest lands.

#### *3.1.2.2 Alternative B (Proposed Action)*

Under Alternative B, the Service would designate 13,963,600 ac of critical habitat for the northern spotted owl. Designation would occur on Federal, State, and private lands (Table 1). Compared with the existing critical habitat designation under the 2008 rule (Alternative A), this alternative increases the overall amount of designated critical habitat by 8,651,300 ac (6,711,400 additional acres of Federal land, 671,000 ac of State land, and 1,268,900 ac of private land). For Federal lands, the acres of allocations programmed for timber harvest included under this alternative is 3,811,900 ac, an increase of 3,590,600 ac from the No Action Alternative; this acreage figure includes Riparian Reserves that overlay these allocations, so the actual area available for timber harvest is reduced from this number.

Land ownerships subject to critical habitat designation under this alternative that were not designated under the No Action Alternative are private lands (1,268,900 ac), State lands (671,000 ac), National Park Service (998,600 ac) and Department of Defense (14,300 ac) lands. Included in the Forest Service and BLM ownership under this alternative are Wilderness Areas and other Congressionally reserved natural areas (1,633,900 ac), which are allocations that were not designated under the No Action Alternative. These additional acres would be subject to the land-use management described below in this alternative (Table 4).

*Federal lands—Department of Defense*

Joint Base Lewis-McChord in Washington (critical habitat subunit NCO-3, which comprises DOD lands in its entirety) is the only critical habitat subunit in the proposed revised critical habitat that appears to be currently unoccupied by the northern spotted owl. The Service has not identified any substantive changes from existing management necessary to meet the conservation goal and contribution of this subunit (Appendix D). Given that JBLM is not occupied by spotted owls, DOD does not currently consult on proposed actions regarding potential effects on territorial northern spotted owls. However, section 7 consultations focusing on the effects to spotted owl movement through the area may occur. Under the existing INRMP, critical habitat would not be expected to generate changes to forest management practices; however, DOD lands may be subject to new or additional section 7 consultations as a result of critical habitat designation (IEc 2012, Appendix B). The DOD is revising their INRMP for JBLM and the Service is working with them to ensure the revision continues to meet the conservation needs of the northern spotted owl. However, we do not yet know how the revision will affect northern spotted owls. Consequently, we can't yet determine whether the revised INRMP will provide the necessary conservation benefits for spotted owls to meet the exemption provisions of section 4(1)(3)(B) of the ESA and, if not, how a potential designation of critical habitat may affect land-use management on JBLM. We will incorporate any additional information gained between now and the final EA into our final document.

*Federal lands—National Park Service and other Congressionally Reserved lands*

Currently, there are no Congressionally reserved areas designated as critical habitat under the 2008 rule. Congressionally reserved areas, as described in the 2012 proposed revised rule, include NPS lands, as well as Wilderness Areas, National Scenic Areas, and other Congressionally reserved allocations on Forest Service and BLM lands. There are currently no logging and no active forest-management practices on NPS lands (IEc 2012). Timber harvest is not allowed in other areas unless specified by Congress. Current management practices on Congressionally reserved lands are generally consistent with the conservation needs of the northern spotted owl (IEc 2012, Appendix C; 77 FR 14062).

While critical habitat is not expected to generate changes to forest management, actions on NPS ownership and other non-Wilderness lands may be subject to new or additional section 7 consultations as a result of critical habitat designation. For example, activities that may involve section 7 consultation include the construction or maintenance of visitor facilities and access roads to projects. Given the statutory purpose of Wilderness Areas, it is unlikely that activities proposed in these areas would affect critical habitat.

*Federal lands—Other Forest Service and BLM land allocations*

The effects of designating critical habitat on Forest Service and BLM lands that are not Congressionally reserved will depend on the land allocation and the planned activities that may have otherwise occurred in these allocations. All BLM and Forest Service lands within the proposed revised critical habitat are managed under the RMPs and LRMPs that incorporated the standards and guidelines of the NWFP (USDA and USDI 1994a, b). Under the NWFP, BLM and Forest Service timber-harvest practices on LSRs are consistent with proposed critical habitat objectives as these lands are currently being managed for the benefit of the spotted owl and other species associated with old-growth. The NWFP also restricts or limits timber harvest on Riparian Reserves, consistent with proposed critical habitat objectives. Therefore, reserved lands are not likely to experience any changes in proposed land management as a result of critical habitat designation.

Matrix and AMA allocations, wherein timber harvest is programmed under the NWFP (3,811,900 ac), are the allocations wherein project modifications are relatively more likely to occur as a result of critical habitat designation. However, we know that the agencies have been implementing discretionary conservation measures from the Revised Recovery Plan (section 3.1.1.1). These measures provide conservation benefits to high-quality habitat and spotted owl sites on all allocations, including those programmed for timber harvest. If agencies were to apply these discretionary measures on all projects, then additional project modifications specific to critical habitat designation may affect only a subset of Matrix and AMA allocations; specifically younger stands and unoccupied spotted owl habitat, which result in as few as 1,389,800 ac being affected under this alternative (IEc 2012).

Specific project modifications that may be incorporated to avoid destruction or adverse modification of critical habitat in these allocations programmed for timber harvest would be at the discretion of the action agency consistent with their land-use plans and statutory authorities; modifications may range from none, to relatively minor changes, to avoidance of the action altogether. Determining the specific modification is speculative, and not reasonably foreseeable. In addition, while the agencies have a history of implementing recovery actions form the Revised Recovery Plan that provide additional conservation benefits to the northern spotted owl in lands programmed for timber harvest, the degree to which they may continue to apply them is unknown. Because we cannot reasonably foresee the degree and extent to which the agencies will continue to apply discretionary conservation measures, we consider a range of potential changes in land-use management that the agencies may experience under this alternative. If the agencies choose not to apply voluntary conservation measures from the Revised Recovery Plan, land-use changes may occur on all of the lands programmed for timber harvest (3.8 million ac), although, as stated above, determining specific changes as a result of critical habitat designation is speculative at this time; conversely, if the agencies choose to apply conservation measures described in the Revised Recovery Plan, then land-use changes may only affect a subset of lands programmed for timber harvest (1,389,800 ac).

Recovery Action 12 is another discretionary conservation recommendation from the Revised Recovery Plan that could be implemented by the Forest Service and BLM. This recovery action relates to post-fire salvage management, and recommends “conserving and restoring habitat elements that take a long time to develop (e.g., large trees, medium and large snags, downed wood)" in "lands where management is focused on development of spotted owl habitat" (USFWS 2011a). A critical habitat designation may be considered as "lands where management is focused on development of spotted owl habitat," thus action agencies may decide to modify projects that would otherwise occur in Matrix allocations under this Recovery action. Therefore, changes in management may occur for fire salvage projects in proposed critical habitat on land allocations subject to programmed timber harvest if the agencies opt to follow recommendations of the Revised Recovery Plan. Implementing the Revised Recovery Plan would be at the discretion of the land manager. Because the timing, extent, and severity of fire events are not predictable, we cannot provide acreages of Federal land that would fall into this category and be affected by critical habitat. Likewise, for reasons stated above, we cannot assess the degree to which the agencies will follow recommended actions from the Revised Recovery Plan.

Where the Federal action agency has retained discretionary involvement or control over the project, existing consultations on projects that may affect the proposed spotted owl critical habitat will need to be reinitiated once critical habitat has been designated. By minimizing the impacts of proposed projects to the spotted owl we consider it likely that we have also minimized the impacts to the proposed critical habitat network, since many (but not all) of the minimization actions overlap both the species and its important habitat. This is most likely true in areas of spotted owl habitat that were considered occupied during the original consultation. In younger stands or areas unoccupied by northern spotted owls (i.e. 1,389,800 ac described above), effects of these projects on habitat may not have been minimized and could result in additional project modification to avoid destruction or adverse modification of critical habitat.

In summary, for Federal lands, of the approximately 12.0 million ac of Federal lands proposed for critical habitat designation, a range of approximately 1.4 million (implementing Revised Recovery Plan on all actions) to 3.8 million ac (not implementing Revised Recovery Plan) could potentially experience some changes in land-use management as a result of designation of critical habitat. Compared with the No Action Alternative, this is an increase of approximately 1.3 to 3.6 million ac. This range in acres includes Riparian Reserves that overlay these allocations, so the actual area exposed to any potential change in management is reduced from this number. An unquantifiable amount of Forest Service and BLM land may also be subject to additional conservation measures where future high-severity fires may occur should the agencies follow the recommendations of the Revised Recovery Plan.

Federal agencies are legally obligated to avoid the destruction or adverse modification of critical habitat; however, the means by which they choose to do so is at the agency's discretion, subject to the laws and management authorities under which they operate, and is not mandated by the critical habitat designation itself. By designating critical habitat, the Service is not dictating how the action agencies manage (i.e., the Service is not mandating ecological forestry or active forest management), nor is the Service changing existing agency management plans. There is a wide spectrum of management options that action agencies may choose to implement to avoid adverse modification of critical habitat, ranging from no projects, passive restoration actions such as closing roads or allowing for wildland fire use, or applying silvicultural treatments that meet ecological-forestry principles recommended in the Revised Recovery Plan. The Service cannot predict which of these or what combination of these, if any, the action agencies will pursue in critical habitat; as such, the effects of these actions are not reasonably foreseeable and we cannot analyze them. These subsequent actions will be subject to NEPA and ESA compliance, at which time, project- or program-specific analyses can occur.

*Non-Federal (primarily State and private) lands – Federal nexus*

For the purpose of this analysis, we divided effects of critical habitat designation on non-federal lands into two general categories. One category includes effects of the regulatory requirement of section 7 on these lands should a Federal nexus occur (that is, the landowner implements a project that is Federally funded or requires Federal authorization). The second category includes all other effects that are not necessarily tied to a Federal nexus. One example may be additional regulatory requirements implemented by a State agency. These two categories are not mutually exclusive.

The effects of critical habitat designation on non-federal lands where a Federal nexus occurs stem from the consideration of the potential for destruction or adverse modification of critical habitat during the section 7 consultations. Prohibitions under Section 9 of the Act making “take” unlawful apply only to the species, not to critical habitat. Thus, non-federal lands may be affected by the designation of critical habitat only if a Federal nexus exists—that is, the action either requires a Federal permit or other Federal approval, or receives Federal funding (see section 1.4.3 Regulatory Mechanisms Associated with Critical Habitat). Where there is a Federal nexus, the Federal agency (and non-federal project proponent if they seek applicant status) may need to consult with the Service under section 7 of the ESA, and may need to make modifications to their project to avoid “destruction or adverse modification” of critical habitat. Based on the Service’s work with non-federal lands, there is a low likelihood of there being a Federal nexus on many of these lands (see Appendix D).

Re-initiation of existing consultations may also occur to consider the potential for the project to adversely modify critical habitat. However, by minimizing the effects of proposed projects to the spotted owl and its habitat during the initial consultation, it is likely that effects to the proposed critical habitat network have also been minimized because many, though not all, of the minimization actions overlap both the species and its important habitat. Thus, additional project modifications are not anticipated to result from such consultations because project effects should have already been minimized during the initial consultation on the species (IEc 2012, Appendix

B). In younger stands or areas unoccupied by northern spotted owls effects of these projects on habitat may not have been minimized and could result in additional project modification to avoid destruction or adverse modification of critical habitat. For existing HCPs and SHAs, however, this is unlikely given the existing conservation provisions in the current agreements (Appendix D).

*Non-Federal (primarily State and private) lands – other effects*

As a result of critical habitat designation, additional effects on projects without a Federal nexus may include a State permitting agency altering its own requirements relative to land-use management on private lands to further protect the habitat in question. These changes may result in additional changes to land use associated with carrying out that activity in compliance with new regulations. In other cases, designation of one's property may result in concern or uncertainty about potential future regulation, altering the decisions made about uses of that land. We assess each of these effects below.

*Effects on State lands as a result of changes in State management*

Informational interviews with State agencies currently involved in managing timber harvest on State and private lands in Washington, Oregon, and California were conducted as part of the economic analysis. Managers in all three states concluded that they do not anticipate revising current management practices on State lands as a result of critical habitat overlaying their land (IEc 2012). Managers further concluded that their current management efforts are sufficient to protect northern spotted owls. In addition, timber harvest does not occur on lands managed by the Washington Department of Wildlife, or in Washington State Parks, and it is not anticipated to occur in California State Park lands; therefore, no change in land-use management is expected to occur on these lands.

Hence, for the approximately 671,000 ac of State lands proposed for designation of critical habitat, State agencies do not anticipate altering management on any of these lands in response to critical habitat designation (IEc 2012). In addition, the Service's assessment of effects of critical habitat designation on State lands indicates that a change to management is not likely (Appendix D). Thus, we conclude that land-use management on State lands is unlikely to be affected by the designation of critical habitat for the northern spotted owl.

*Effects on private lands as a result of changes in State management*

***Washington***. As part of interviews with Washington Department of Natural Resources representatives (IEc 2012), they would not speculate on the likelihood of any specific modification to the State Forest Practices Rules that might occur in response to the designation of critical habitat on private lands in Washington. Modification to the State Practices Rules to enact any such response is the decision of the State Forest Practices Board (IEc 2012). Instead, DNR officials described two scenarios that describe the range of additional restrictions that could be implemented by the State Forest Practices Board in response to the designation of critical habitat (IEc 2012):

- **Scenario 1: No changes.** Under this scenario, the Forest Practices Board reviews the Services' critical habitat designation and sees that the private lands proposed all fall within State-designated SOSEAs. The Board concludes that current Forest Practices Rules are in line with the Service's intent, and makes no changes to the Forest Practices Rules.
- **Scenario 2: Re-designation of "critical habitat state."** Under this second scenario, which represents perhaps the most restrictive possible response of the State, the Forest Practices Board designates all suitable habitat within the SOSEAs overlapping Federal critical habitat as "critical habitat state" and rewrites the SEPA guidelines such that harvest on any suitable habitat within the SOSEAs likely necessitates an EIS. As a result, harvest of any suitable spotted owl habitat within a SOSEA overlapping Federal critical habitat (not just within a median home range circle) will require a Class IV Special application, which triggers SEPA and likely leads to a need to develop an EIS. As a result, landowners may experience an administrative burden to develop the state-required EIS. They may also choose to forego any management activities. However, these scenarios are speculative and we cannot reasonably foresee what any given landowner may choose to do. Existing exemptions for landowners holding less than 500 ac would continue.

Of the private lands in Washington that are overlain by proposed critical habitat in this alternative, 421 ac have an approved SHA, and 45,539 ac are covered by existing HCPs. Private lands with an approved HCP or SHA are effectively exempted from the SOSEA/Median Home Range Circle requirements, as the State determines that the landowner has provided conservation for the northern spotted owl in a different manner that has been approved by Service. As such, they do not anticipate modifying how timber harvest is carried out on those lands (IEc 2012). Furthermore, the Service has not identified any additional regulations that may be implemented by the states as a result of critical habitat designation (Appendix D). Hence, we do not anticipate designation of critical habitat to result in modification of land-use activities by private landowners in Washington with completed HCPs or SHAs.

The balance of proposed private lands (149,900 ac) all fall within the State's Spotted Owl Special Emphasis Areas. It is unknown whether the State Forest Protection Board would place additional restrictions on these lands as a result of critical habitat designation. Furthermore, it is unknown what these restrictions would be, if any, and how any potential restriction may alter land-use management. The Service did not identify any additional regulations that could be implemented by the State of Washington on lands without conservation agreements (Appendix D). Potential State action is speculative and thus, it is not reasonably foreseeable to analyze changes in management of private lands in Washington that do not have completed HCPs or SHAs.

***California***. A total of 1,073,000 ac of private land are proposed for designation in California. Of these, activities on 665,800 ac are already covered by final HCPs, SHAs, or conservation easements. Formal conservation agreements are not in place for the remaining 407,200 ac (including 211,700 ac where an HCP is currently being developed). All private lands, whether or not formal agreements are in place, must comply with the California Forest Practice Rules; CAL FIRE is unlikely to request additional protective measures for habitat beyond those already required by these regulations (IEc 2012). In addition, the Service did not identify any additional protection measures that could be implemented by the State of California (Appendix D). Thus, project modification resulting from changes in State approval of THPs appears unlikely.

*Additional potential effects on private lands*

A variety of other effects could occur on private lands as a result of critical habitat designation. Per interviews with private parties (IEc 2012), the following changes in timber harvest could occur as a result of regulatory uncertainty related to the protection of northern spotted owls and their habitat:

- Harvesting existing trees as early as is economically feasible to capture their financial value in advance of presumed future regulatory limits;
- Maintaining shorter harvest rotations, which results in younger forest stands, thereby ensuring that suitable northern spotted owl habitat does not develop on private property and trigger possible additional regulation; or
- Discontinuing the use of private property for timber production and switching to development or other land uses to protect against possible future regulation that limits the property's timber production potential.

Although concerns about the ability of the landowner to sell their property were raised as a potential result of critical habitat designation, the Service did not identify any instances in which regulatory uncertainty may result in a change in land-use management (Appendix D). Furthermore, the Service noted that designation of critical habitat was unlikely, if at all, to provide an inducement to prematurely harvest existing habitat because State regulations barring take of spotted owls would still be in effect and limit such activity (Appendix D).

Landowners may also choose to enter into a conservation partnership with the Service through development and approval of an HCP or SHA; this would allow the landowners some control over the measures that will be employed to protect the spotted owl and its habitat, and some certainty regarding potential future regulation. For lands not currently covered by a conservation agreement, this was consistently identified by the Service as a potential effect of critical habitat designation (Appendix D).

This list of potential responses to critical habitat designation encompasses a range of potential actions and is speculative. There is a high degree of uncertainty as to which, if any, of these measures landowners may implement. Consequently, we are unable to reasonably foresee potential effects from these outcomes and are unable to analyze them further as part of this analysis.

*Summary of effects on Private lands*

In total, the Service is considering designating critical habitat on 1,268,900 ac of private land in Washington and California under this alternative. These lands are not designated under the No Action Alternative. No private land in Oregon is proposed for designation under this alternative. No change in land use is expected on the private lands in California (1,073,000 ac), whether or not these lands have formal conservation agreements in place. In Washington, no changes in land use are expected to occur on the 46,000 ac of lands with completed HCPs and SHAs. Changes in land use may be possible on the remaining 149,900 ac without completed HCPs and SHAs, but it is speculative as to what restrictions, if any, may be enacted by the State Forest Practices Board, and how land use may change as a result. Likewise, we cannot reasonably foresee how regulatory uncertainty may affect land management on private lands, as potential responses by landowners are speculative. For the 557,100 ac of private lands without formal conservation agreements in both states, landowners may choose to develop HCPs, SHAs, or other formal conservation agreements, but we cannot reasonably foresee the number and types of agreements that may be developed, or the extent of area the agreements may cover.

#### ***3.1.2.3 Alternative C (Outcome 2 in proposed revised rule)***

Under Alternative C, 13,026,800 ac of critical habitat may be designated on Federal, State, and private lands. However, private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation. This is a reduction in private and State lands of 936,800 ac from the 1,939,900 ac proposed under Alternative B. Private and State Lands that would be excluded under this alternative are listed in Table 2.

This alternative would increase the overall amount of designated critical habitat by 7,714,500 ac (6,711,400 additional acres on Federal land, 446,000 ac on State land, and 557,100 ac of private land) as compared to the No Action Alternative; for Federal lands, the acres of lands subject to programmed timber harvest increase by 3,590,600 ac.  Land ownerships subject to critical habitat designation under this alternative that were not designated under the No Action Alternative are private lands (557,100 ac), State lands (446,000 ac), National Park Service (998,600 ac) and Department of Defense (14,300 ac) lands.  In addition, Wilderness Areas and other Congressionally reserved natural areas on Forest Service and BLM lands (1,633,900 ac) are allocations that were not designated under the No Action Alternative but would be designated under this alternative.  These additional acres would be subject to the land-use management described below in this alternative (Table 4).

*Federal lands—all agencies*

The consequences to Federal land management under this alternative would be as described in Alternative B.

*State lands*

Under this alternative 225,000 ac of State lands in Washington would be excluded from designation of critical habitat.  While this alternative would have fewer State lands designated as critical habitat, the effect on land-use planning on the remaining 446,000 ac without formal conservation agreements would be much the same as Alternative B, wherein it was determined that management efforts would likely not change from the status quo on State lands were they to be designated critical habitat (see section 3.1.2.2) (IEc 2012).

*Private lands*

This alternative would exclude 711,800 ac of private lands in Washington (46,000 ac) and California (665,800 ac) from designation of critical habitat.  Effects on land use for the remaining private lands are as described in Alternative B for lands without HCPs, SHAs or other formal agreements.

#### ***3.1.2.4  Alternative D (Outcome 3 in proposed revised rule)***

Under Alternative D 10,229,500 ac of critical habitat would be designated on Federal, State, and private lands.  As in Alternative C, private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation.  In addition, State Parks would be excluded as part of this alternative.  Also, Congressionally reserved Federal lands (e.g., Wilderness areas, National Park Service lands, Wild and Scenic Areas) would be excluded.  This is a reduction in Federal, private, and State lands of 3,734,100 ac from the 13,963,600 ac proposed under Alternative B.

This Alternative increases the overall amount of designated critical habitat by 4,917,200 ac (4,078,900 additional acres on Federal land, 281,200 ac on State land, and 557,100 ac of private land) as compared to the No Action Alternative; for Federal lands, the acres of lands subject to programmed timber harvest increase by 3,590,600 ac. Land ownerships subject to critical habitat designation under this alternative that were not designated under the No Action Alternative are private (557,100 ac), State (281,200 ac), and Department of Defense (14,300 ac) lands. For Federal lands, with the exception of the inclusion of DOD lands, this alternative is similar to the No Action Alternative in that no Congressionally reserved natural areas would be designated. These additional acres would be subject to the land-use management described below in this alternative (Table 4).

*Federal lands—all agencies*

Under this alternative, 2,632,500 ac of Congressionally reserved natural areas would be excluded from designation of critical habitat. The consequences to Federal land management for Federal lands remaining under this alternative (i.e., those lands not Congressionally reserved) would be as described for those lands in Alternative B.

*State lands*

This alternative would exclude 164,800 ac of State Parks in Washington and California from designation of critical habitat. The consequences for managing the remaining State lands that may be designated critical habitat under this alternative would be as described in Alternative B.

*Private lands*

With respect to private lands, this alternative retains the same exclusions as in Alternative C (exclude all State and private lands with completed HCPs, SHAs, and other management agreements). Therefore, the effects of this alternative on private lands are the same as described in Alternative C.

#### 3.1.2.5 Alternative E (Outcome 4 in proposed revised rule)

Alternative E would designate 9,391,200 ac of critical habitat on Federal lands only. As in Alternative D, Federal lands that are Congressionally reserved would also be excluded under this alternative. All State lands originally proposed are excluded in this alternative. In addition, all private lands originally proposed, regardless of whether HCPs, SHAs, or other conservation agreements are in place on those properties are excluded from critical habitat designation in this alternative. This is a reduction in Federal, private, and State lands of 4,572,400 ac from the 13,963,600 ac originally proposed under Alternative B.

Compared with the No Action Alternative, this alternative would result in an increase of 4,078,900 ac in Federal lands designated as critical habitat; for Federal lands, the acres of NWFP land allocations subject to programmed timber harvest increase by 3,590,600 ac. Federal lands proposed for designation under this alternative are primarily limited to Forest Service and BLM lands, similar to the No Action Alternative. Unlike the No Action Alternative, 14,300 ac of DOD land would be designated as part of this alternative. Similar to the No Action Alternative, this alternative would not have private or State lands designated as critical habitat (Table 4).

*Federal lands*

With respect to the Federal lands that are designated as critical habitat, this alternative is the same as Alternative D. Hence, the consequences to Federal land management under this alternative are as described in Alternative D. Land management on the remaining Federal lands under this alternative (i.e., those lands not Congressionally reserved) would be as described in Alternative B.

*State and private lands*

This alternative excludes all State and private lands from designation of critical habitat. As a consequence of this alternative, no State or private lands would be affected by designation of critical habitat, and as such, no change in land-use management as a result of critical habitat designation would be expected.

#### *3.1.2.6 Option 1 (Exemption of DOD lands from critical habitat designation)*

This option, which may be combined with Alternatives B, C, D, or E, would exempt DOD lands from designated critical habitat. If exempted, the 14,300 ac of JBLM would not be subject to land management changes through section 7 consultation for critical habitat.

## 3.2 Affected Environment and Environmental Consequences – Fish, Wildlife, and Plant Species

### 3.2.1 Existing Condition

Over 1,200 terrestrial and aquatic species have been identified as associated with late-successional forests within the range of the northern spotted owl (FEMAT 1993). These species include vertebrates (fish, birds, mammals, and amphibians), mollusks (snails and clams), plants, lichens, bryophytes, and fungi. In addition, there may be as many as 7,000 species of arthropods (e.g., species such as insects and crayfish) that are closely associated with late-successional forests (FEMAT 1993).

Essential features of proposed critical habitat are forested lands that provide the functional categories of northern spotted owl habitat (i.e., nesting, roosting, foraging, and dispersal). This habitat includes PCEs that are essential for northern spotted owls and represent components that are characteristic features of late-successional forests (e.g., complex canopy layers, large trees, snags and down wood). These features are often valued habitat characteristics for late-successional-associated species. The presence of these elements and the potential to develop or restore them indicate the value of proposed critical habitat for the northern spotted owl to many other fish, wildlife, and plant species. Whether any of these species may be found within individual critical habitat units or subunits is highly variable and will depend on a host of local and regional environmental conditions such as, but not limited to, elevation, climate, forest type and tree composition, forest management activities, and proximity to population sources. Because it is not possible to consider effects of designating critical habitat for the northern spotted owl on all 1,200 plus wildlife and plant species occurring within the spotted owl range, we will limit our analysis to effects on those species listed as endangered or threatened by the ESA that could occur within northern spotted owl critical habitat; we conclude that these are the most salient species relative to the action. In addition, we will consider the effects of critical habitat designation on barred owls because they are considered one of the primary threats to northern spotted owls (see section 1.3.6). We also look at the effects of the multiple alternatives on the northern spotted owl.

#### *3.2.1.1 Northern Spotted owl*

Background and species description of the northern spotted owl is provided earlier in this document (see section 1.3 Northern Spotted Owl). In the process of identifying critical habitat and what is considered essential to the spotted owl, the Service developed multiple habitat scenarios, on which population performance was tested. We evaluated spotted owl population metrics, such as relative population size and extinction risk, to determine what is essential to owl conservation, both to assess what physical or biological features are essential and how much unoccupied habitat is essential to conserve the owl, as informed by the Revised Recovery Plan (USFWS 2011a) and detailed in Dunk *et al*. (2012) (77 FR 14096-14100).
The Primary Constituent Elements identified in the proposed revised rule are (77 FR 14092):

(1) Forest types that may be in early-, mid-, or late-seral stages and that support the northern spotted owl across its geographical range, plus any one of the following three elements;
(2) Habitat that provides for nesting and roosting;

(3) Habitat that provides for foraging, which varies widely across the northern spotted owl's range, in accordance with ecological conditions and disturbance regimes that influence vegetation structure and prey species distribution; and
(4) Habitat to support the transience and colonization phases of dispersal, which in all cases would optimally be composed of nesting, roosting, or foraging habitat (PCEs (2) or (3)), but which may also be composed of other forest types that occur between larger blocks of nesting, roosting, and foraging habitat.

This chapter will evaluate how managing for these features will affect not only the northern spotted owl, but the barred owl and species that are listed as threatened or endangered under the ESA.

### *3.2.1.2 Other Threatened and Endangered Wildlife and Plant Species*

There are 28 Federally listed threatened and endangered wildlife and plant species that may be found in spotted owl critical habitat (Table 3). Of the listed species, 17 have their own designated critical habitat found within the range of the northern spotted owl.

Ranges of the Canada lynx, gray wolf, and grizzly bear all overlap spotted owl critical habitat units in the Cascades of Washington. The PCEs of northern spotted owl critical habitat may provide for some portion of the habitat needs for these species. However, these large carnivores also require other habitat components that are not provided by spotted owl critical habitat. All three species are likely infrequent users of habitat conducive to northern spotted owls, either because they generally frequent other types of habitat, or they have low populations in the Washington Cascades. The patchy and transitional nature of the boreal forest habitats that lynx use, in addition to the limitation of their natural food source, snowshoe hare, tend to limit lynx populations in the contiguous U.S (77 FR 8616). Their habitat requirements are typically associated with higher elevation forests less conducive to northern spotted owl habitat; in addition, they need densely stocked young forest stands that support snowshoe hare. Such stands typically do not provide habitat for northern spotted owls. Grizzly bears use a mix of meadow and forested habitats, some of which may be essential spotted owl habitat. However, their population in the Washington Cascades is estimated to be no more than 50 bears, and perhaps as few as 10 to 20 (USFWS 1997). Wolves are habitat generalists, requiring an adequate source of ungulate (e.g., deer and elk) prey items.

Marbled murrelets are found along the western portion of the northern spotted owl range, occurring within 25 miles of the ocean in parts of California and increasing in distance from the ocean to as far away as 55 miles in Washington. Murrelet nesting habitat is similar to that essential for spotted owls, requiring primarily older conifer forests with large trees that contain limbs large enough to hold a nest and sufficient cover to provide protection from predators and from the elements. Of all the listed species described in this section, marbled murrelets are the most-closely associated with late-successional forests and, at least for nesting, require much the same PCEs as nesting northern spotted owls.

Aquatic species (California red-legged frog, Shasta crayfish, and most fish species) typically benefit from forest riparian cover that provides woody structure to streams and ponds, as well as shading from solar radiation. Though listed suckers are primarily associated with lakes in the Klamath Basin that are outside of mapped spotted owl critical habitat units, they can also be found in nearby rivers that flow through designated northern spotted owl critical habitat (76 FR 76337). However, they are typically not associated with waterbodies in forested areas. While the Oregon chub tends to be found in warmer, slow moving river systems, they are also found in forested regions within spotted owl critical habitat.

Butterflies listed in Table 3 are primarily associated with open habitats (e.g., meadows, coastal headlands). Habitats for these species may occur in areas associated with frequent disturbances (e.g., fires or windstorms) that created or maintain these early seral conditions. In addition, these species may occur in areas with nutrient-poor soils and low site capability; these areas are typically not capable of developing or maintaining forest habitat. Locations of these species are often clustered in limited, specific areas. These lands would not contain the PCEs of northern spotted owl critical habitat, nor would many areas be able to support development of these PCEs.

Listed plants occur infrequently and are generally found in specific habitats. All listed plants in Table 3 are primarily associated with more open habitats (e.g., meadows, coastal headlands, serpentine soils, oak woodlands) than typically used by northern spotted owls. These open habitats are often associated with frequent disturbances (e.g., fires or windstorms) that created or retained these early seral conditions. In addition, these species may be associated with soils that are nutrient-poor and have low site capability; these areas are typically not capable of developing or maintaining forest habitat conducive to sustaining northern spotted owls. These listed plant species are often clustered in limited, specific locations.

In summary, listed species are associated with essential spotted owl habitat to varying degrees. Marbled murrelets are the only listed species closely associated with the late-successional forests that northern spotted owls use, though they only use forested habitats for nesting, spending the rest of their time on the ocean. Listed plant and butterfly species are all closely associated with open habitats that are explicitly not included in the proposed critical habitat revision (77 FR 14100). Large carnivores may use spotted owl habitat for some of their life history needs, but require other habitats as well. Similarly, listed aquatic species may be found in water bodies associated with forested habitats, but may be found in other water bodies to varying degrees.

**Table 3. Federally listed wildlife and plant species (other than the northern spotted owl) that could occur in the proposed action area**

| Common name | Scientific name | Listing status[1] | State(s) found[2] | Critical Habitat within northern spotted owl range? |
|---|---|---|---|---|
| **MAMMALS** | | | | |
| Canada Lynx | *Lynx canadensis* | T | WA | Yes |
| Gray Wolf | *Canis lupis* | E | WA | No |
| Grizzly Bear | *Ursus arctos* | T | WA | Proposed |
| **BIRDS** | | | | |
| Marbled murrelet | *Brachyramphus marmoratus* | T | CA, OR, WA | Yes |
| **REPTILES AND AMPHIBIANS** | | | | |
| California red-legged frog | *Rana draytonii* | T | CA | Yes |
| **FISH** | | | | |
| Bull trout DPSs[3] | *Salvelinus confluentus* | T | OR, WA | Yes |
| Dolly Varden | *Salvelinus malma* | P | WA | Proposed |
| Lost River sucker | *Deltistes luxatus* | E | CA, OR | Yes |
| Shortnose sucker | *Chasmistes brevirostris* | E | CA, OR | Yes |
| Oregon Chub | *Oregonichthys crameri* | T | OR | Yes |
| Chum salmon DPSs | *Oncorhynchus keta* | T | OR, WA | Yes |
| Coho salmon DPSs | *Oncorhynchus kisutch* | T/E | CA, OR, WA | Yes |
| Steelhead DPSs | *Oncorhynchus mykiss* | T | CA, OR, WA | Yes |
| Chinook Salmon DPSs | *Oncorhynchus tshawytscha* | T/E | CA, OR, WA | Yes |
| Pacific eulachon | *Thaleichthys pacificus* | T | CA, OR, WA | Yes |
| **INVERTEBRATES** | | | | |
| *Insects* | | | | |

| Common name | Scientific name | Listing status[1] | State(s) found[2] | Critical Habitat within northern spotted owl range? |
|---|---|---|---|---|
| Fender's blue butterfly | *Icaricia icarioides fenderi* | E | OR | Yes |
| Oregon silverspot butterfly | *Speyeria zerene hippolyta* | T | OR | Yes |
| Behren's Silverspot Butterfly | *Speyeria zerene behrensii* | E | CA | No |
| *Crustaceans* | | | | |
| Shasta crayfish | *Pacifastacus fortis* | E | CA | No |
| **PLANTS** | | | | |
| Gentner's fritillary | *Fritillaria gentneri* | E | OR | No |
| Kincaid's lupine | *Lupinus sulphureus ssp. kincaidii* | T | OR, WA | Yes |
| McDonald's rockcress | *Arabis macdonaldiana* | E | CA, OR | No |
| Nelson's checker-mallow | *Sidalcea nelsoniana* | T | OR, WA | No |
| Showy stickseed | *Hackelia venusta* | E | WA | No |
| Wenatchee Mountains checker-mallow | *Sidalcea oregana var. calva* | E | WA | Yes |
| Western lily | *Lilium occidentale* | E | CA, OR | No |
| Yreka phlox | *Phlox hirsuta* | E | CA | No |
| Willamette daisy | *Erigeron decumbens var. decumbens* | E | OR | Yes |
| [1]E = listed as Endangered; T= listed as Threatened; P = proposed for listing.<br>[2]CA = California; OR = Oregon; WA = Washington<br>[3]DPS = Distinct Population Segment | | | | |

#### *3.2.1.3 Barred Owls*

Barred owls are identified as a threat to northern spotted owls and a factor contributing to declines in spotted owl demographic rates (see section 1.3.6 Threats above). Barred owls have been found in all areas where surveys have been conducted for spotted owls. In addition, barred owls inhabit all forested areas throughout Washington, Oregon, and northern California where nesting opportunities exist, including areas outside of the specific range of the spotted owl (Kelly and Forsman 2003; Buchanan 2005; Gutiérrez *et al.* 1995, 2007; Livezey 2009). Consequently, the Service assumes barred owls now occur at some level in all areas used now or in the past by spotted owls. While barred owls may use a wide range of forest types, they can also be strongly associated with mature and older forests in areas such as the Oregon Coast Range (Wiens 2012). Larger areas of spotted owl habitat are required to maintain sustainable spotted owl populations in the face of competition with the barred owl (Dugger *et al*. 2011). By proposing to designate additional habitat distributed across the range of the northern spotted owl, the Service's goal would be to increase the likelihood that spotted owls would be able to persist in areas where barred owls are also present.

The long-term removal of a substantial number of barred owls, along with a suite of other recovery actions, may be assessed as a possible approach to recover the spotted owl. Before considering whether to fund and fully implement such an action, however, the Service needs to be confident this removal is feasible and would benefit spotted owls. The Service has developed a draft Environmental Impact Statement (EIS) (FR 77 14036, March 8, 2012) to assess the effects of barred owl removal experiments proposed in the Revised Recovery Plan for the northern spotted owl (USFWS 2011a). Comments on the draft EIS will be considered and a final EIS and subsequent Record of Decision published thereafter.

### 3.2.2 Environmental Consequences

Critical habitat does not dictate specific management actions nor amend existing agency management plans. Once finalized, the effect of designation of critical habitat for a listed species is to add an independent requirement that Federal agencies ensure that their actions are not likely to result in the destruction or adverse modification of that critical habitat. An action agency may go about this on a project-by-project basis or by amending its existing land-use plan, subject to the laws and management authorities under which they operate. Section 7(a)(2) of the ESA requires that Federal agencies, in consultation with and with the assistance of the Service, ensure that any action authorized, funded or carried out by that Federal agency is not likely to jeopardize the continued existence of a listed species (this is referred to as the "jeopardy standard"). Thus, in areas where northern spotted owls occur, including most areas included in this proposed rule, Federal agencies are already consulting with the Service on the potential effects of their proposed actions under the “jeopardy standard,” regardless of whether these lands are currently designated as critical habitat.

Aside from the requirement specific to Federal agencies, critical habitat designation does not provide additional regulatory protection for a species on non-federal lands, unless the activities proposed involve Federal funding or permitting. In other words, designation of private or other non-federal lands as critical habitat has no regulatory impact on the use of that land unless there is such a Federal connection. Identifying non-federal lands that are essential to the conservation of a species may nonetheless be relevant, in that it alerts State and local government agencies and private landowners to the value of the habitat, and may help facilitate voluntary conservation partnerships such as Safe Harbor Agreements and Habitat Conservation Plans that may contribute to the recovery and delisting of the species.

How agencies and individual landowners will respond to critical habitat designation will vary with the individual, as well as by ownership, agency, and to what degree the designation overlays land-use management plan allocations that are already consistent with managing for conditions conducive to spotted owl conservation and recovery (see section 3.1 Affected Environment and Environmental Consequences—Land-Use Management). Changes in management that may affect wildlife species, including the spotted owl, as a result of CH designation may or may not occur. On lands where management already favors the development of spotted owl habitat (e.g., Federal reserve lands), there may be little change in land use. Likewise, on lands where there is no regulatory mechanism to prohibit the adverse modification of designated critical habitat (e.g., on non-federal lands where an action is not authorized or funded by the Federal government), management may stay the same as in the past. In general, any potentially substantive changes in management would likely occur primarily on those lands that have a Federal nexus (the regulatory mechanism that requires avoidance of adverse modification of critical habitat), that are not currently managed consistent with owl conservation needs.

Land managers have wide discretion over how to manage their lands. Even for those that have a regulatory requirement to avoid adverse modification of critical habitat, the practices they use to meet that requirement are also at their discretion and the types of projects that could be implemented would vary. It is thus not possible to predict the intensity and magnitude of future actions that may occur in response to the designation of spotted owl critical habitat. Instead, we provide a relative comparison of effects among alternatives based on possible land management changes (e.g., no change vs. increased management for northern spotted owl habitat; see section 3.1 Affected Environment and Environmental Consequences—Land-Use Management) as a result of critical habitat designation, and how those changes might affect management of critical habitat and, subsequently, wildlife species.

#### *3.2.2.1 Alternative A (No Action)*

Under Alternative A, the No Action Alternative, 5,312,300 ac of land would remain designated as critical habitat for the northern spotted owl under the 2008 rule, and no additional critical habitat would be designated for this species under the ESA. Current designation of critical habitat is limited to Federal lands, with a small portion of the designation encompassing NWFP allocations subject to programmed timber harvest (221,300 ac) on Forest Service and BLM lands; this acreage figure includes Riparian Reserves that overlay these allocations, so the actual area available for timber harvest is reduced from this number. Because this is the status quo, no changes to management of spotted owl habitat in these lands would occur (Table 5).

*Effects to the northern spotted owl*

Similar to the 2012 proposed revised rule, the 2008 rule describes PCEs as:

(1) Forest types that support the northern spotted owl across its geographic range.
(2) Nesting, roosting, foraging habitat.
(3) Dispersal habitat.

PCE number 1 must occur in concert with at least PCE number 2 or 3. The PCEs in the 2008 rule are not described in as great a detail and specificity as they are in the 2012 rule.

Section 7 consultations would continue for proposed actions with a Federal connection based solely on the presence of designated critical habitat. Areas occupied by the northern spotted owl would continue to be subject to section 7 consultations regardless of the area's status as critical habitat. While it is difficult to predict how or if specific actions would be changed to avoid adverse modification, such changes generally would be limited to those NWFP land allocations where timber harvest is programmed (221,300 ac). However, voluntary implementation of Revised Recovery Plan conservation measures on all applicable projects may result in only 99,400 ac (IEc 2012, unpublished data) being subject to additional project modifications as a result of critical habitat. These acreages include Riparian Reserves that overlay these allocations, so the actual area available for timber harvest is reduced from this number. Management of these lands is described in Section 3.1.2.2 under the subheading Federal Lands—Other Forest Service and BLM land allocations.

Modeling of northern spotted owl population performance under multiple habitat network scenarios, including the 2008 critical habitat designation, showed poor performance by the 2008 critical habitat designation relative to other scenarios that encompassed greater amounts of quality owl habitat. (USFWS 2011a, Appendix C; Appendix C this document). Research further indicates that more habitat may be necessary to maintain sustainable populations of northern spotted owls in the face of competition with barred owls (Dugger *et al.* 2011; Forsman *et al.* 2011). Thus, this alternative does not provide the greatest conservation benefit for the northern spotted owl as compared with the action alternatives.

*Effects to listed wildlife and plant species*

Management for the PCEs of nesting habitat under the 2008 critical habitat rule (moderate-to-high canopy closure; multi-layered, multi-species canopy with large overstory trees; and a high incidence of large trees with various deformities) provides structural features that also meet the nesting habitat needs of marbled murrelets. Thus, additional protections may be afforded to marbled murrelets on those NWFP Matrix and AMA land allocations not already designated as marbled murrelet critical habitat.

Listed butterfly and plant species in Table 3 generally require open, early seral or woodland habitats. Management of spotted owl habitat under the 2008 rule may not be conducive to these species, as it may lead to forest encroachment in some of these habitats that may be capable of developing into late-successional forests, but were generally maintained in more open conditions through disturbance events that humans have since suppressed. Based on past consultations under the existing 2008 critical habitat rule, maintenance and restoration of these habitats under this alternative is not totally precluded within critical habitat. The degree to which these habitats are actively maintained or developed would depend on the scale of the proposed restoration and maintenance and whether it would reduce the functional ability of the affected spotted owl habitat to provide for spotted owls. Therefore, conservation and maintenance of these early-seral, listed species and their habitats is still possible under this alternative, but may be limited in scale.

For the remaining species (large carnivores and aquatic species), critical habitat in this alternative affords some suitable habitat, although these species require other habitats to varying degrees. Hence, there may be some moderate benefit to these species under the current designation of critical habitat for the northern spotted owl.

*Effects to the barred owl*

Although barred owls can use a broader array of forested habitats than can spotted owls, they also use forest types similar to what spotted owls use. As such, management for the PCEs for spotted owl critical habitat under the 2008 rule may provide habitat features that are beneficial to barred owls across the range of the northern spotted owl. However, because of the wide variety of forest types that barred owls can use, we predict that implementation of this alternative will have a neutral effect on barred owls.

#### 3.2.2.2 Alternative B (Proposed Action)

Under Alternative B, the Service would designate 13,963,600 ac of critical habitat for the northern spotted owl. Designation would occur on Federal, State, and private lands (Table 1). Compared with the existing critical habitat designation (2008 rule), this alternative increases the overall amount of designated critical habitat by 8,651,300 ac (6,711,400 additional acres on Federal land, 671,000 ac on State land, and 1,268,900 ac on private land). Land ownerships subject to critical habitat designation under this alternative that are not subject to designation under the No Action Alternative are private and State lands noted above, National Park Service (998,600 ac) and Department of Defense (14,300 ac) lands. In addition, Wilderness Areas and other Congressionally reserved natural areas on Forest Service and BLM lands (1,633,900 ac) are allocations that are not designated under the No Action Alternative but would be designated under this alternative. These additional acres would be subject to the prohibition on the destruction or adverse modification of northern spotted owl critical habitat (Table 5).

*Summary of changes in potential land use under this alternative*

Although described in more detail in Section 3.1 (Affected Environment and Environmental Consequences—Land-Use Management), we summarize the potential changes in land-use management that could occur as a result of designation of critical habitat. This allows us to assess how those potential changes in management could affect conservation and recovery of the northern spotted owl.

<u>Federal lands</u>. As described earlier (section 3.1 Affected Environment and Environmental Consequences—Land-Use Management), designation of critical habitat may not necessarily result in a change in land-use management, depending on ownership, land allocation, and location. Matrix and AMA allocations, wherein timber harvest is programmed under the NWFP (3,811,900 ac), are the allocations where project modifications are most likely to occur as a result of critical habitat designation. However, agencies have been implementing discretionary conservation measures from the Revised Recovery Plan (section 3.1.1.1). These measures provide conservation benefits to high-quality habitat and spotted owl sites on all allocations, including those programmed for timber harvest. If agencies apply these discretionary measures on all applicable projects, then additional project modifications specific to critical habitat designation may affect as little as 1,389,800 ac under this alternative (IEc 2012); that is, that subset of Matrix and AMA allocations containing younger stands and unoccupied spotted owl habitat. Acreage figures for Matrix and AMA include Riparian Reserves that overlay these allocations, so the actual area available for timber harvest is reduced from that shown.

In summary for Federal lands, a total of 6,711,400 additional acres of spotted owl critical habitat would be designated under Alternative B compared with the No Action Alternative. Of those lands, a range of approximately 1.4 million to 3.8 million ac are predicted to be areas where land management may change from past management to provide additional conservation benefits to the northern spotted owl and avoid adverse modification of critical habitat; this range is an overestimate of affected acres because it includes Riparian Reserves that are not subject to programmed timber harvest. Compared with the No Action Alternative, this is an approximate increase of 1.3 to 3.6 million acres of Federal lands that may be most likely subject to a change in management.

*State lands*. There are approximately 671,000 ac of State lands proposed for designation of critical habitat. State agencies do not anticipate altering management on any of these lands in response to critical habitat designation, resulting in no intentional changes to the conservation value of these lands for spotted owls. However, should a project require Federal funding or authorization, Section 7 of the ESA would apply, requiring the state to avoid destruction and adverse modification of critical habitat. In addition, designation of critical habitat alerts the States to the value of the habitat and may facilitate voluntary conservation partnerships that may contribute to spotted owl recovery. Thus, while there may be no intended change in management to the critical habitat proposed for designation on State lands, designation of critical habitat could provide incentive for a possible conservation partnership with the Service. While section 7 of the ESA would require avoiding destruction and adverse modification of critical habitat for Federal actions, there typically are limited opportunities for a Federal nexus to trigger section 7 consultation (Appendix D).

*Private lands*. In total, the Service is considering designating critical habitat on 1,268,900 ac of private land in Washington and California. No private land in Oregon is proposed for designation. Of these acres, activities on 711,800 ac are subject to existing HCPs, SHAs, or other conservation agreements where changes in management practices that could affect northern spotted owl critical habitat are considered unlikely; State regulatory burdens are not expected to increase on these lands. However, there remains the potential for added conservation benefit through section 7 consultation with any Federal nexus. However, as described for State lands above, there typically are limited opportunities for a Federal nexus to trigger section 7 consultation (Appendix D).

Potential changes in management in response to critical habitat designation could occur on the remaining 557,100 ac. These lands include 149,900 ac in Washington and 407,200 ac in California. Potential changes to essential habitat on these lands could occur in multiple ways. First, a Federal nexus could occur under certain situations (see section 3.1 Affected Environment and Environmental Consequences—Land-Use Management), requiring the landowner to avoid destruction or adverse modification of critical habitat and resulting in a conservation benefit to the spotted owl that may not have otherwise occurred without critical habitat designation. The second possibility is that, faced with regulatory uncertainty, private landowners in both States may harvest their timber as soon as possible (if the stands currently provide suitable habitat for the species) or shorten their harvest rotations to prevent the stands from becoming suitable habitat. This could result in hastening the loss or limiting the development of essential habitat that may not have otherwise occurred had critical habitat not been designated. Third, designation of critical habitat may facilitate voluntary conservation partnerships that may contribute to spotted owl recovery. Lastly, specific to private landowners in Washington, there is the possibility that the Washington Forest Practices Board could redefine "critical habitat state" to include suitable owl habitat within SOSEAs overlapping Federally designated critical habitat (see section 3.1 Affected Environment and Environmental Consequences—Land-Use Management.

In summary for private lands, all lands not under existing conservation agreements retain the potential for added conservation benefit through a possible conservation partnership. Limited opportunities are available for a Federal nexus to trigger section 7 consultation. For those 711,800 ac of private lands that are under an existing conservation agreement, we anticipate no changes to habitat on those lands as a result of critical habitat designation. For the remaining acres of private lands, a variety of responses could occur that could either benefit or be detrimental to spotted owl habitat. Responses will likely be mixed, depending on the landowner and the existing habitat condition; however, we cannot reasonably foresee what will happen to essential habitat on these lands.

*All land ownership summary*. Compared to the 2008 critical habitat rule (No Action Alternative), the gross increase in acres that would be designated under this alternative is 8,651,300. The prohibition on adverse modification may result in additional conservation of northern spotted owl critical habitat and its associated PCEs on a range of approximately 1.4 to 3.8 million ac of Federal lands. There are 557,100 ac of private lands where it is uncertain as to whether management of critical habitat may be beneficial or detrimental. For the remaining 671,000 ac of State land and 711,800 ac of private lands with conservation agreements, management of these stands is expected to remain unchanged as they are already contributing to northern spotted owl conservation. On all of the non-federal lands, there also remains the potential for added conservation benefit through section 7 consultation for Federal actions, although the likelihood of a Federal nexus tends to be limited. For non-federal lands that are not currently under an existing conservation agreement, designation of critical habitat may provide an inducement to enter into a conservation partnership with the Service.

*Effects on northern spotted owl*

The 2012 proposed revised rule (77 FR 14101) (this alternative) includes more habitat than the 2008 rule for the following reasons:

(1) There has been an unanticipated steep decline of the spotted owl and the barred owl has affected spotted owl population trends (Forsman *et al*. 2011). This results in spotted owls requiring larger areas of habitat to maintain sustainable populations in the face of competition with the barred owl (Dugger *et al*. 2011);
(2) The scientific community has recommended that the conservation of more occupied and

high-quality habitat is essential to the conservation of the species (Forsman *et al*. 2011);

(3) There is a need to maintain sufficient suitable habitat for northern spotted owls on a landscape level in areas prone to frequent natural disturbances, such as the drier, fire-prone regions of its range (Noss *et al*. 2006; Thomas *et al*. 2006; Kennedy and Wimberly 2009);

(4) There is a recognition that some State and private lands may be necessary in areas where Federal lands were not sufficient to meet the conservation needs of the spotted owl.

Including more habitat in critical habitat designation would provide increased conservation benefits for northern spotted owls in the face of predicted climate change in the Pacific Northwest and the threat from barred owls. Hotter, drier summers and wetter nesting seasons, as predicted for the Pacific Northwest, have the potential to negatively affect northern spotted owls. The presence of high quality habitat my buffer the negative effects of climate change (see section 3.4.3 Climate Change). In addition, maintaining additional habitat distribution across the range of the species may increase the likelihood that spotted owls will persist in areas where barred owls are also present (Dugger *et al.* 2011).

Modeling of spotted owl population performance indicates that populations would fare worse under the 2008 critical habitat designation than under the proposed action (Dunk *et al*. 2012; USFWS 2011a). We incorporate this modeling by reference, and have included these documents in Appendices B and C of this draft EA. The modeling was used to compare the relative response of spotted owl populations to various potential critical habitat designations. These models also incorporated effects of barred owls and variation in future forest conditions that could occur from fire, climate change, or other factors. These models provided relative comparisons of long-term spotted owl population size and risk of extinction amongst other measures. Simulations from these models are not meant to be estimates of what will occur in the future, but rather provide information on trends predicted to occur under different network designs; this allowed us to compare the relative performance of various habitat scenarios. Relative to other habitat network scenarios that were evaluated, the simulated spotted owl population performance of the proposed action was among the highest in simulated population size, and among the lowest in simulated extinction rate (Dunk *et al.* 2012). Although larger habitat networks exhibited the highest overall population performance, the 2012 critical habitat designation was a smaller, more efficient network of critical habitat that supported similar population performance while providing for the conservation of the northern spotted owl (Dunk *et al.* 2012) and minimizing potential land-use conflicts. This alternative provides the greatest relative contribution to northern spotted owl conservation compared with the other alternatives.

Compared to the No Action Alternative, this alternative provides more conservation benefit to the northern spotted owl due to the greater area designated, as well as the configuration of habitat areas identified (e.g., to provide connectivity and support population expansion). Of the almost

14 million ac designated under this alternative, a range of approximately 1.4 to 3.8 million ac of NWFP lands designated for programmed timber harvest may provide the most improvement in terms of increased conservation value for the northern spotted owl. This is because fewer protections are currently applied for spotted owls in these areas. Under this alternative, Federal agencies would need to avoid destruction or adverse modification of these areas, providing additional conservation benefits to the northern spotted owl.

On all 1,939,900 ac of non-federal land, there exists the potential for added conservation benefit through a possible section 7 nexus or a possible conservation partnership that would not otherwise occur without critical habitat designation. However, there are often limited opportunities for a Federal nexus on these lands (Appendix D). Designating critical habitat on the 936,800 ac of non-federal land with an existing conservation agreement may provide limited to no additional conservation benefits to the northern spotted owl over and above the conservation measures already in place in these agreements (Appendix D). For those 1,003,100 ac of non-federal lands without an existing conservation agreement, critical habitat designation may provide an incentive to develop a conservation partnership with the Service to further conservation of the northern spotted owl (Appendix D). However, for the 557,100 ac of private land that do not have an existing conservation agreement, management of owl habitat on those lands could have a mixture of beneficial and deleterious effects, ranging from premature removal of existing PCEs, to potentially increased permitting requirements in the State of Washington that could potentially thwart any modification of critical habitat, to incentivizing the development of conservation partnerships with the Service; however, predicting actual changes in land management, if any, is speculative and thus, effects are not reasonably foreseeable.

*Effects to listed wildlife and plant species*

Management for the PCEs for nesting habitat under the 2012 proposed revised critical habitat rule (e.g., moderate to high canopy closure; multi-layered, multi-species canopy with large overstory trees; and a high incidence of large trees with various deformities) provides structural features that also meet the nesting structure needs of marbled murrelets. However, if certain recommendations of the 2011 Revised Recovery Plan are followed in parts of critical habitat, these actions may be detrimental to murrelet nesting habitat. Active forest management in young stands capable of developing into marbled murrelet habitat may facilitate the development of suitable murrelet habitat as well as spotted owl habitat, which would be a positive effect on murrelets. However, such management would open up forest canopies and fragment the landscape for murrelets, inviting corvids (e.g., crows, ravens, and jays) and increasing the predation pressures on nesting murrelets, reducing the ability of this species to reproduce (Nelson *et al.* 2006). Thus, active forest management that is in the vicinity of murrelet nesting stands may be detrimental to the species survival and recovery.

For those listed butterfly and plant species, all of which require open, early seral habitats, management of spotted owl habitat would generally not be conducive to these species. However, the proposed revised rule explicitly states that grasslands, meadows, oak woodlands, or aspen woodlands are not considered part of critical habitat if found within a mapped unit (77 FR 14062, p. 14100). Furthermore, we do not expect these species to occur in areas containing the PCEs described in the proposed revised rule. Therefore, conservation and maintenance of these species and their habitats would still be possible in areas mapped as spotted owl critical habitat. Furthermore, the proposed revised rule emphasizes the management of the ecosystems on which endangered species depend and recognizes the value of incorporating the dynamic ecological processes such as fire into critical habitat so as to retain the natural mosaics on the landscape. As such, we conclude that designation of critical habitat for the northern spotted owl in this alternative would have a neutral effect on those species associated with open, early seral habitats.

For the remaining species (large carnivores and aquatic species), critical habitat in this alternative affords some suitable habitat, although these species require other habitats to varying degrees. We conclude that the designation of critical habitat for the northern spotted owl under this alternative would provide an increased benefit with the increased amount of acres designated as compared to the 2008 rule.

*Effects to the barred owl*

Although barred owls can use a broader array of forested habitats than can spotted owls, they also use forest types similar to what spotted owls use. As such, management for the PCEs for spotted owl critical habitat under the proposed revised rule may provide habitat features that are beneficial to barred owls across the range of the northern spotted owl. Additional habitat could allow for continued expansion of barred owl populations further increasing competition with spotted owls. Conversely, additional critical habitat may allow for coexistence of the two species, potentially reducing competition (Dugger *et al.* 2011; Forsman *et al*. 2011). In order to reduce or not increase this potential competitive pressure while the threat from barred owls is being addressed, the Revised Recovery Plan now recommends conserving and restoring older, multi-layered forests across the range of the spotted owl. This alternative provides the largest area of designated critical habitat. Because of the wide variety of forest types that barred owls can use, we predict that implementation of this alternative will have a neutral effect on barred owls. However, designating additional critical habitat that is distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

#### ***3.2.2.3 Alternative C (Outcome 2 of 2012 proposed revised critical habitat rule)***

Alternative C would designate 13,026,800 ac of critical habitat on Federal, State, and private lands. Private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation. This is a reduction in private and State lands of 936,800 ac from that proposed under Alternative B. Private and State Lands that would be excluded under this alternative are listed in Table 2. A summary of effects of this alternative are described in Table 5.

*Summary of changes in potential land use under this alternative*

*Federal lands*. Designation of critical habitat on Federal lands remains unchanged from Alternative B, with 12,023,700 ac designated. As such, changes in habitat on these lands remain the same as described in Alternative B.

*State lands*. With the exclusion of State lands with existing HCPs, SHAs, or other conservation agreements, critical habitat would only be designated on 446,000 ac of State land in Washington and California under this alternative. As such, potential changes in habitat on these remaining lands remain as described in Alternative B for the State lands without HCPs, SHAs, or other conservation agreements.

*Private lands*. With the exclusion of private lands with existing HCPs, SHAs, or other conservation agreements, critical habitat would only be designated on 557,100 ac of private land in Washington and California under this alternative. On all of the non-federal lands, there also remains the potential for added conservation benefit through section 7 consultation for Federal actions, although the likelihood of a Federal nexus tends to be limited. For non-federal lands that are not currently under an existing conservation agreement, designation of critical habitat may provide an inducement to enter into a conservation partnership with the Service.

*All land ownership summary*. Compared to the 2008 critical habitat rule (No Action Alternative), the gross increase in acres designated under this alternative is 7,713,333. The prohibition on adverse modification may result in additional conservation of northern spotted owl critical habitat and its associated PCEs on a range of approximately 1.4 to 3.8 million ac of Federal lands. This range is an overestimate of affected acres because it includes Riparian Reserves that are not subject to programmed timber harvest. For the remaining 557,100 ac of private lands, it is uncertain as to whether management of critical habitat may be beneficial or detrimental. For the remaining 446,000 ac of State land, management of these stands is expected to remain unchanged as they are already contributing to northern spotted owl conservation. On all of the non-federal lands, there also remains the potential for added conservation benefit through section 7 consultation for Federal actions, although the likelihood of a Federal nexus tends to be limited. For non-federal lands that are not currently under an existing conservation agreement, designation of critical habitat may provide an inducement to enter into a conservation partnership with the Service.

*Effects on northern spotted owl*

Effects to the northern spotted owl remain as described under Alternative B, except that fewer overall acres would be designated as critical habitat under this alternative. Compared to the no action alternative, this alternative would provide more conservation benefit to the northern spotted owl due to the greater area designated. The exclusion of private and State lands with HCPs, SHAs, and other conservation agreements results in a reduction of 936,800 ac of critical habitat from that designated in Alternative B. This represents a reduction in the acres of land that have the potential for added conservation benefit through a possible section 7 nexus that would not otherwise occur without critical habitat designation. However, designating critical habitat on the 936,800 ac of non-federal land with an existing conservation agreement may provide limited to no additional conservation benefits to the northern spotted owl over and above the conservation measures already in place in these agreements (Appendix D).

Including more habitat in critical habitat designation would provide increased conservation benefits for northern spotted owls in the face of predicted climate change in the Pacific Northwest and the threat from barred owls. Hotter, drier summers and wetter nesting seasons, as predicted for the Pacific Northwest, have the potential to negatively affect northern spotted owls. The presence of high quality habitat my buffer the negative effects of climate change (see section 3.4.3 Climate Change). In addition, maintaining additional habitat distribution across the range of the species may increase the likelihood that spotted owls will persist in areas where barred owls are also present (Dugger *et al.* 2011).

While this alternative would result in fewer acres of designated critical habitat than Alternative B, the net effects on northern spotted owls may be similar to Alternative B. This is because there may be little to no expected change in conservation value to the northern spotted owl between including and excluding lands with existing conservation agreements (Appendix D). This alternative provides a greater relative contribution to spotted owl conservation than does the No Action Alternative. Its contribution to spotted owl conservation is similar to Alternative B.

*Effects to listed wildlife and plant species*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat under this alternative. The exclusion of private and State lands with HCPs, SHAs, and other conservation agreements results in a reduction of 936,800 ac of critical habitat from that designated in Alternative B. In general, management of spotted owl habitat and PCEs on these lands was not projected to change in response to designation of critical habitat, generally resulting in no net change in spotted owl habitat management under this alternative as compared to Alternative B;

however, compared to Alternative B, this does represent a reduction in the acres of land that have the potential for added conservation benefit through a possible section 7 nexus or a possible conservation partnership that would not otherwise occur without critical habitat designation.

Because of the increase in critical habitat designation as compared to the No Action Alternative, we conclude that effects to listed wildlife and plant species remain as under Alternative B. That is, a mix of beneficial and detrimental effects to marbled murrelets, neutral effects to listed plant and butterfly species, and beneficial effects to remaining species.

*Effects to the barred owl*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat under this alternative. The exclusion of private and State lands with HCPs, SHAs, and other conservation agreements results in a reduction of 936,800 ac of critical habitat from that designated in Alternative B. In general, management of spotted owl habitat and PCEs on these lands was not projected to change in response to designation of critical habitat, generally resulting in no net change in spotted owl habitat management under this alternative as compared to Alternative B; however, compared to Alternative B, this does represent a reduction in the acres of land that have the potential for added conservation benefit through a possible section 7 nexus or a possible conservation partnership that would not otherwise occur without critical habitat designation. Because of the wide variety of forest types that barred owls can use, we conclude that implementation of this alternative will have a neutral effect on barred owls. However, designating additional critical habitat that is distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

#### ***3.2.2.4 Alternative D (Outcome 3 of 2012 proposed revised critical habitat rule)***

Alternative D would designate 10,229,500 ac of critical habitat on Federal, State, and private lands. As in Alternative C, private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation. In addition, State Parks would be excluded as part of this alternative. Also, Congressionally reserved Federal lands (e.g., Wilderness areas, National Park Service lands, Wild and Scenic Areas) would be excluded. This is a reduction in Federal, private, and State lands of 3,734,100 ac from the 13,963,600 ac proposed under Alternative B. However, this still represents an increase of 4,917,200 ac in critical habitat designation as compared to Alternative A (281,200 ac of State land, 557,100 ac of private land, and an increase in 4,078,900 ac of Federal land) (Table 5).

*Summary of changes in potential land use under this alternative*

*Federal lands*. Exclusion of Congressionally reserved lands would result in 9,391,200 ac of Federal lands being designated as critical habitat. Because management in these Congressionally reserved lands is considered consistent with management for spotted owl critical habitat, there would be, in general, no net change in management by excluding these lands from critical habitat. Of the remaining lands, a range of approximately 1.4 to 3.8 million acres of NWFP land allocations subject to programmed timber harvest would likely experience changes in land-use management as a result of designation of critical habitat; compared with the No Action Alternative, This range is an overestimate of affected acres because it includes Riparian Reserves that are not subject to programmed timber harvest. This would provide a net increase in conservation benefits to the northern spotted owl.

*State lands*. Exclusion of State Parks under this alternative results in approximately 281,200 ac of State lands proposed for designation of critical habitat compared to the No Action Alternative. Potential changes in land use on these lands remain as described in Alternative B.

*Private lands*. As in Alternative C, with the exclusion of private lands with existing HCPs, SHAs, or other conservation agreements, critical habitat would only be designated on 557,100 ac of private land in Washington and California under this alternative. As such, potential changes in habitat on these lands remain as described in Alternative B for the private lands without HCPs, SHAs, or other conservation agreements.

*All land ownership summary*. Compared to the 2008 critical habitat rule (No Action Alternative), the gross increase in acres designated under this alternative is 4,917,200. Projected increases in net benefit to conservation of northern spotted owl critical habitat and its associated PCEs are most likely to occur on approximately 1.4 to 3.8 million ac of Federal lands (the same as Alternatives B and C). This range is an overestimate of affected acres because it includes Riparian Reserves that are not subject to programmed timber harvest. There are 557,100 ac of private lands where it is uncertain as to whether management of critical habitat may be beneficial or detrimental. For the remaining 281,200 ac of State land, management of these stands is expected to remain unchanged as they are already contributing to northern spotted owl conservation. On all of the non-federal lands, there remains the potential for added conservation benefit through section 7 consultation for Federal actions, although the likelihood of a Federal nexus tends to be limited. Designation of critical habitat may also provide an inducement to enter into a conservation partnership with the Service.

*Effects on northern spotted owl*

Effects to the northern spotted owl remain as described under Alternative C, with the following exceptions. Although fewer acres would be designated as critical habitat under this alternative it continues to provide more conservation benefit to the northern spotted owl compared to the No Action Alternative because of the increase in 4,917,200 ac of area proposed for designation. The exclusion of: (1) private lands with HCPs, SHAs, and other conservation agreements; (2) State Parks; and (3) Congressionally reserved natural areas on Federal lands results in a reduction of 3,733,328 ac of critical habitat from that designated in Alternative B. Because management on excluded State Parks and Congressionally reserved natural areas is generally already conducive to the conservation of the northern spotted owl, there may be little reduction in conservation benefit to the spotted owl with the exclusion of these lands from critical habitat designation under this alternative. However, by excluding State Parks, there is a reduced incentive for those units to enter into a conservation partnership with the Service that would otherwise occur under Alternatives B and C (Appendix D).

Including more habitat in critical habitat designation would provide increased conservation benefits for northern spotted owls in the face of predicted climate change in the Pacific Northwest and the threat from barred owls. Hotter, drier summers and wetter nesting seasons, as predicted for the Pacific Northwest, have the potential to negatively affect northern spotted owls. The presence of high quality habitat my buffer the negative effects of climate change (see section 3.4.3 Climate Change). In addition, maintaining additional habitat distribution across the range of the species may increase the likelihood that spotted owls will persist in areas where barred owls are also present (Dugger *et al.* 2011).

This alternative provides a greater relative contribution to spotted owl conservation than does the No Action Alternative. Its contribution to spotted owl conservation is reduced from Alternatives B and C given the reduced incentives for excluded State Parks to enter into conservation agreements with the Service.

The exclusion of Congressionally reserved natural areas would affect the adverse modification analysis done under section 7. Pursuant to the ruling in *Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service*, 378 F.3d 1059, 1075-76 (9th Cir. 2004), the Service may only consider lands designated as critical habitat when determining whether a proposed action will impact the conservation function of a unit. Therefore, reducing critical habitat by excluding these areas could make it more likely that proposed actions in designated areas would rise to the level of "destruction or adverse modification of critical habitat."

*Effects to listed wildlife and plant species*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat under this alternative. The exclusion of: (1) private lands with HCPs, SHAs, and other conservation agreements; (2) State Parks; and (3) Congressionally reserved natural areas on Federal lands results in a reduction of 3,734,100 ac of critical habitat from that designated in Alternative B. In general, management of spotted owl habitat and PCEs on these lands was not projected to change in response to designation of critical habitat, generally resulting in no net change in spotted owl habitat management under this alternative as compared to Alternative B; however, compared to Alternative B, the exclusion of State Parks from critical habitat designation does represent a reduction in 164,800 ac of land that have the potential for added conservation benefit through a possible section 7 nexus or a possible conservation partnership that would not otherwise occur without critical habitat designation.

Because of the increase in critical habitat designation as compared to the No Action Alternative, we conclude that effects to listed wildlife and plant species remain as under Alternative B. That is, a mix of beneficial and detrimental effects to marbled murrelets, neutral effects to listed plant and butterfly species, and beneficial effects to remaining species.

*Effects to the barred owl*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat under this alternative. The exclusion of: (1) private lands with HCPs, SHAs, and other conservation agreements; (2) State Parks; and (3) Congressionally reserved natural areas on Federal lands results in a reduction of 3,734,100 ac of critical habitat from that designated in Alternative B. In general, management of spotted owl habitat and PCEs on these lands was not projected to change in response to designation of critical habitat, generally resulting in no net change in spotted owl habitat management under this alternative as compared to Alternative B; however, compared to Alternatives B and C, this does represent a reduction in the acres of land that have the potential for added conservation benefit through a possible section 7 nexus or a possible conservation partnership that would not otherwise occur without critical habitat designation. Because of the wide variety of forest types that barred owls can use, we conclude that implementation of this alternative will have a neutral effect on barred owls. However, designating additional critical habitat that is distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

#### *3.2.2.5 Alternative E (Outcome 4 of 2012 proposed revised critical habitat rule)*

Alternative E would designate 9,391,200 ac of critical habitat on Federal lands only. As in Alternative D, Federal lands that are Congressionally reserved would also be excluded under this alternative. All State lands originally proposed are excluded in this alternative. In addition, all private lands originally proposed, regardless of whether HCPs, SHAs, or other conservation agreements are in place on those properties, are excluded from critical habitat designation in this alternative. When compared with the No Action Alternative, this alternative is an increase in designation of critical habitat on Federal lands by 4,078,900 ac. As compared to the proposed action (Alternative B) this alternative represents a reduction in designation on Federal (2,632,500 ac), private (1,268,900 ac), and State (671,000 ac) (Table 5).

*Summary of changes in potential land use under this alternative*

*Federal lands.* Specific to Federal lands, there is no change in critical habitat designation and its potential management from that described in Alternative D.

*State and private lands*. Exclusion of all State and private lands under this alternative results in no critical habitat designation on these lands, similar to the 2008 rule (No Action Alternative).

*All land ownership summary*. Similar to the 2008 critical habitat rule (No Action Alternative), all designated critical habitat acres under this alternative are on Federal lands; the gross increase in acres designated under this alternative is 4,078,900. Projected increases in net benefit to conservation of northern spotted owl critical habitat and its associated PCEs are expected to occur on approximately 1.4 to 3.8 million ac of Federal lands as a result of possible changes in land management (the same as Alternatives B, C, and D). This range is an overestimate of affected acres because it includes Riparian Reserves that are not subject to programmed timber harvest.

*Effects on northern spotted owl*

Effects to the northern spotted owl remain as described under Alternative D, with the following exceptions. Although fewer acres would be designated as critical habitat under this alternative it continues to provide more conservation benefit to the northern spotted owl compared to the No Action Alternative because of the increase in 4,078,900 ac of area proposed for designation. Exclusion of all non-federal lands not currently under existing conservation agreements (838,300 ac) may reduce potential conservation benefits to northern spotted owls compared to other action alternatives. This is because of the removal of an incentive to enter into a conservation agreement with the Service, as well as the removal of potential opportunities for section 7 consultation for Federal actions on these lands, although the likelihood of a Federal nexus may be limited. This alternative, like all the other action alternatives, includes 1.4 to 3.8 million ac of NWFP land allocations where programmed timber harvest occurs and critical habitat designation may result in project modification that provides an increased benefit to conservation and recovery of northern spotted owls.

Including more habitat in critical habitat designation would provide increased conservation benefits for northern spotted owls in the face of predicted climate change in the Pacific

Northwest and the threat from barred owls. Hotter, drier summers and wetter nesting seasons, as predicted for the Pacific Northwest, have the potential to negatively affect northern spotted owls. The presence of high quality habitat my buffer the negative effects of climate change (see section 3.4.3 Climate Change). In addition, maintaining additional habitat distribution across the range of the species may increase the likelihood that spotted owls will persist in areas where barred owls are also present (Dugger *et al.* 2011).

This alternative provides a greater relative contribution to spotted owl conservation than does the No Action Alternative. Its contribution to spotted owl conservation is reduced from Alternatives B, C, and D given the reduced incentives for excluded non-federal lands to enter into conservation agreements with the Service.

*Effects to listed wildlife and plant species*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat, and it is limited to Federal lands under this alternative. The exclusion of Congressionally reserved natural areas on Federal lands, as well as all State and private lands, results in a reduction of 4,572,400 ac of critical habitat from that designated in Alternative B. Habitat management on State lands and on private lands with conservation agreements was not projected to change substantially in response to designation of critical habitat, but exclusion of these 1,382,800 ac, in addition to the 557,100 ac of private lands without conservation agreements, forecloses the possibility of a section 7 nexus or conservation partnerships that could further conservation of northern spotted owl habitat and habitat features beneficial to other listed species.

Although the area of designation would be reduced compared to Alternative B, because there is still a net increase in critical habitat designation as compared to the No Action Alternative, we predict that effects to listed wildlife and plant species would remain as described under Alternative B, but on a reduced scale. That is, a mix of beneficial and detrimental effects to marbled murrelets, neutral effects to listed plant and butterfly species, and beneficial effects to remaining species.

*Effects to the barred owl*

Effects of this alternative on listed wildlife and plant species remain as described under Alternative B, except that fewer acres would be designated as critical habitat, and it is limited to Federal lands under this alternative. The exclusion of Congressionally reserved natural areas on Federal lands, as well as all State and private lands, results in a reduction of 4,572,400 ac of critical habitat from that designated in Alternative B. Habitat management on State lands and on private lands with conservation agreements was not projected to change in response to designation of critical habitat, but exclusion of these 1,382,800 ac, in addition to the 557,100 ac of private lands without conservation agreements, forecloses the possibility of a section 7 nexus or conservation partnerships that could further conservation of northern spotted owl habitat. Because of the wide variety of forest types that barred owls can use, we conclude that implementation of this alternative will have a neutral effect on barred owls. However, designating additional critical habitat that is distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

#### *3.2.2.6 Option 1 (Exemption of DOD lands from critical habitat designation)*

This option, which may be combined with Alternatives B, C, D, or E, would exempt 14,300 ac of DOD lands (JBLM) from designated critical habitat under section 4(a)(3)(B) of the ESA. This exemption would occur if the ownership is subject to an INRMP and "if the Secretary determines in writing that such plan provides a benefit to the species for which critical habitat is proposed for designation."

*Changes in potential land use under this option*

Applying this option to any alternative would result in a decrease in designated critical habitat of 14,300 ac for that alternative. Because forest management actions on JBLM under the current INRMP are generally designed to develop spotted owl habitat and late-successional forest structure, land management on JBLM is not expected to appreciably differ with critical habitat designation. However, the DOD is revising their INRMP for JBLM and the Service is working with them to ensure the revision continues to meet the conservation needs of the northern spotted owl.

*Effects on northern spotted owl*

Effects to the northern spotted owl of implementing this option would remain as described under each of the individual action alternatives to which this option would apply, except that 14,300 fewer acres on JBLM would be designated as critical habitat under the individual alternative. However, compared to the no action alternative, all alternatives with this option continue to provide more conservation benefit to the northern spotted owl due to the greater area designated outside of DOD lands. Because exemption of DOD lands requires the INRMP to provide conservation benefits to the northern spotted owl, there would be little to no difference in conservation value to the northern spotted owl between exempting and not exempting these lands from critical habitat designation.

Available information indicates that DOD lands in Washington (JBLM) were unoccupied by spotted owls at the time of listing. However, these lands provide essential habitat connectivity for owls dispersing between occupied habitats in the Olympic Peninsula and the Western Cascades. Populations in the Olympic Peninsula are currently-isolated, and require stepping-stones containing both nesting and dispersal habitat to provide for genetic exchange with other owl populations. Without these lands, it may be more difficult for spotted owls to successfully disperse from the Olympic Peninsula to the Western Cascades.

*Effects to listed wildlife and plant species*

Effects to the listed wildlife and plant species of implementing this option would remain as described under each of the individual action alternatives to which this option would apply, except that 14,300 fewer acres on JBLM would be designated as critical habitat under the individual action alternative.

Although the area of designation would decrease under the individual action alternatives to which this option is applied, because there is still a net increase in critical habitat designation as compared to the No Action Alternative, we predict that effects to listed wildlife and plant species remain as under Alternative B. That is, a mix of beneficial and detrimental effects to marbled murrelets, neutral effects to listed plant and butterfly species, and beneficial effects to remaining species.

*Effects to the barred owl*

Effects to the barred owl of implementing this option would remain as described under each of the specific alternatives to which this option would apply, except that 14,300 fewer acres on JBLM would be designated as critical habitat under the individual alternative.

Barred owls were detected in multiple locations on JBLM during surveys in 2009 (Thomas 2012, pers. com). Because of the wide variety of forest types that barred owls can use, we conclude that implementation of this alternative will have a neutral effect on barred owls. However, designating additional critical habitat that is distributed across the range of the northern spotted owl may increase the likelihood of management actions being taken that will enable spotted owls to persist in areas where barred owls are also present.

## 3.3 Affected Environment and Environmental Consequences – Linear road maintenance/repair and energy transmission projects

### 3.3.1 Existing Condition

This chapter evaluates how the designation of northern spotted owl critical habitat will affect the design and implementation of linear road maintenance/repair and energy transmission projects under the varying potential scenarios of the proposed rule.

Linear road maintenance/road-building projects and energy transmission projects (e.g., gas pipelines, electrical lines, etc.) are routinely permitted by the Federal Highway Administration or the Department of Energy and may cross Forest Service and/or BLM lands where authorization is required. Given the clear Federal nexuses, the Service routinely enters the section 7 consultation process with these lead agencies. Consultations involve in-depth discussions about how to best design proposed actions of these types in a manner that will be consistent with the recovery of the spotted owl while still meeting the needs of the original project; this may include project design modifications that minimize the take of spotted owls.

We are currently working with applicants on at least two section 7 consultations on energy-transportation projects and their associated rights-of-way that could affect lands under consideration for critical habitat designation for the spotted owl. These energy projects include one natural-gas pipeline and two electricity-transmission power lines, all of which require the complete removal of forest structure within their rights-of-way. The natural-gas pipeline would require an approximately 100-foot-wide right-of-way corridor where all trees would initially be removed, but then allowed to regrow to original forested habitat conditions over time. The electricity-transmission projects would require an approximately 250-foot-wide right-of-way corridor where all trees would be removed and not be allowed to regrow to original habitat conditions; these areas would remain cleared. These rights-of-way would resemble long, narrow, clearcuts.

### 3.3.2 Environmental Consequences

When the Service enters the section 7 consultation process on timber sale projects, there are often timber harvest design options that will reduce the impacts to spotted owls by modifying the location of how trees are removed or left in the stand. Within unoccupied spotted owl habitat in critical habitat the Service might, for example, recommend retention of habitat elements that would benefit spotted owl habitat development. However, with road construction/maintenance and linear energy transmission projects, there may be fewer such opportunities because these types of projects require complete forest removal to meet their purpose. .In these cases, the Service works with the project proponent to minimize impacts to spotted owls and critical habitat through early involvement in the planning process. This provides the Service the chance to recommend those routes that have the least impact on spotted owls and still meet the project's goals.

At the scale energy-transmission projects are planned, it would be highly unlikely for there to be impacts to spotted owl critical habitat but not to spotted owls (e.g., a project limited entirely to younger forest). Therefore, we anticipate consultations will be formal in nature and will include effects resulting in take of spotted owls to be minimized to the extent possible which may, except for timing restrictions, serve to minimize impacts to critical habitat as well. With these minimizations in place for spotted owls the designation of critical habitat would not likely have much, if any additional impact on the design or location of energy- transmission projects.

#### *3.3.2.1 Alternative A (No Action)*

Under Alternative A, the No Action Alternative, 5,312,300 ac of land would remain designated as critical habitat for the northern spotted owl under the 2008 rule, and no additional critical habitat would be designated for this species under the ESA. The current designation of critical habitat is limited to Federal lands; most of this existing designation overlays NWFP land allocations that are reserve lands, but there are 221,300 ac of Matrix and AMA (areas allocated for timber harvest) within the 2008 designation of critical habitat. This acreage figure includes Riparian Reserves that overlay these allocations. Because this is the status quo, no changes to management of spotted owl habitat in these lands would occur.

*Effects to road maintenance/road-building projects and energy transmission projects*

Selecting the no action alternative would result in a smaller overall critical habitat designation with more widely spaced critical habitat units which may make it less likely that the above types of projects would affect designated critical habitat. In addition, since the 2008 critical habitat designation did not include any non-federal lands a project proponent could avoid critical habitat by planning their project exclusively on non-federal lands.

Where road maintenance/road-building projects and energy transmission projects are likely to intersect with designated critical habitat we have determined there would be either little additional opportunity or little need to modify the design or location of the projects to minimize impacts to critical habitat. This is primarily because any project of this magnitude (i.e., large area and complete forest removal) that impacts spotted owl critical habitat often has effects to spotted owls; effects to owls are minimized to the maximum extent practicable through the informal consultation process while still meeting the goals of the proposed project. There are few modifications that benefit spotted owls that do not also benefit spotted owl critical habitat, except altering the project timing to avoid disturbing individual spotted owls. The only minimization measures that may need to be applied for the sake of critical habitat, in addition to those being already implemented for the owl itself would be the recommended retention and management of habitat elements that would benefit spotted owl habitat development in unoccupied stands. The flexibility to implement these recommendations on projects that require the complete removal of vegetation (where roads are placed or for design or safety reasons around energy transmission corridors) is limited or non-existent. Therefore, it is unlikely there will be additional minimizations applied to a project solely for the sake of critical habitat.

#### 3.3.2.2 Alternative B (Proposed Action. Outcome 1 of 2012 proposed revised critical habitat rule)

Under Alternative B, the Service would designate 13,963,600 ac of critical habitat for the northern spotted owl. Designation would occur on Federal, State, and private lands (Table 1). Compared with the No Action Alternative (existing critical habitat designation from 2008 rule), this alternative would increase the overall amount of designated critical habitat by 8,651,300 ac (6,711,400 additional acres on Federal land, 671,000 ac on State land, and 1,268,900 ac of private land). Land ownerships subject to critical habitat designation under this alternative that are not designated under the No Action Alternative are private and State lands noted above, National Park Service (998,600 ac) and Department of Defense (14,300 ac) lands. Included in the above Federal acres are Wilderness Areas and other Congressionally reserved natural areas on Forest Service and BLM lands (1,633,900 ac) that are not designated under the No Action Alternative but would be designated under this alternative. These additional acres would be subject to the land-use management described in section 3.1.1.1

*Summary of Effects to road maintenance/road-building projects and energy transmission projects under Alternative B*

Alternative B represents an approximately 163 percent increase in the acres included in the critical habitat network from Alternative A. With this increase in acres there is a proportional increase in the likelihood that a road maintenance/road-building project or energy transmission project would intersect critical habitat. This is particularly true because this alternative would include designated critical habitat on non-federal lands which introduces the possibility of impacting critical habitat in portions of the range that would not occur under Alternative A (i.e., State and private lands).

There is no difference, however, in the effects to road maintenance/road-building projects or energy transmission projects that do intersect critical habitat under this alternative than under Alternative A (Table 6).

#### 3.3.2.3 Alternative C (Outcome 2 of 2012 proposed revised critical habitat rule)

Alternative C would designate 13,026,800 ac of critical habitat on Federal, State, and private lands. Private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation. This is a reduction in private and State lands of 936,800 ac from Alternative B. Private and State Lands that would be excluded under this alternative are listed in Table 2.

This alternative represents an approximately 145 percent increase in the acres that would be included in the critical habitat network compared to Alternative A and an approximately 7 percent reduction in the acres that would be included in the critical habitat network in Alternative B. This increase in acres from Alternative A could increase the likelihood that a road maintenance/road-building project or energy transmission project would intersect critical habitat, while the reduction in acreage from Alternative B could slightly decrease the likelihood that a road maintenance/road-building projects or energy transmission project might intersect with critical habitat, particularly with some private and State lands that would be excluded under this proposal.

There is no difference, however, in the effects to road maintenance/road-building projects or energy transmission projects that do intersect critical habitat under this alternative than under Alternative A or B (Table 6).

#### 3.3.2.4 Alternative D (Outcome 3 of 2012 proposed revised critical habitat rule)

Alternative D would designate 10,229,500 ac of critical habitat on Federal, State, and private lands. As in Alternative C, private and state lands with completed HCPs, SHAs, and other active conservation agreements would be excluded from designation. In addition, State Parks would be excluded as part of this alternative. Also, Congressionally reserved Federal lands (e.g., Wilderness areas, National Park Service lands, Wild and Scenic Areas) would be excluded. This is a reduction in Federal, private, and State lands of 3,734,100 ac from Alternative B. However, this still represents an increase of 4,917,200 acres in critical habitat designation as compared to Alternative A (281,200 ac on State land, 557,100 ac on private land, and an increase in 4,078,900 ac of Federal land).

Alternative D represents an approximately 92 percent increase in acres from Alternative A, an approximately 27 percent decrease in acres from Alternative B, and an approximately 21 percent decrease in acres from Alternative C. As mentioned previously, the likelihood of critical habitat and road construction/maintenance and energy transmission projects intersecting would generally increase or decrease with the number of acres included in a selected alternative.

There is no difference, however, in the effects to road maintenance/road-building projects or energy transmission projects that do intersect critical habitat under this alternative than under Alternative A, B or C (Table 6).

#### 3.3.2.5 Alternative E (Outcome 4 of 2012 proposed revised critical habitat rule)

Alternative E would designate 9,391,200 ac of critical habitat on Federal lands only. As in Alternative D, Federal lands that are Congressionally reserved would also be excluded under this alternative. All State lands originally proposed are excluded in this alternative. In addition, all private lands originally proposed, regardless of whether HCPs, SHAs, or other conservation agreements are in place on those properties, are excluded from critical habitat designation in this alternative. This continues to be an increase in designation of critical habitat on Federal lands by 4,078,900 ac. As compared to the proposed action (Alternative B) this alternative represents a reduction in designation on Federal (2,632,500 ac), private (1,268,900 ac), and State (671,000 ac).

Alternative E represents an approximately 77 percent increase in acres from Alternative A, an approximately 32 percent decrease in acres from Alternative B, an approximately 28 percent decrease in acres from Alternative C, and an approximately 8 percent decrease in acres from Alternative D. As mentioned previously, the likelihood of critical habitat and road construction/maintenance and energy transmission projects intersecting would likely increase or decrease with the number of acres included in a selected alternative.

There is no difference in the effects to road maintenance/road-building projects or energy transmission projects that do intersect critical habitat under this alternative than under Alternative A, B, C or D (Table 6).

#### 3.3.2.6 Option 1 (Exemption of DOD lands from critical habitat designation)

This option, which may be combined with Alternatives B, C, D, or E, would exempt DOD lands from designated critical habitat. The 14,300 ac of JBLM would not be subject to land management changes through section 7 consultation for critical habitat This sub-unit of critical habitat is currently unoccupied by spotted owls, however, so we would not anticipate that take of spotted owls would occur. A jeopardy analysis focusing on the effects to spotted owl movement through the area would potentially be necessary.

If DOD lands were exempted from the critical habitat designation there would be a slight decrease in the acres from Alternatives B, C, D and E which would, theoretically, reduce the likelihood of road construction/maintenance and energy transmission projects intersecting spotted owl critical habitat. With that said, we think it is unlikely that large-scale energy transmission projects would be sited through these DOD lands, so there is probably no effect to energy transmission projects from the exemption of these lands. Road maintenance/construction projects likely are necessary on these DOD lands so exempting them would reduce the likelihood of critical habitat being affected by road projects.

Table 4. Summary of effects, by alternative, of proposed critical habitat designation on land-use management. Effects are categorized by ownership, land allocation, location, and presence or lack of conservation agreements.

| Category of ownership, allocation, location, and conservation agreements | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|
| **FEDERAL** | | | | |
| **Congressionally Reserved Lands (National Park Service, Wilderness Areas, etc).** | **Acres Proposed:** 2,632,500 ac<br>(998,600 ac NPS and 1,633,900 ac of Congressionally Reserved land on FS and BLM).<br><br>This is a 2,632,500 ac increase over the No Action alternative.<br><br>**Effects:**<br>Land-use management not expected to change for these lands because current management is generally consistent with critical habitat management. | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed:**<br>0 acres.<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect | **Acres Proposed and Effects:**<br><br>Same as Alternative D |
| **Forest Service and BLM land allocations that are not Congressionally Reserved Lands** | **Acres Proposed:** 9,376,900 ac<br><br>This is a 4,064,600 ac increase over the no action alternative<br><br>**Effects**<br>On 3,811,900 ac of Matrix and AMA lands where timber harvest is programmed, land-use management could change as a result of critical habitat designation; this acreage may be reduced to 1,389,800 ac if action agencies choose to fully apply discretionary conservation measures recommended in the Revised Recovery Plan.<br><br>Land-use management not expected to change in remaining NWFP land allocations (reserves and lands not otherwise programmed for timber harvest) because management on these lands assumed to already be consistent with critical habitat management. | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B |

| Category of ownership, allocation, location, and conservation agreements | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|
| **Forest Service and BLM non-reserve lands that comprise either younger stands or habitat unoccupied by spotted owls.** | **Acres Proposed:** 1.4 million acres.<br><br>This is a 1.3 million acre increase over the no action alternative.<br><br>**Effects:** | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B |
| **Department of Defense lands (Joint Base Lewis-McChord) if Option 1 is not applied.** | **Acres Proposed:** 14,300 ac<br><br>**Effects:**<br>Changes in land-use management not expected. | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B |
| **Department of Defense lands (Joint Base Lewis-McChord) if Option 1 is applied.** | **Acres Proposed:** 0 ac<br><br>**Effects:**<br>No effect. | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B | **Acres Proposed and Effects:**<br><br>Same as Alternative B |
| **STATE** | | | | |
| All state lands | **Acres Proposed:** 671,000 ac<br><br>This is an increase in 671,000 ac of State land compared to No Action Alternative<br><br>**Effects:**<br>States predict no change in land management with critical habitat designation, regardless of agency or whether a formal conservation agreement is in place. | **Acres Proposed:**<br>446,000 ac<br><br>This is an increase in 446,000 ac of State land compared to No Action Alternative<br><br>**Effects:**<br>Same as in Alternative B | **Acres Proposed:**<br>281,200 ac<br><br>This is an increase in 281,200 ac of State land compared to No Action Alternative.<br><br>**Effects:**<br>Same as in Alternative B | **Acres Proposed:**<br>0 acres<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect |

| Category of ownership, allocation, location, and conservation agreements | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|
| **PRIVATE** | | | | |
| All private lands | **Acres proposed:** 1,268,900 ac<br><br>This is an increase in 1,268,900 ac of private land compared to No Action Alternative<br><br>**Effects:**<br>Regulatory uncertainty may occur, but specific regulations and subsequent land-use management responses are not reasonably foreseeable. | **Acres proposed:**<br>557,100 ac<br><br>This is an increase in 557,100 ac of private land compared to No Action Alternative<br><br>**Effects:**<br>Same as Alternative B | **Acres Proposed and Effects:**<br>Same as Alternative C | **Acres proposed:**<br>0<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect |
| All private lands in California under a formal conservation agreement. | **Acres proposed:** 665,800 ac<br><br>**Effects:**<br>Changes in land-use management as a result of State requirements are unlikely.<br><br>Activities covered under an existing agreement not considered likely to adversely modify critical habitat based on preliminary analysis, so no expected changes in land-use management. | **Acres proposed:**<br>0 ac<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect | **Acres Proposed and Effects:**<br>Same as Alternative C | **Acres Proposed and Effects:**<br>Same as Alternative C |

| Category of ownership, allocation, location, and conservation agreements | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|
| All private lands in California not under a formal conservation agreement. | **Acres proposed:** 407,200 ac<br><br>**Effects:**<br>Changes in land-use management as a result of State requirements are unlikely.<br><br>Actions that require an incidental take permit from the Service would require development of an HCP. This Federal nexus would require section 7 consultation wherein destruction of adverse modification of critical habitat would be prohibited. However, an adverse modification finding considered unlikely.<br><br>Landowners may choose to enter into a formal conservation agreement with the Service or another entity, which may influence land management. | **Acres Proposed and Effects:**<br>Same as Alternative B | **Acres Proposed and Effects:**<br>Same as Alternative B | **Acres proposed:**<br>0<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect |
| Private lands in Washington under a formal conservation agreement. | **Acres proposed:** 46,000 ac<br><br>**Effects:**<br>Changes in land-use management as a result of State requirements are unlikely.<br><br>Activities covered under an existing agreement not considered likely to adversely modify critical habitat based on preliminary analysis, so no expected changes in land-use management. | **Acres proposed:**<br>0 ac<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect | **Acres Proposed and Effects:**<br>Same as Alternative C | **Acres Proposed and Effects:**<br>Same as Alternative C |

| Category of ownership, allocation, location, and conservation agreements | Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|---|
| Private lands in Washington not under a formal conservation agreement. | **Acres proposed:** 149,900 ac<br><br>**Effects:**<br>State Forest Practices Board may enact additional restrictions on these landowners. However, specific restrictions, if any, and subsequent land-use management responses are not reasonably foreseeable.<br><br>Actions that require an incidental take permit from the Service would require development of an HCP. This Federal nexus would require section 7 consultation wherein destruction of adverse modification of critical habitat would be prohibited. However, an adverse modification finding considered unlikely.<br><br>Landowners may choose to enter into a formal conservation agreement with the Service or another entity, which may influence land management. | **Acres Proposed and Effects:**<br>Same as Alternative B | **Acres Proposed and Effects:**<br>Same as Alternative B | **Acres proposed:**<br>0<br><br>Same as No Action Alternative<br><br>**Effects:**<br>No effect |

Table 5. Summary of effects, by alternative, of proposed critical habitat designation on fish, wildlife, and plant species.

| Species Affected | Alternative B<br>13,963,600 ac proposed<br>This is a 8,651,300 ac increase over the No Action Alternative | Alternative C<br>13,026,800 acres proposed<br>This is a 7,714,500 ac increase over the No Action Alternative | Alternative D<br>10,229,500 acres proposed<br>This is a 4,917,200 ac increase over the No Action Alternative | Alternative E<br>9,391,200 acres proposed<br>This is a 4,078,900 ac increase over the No Action Alternative |
|---|---|---|---|---|
| Northern Spotted owl | Increased conservation benefit compared to No Action given increased acres designated.<br><br>1.4 to 3.8 million acres of Federal land allocations subject to programmed timber harvest will have greatest change in conservation value for the species.<br><br>On 1,939,900 ac of non-federal lands, critical habitat designation:<br>--provides a potential for added conservation benefit through section 7 if a Federal nexus occurs, though a Federal nexus typically won't occur.<br>--alerts landowner of the conservation benefit of the area to the species<br><br>For the 557,100 acres of private land with no existing conservation agreement, management of these lands in response to critical habitat designation may have a mix of beneficial and deleterious responses. However, predicting landowner response is speculative and not reasonably foreseeable. Designation may provide incentive for landowner to enter into conservation partnership with the Service. | Increased conservation benefit compared to No Action given increased acres designated.<br><br>1.4 to 3.8 million acres of Federal land allocations subject to programmed timber harvest will have greatest change in conservation value for the species.<br><br>On 1,003,100 ac of non-federal lands, critical habitat designation:<br>--provides a potential for added conservation benefit through section 7 if a Federal nexus occurs, though a Federal nexus typically won't occur.<br>--alerts landowner of the conservation benefit of the area to the species<br><br>For the 557,100 acres of private land with no existing conservation agreement, management of these lands in response to critical habitat designation may have a mix of beneficial and deleterious responses. However, predicting landowner response is speculative and not reasonably foreseeable. Designation may provide incentive for landowner to enter into conservation partnership with the Service. | Increased conservation benefit compared to No Action given increased acres designated.<br><br>1.4 to 3.8 million acres of Federal land allocations subject to programmed timber harvest will have greatest change in conservation value for the species.<br><br>On 838,300 ac of non-federal lands, critical habitat designation:<br>--provides a potential for added conservation benefit through section 7 if a Federal nexus occurs, though a Federal nexus typically won't occur.<br>--alerts landowner of the conservation benefit of the area to the species<br><br>For the 557,100 acres of private land with no existing conservation agreement, management of these lands in response to critical habitat designation may have a mix of beneficial and deleterious responses. However, predicting landowner response is speculative and not reasonably foreseeable. Designation may provide incentive for landowner to enter into conservation partnership with the Service. | Increased conservation benefit compared to No Action given increased acres designated.<br><br>1.4 to 3.8 million acres of Federal land allocations subject to programmed timber harvest will have greatest change in conservation value for the species. |

| Species Affected | Alternative B<br>13,963,600 ac proposed<br>This is a 8,651,300 ac increase over the No Action Alternative | Alternative C<br>13,026,800 acres proposed<br>This is a 7,714,500 ac increase over the No Action Alternative | Alternative D<br>10,229,500 acres proposed<br>This is a 4,917,200 ac increase over the No Action Alternative | Alternative E<br>9,391,200 acres proposed<br>This is a 4,078,900 ac increase over the No Action Alternative |
|---|---|---|---|---|
| Marbled murrelet | Increased area managed for PCEs that also provide suitable murrelet nesting habitat is beneficial to murrelets. However, active management in these stands may fragment the landscape and reduce reproductive capability of the species, resulting in a detriment to murrelet nesting habitat. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative B. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative C. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative D. |
| Large carnivores and aquatic species | Increased area managed for PCEs will also provide some additional habitat benefits to these species. However, these species require other habitat features not provided by spotted owl critical habitat. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative B. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative C. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative D. |
| Plants and butterflies | Management of the PCEs for spotted owl habitat generally not conducive to these species, which are associated with more open meadows or woodlands. However, the proposed revised rule specifically states these habitats found within a unit boundary are not considered critical habitat. Conservation and maintenance of these areas would still be possible. Predict a neutral effect on these species. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative B. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative C. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative D. |

| Species Affected | Alternative B<br>13,963,600 ac proposed<br>This is a 8,651,300 ac increase over the No Action Alternative | Alternative C<br>13,026,800 acres proposed<br>This is a 7,714,500 ac increase over the No Action Alternative | Alternative D<br>10,229,500 acres proposed<br>This is a 4,917,200 ac increase over the No Action Alternative | Alternative E<br>9,391,200 acres proposed<br>This is a 4,078,900 ac increase over the No Action Alternative |
|---|---|---|---|---|
| Barred owls | Management of PCEs for spotted owl habitat may also provide habitat beneficial to barred owls. However, because the species is a habitat generalist, they also use areas that do not contain these features. Thus, we predict a neutral effect on barred owls. However, with increased protection of habitat conducive to spotted owls, competition from barred owls may decrease. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative B. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative C. | Same as Alternative B<br><br>Scale of effects are reduced from Alternative D. |

Table 6. Summary of effects, by alternative, of proposed critical habitat designation on linear road maintenance/repair and energy transmission projects.

| Alternative B | Alternative C | Alternative D | Alternative E |
|---|---|---|---|
| 13,963,600 ac proposed<br>This is a 8,651,300 ac increase over the No Action Alternative | 13,026,800 acres proposed<br>This is a 7,714,500 ac increase over the No Action Alternative | 10,229,500 acres proposed<br>This is a 4,917,200 ac increase over the No Action Alternative | 9,391,200 acres proposed<br>This is a 4,078,900 ac increase over the No Action Alternative |
| This alternative represents a 163 percent increase over the No Action Alternative in terms of area included as critical habitat. Would likewise predict a proportionate increase in the likelihood that projects would intersect critical habitat.<br><br>Unlikely to be additional modifications applied to the project that would not also be applied to protect the spotted owl itself. | This alternative represents a 145 percent increase over the No Action Alternative in terms of area included as critical habitat. Would likewise predict a proportionate increase in the likelihood that projects would intersect critical habitat.<br><br>Unlikely to be additional modifications applied to the project that would not also be applied to protect the spotted owl itself. | This alternative represents a 92 percent increase over the No Action Alternative in terms of area included as critical habitat. Would likewise predict a proportionate increase in the likelihood that projects would intersect critical habitat.<br><br>Unlikely to be additional modifications applied to the project that would not also be applied to protect the spotted owl itself. | This alternative represents a 77 percent increase over the No Action Alternative in terms of area included as critical habitat. Would likewise predict a proportionate increase in the likelihood that projects would intersect critical habitat.<br><br>Unlikely to be additional modifications applied to the project that would not also be applied to protect the spotted owl itself. |

## 3.4 Additional Effects

### 3.4.1 Social and Economic Conditions

A draft economic analysis of critical habitat designation for northern spotted owl has been developed (IEc 2012). The scope of the economic analysis includes those areas included in the proposed revised rule (77 FR 14062, March 8, 2012). The economic analysis uses as its baseline for comparison only the protections afforded to the owl by listing it as a threatened species, not subsequent protections that are in place as a result of the 2008 designation of critical habitat. That is, the economic analysis assesses the effects of the 2012 critical habitat designation as compared with no critical habitat being designated on the landscape. This baseline differs from that used in NEPA, where the baseline (No Action Alternative) is the current situation that includes the 2008 critical habitat designation, with no other actions taken.

In sum, the draft economic analysis concludes that the impacts of the proposed revised critical habitat designation, beneficial or otherwise, are uncertain. The breadth of possible outcomes considered range from a potential reduction in timber harvest due to voluntary agency restrictions on actions in designated critical habitat, to essentially no change from current practices, to a potential increase in timber harvest relative to current conditions resulting from the possible implementation of ecological forestry practices (Industrial Economics, 2012). The social and economic effects of the proposed revised critical habitat are therefore not reasonably foreseeable. We further note the focus of this analysis is the potential effects of the proposed action on the human environment. The CEQ regulations state that the "[h]uman environment shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment . . . This means that economic or social effects are not intended by themselves to require preparation of an environmental impact statement.” (40 CFR 1508.14).

### 3.4.2 Indian Lands and Trust Resources

The United States has a trust responsibility and treaty obligations to Indian tribes and members of those tribes. Tribal trust resources are natural resources that are retained by or reserved for Indian tribes through treaties, statutes, judicial decisions, and executive orders. The United States is entrusted with these resources for the benefit of Indian tribes. However, tribal lands are not Federal public lands or part of the Federal domain and are therefore not subject to Federal land laws, such as the National Forest Management Act. Tribal lands are managed by Indian tribes consistent with their goals and objectives.

We included Indian lands in our modeling of potential critical habitat networks. Although some Indian lands identified in our habitat modeling demonstrated the potential to contribute to the conservation of the northern spotted owl, our analysis did not suggest that these areas were essential to conserve the northern spotted owl (77 FR 14142). Thus, the proposed revision of critical habitat does not overlay Indian lands in any of our alternatives and does not affect these lands.

### 3.4.3 Climate Change

Our analyses under the National Environmental Policy Act include consideration of ongoing and projected changes in climate. The terms "climate" and "climate change" are defined by the Intergovernmental Panel on Climate Change (IPCC). "Climate" refers to the mean and variability of different types of weather conditions over time, with 30 years being a typical period for such measurements, although shorter or longer periods also may be used (IPCC 2007). The term "climate change" thus refers to a change in the mean or variability of one or more measures of climate (e.g., temperature or precipitation) that persists for an extended period, typically decades or longer, whether the change is due to natural variability, human activity, or both (IPCC 2007). Various types of changes in climate can have direct or indirect effects on species. These effects may be positive, neutral, or negative and they may change over time, depending on the species and other relevant considerations, such as the effects of interactions of climate with other variables (e.g., habitat fragmentation) (IPCC 2007). In our analyses, we use our expert judgment to weigh relevant information, including uncertainty, in our consideration of various aspects of climate change.

In the Pacific Northwest, mean annual temperatures increased 1.5 $^{o}$ F in the 20$^{th}$ century and are expected to continue to warm from 0.2$^{o}$ to 1$^{o}$ F per decade (Mote and Salathe 2010). 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 2010). Regional models of potential climate changes are much more variable, but the models generally indicate a warming trend in mean annual temperature, reduced snowpack, and increased frequency of extreme weather events (Salathe *et al.* 2010). Downscaled regional climate models, such as those presented by www.climatewizard.org have tremendous variation in projections for annual changes in temperature or precipitation depending upon the climate model or scenario. Averaged values across large areas generally indicate a general warming trend in mean annual temperature consistent with the climate projections reported by Salathe *et al*. (2010).

On the cooler, moister west side of the Cascades, the summer water deficit is projected to increase two- to three-fold over current conditions (Littell 2009). East of the Cascade Crest, summer soil deficits may not change as much or may even moderate slightly over current conditions (Elsner *et al.* 2009). Researchers expect some ecosystems to become more water-limited, more sensitive to variability in temperature, and more prone to disturbance (McKenzie *et al.* 2009). 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 (Graumlich *et al.* 1989; Case and Peterson 2009). 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 2009). This may result in a change in species composition or reduction in the acreage of existing low-elevation forests.

The Revised Recovery Plan provides a detailed discussion of the possible environmental impacts to the habitat of the northern spotted owl from the projected effects of climate change (USFWS 2011a). Climate change may modify disturbance regimes across the range of the spotted owl, resulting in substantial changes to the frequency and extent of habitat disruption by natural events. For example, in drier, more fire-prone regions of the owl's range, habitat conditions will likely be more dynamic, and more active management may be required to reduce the risk of the essential physical or biological features from fire, insects, disease, and climate change as well as to promote regeneration following disturbance. Both the frequency and intensity of wildfires and mountain pine beetle (*Dendroctonus ponderosae*) outbreaks are expected to increase over the next century in the Pacific Northwest (Littell *et al.* 2010).

Predicted climate changes in the Pacific Northwest have implications for forest disturbances that are important for maintaining late seral old growth habitats. For example, fire activity is expected to increase in all major forest types in Oregon, and areas burned by fire in the Pacific Northwest are likely to increase substantially in the coming century (Hessburg *et al.* 2005, 2007; Kennedy and Wimberly 2009; Littell *et al.* 2009, 2010; Shafer *et al.* 2010). The gradual loss of late seral old growth habitats over the past century is linked to fire suppression and lack of disturbance. Natural landscape resilience mechanisms have been decoupled by fire exclusion and wildfire suppression activities (Hessburg *et al.* 2005; Moritz *et al.* 2011). Increased wildfire or insect disturbances associated with climate change are likely to have negative effects on spotted owl habitat due to increases in early seral habitat. Because wildfires typically result in a mosaic of burned and unburned areas, it is unlikely that increased incidence of wildfires associated with climate change would result in the loss of multiple populations across large areas within the species or subspecies range.

Though there is uncertainty with how climate change may specifically alter fire regimes, McKenzie *et al.* (2004) proposed several inferences that can be made given our understanding of fire-climate interactions and our understanding of vegetation response to fire. The first inference is that warmer and drier summers will produce more frequent and extensive fires. Second is that reduced snowpack and earlier snowmelt will likely extend the time span of moisture deficits in water-limited systems. Finally, drought stress on plants will increase as a result of the drier conditions and longer moisture deficits, increasing their vulnerability to other multiple disturbances such as fire and insects; these disturbances often have a synergistic effect.

Climate change is affecting the location, size and intensity of insect outbreaks, which in turn affect fire and other forest processes (Joyce *et al.* 2008; Kurz *et al.* 2008; Littell *et al.* 2009, 2010; Latta *et al.* 2010; Spies *et al.* 2010). Warming temperatures have led to mountain pine beetle outbreaks, with large-scale effects in some western forests, including in the eastern Cascades. In warmer winters more mountain pine beetles survive and shorten their generation time, resulting in larger and more severe outbreaks. Drought can heighten the susceptibility of host trees to attack (Littell *et al.* 2010). Littell *et al.* (2010) suggest that the greatest likelihood of mountain pine beetle attack is when conditions are hot and dry combined with a fairly short period of extreme vapor pressure deficit, when trees are most vulnerable. In the future, outbreaks are projected to increase at higher elevations and decrease at lower elevations (Littell *et al.* 2010), with uncertain implications for spotted owls. Littell *et al.* (2010) have projected that the combination of increased tree susceptibility and mountain pine beetle outbreaks could lead to the loss of pine species in the eastern Cascades as early as the 2040s. Mixed conifer stands in the eastern Cascades, which include pine species, provide den sites and food resources for bushy-tailed woodrats, an important prey species of spotted owls (Lehmkuhl *et al.* 2006a). Warmer winters have also been shown to increase the incidence of Swiss needle cast, a fungal disease in Douglas-fir on the Oregon coast (Manter *et al.* 2005) inhibiting tree growth, and causing severe chlorosis and defoliation. We are uncertain how much this will affect spotted owl habitat.

Recent bark beetle outbreaks have exceeded the magnitude of outbreaks documented during the prior 125 years in parts of the U.S. (Raffa *et al.* 2008). It appears that human activities have influenced recent increases in bark beetle activity (Logan and Powell 2001; Logan *et al.* 2003). Changing climate, particularly increased temperature and drought, combined with management that has favored continuous, uninterrupted distributions of host tree species (*e.g.,* Douglas-fir and true fir species), tend to foster outbreaks (Hicke and Jenkins 2008; Raffa *et al.* 2008). Unusually hot and dry weather is already responsible for increased insect outbreaks in forests in several North American localities, from pinyon pine in the southwest U.S. (Breshears *et al.* 2005) to lodgepole pine forests in British Columbia where the beetle outbreak is larger than any recorded in Canada (Carroll *et al.* 2004 as cited in Whitehead *et al.* 2006; Taylor *et al.* 2006).

With respect to forest pathogens, Kliejunas *et al.* (2009) summarize the literature on the relationship between climate change and tree diseases in western North America. They note that while there is great uncertainty with how specific pathogens will respond to climate change, general inferences can be made, all of which can vary by ecosystem and specific climate conditions. Similar to forest insects, pathogen distributions are expected to change, including invasion of new areas by nonnative pathogens. The epidemiology of plant diseases is also expected to change, complicating the prediction of disease outbreaks. The rate that pathogens evolve and overcome host resistance may increase in a rapidly changing climate. With increasing temperatures, we should expect an increase in overwintering survival of pathogens, as well as an increase in disease severity. Predicted drought stress on many host species will increase their vulnerability to, and exacerbate the effect of, many pathogens. Finally, with the exception of extremely dry conditions, climate change may alter fungal pathogens that could have a profound change on rates of wood decay, shortening the length of time valuable legacies like down wood can be retained in the ecosystem (Yin 1999).

Changes to the range and composition of current vegetation species are expected as local climates transform and become more favorable for some species and less favorable for others (van Mantgem *et al.* 2009; Allen *et al.* 2010; Haugo *et al.* 2010; Littell *et al.* 2010; Shafer *et al.* 2010). Increased mortality rates of trees have already been attributed to drought and heat stress caused by increasing temperatures (van Mantgem *et al.* 2009; Allen *et al.* 2010). With respect to animal species, climate change can increase the success of introduced or invasive species in colonizing new territory (Dale *et al.* 2001). Invasive animal species are more likely to be generalists, such as the barred owl, than specialists, such as the spotted owl and adapt more successfully to a new climate than natives (Dukes and Mooney 1999).

While a change in forest composition or extent is likely as the result of climate change, the rate of that change is uncertain. In forests with long-lived dominant tree species, mature individuals can survive these stresses, so 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). Some changes appear to be already occurring. 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). Finally, several studies imply that some areas on the landscape may resist climate-driven disturbances that may affect spotted owls and their habitat (Camp *et al.* 1997; Daley *et al.* 2009).

Spotted owls can be affected by changes in weather and climate directly, or through changes in forest composition, prey species abundance and distribution that may result from climate change. The influence weather and climate on spotted owl populations was evidenced in northern California (Franklin *et al*. 2000), Oregon (Olson *et al*. 2005; Dugger *et al*. 2005), and Washington (Glenn 2009). Wet, cold weather during the winter or nesting season, particularly the early nesting season, has been shown to negatively affect spotted owl reproduction (Olson *et al*. 2004; Dugger *et al*. 2005), survival (Franklin *et al*. 2000; Olson *et al*. 2004; Glenn 2009), and recruitment (Franklin *et al*. 2000). Drought or hot temperatures during the previous summer have also reduced spotted owl recruitment and survival (Franklin *et al*. 2000; Glenn 2009). The presence of high-quality habitat appears to buffer the negative effects of cold, wet springs and winters on survival of spotted owls as well as ameliorate the effects of heat. High-quality habitat might help maintain a stable prey base, thereby reducing the cost of foraging during the early breeding season when energetic needs are high (Carey *et al*. 1992; Franklin *et al*. 2000).

Population trends in birds of prey have frequently been associated with prey availability (Newton 1979) as well as with average annual or seasonal temperature and precipitation (Nicholl *et al*. 2003). Population sizes of northern flying squirrels, deer mice, and other mammal species that comprise spotted owl diets are often characterized by large annual variations in population size driven primarily by food availability (Ransome and Sullivan 1997; Waters and Zabel 1998; Gomez *et al*. 2005). Variation in weather can have substantial influence on food availability for small mammals. Small mammal populations have shown declines during drought (Spevak 1983), and population dynamics have been shown to be associated with regional climate cycles (Lima *et al*. 2001). Northern flying squirrels, the primary prey of northern spotted owls, feed primarily on hypogeous fungi (Gomez *et al*. 2005), which are most abundant during wet conditions particularly during late summer and fall (Luoma *et al*. 2003). While it is not clear how variation in weather or climate change affect small mammals in the Pacific Northwest, it is likely that effects of climate on spotted owls are related to how climatic conditions affect their prey.

Predicted effects of climate change in the Pacific Northwest in the 21st century include warmer, wetter winters and hotter, drier summers (Parson *et al*. 2001). Many climate models project an average warming of 2.7 $^{o}$F by 2030, 5.4 $^{o}$ F by 2050, and 7.2 - 10.8 $^{o}$ F by 2090 (Mote *et al*. 2008). Precipitation is projected to increase as well, but with the increase greatest in winter and potentially a decrease during the summer, resulting in an overall decrease in water availability. The increase in summer water limitation increases the risk of fire activity and creates drought stress on trees, making them more susceptible to insect and pathogen attacks. Even on the relatively humid west slope of the Cascade Range, forests are often constrained by water deficiencies during dry summers (Parson *et al*. 2001). Although global climate change has the potential to cause fundamentally different climate patterns with unpredictable consequences on population dynamics of the Northern Spotted Owl, results from demographic studies that looked at climate (Franklin *et al*. 2000; Olson *et al*. 2004; Dugger *et al*. 2005; Glenn *et al*. 2010, 2011a, b) suggest that both hotter, drier summers and wetter winters and nesting seasons have the potential to negatively affect spotted owls. Thus, increased habitat designation through this proposed action is intended to compensate for these effects.

### 3.4.4 Cumulative Impacts

Past actions relevant to the proposed action have been described earlier as part of the descriptions of the affected environment, as well as in the introduction and background sections at the beginning of the document. Here we focus on the ongoing and future actions that, when combined with the action, may affect the environment.

The Revised Recovery Plan for the Northern Spotted Owl was completed in September 2011 (USFWS 2011a). The plan establishes recovery criteria and contains multiple recovery actions recommended to conserve and recover the northern spotted owl. Recovery plans are not regulatory and implementation of recovery actions is discretionary. Given that it has only recently been finalized, there has been limited opportunity to implement the recommendations within it. As such, a track record has not yet been established to help determine to what extent recommendations within the Revised Recovery Plan will be implemented across the range of the northern spotted owl. The publication of the draft EIS to test experimental removal of barred owls (described below) is one of the recovery actions that may be implemented, depending on the alternative the Service selects in the final EIS. Workgroups described under recovery actions in the plan have been formed and are working on actions to assist the Service with spotted owl recovery. The Service is actively working with action agencies to address ways to best implement recovery actions that recommend retention of high quality habitat and conservation of spotted owl sites (see section 3.1.1.1 Federal Lands (Forest Service, BLM, and National Park Service). BLM units in southwest Oregon are developing pilot projects to test effectiveness of ecological forestry actions recommended in the Revised Recovery Plan. Federal agencies are beginning to implement discretionary measures described in the Revised Recovery Plan, which would provide conservation and recovery benefits to the spotted owl. However, it is still too early to foresee the degree and extent to which recommendations within the Revised Recovery Plan will be implemented across the range of the northern spotted owl.

The BLM is beginning another revision of their resource management plans, in part because of new science related to forest resiliency that has been applied in the northern spotted owl Revised Recovery Plan (BLM 2012). BLM announced their notice of intent to develop an Environmental Impact Statement on March 9, 2012 (77 FR 14414), with scoping concluding on June 7, 2012. Though still in the very early stages of planning (that is, just concluding scoping) BLM has indicated a shift towards use of ecological forestry actions to further northern spotted owl conservation. While this action may likely benefit northern spotted owls, the extent and degree to which their resource management plans direct the implementation of these actions, and potentially other recommendations from the Revised Recovery Plan is not reasonably foreseeable. As details of these actions develop, they will be subject to NEPA analysis, as will the individual projects implemented under these revised resource management plans; more specifics will be available in those analyses to more accurately determine effects.

While the Forest Service still continues to operate under the NWFP within the range of the northern spotted owl, the Okanogan-Wenatchee National Forest is undergoing a revision of their land use management plan. This forest covers over 4 million ac in the eastern Washington Cascades, and most of it overlays the range of the northern spotted owl. The forest has a proposed action (USFS 2011) and is in the process of developing their draft Environmental

Impact Statement, which is due out the first half of 2013. Key features of their proposed action relevant to spotted owl critical habitat are:

(1) A shift in focus from commodity production to ecosystem restoration.
(2) Addressing spotted owl recovery and better integrating habitat conservation with disturbance processes, climate change, and barred owl establishment by moving from smaller scale analyses and projects to incorporating a landscape-scale approach. The forest proposes managing habitat across the landscape, rather than limited to reserve areas, in configurations that are most likely to be, "sustainable, appropriately connected, and most resilient to changing climatic conditions." (USFS 2011, p. 39).
(3) Managing for spotted owl habitat, at the forest-wide scale, on 30 to 75 percent of the habitat capable lands, depending on forest type. Seventy-five percent of the habitat would be within a 1.8 mile radius of a northern spotted owl activity center.

The Forest's proposed action, as described above, mirrors recommendations from the Revised Recovery Plan for northern spotted owl conservation in dry-forest ecosystems. As such, their proposal, if implemented, would likely provide additional conservation benefit to northern spotted owls. However, the forest is still developing their draft Environmental Impact Statement and it remains to be seen whether and to what degree these features are included in the final management plan. As details of these actions develop, they will be subject to NEPA analysis, as will the individual projects implemented under the revised forest plan; more specifics will be available in these analyses to more accurately determine effects.

Joint Base Lewis-McChord (JBLM) is in the process of updating their Integrated Natural Resource Management Plan (INRMP) and is scheduled to provide a revised INRMP to the Service this year. Thus, it is currently unknown whether or how management at JBLM may change and how that change may affect conservation of the northern spotted owl.

The revised proposed rule identifies two habitat conservation plans currently being negotiated with the Service (77 FR 14134). These include lands owned by the Mendocino Redwood Company, which covers over 232,000 ac in California, and lands jointly owned and managed by the SDS Company and Broughton Lumber Company in Washington, which covers approximately 16,000 ac. Conservation measures as described in the existing proposals would provide increased conservation measures for the northern spotted owl as compared to no HCP development. However, these agreements are still under negotiation and not yet final. As such, ensuing conservation benefits are not yet certain.

As part of implementing recovery action 29 in the Revised Recovery Plan, (USFWS 2011a), the Service has published a draft EIS analyzing multiple alternatives to determine if experimentally removing barred owls will benefit northern spotted owl populations and to inform decisions on whether to move forward with future barred owl management. Depending on the alternative selected by the Service, experimental removal studies may take from 3 to 10 years. The Service, if it selects an action alternative, may then use the results from these experimental removals to inform any future decision regarding barred owl management. Although these experiments may provide key information that may shape spotted owl recovery in the face of barred owl competition, results are from several years to as much as a decade or more away.

A complaint filed against the Service (*AFRC v. Ashe* Civil No. 12-111-JDB, (D.D.C.)) has challenged our designation of critical habitat for the marbled murrelet. It also challenges the Service's denial of AFRC's petition to delist the species. Although it is speculative to predict a potential result of this litigation, a change in the designation of critical habitat for marbled murrelets could result in incremental effects on the environment additive to the effects of the proposed action.

A potential future action that could create effects in addition to the designation of critical habitat for the northern spotted owl is a result of a settlement agreement in *In re Endangered Species Act Section 4 Deadline Litigation* (Misc. Action No 10-377 (D.D.C.)) The settlement requires the Service, over the next five years, to make listing decisions (either a proposed rule or a not-warranted finding) on hundreds of species that are currently on the candidate list. Within the range of the northern spotted owl, the west coast distinct population segment (DPS) of the fisher (*Martes pennanti*) is a the only terrestrial forest species affected by this agreement; a decision on whether to list the fisher and its critical habitat will be put forth by September 30, 2014 as a result of this agreement. The fisher has habitat requirements that closely correspond with the northern spotted owl. Fishers use the same or similar features as the PCEs identified for the spotted owl (e.g., moderate to dense forest canopy; complex forest structure; large, deformed or deteriorating trees and logs; cavities in large trees) (Lofroth *et al*. 2010). The west coast DPS generally covers the range of the northern spotted owl as far south as Mendocino County, California; in addition, the fisher DPS also extends outside of the northern spotted owl range across the southern Cascades of California and south into the Sierra Nevada range (69 FR 18770).

While a listing decision on the west coast DPS of the fisher must be made in 2014 to comply with the settlement, the decision itself is not reasonably foreseeable. It does not automatically follow that a candidate species will ultimately become proposed for listing; during its time on the candidate list, species may recover or threats may be reduced to the point that the species no longer warrants listing. Thus, we cannot reasonably predict whether the fisher and its associated critical habitat will ultimately be listed or the cumulative effects on the environment.

# 4 COMPLIANCE, CONSULTATION AND COORDINATION WITH OTHERS

## 4.1 Compliance with Other Laws and Regulations

The Proposed Rule for critical habitat designation describes numerous laws and policies that are considered during the rulemaking process (77 FR 14062, pp. 14143-14147).

### 4.1.1 Permits Required for Implementation

The action of designating critical habitat does not require a permit. Designation of critical habitat occurs through a rule-making process under the Administrative Procedures Act and the Endangered Species Act.

## 4.2 Consultation and Coordination with Others

The designation of revised critical habitat for northern spotted has and will continue to be coordinated with the States of California, Oregon, and Washington; Tribes; other Federal agencies; counties; and other interested parties through letters, faxes, e-mails, telephone calls and our website. The Service initiated tribal consultation on this project through a consultation letter sent to sovereign nations within the range of the northern spotted owl. We met with key stakeholders (environmental groups and timber industry representatives), representatives of all three states, county commissioners, and representatives from the Forest Service, BLM, and Department of Defense.

## 4.3 Environmental Justice

Federal agencies are required to "identify and address disproportionately high and adverse human health and environmental effects" of their programs and actions on minority populations and low-income populations, as directed by Executive Order 12398 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations). The areas under consideration for this assessment are rural. This assessment has not identified any adverse or beneficial effects unique to minority or low-income human populations in the affected areas.

## 4.4 Public Review (and Comments in Final)

The proposed rule revising designation of critical habitat for the northern spotted owl was published in the Federal Register March 8, 2012 with an initial 90-day comment period (77 FR 14062). This draft Environmental Assessment and the Economic Analysis for the proposed designation were announced in the Federal Register on June 1, 2012 (77 FR 32483); the Service will accept comments on these documents, as well as the proposed revised rule, until July 6, 2012. All comments received will be reviewed and incorporated into the final Environmental Assessment as applicable. These documents are also available on the Service's website (http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/main.asp). The final environmental assessment will be made available to the public along with a determination by the USFWS Regional Director, Pacific Region, of either a Finding of No Significant Impacts (FONSI) or that an Environmental Impact Statement is required.

## 4.5 List of Contributors

The principle authors on this document are staff of the Oregon Fish and Wildlife Office, and staff from the Mountain Prairie Regional Office, U.S. Fish and Wildlife Service. Staff from the Pacific Regional office of the U.S. Fish and Wildlife Service and from the Pacific Northwest Regional Office of the Department of the Interior Office of the Solicitor provided review and assistance.

**Figure 1**. Eleven regions and four zones of habitat associations of northern spotted owls in Washington, Oregon, and California.

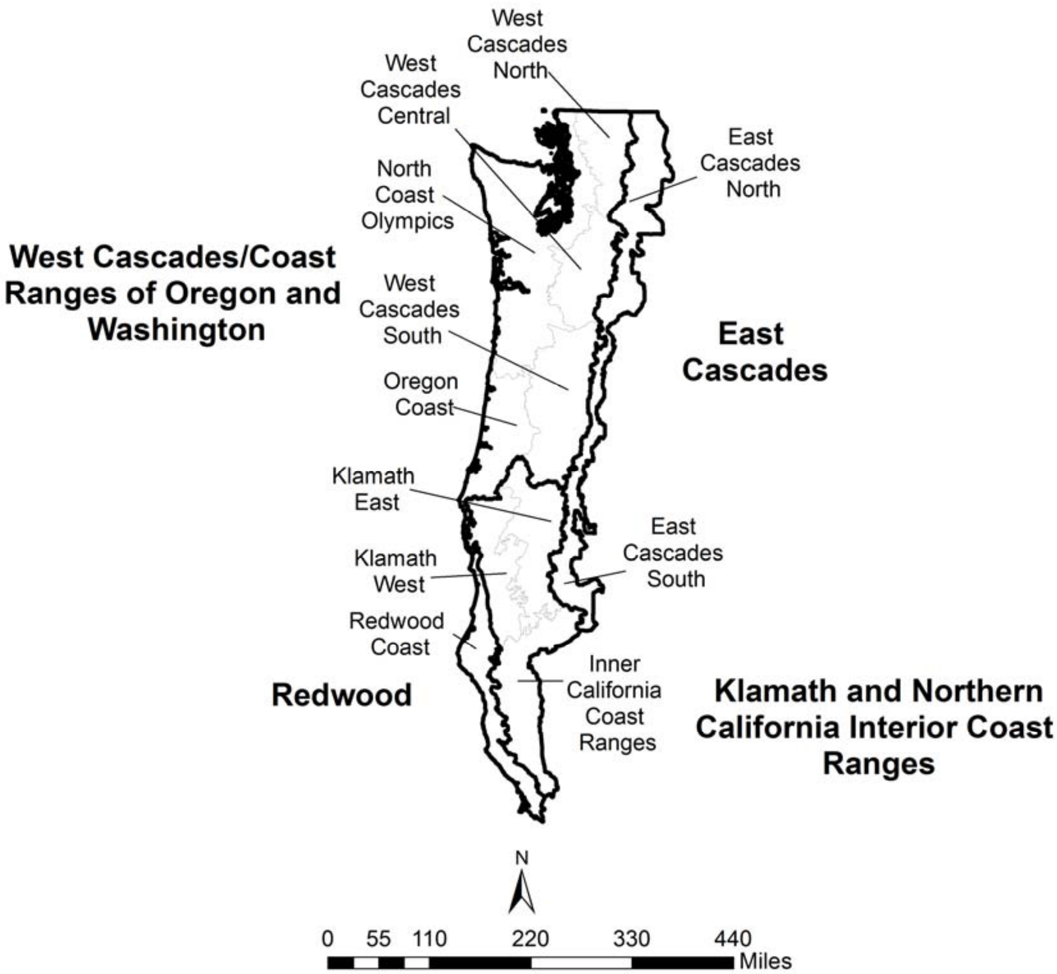


**Figure 2. Alternative A (No Action) map of critical habitat units in Washington (2008 Critical Habitat rule).**

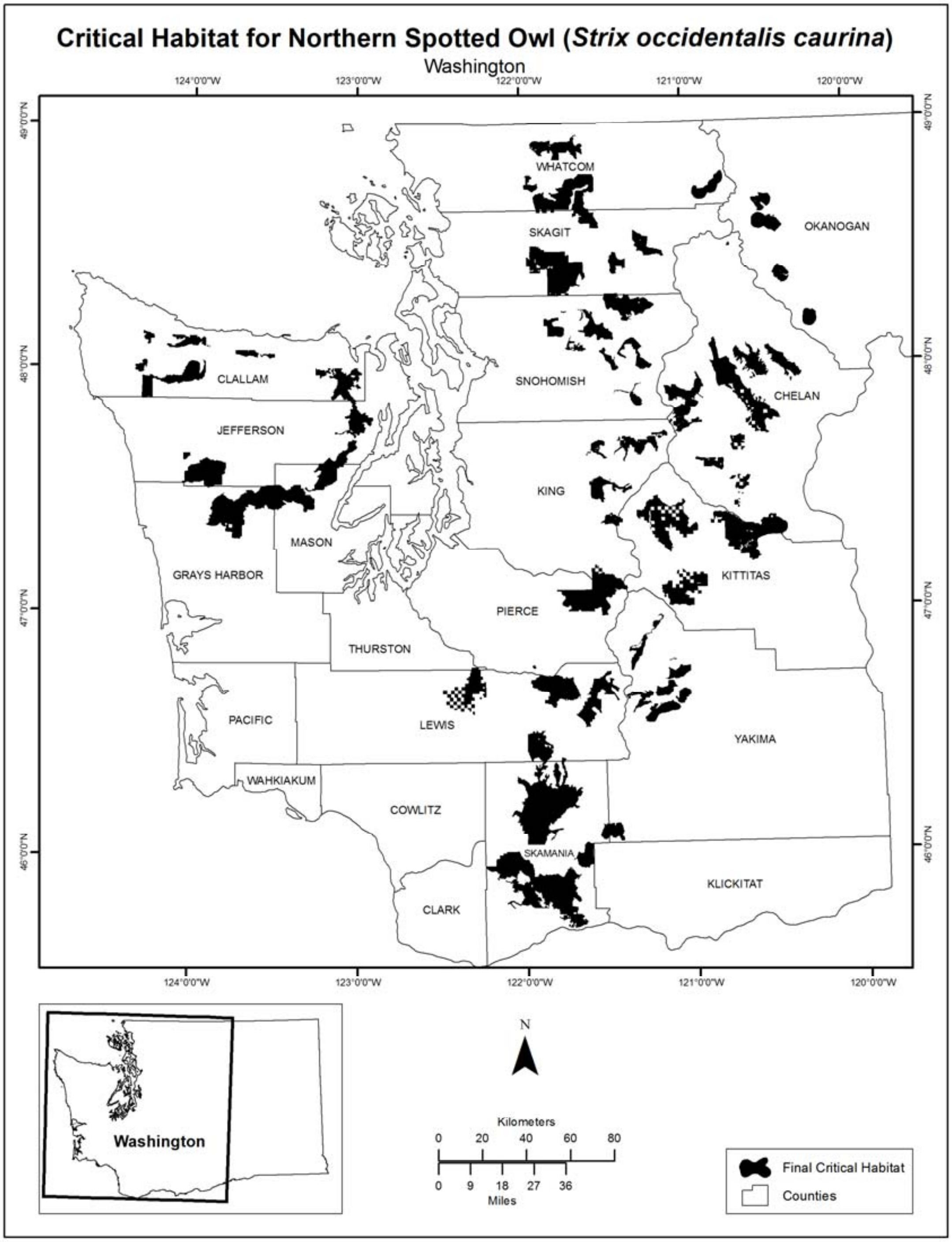


**Figure 3. Alternative A (No Action) map of critical habitat units in Oregon (2008 Critical Habitat rule).**

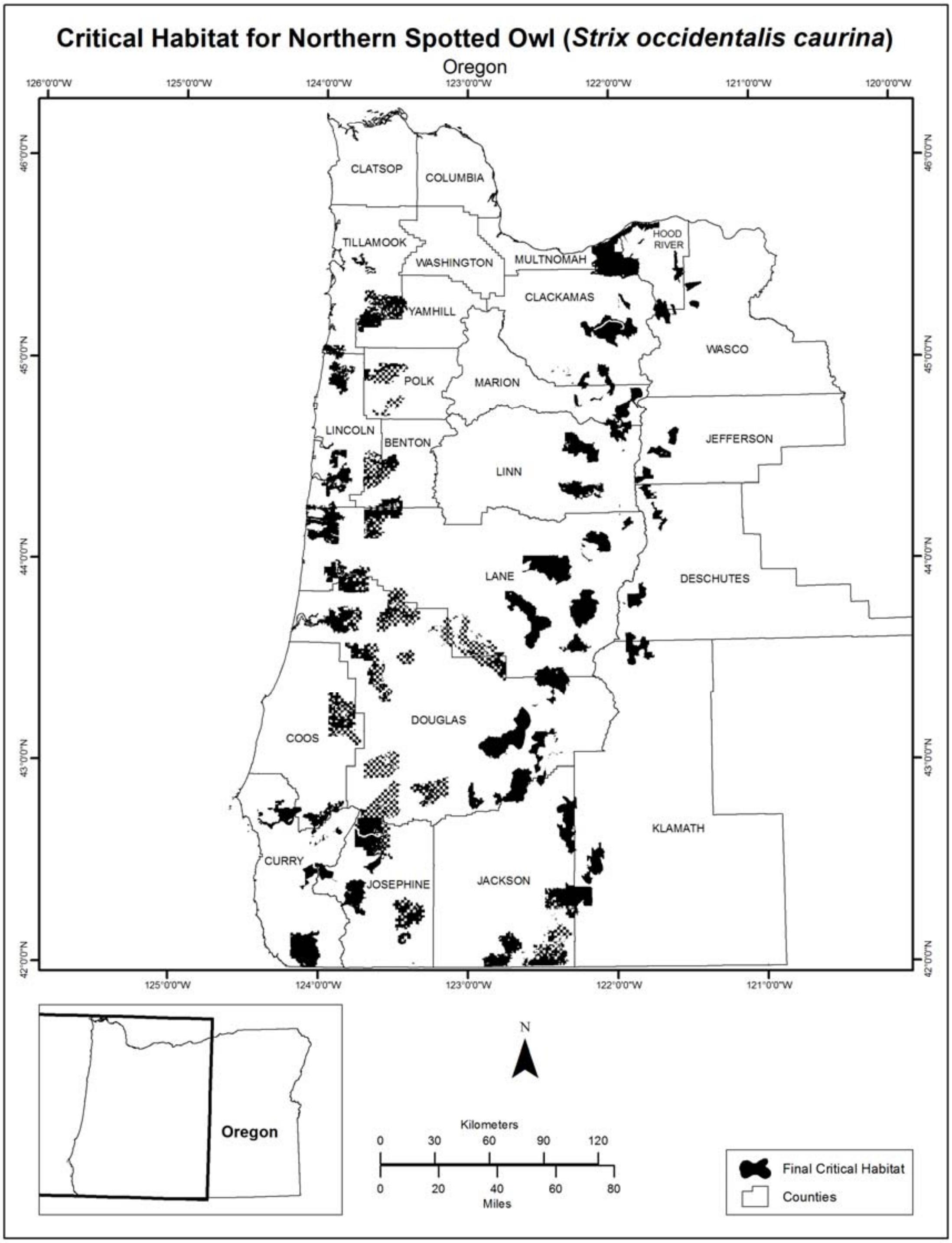


**Figure 4. Alternative A (No Action) map of critical habitat units in California (2008 Critical Habitat rule).**

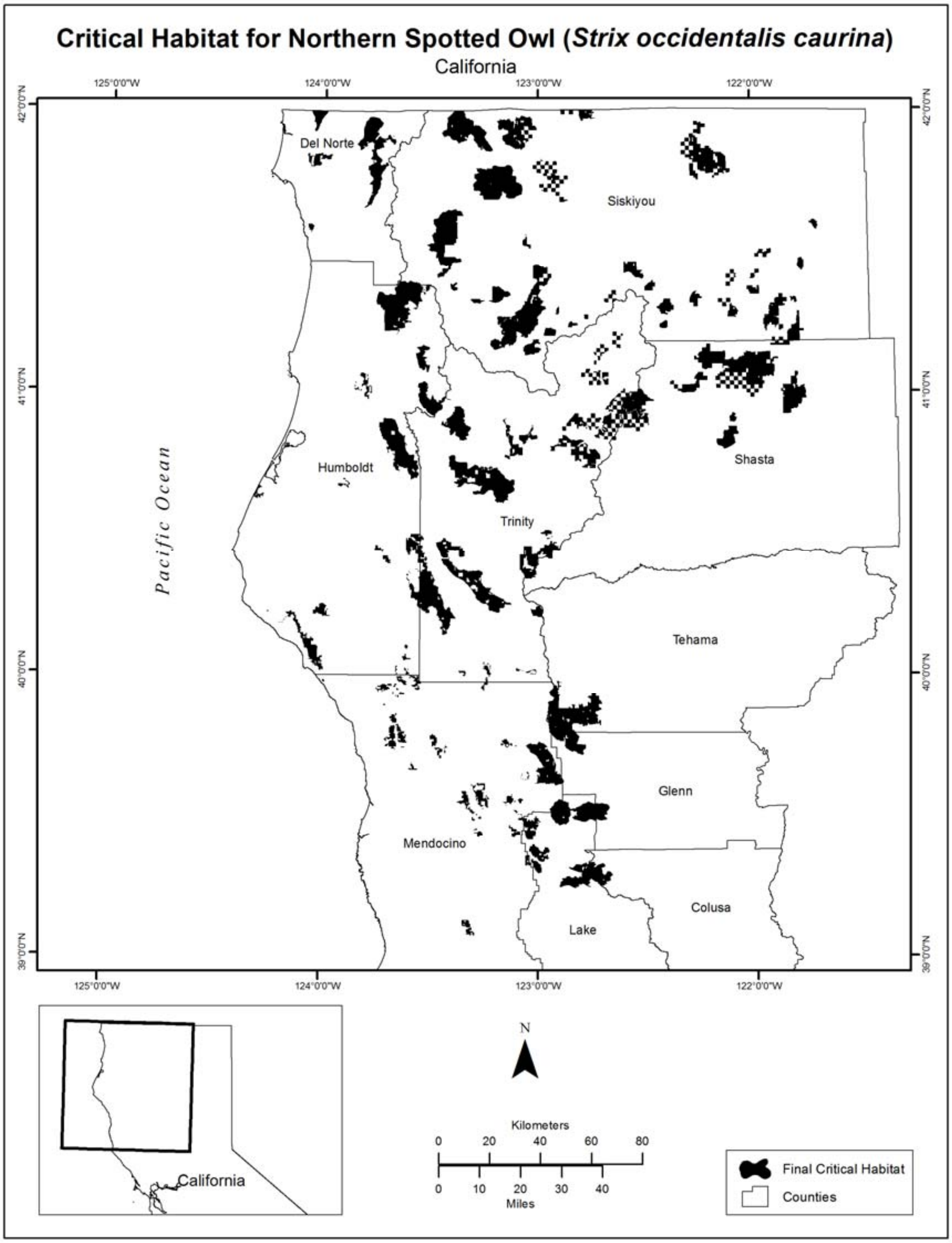


**Figure 5. Alternative B map of critical habitat units in Washington (Proposed Action).**

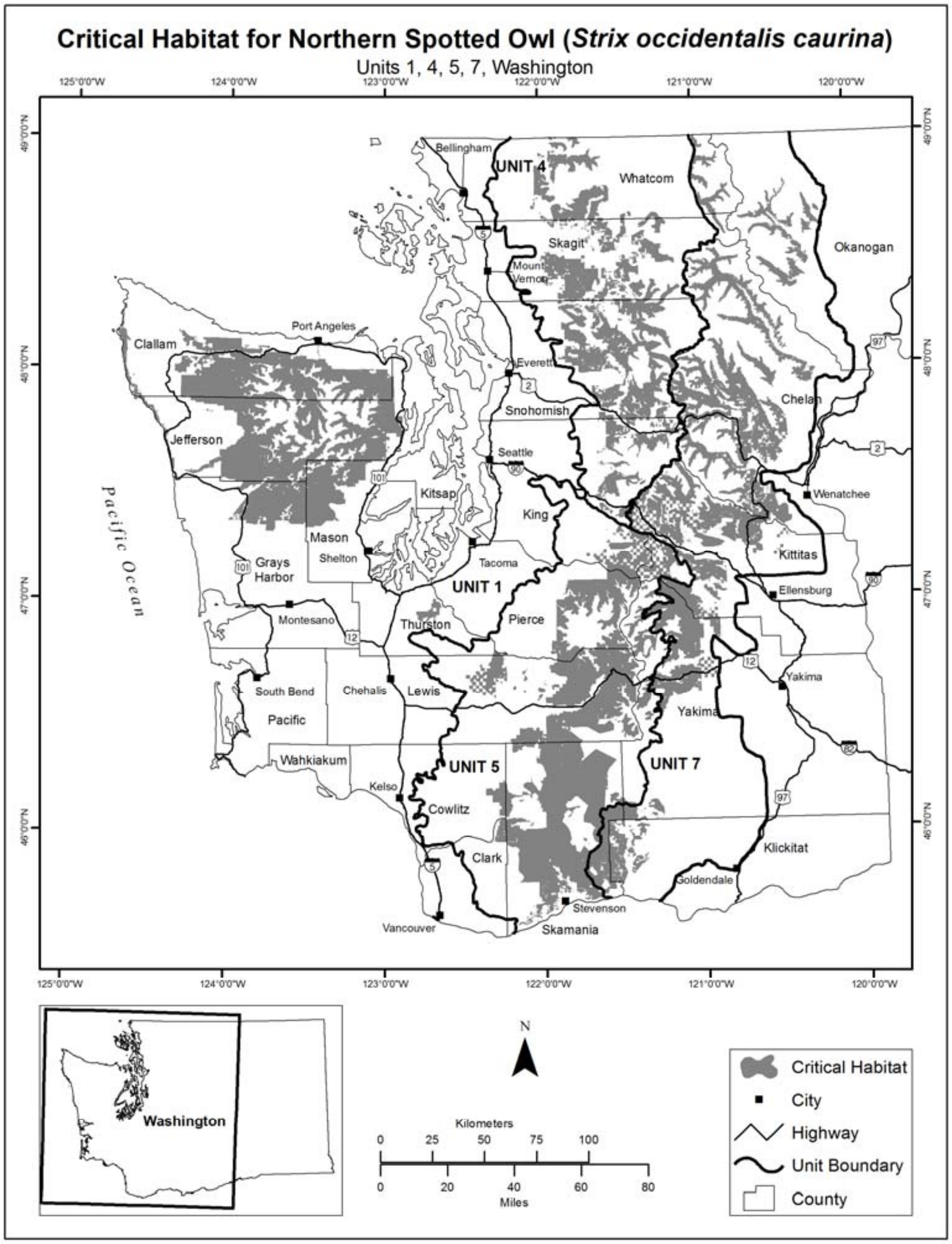


**Figure 6. Alternative B map of critical habitat units in Oregon (Proposed Action).**

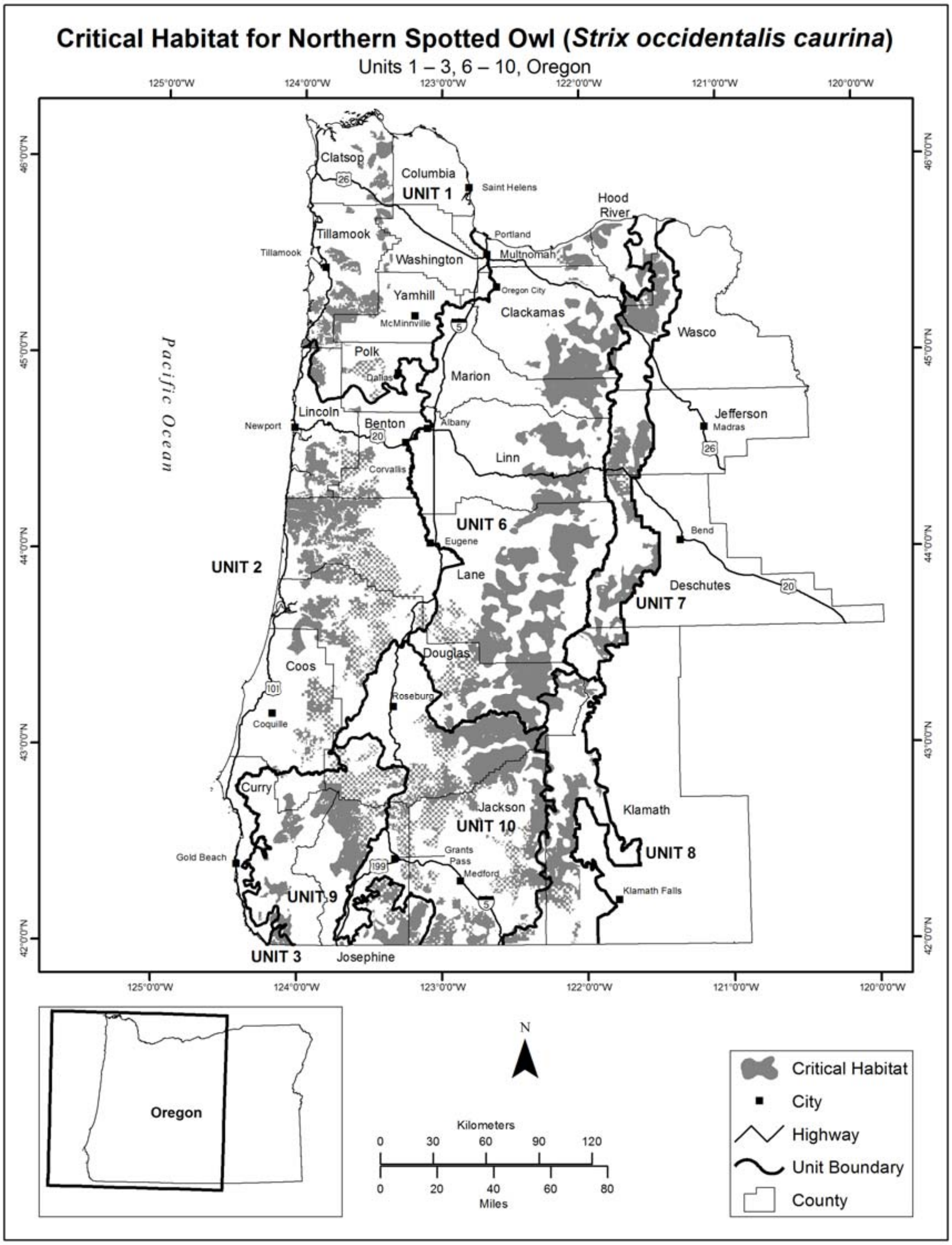


**Figure 7. Alternative B map of critical habitat units in California (Proposed Action).**

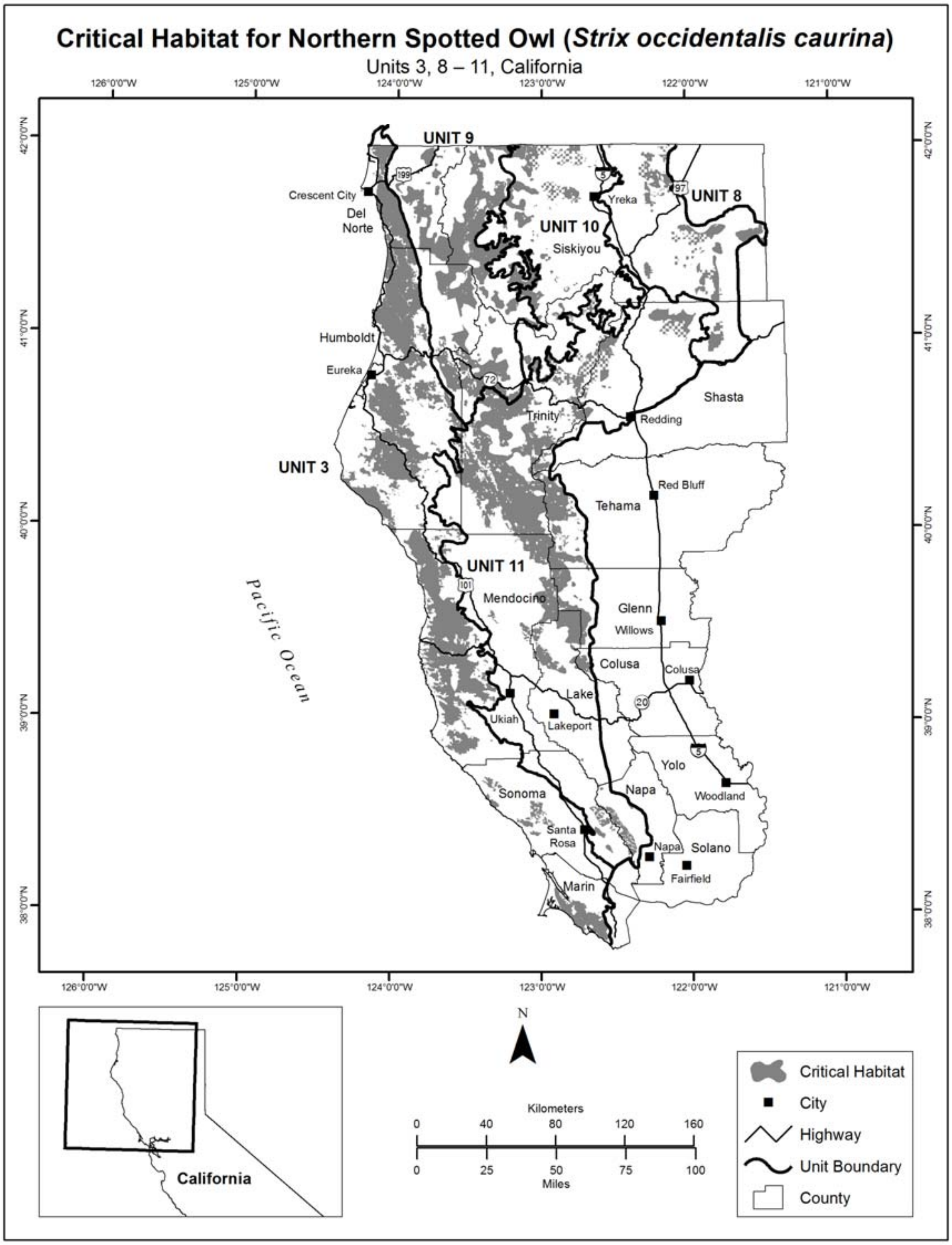


**Figure 8. Alternative C map of critical habitat units in Washingtion (Option 2 in proposed revised rule).**

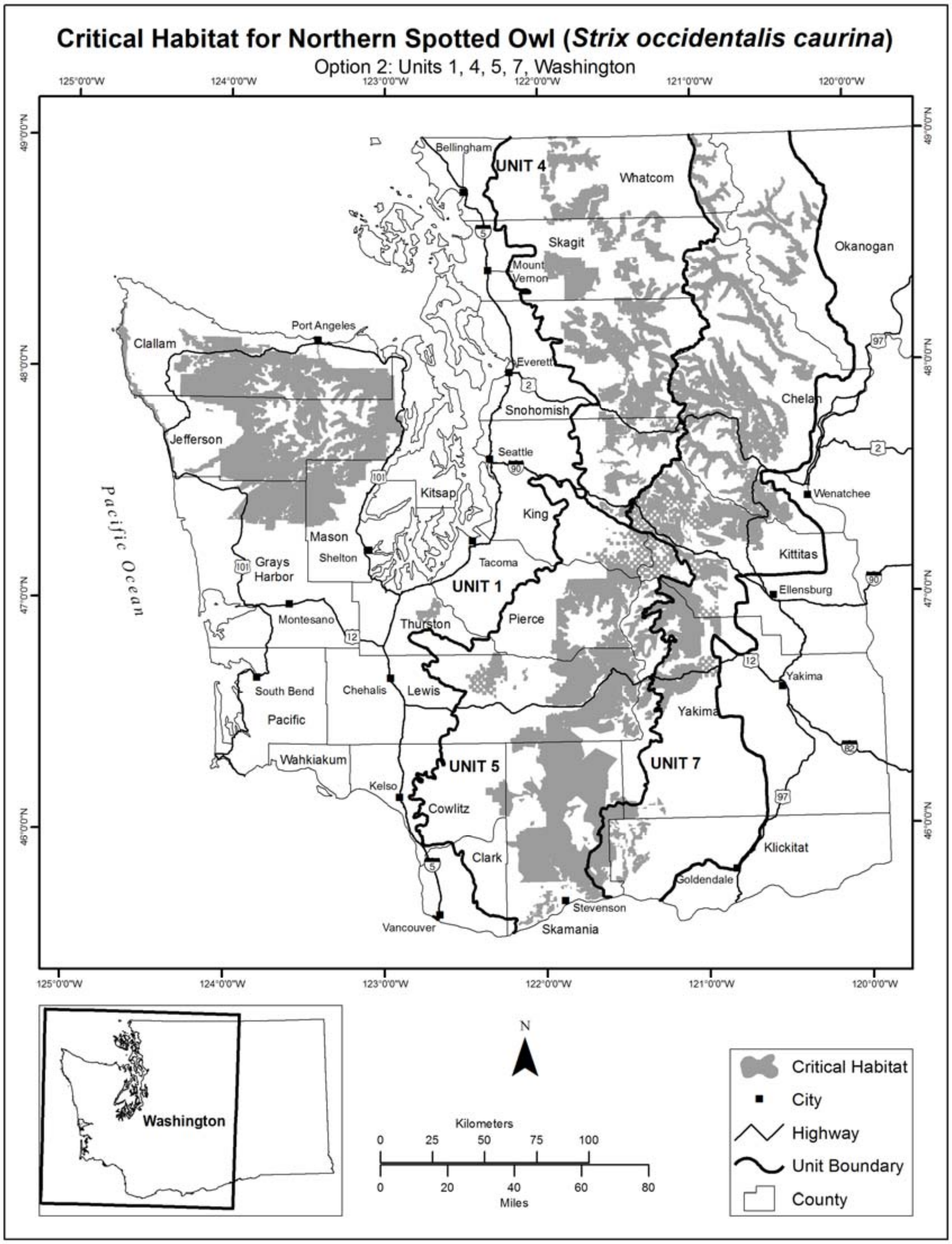


**Figure 9. Alternative C map of critical habitat units in Oregon (Option 2 in proposed revised rule).**

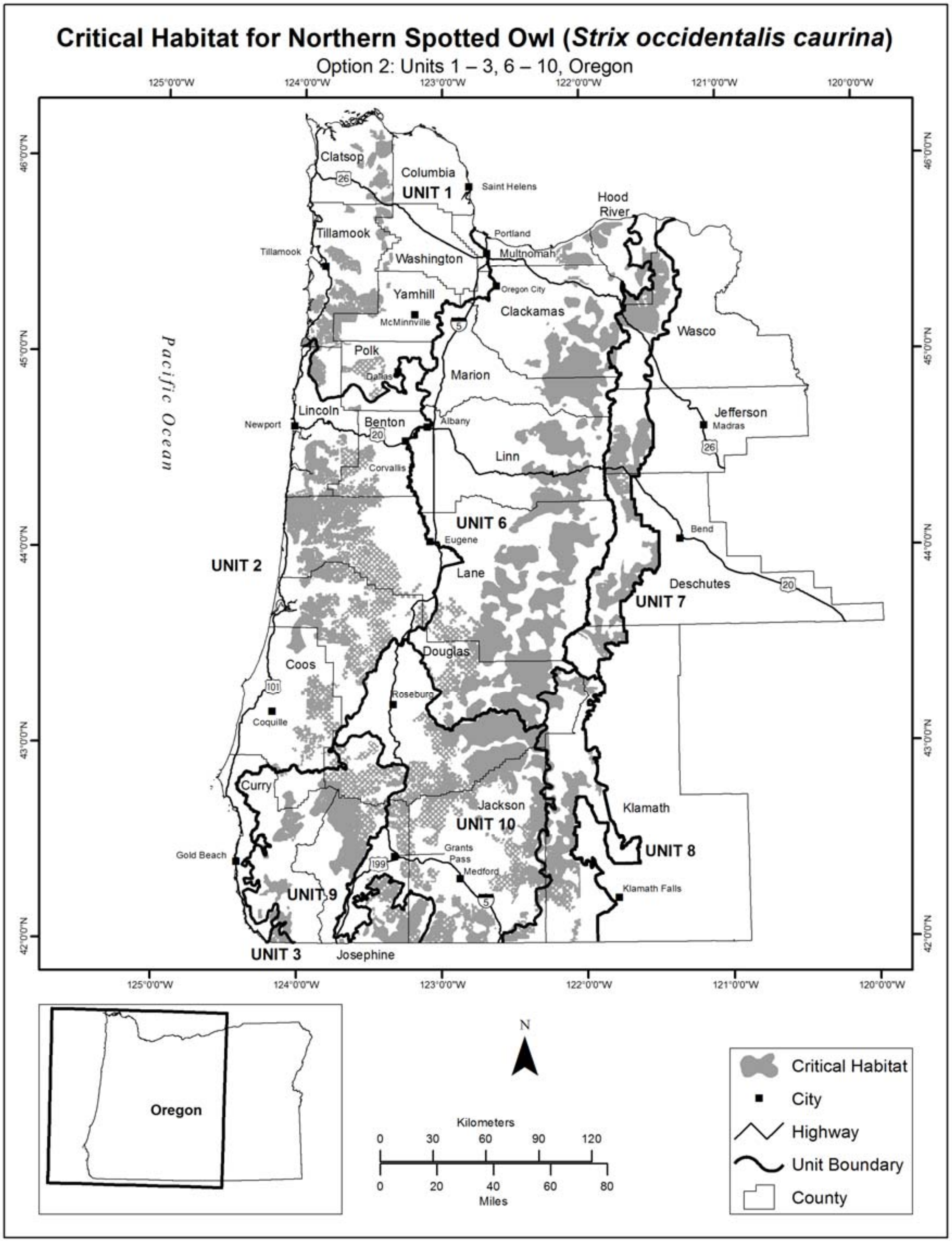


**Figure 10. Alternative C map of critical habitat units in California (Option 2 in proposed revised rule).**

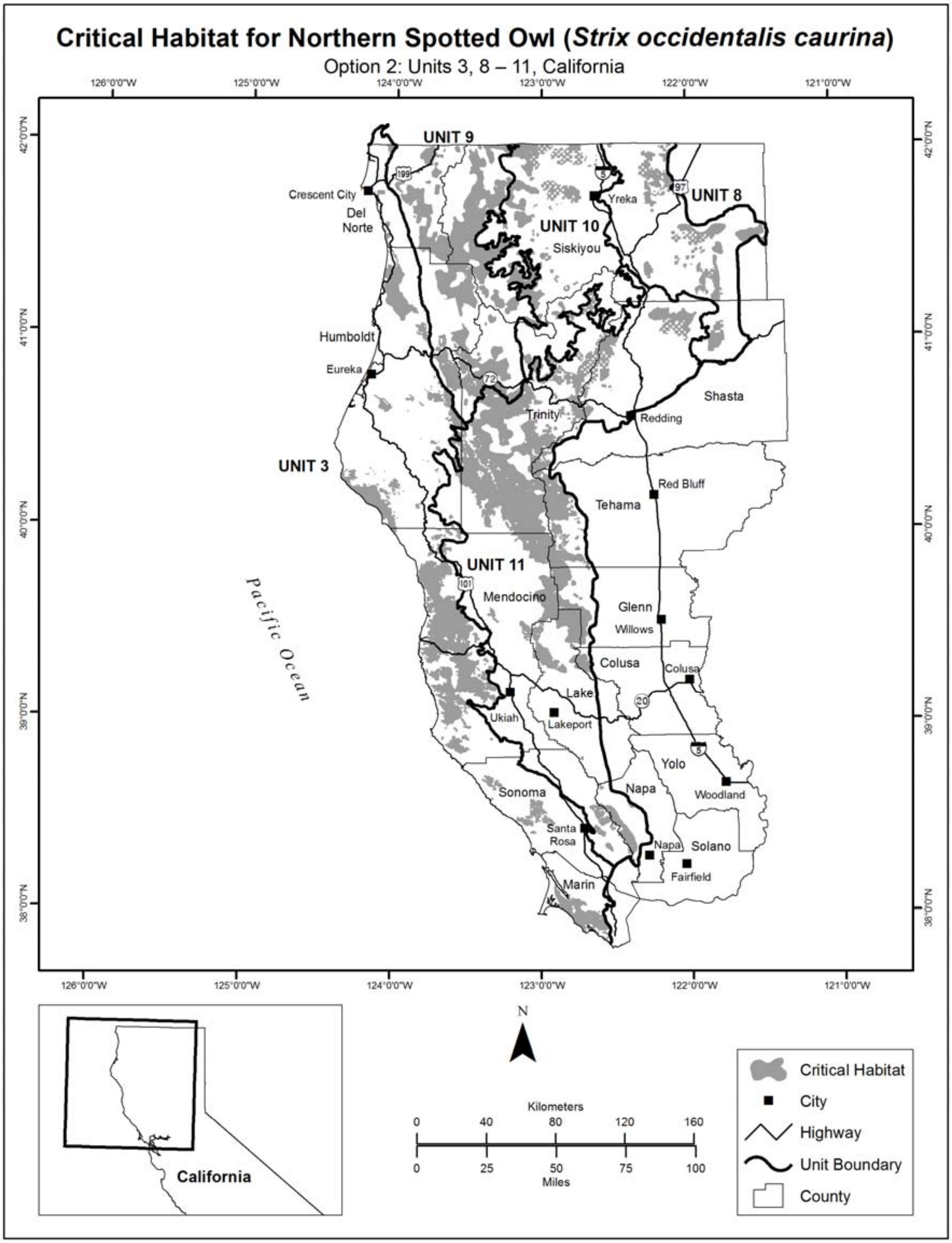


**Figure 11. Alternative D map of critical habitat units in Washingtion (Option 3 in proposed revised rule).**

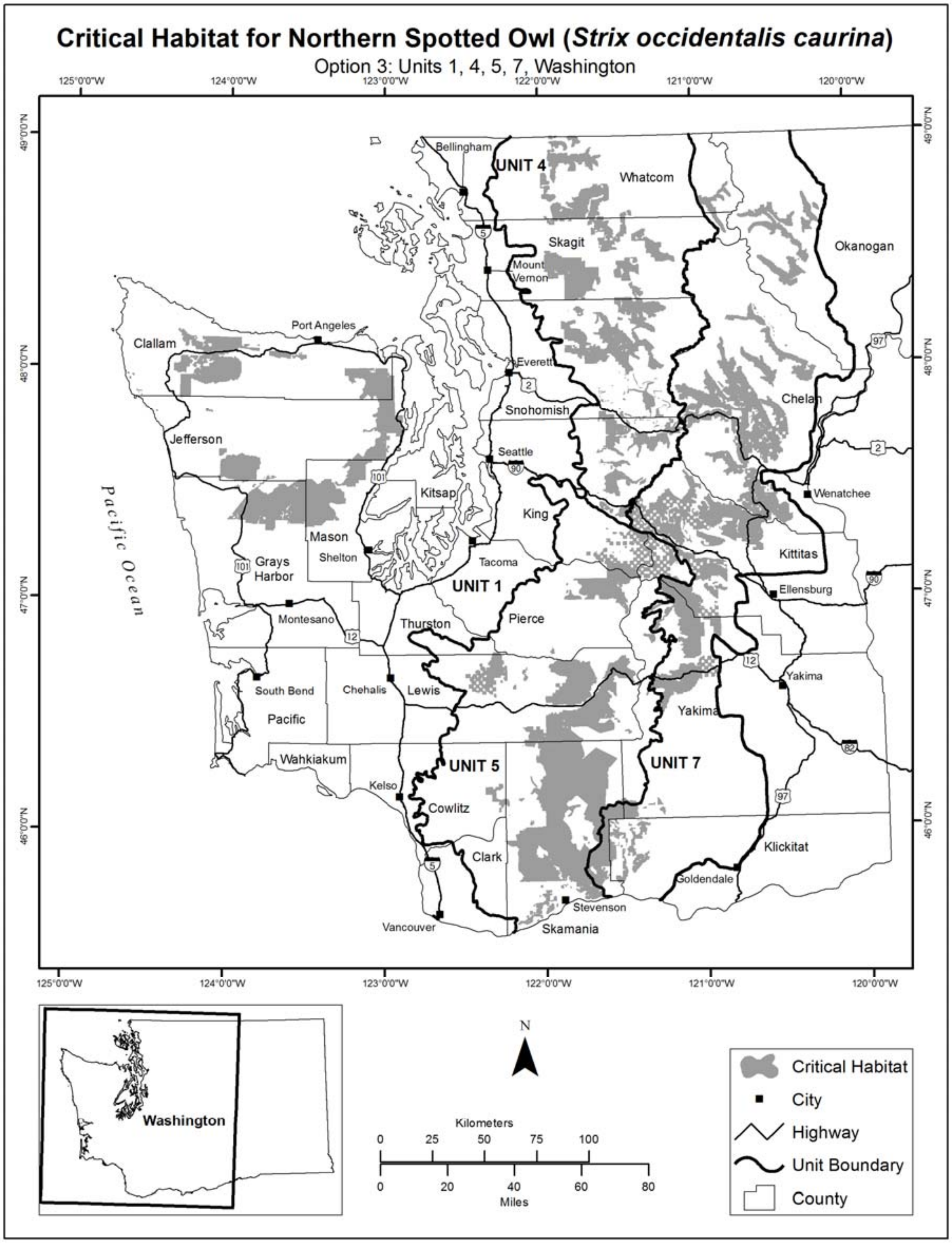


**Figure 12. Alternative D map of critical habitat units in Oregon (Option 3 in proposed revised rule).**

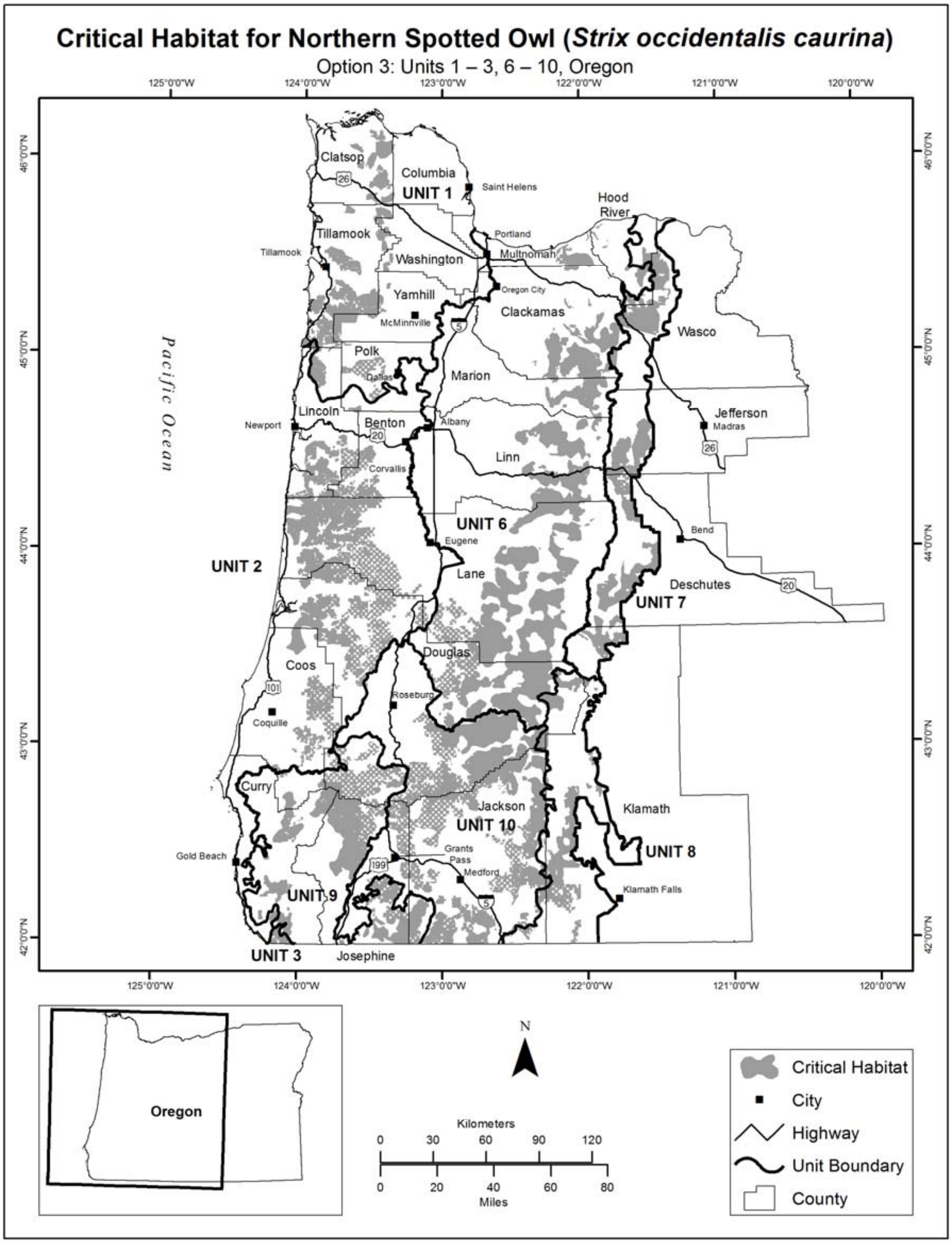


**Figure 13. Alternative D map of critical habitat units in California (Option 3 in proposed revised rule).**

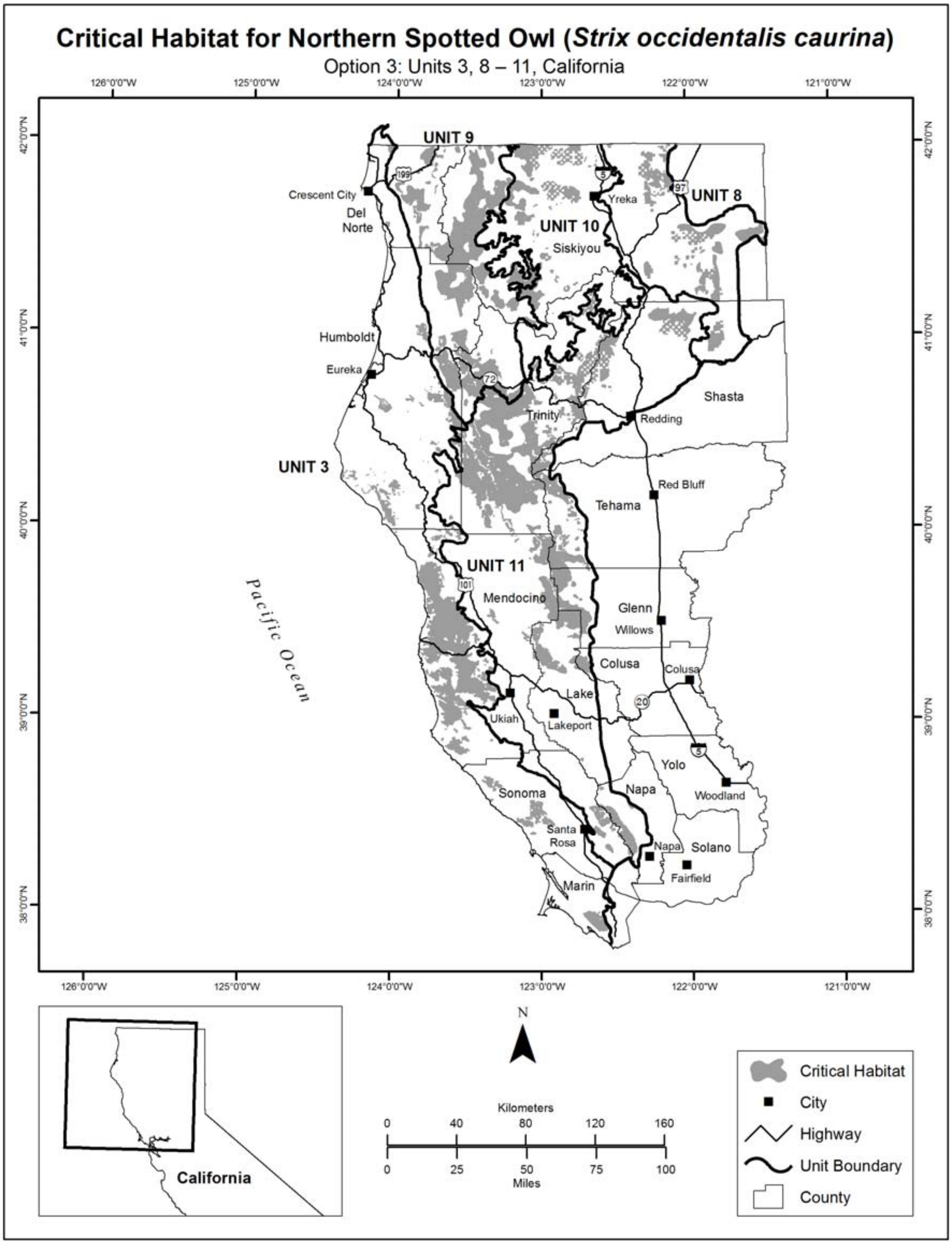


**Figure 14. Alternative E map of critical habitat units in Washingtion (Option 4 in proposed revised rule).**

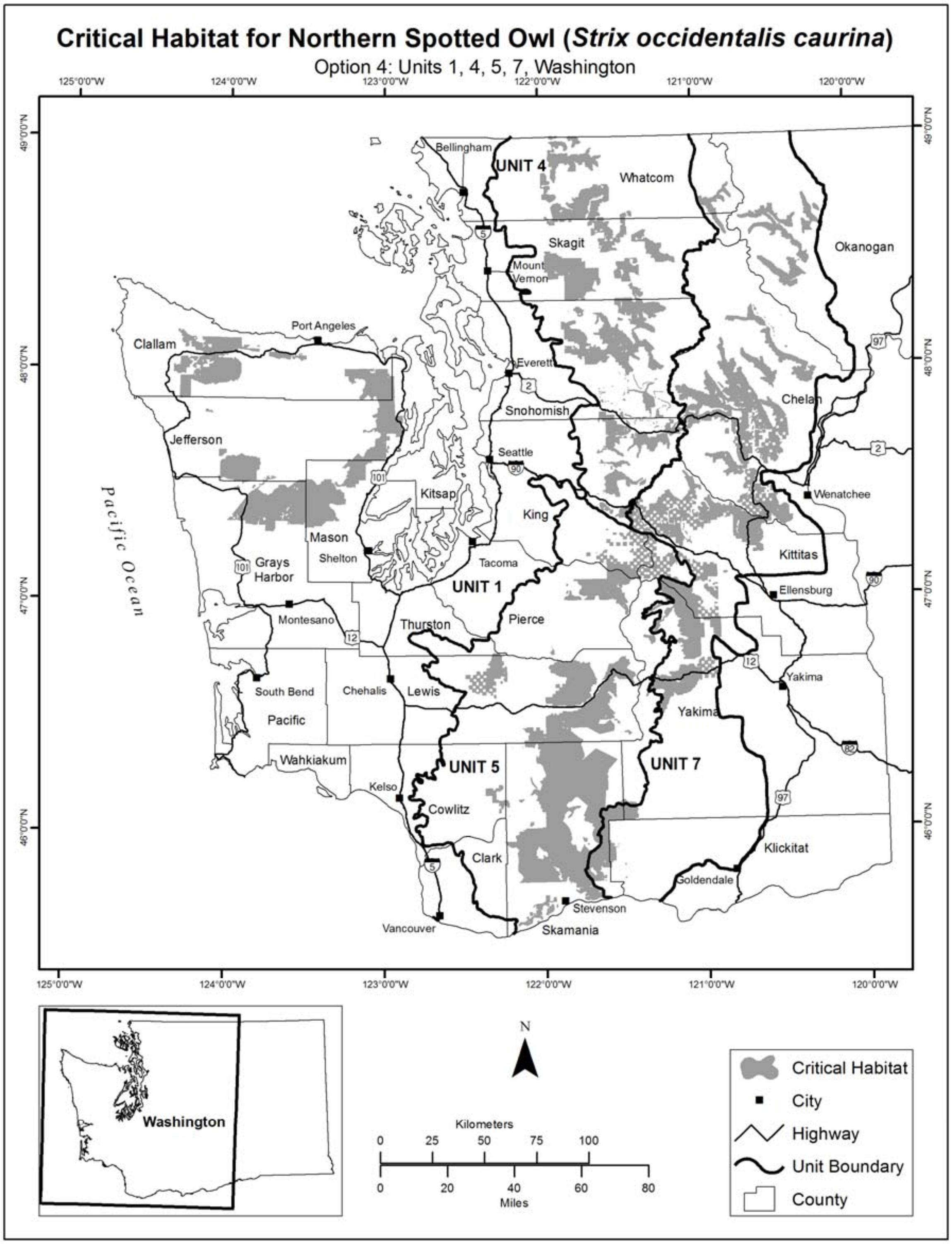


**Figure 15. Alternative E map of critical habitat units in Oregon (Option 4 in proposed revised rule).**

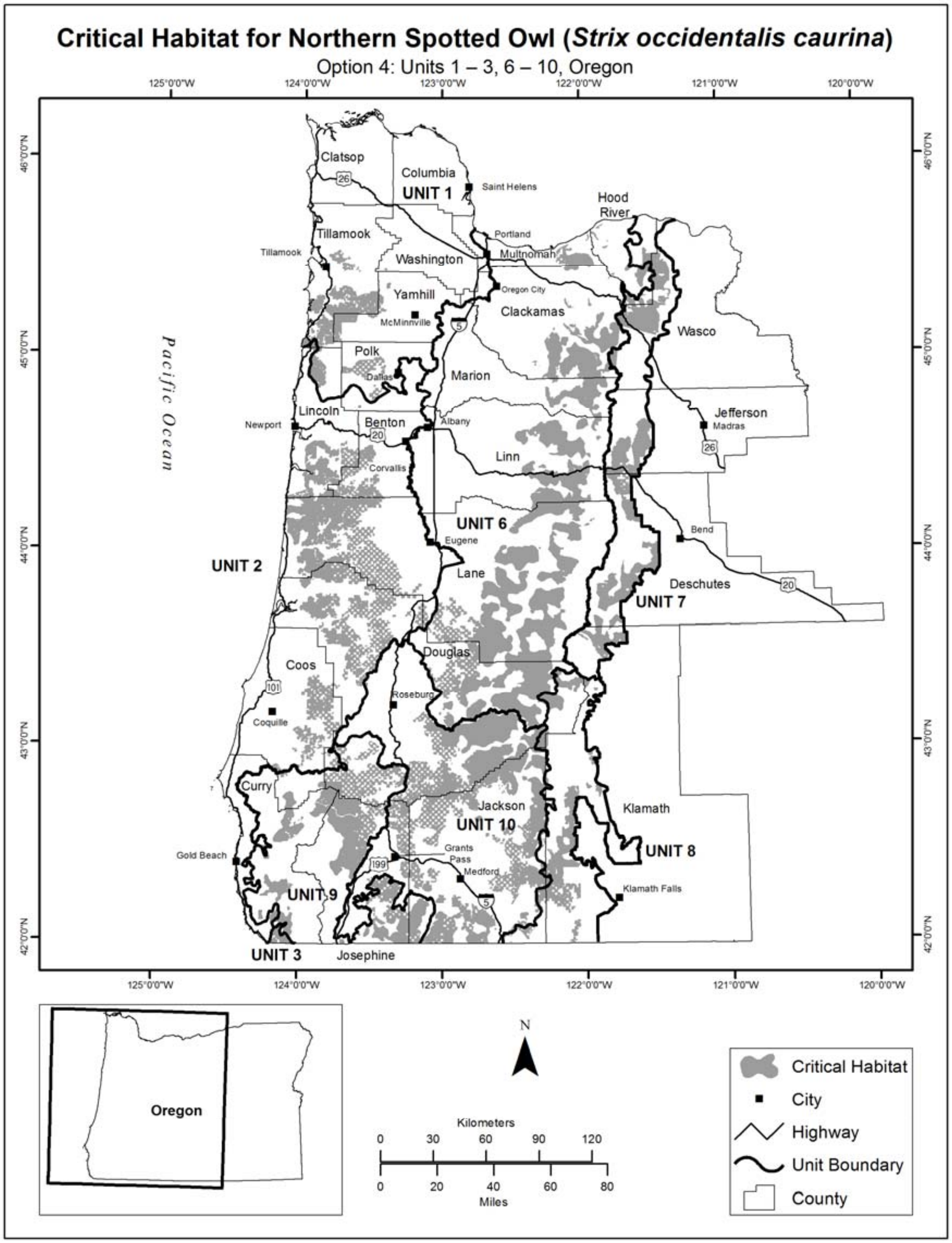
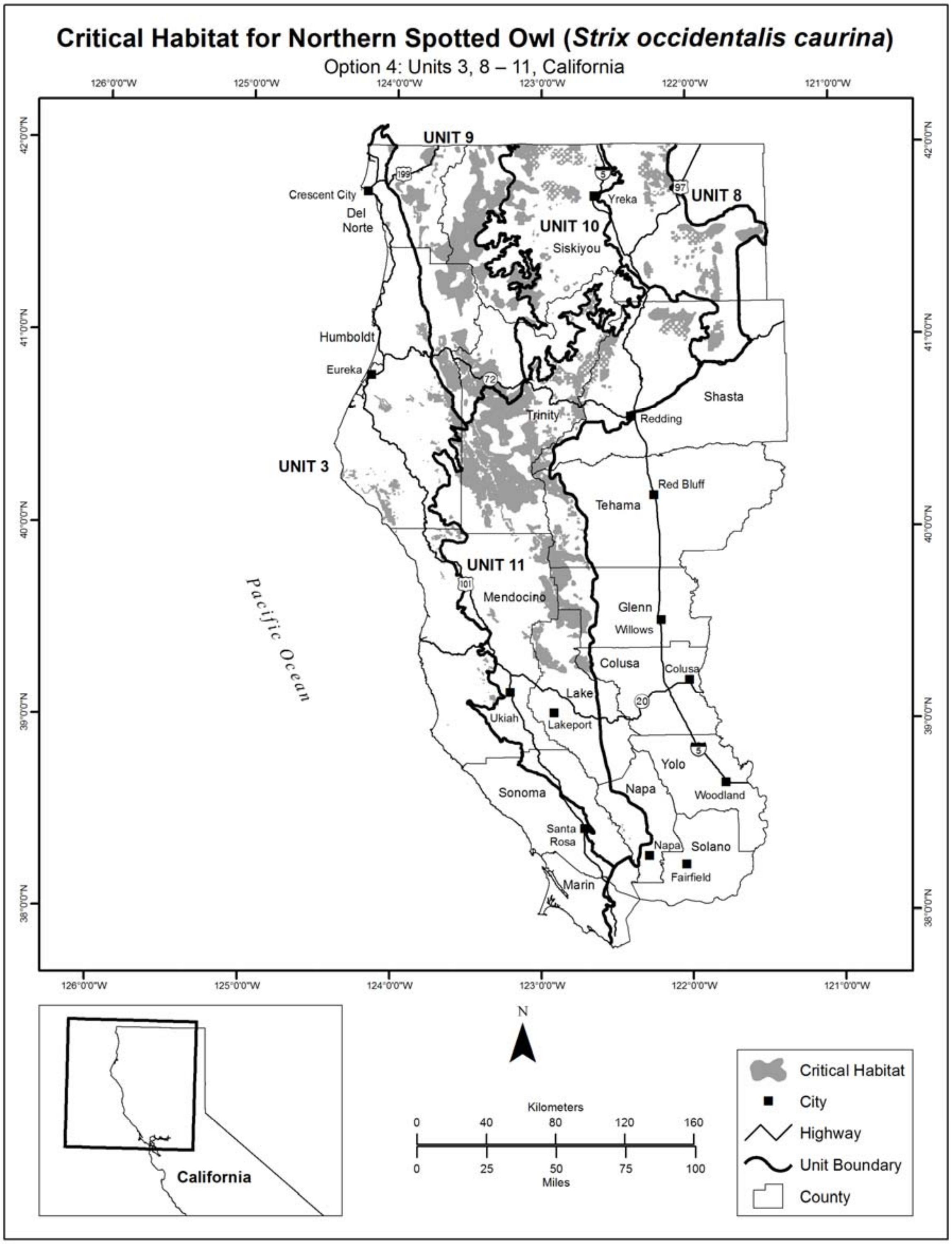


**Figure 16. Alternative E map of critical habitat units in California (Option 4 in proposed revised rule).**



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# Appendices to the DRAFT Environmental Assessment for the Designation of Critical Habitat for Northern Spotted Owl.

## Prepared by the U.S. Fish and Wildlife Service
## Region 1
## Portland, Oregon
## June 2012

# Appendix A

Table A-1. List of State Parks and Congressionally Reserved Natural Areas Excluded from critical habitat designation. Does not include Wild and Scenic River land designations.

| Entity excluded | State |
|---|---|
| **California State Parks** | |
| Del Norte Coast Redwoods State Park | California |
| Grizzly Creek Redwoods State Park | California |
| Hendy Woods State Park | California |
| Humboldt Redwoods State Park | California |
| Jedediah Smith Redwoods State Park | California |
| Mendocino Headlands State Park | California |
| Mount Tamalpais State Park | California |
| Navarro River Redwoods State Park | California |
| Prairie Creek Redwoods State Park | California |
| Richardson Grove State Park | California |
| Russian Gulch State Park | California |
| Salt Point State Park | California |
| Samuel P. Taylor State Park | California |
| Sonoma Coast State Park | California |
| Tomales Bay State Park | California |
| Van Damme State Park | California |
| | |
| **Wilderness Areas** | |
| Alpine Lakes Wilderness Area | Washington |
| Badger Creek Wilderness Area | Oregon |
| Boulder Creek Wilderness Area | Oregon |
| Boulder River Wilderness Area | Washington |
| Buckhorn Wilderness Area | Washington |
| Bull of the Woods Wilderness Area | Oregon |
| Chanchelulla Wilderness Area | California |
| Clackamas Wilderness Area | Oregon |
| Clearwater Wilderness Area | Washington |
| Colonel Bob Wilderness Area | Washington |
| Cummins Creek Wilderness Area | Oregon |
| Diamond Peak Wilderness Area | Oregon |
| Drift Creek Wilderness Area | Oregon |
| Elkhorn Ridge Wilderness Area | California |

| | |
|---|---|
| Glacier Peak Wilderness Area | Washington |
| Glacier View Wilderness Area | Washington |
| Goat Rocks Wilderness Area | Washington |
| Henry M. Jackson Wilderness Area | Washington |
| Indian Heaven Wilderness Area | Washington |
| Kalmiopsis Wilderness Area | Oregon |
| King Range Wilderness Area | California |
| Lake Chelan-Sawtooth Wilderness Area | Washington |
| Marble Mountain Wilderness Area | California |
| Mark O. Hatfield Wilderness Area | Oregon |
| Menagerie Wilderness Area | Oregon |
| Middle Santiam Wilderness Area | Oregon |
| Mount Adams Wilderness Area | Washington |
| Mount Hood Wilderness Area | Oregon |
| Mount Jefferson Wilderness Area | Oregon |
| Mount Lassic Wilderness Area | California |
| Mount Rainier Wilderness Area | Washington |
| Mount Skokomish Wilderness Area | Washington |
| Mount Thielsen Wilderness Area | Oregon |
| Mount Washington Wilderness Area | Oregon |
| Mountain Lakes Wilderness Area | Oregon |
| Norse Peak Wilderness Area | Washington |
| North Fork Wilderness Area | California |
| Olympic Wilderness Area | Washington |
| Opal Creek Wilderness Area | Oregon |
| Pasayten Wilderness Area | Washington |
| Philip Burton Wilderness Area | California |
| Red Buttes Wilderness Area | California – Oregon |
| Roaring River Wilderness Area | Oregon |
| Rock Creek Wilderness Area | Oregon |
| Rock and Islands Wilderness Area | California |
| Rogue-Umpqua Divide Wilderness Area | Oregon |
| Russian Wilderness Area | California |
| Salmon-Huckleberry Wilderness Area | Oregon |
| Sanhedrin Wilderness Area | California |
| Siskiyou Wilderness Area | California |
| Sky Lakes Wilderness Area | Oregon |
| Snow Mountain Wilderness Area | California |
| Soda Mountain Wilderness Area | Oregon |

| | |
|---|---|
| South Fork Eel River Wilderness Area | California |
| Stephen Mather Wilderness Area | Washington |
| Table Rock Wilderness Area | Oregon |
| Tatoosh Wilderness Area | Washington |
| The Brothers Wilderness Area | Washington |
| Three Sisters Wilderness Area | Oregon |
| Trapper Creek Wilderness Area | Washington |
| Trinity Alps Wilderness Area | California |
| Waldo Lake Wilderness Area | Oregon |
| Washington Islands Wilderness Area | Washington |
| Wild Rogue Wilderness Area | Oregon |
| Wild Sky Wilderness Area | Washington |
| William O. Douglas Wilderness Area | Washington |
| Wonder Mountain Wilderness Area | Washington |
| Yolla Bolly-Middle Eel Wilderness Area | California |
| Yuki Wilderness Area | California |
| | |
| **Other Congressionally Reserved Natural Areas** | |
| Crater Lake National Park | Oregon |
| Golden Gate National Recreation Area | California |
| Mount Rainer National Park | Washington |
| Mount St. Helens National Volcanic Monument | Washington |
| Muir Woods National Monument | California |
| Olympic National Park | Washington |
| Opal Creek Scenic Recreation Area | Oregon |
| Point Reyes National Seashore | California |
| Redwood National Park | California |
| Whiskeytown National Recreation Area | California |

# Appendix B

This appendix contains the following report:

Dunk, J. R., B. Woodbridge, D. LaPlante, N. Schumaker, B. Glenn, B.C. White, K. Halupka, S. Livingston, M. Zwartjes and J. Peters. 2012. Modeling and analysis procedures used to identify and evaluate potential critical habitat networks for the northern spotted owl. U.S. Fish and Wildlife Service.

# Modeling and Analysis Procedures used to Identify and Evaluate Potential Critical Habitat Networks for the Northern Spotted Owl

**U.S. Fish and Wildlife Service • February 28, 2012**

## INTRODUCTION

This document provides a chronological history of the modeling process utilized by the U.S. Fish and Wildlife Service (Service) to identify and evaluate potential critical habitat networks for the northern spotted owl (*Strix occidentalis caurina*). This paper does not utilize the traditional scientific manuscript structure (Introduction, Methods, Results, and Discussion). Due to the complexity of the modeling process, we believe this chronological style leads to a document that is easier to follow and understand.

We consistently base our evaluations on the best scientific information available, while acknowledging that this information is clearly incomplete. However, the best scientific information and data *available* differ from the best *possible* scientific information. We do our best to recognize and articulate uncertainties, and the relative strength of evidence for information versus our use of professional judgment or other sources of information for making recommendations.

There are likely to be multiple defensible approaches to the challenge of identifying a species' critical habitat. We conjecture that most rigorous alternative approaches should result in similar areas being identified as essential for the species of interest. The approach we have adopted makes use of the best available quantitative modeling tools, and is designed to be thorough, transparent, and repeatable.

### *Guiding Principles*

Our critical habitat evaluation process began with the statutory definition of critical habitat, which is aimed at identifying lands occupied at the time of listing containing the physical and biological features essential to the conservation of the species as well as unoccupied areas essential to its conservation. Based on this we developed a set of *Guiding Principles* that generally identified what would be essential to conserving the species These principles formed the basis for establishing quantitative and qualitative criteria used by the Service while evaluating and comparing potential critical habitat networks. As the purpose of critical habitat is to contribute to the conservation of the listed species, we used the recovery goals and criteria of the Revised Recovery Plan for the Northern Spotted Owl (USFWS 2011) as the foundation for our guiding principles and rule set for identifying critical habitat.

#### Guiding Principles for Northern Spotted Owl Critical Habitat

1) Ensure sufficient habitat to support population viability across the range of the species.

   Habitat will be sufficient to support an increasing or stable population trend (e.g., a rate of population change (lambda ≥ 1.0) Habitat will be sufficient to insure a low risk of extinction.

2) Support demographically stable populations in each recovery unit.

   Habitat will be sufficient to support an increasing or stable population trend (e.g. lambda ≥ 1.0) in each recovery unit.

   Habitat will be sufficient to insure a low risk of extinction in each recovery unit.

   Conserve or enhance connectivity within and among recovery units.

   Conserve genetic diversity.

   Ensure sufficient spatial redundancy in critical habitat within each recovery unit.

   Accommodate habitat disturbance due to fire, insects, disease, and catastrophic events.

3) Ensure distribution of spotted owl populations across representative habitats.

   Maintain distribution across the full ecological gradient of the historical range.

4) Incorporate/consider/accommodate uncertainty – barred owls, climate change, fire/disturbance risk, demographic stochasticity.

5) These critical habitat objectives of supporting population viability and demographically stable populations are intended to be met in concert with the implementation of recovery actions to address other non-habitat based threats to the owl.

## OVERVIEW OF MODELING PROCESS

In general, our approach to evaluating potential critical habitat networks for the northern spotted owl involved a series of iterative steps.

The modeling framework presented in *Development of a Modeling Framework to Support Recovery Implementation and Habitat Conservation Planning* (Appendix C of the Revised Recovery Plan for the Northern Spotted Owl; USFWS 2011) was used to help develop, refine and evaluate alternative possible critical habitat networks. The modeling process consisted of three principal steps:

> **Step 1:** At the outset, the attributes of forest composition and structure and characteristics of the physical environment associated with nesting, roosting, and foraging habitat—physical and biological features used by the species-- were identified

based on the habitat selection exhibited by nearly 4,000 known owl pairs (USFWS 2011, pp. C-20 to C-28). We then used these physical and biological features of nesting, roosting, and foraging habitats to create a range-wide map of (relative) habitat suitability (MaxEnt) (Phillips *et al.* 2006, entire; Phillips and Dudik 2008, entire). In addition to providing a map of relative habitat suitability, this process allowed us to evaluate an area's suitability and determine whether the presence of the species was likely based on an assessment of known species-habitat relationships.

**Step 2:** We developed potential northern spotted owl habitat networks based on the relative habitat suitability map created in Step 1 using the Zonation conservation planning model (Moilanen and Kujala 2008, entire). The Zonation model used a hierarchical prioritization of the landscape based on relative habitat suitability and other user-specified criteria (e.g., land ownership) to develop the most efficient solutions for incorporating high value habitat. Zonation analyses were conducted separately for each region to ensure that habitat would be well-distributed across the range of the owl. Zonation also allowed for consideration of land ownership in development of potential network designs.

**Step 3:** In this last step, we determined where the physical and biological features, as well as unoccupied areas, are essential to the conservation of the species. To do this we used a spatially-explicit northern spotted owl population model (HexSim) (Schumaker 2008, entire) to predict relative responses of northern spotted owl populations to different habitat network designs, different assumptions of barred owl (*Strix varia*) impacts, and competing scenarios describing trends in habitat suitability. Results from the HexSim model were used to develop rank-orderings of population performance under varying habitat network designs, habitat change scenarios, and assumptions governing barred owl impacts. We evaluated these responses against the recovery objectives and criteria for the northern spotted owl using a rule set based on those criteria, as described in our Guiding Principles (above). Simulations from these models are not meant to be estimates of what will occur in the future, but rather provide information on trends predicted to occur under different network designs; this allowed us to compare the relative performance of various habitat scenarios.

## Relative Habitat Suitability Model

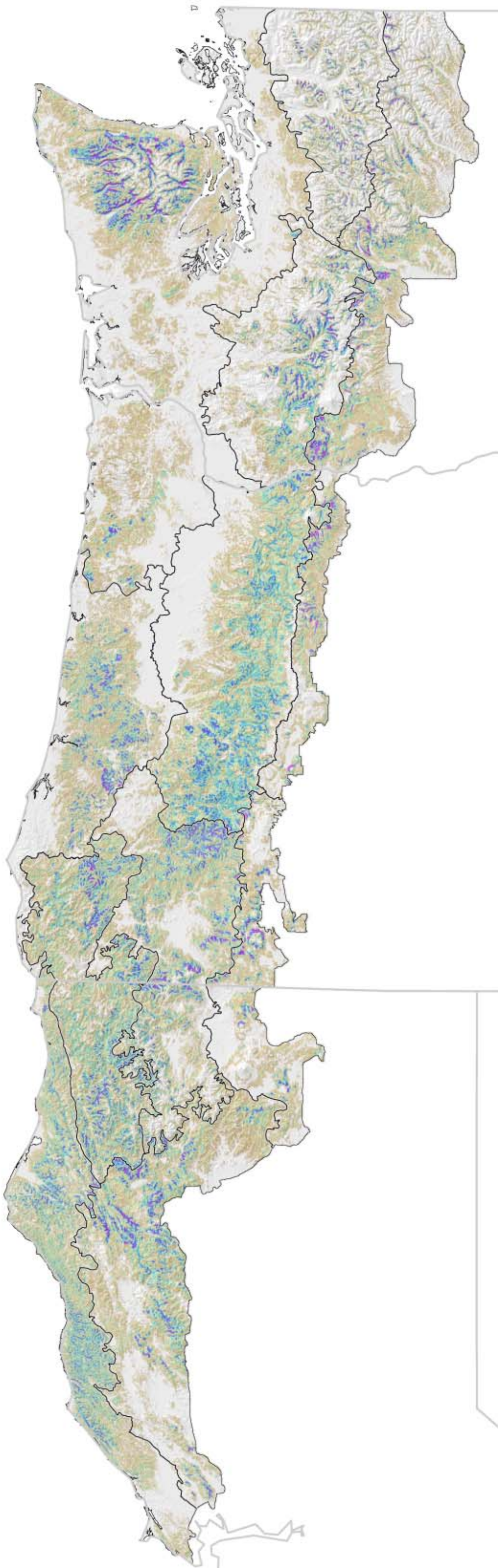
We used spatially explicit relative habitat suitability (RHS) models to identify potential critical habitat networks, and to gauge the responses of owl populations to differing scenarios of changing habitat suitability. Our RHS model performed very well (USFWS 2011) at distinguishing northern spotted owl territories from the conditions available in the landscape. The model's predictions were similar to those reported by Davis et al. (2011). To improve the realism of our models, we divided the range of the northern spotted owl into 11 regions (hereafter "modeling regions") based on differences in forest environments, spotted owl habitat use and prey distribution, and variation in ecological conditions (USFWS 2011), and conducted modeling within each region separately. After each region's best model was attained, we used a geographic information system (GIS) to produce a region-wide map of RHS for the owl's entire range within the United States (Figure 1).

## Habitat Network Scenarios: Approaches to Refining a Critical Habitat Network

The potential habitat network scenarios described here were taken from the ten habitat conservation network scenarios described in Appendix C of the Revised Recovery Plan. The six Zonation scenarios (Z30pub, Z50pub, Z70pub, Z30all, Z50all, and Z70all) used were developed to provide a wide range of potential configurations, sizes, and land ownerships. Zonation enables the user to specify the proportion of habitat value (RHS) to include in a given scenario. These six scenarios were comprised of 30, 50, or 70 percent of habitat value. The "pub" scenarios used a precedence masking technique where non-public lands were removed first and public lands were removed last. This had the effect of prioritizing habitat on public lands, but if the total amount of habitat value specified (e.g., 50% or 70%) could not be acquired from cells in public lands, other lands were included in the solution. All land ownerships were treated equally (that is, no one ownership was prioritized relative to others) in the "all" scenarios, and these scenarios represent the potential of the entire area to provide for spotted owls. The Northwest Forest Plan (NWFP) was also evaluated because it is an existing reserve system, and it served as a benchmark to which we compared the performance of other potential networks.

These initial seven networks varied widely in their sizes and configurations (USFWS 2011). Each of the seven networks was then used to evaluate the relative performance of simulated northern spotted owl populations given assumptions about future habitat conditions and barred owl populations.

**Figure 1. Relative habitat suitability (RHS) of the northern spotted owl based on modeling conducted in each of 11 modeling regions, then combined to create this "wall-to-wall" map. Purples and blues are higher RHS values than browns and white.**



## Population Modeling: Evaluating Spotted Owl Population Responses to Potential Critical Habitat Networks and Conditions

We used HexSim to develop a spatially explicit individual-based model of northern spotted owl populations. We then used this simulator to quantify spotted owl population responses to our alternative habitat networks and assumptions regarding future habitat conditions and barred owl distribution. A detailed description of the HexSim northern spotted owl model can be found in Appendix C of the Revised Recovery Plan (USFWS 2011). For this assessment, however, we used a variant of our HexSim model that also included environmental stochasticity.

Adding environmental stochasticity to the HexSim model greatly increased the variability observed in the results between replicates. Without stochasticity included (as in Phase 1 modeling; see below), five to ten replicates often sufficed for getting a reasonable, or at least general, estimate of population performance. However, with stochasticity, many more replicates were necessary in order to get reliable results. In Phase 2 and 3 modeling we ran 100 replicates of each simulation (for a given potential critical habitat network scenario and set of assumptions about future habitat conditions and barred owl populations).

Every HexSim simulation that included environmental stochasticity was run for 350 time steps (time steps are analogous to years, but should not be equated with “years from the present”). Our simulations started out with 10,000 female owls -- an intentionally large number -- in today's landscape, and the transient behaviors due to the initial conditions typically subsided over the first 25-50 time steps.

Today's trends in spotted owl population size and distribution (see Forsman et al. 2011) are attributable in part to recent land management activities, such as the rate of timber harvesting, and the changing history of other disturbance regimes to which these birds have been exposed (e.g., wildfires, barred owl population trends). But because our HexSim simulations are forward-looking only, they are unable to capture all of the impacts of such past activities. For this, and other reasons, we used the relative steady-state simulated population size and distribution information produced by HexSim as a basis for ranking the potential critical habitat networks. Such relative rankings have the advantage that they are largely immune to model imperfections that cause under- or over-predictions in population size, since these types of errors can be assumed to appear consistently across all scenarios. In our stochastic HexSim simulations, steady-state was generally achieved after time step 150, but because this varied considerably between scenarios, we also recorded how long it took to achieve steady-state under the various potential critical habitat networks.

## PHASE 1 MODELING

As the initial step in an iterative process of comparing and refining potential habitat networks, for Phase 1 modeling we used a "coarse-filter" approach. In Phase 1, we compared spotted owl population responses among seven habitat network scenarios (presented on page 4), three general habitat change scenarios, and four barred owl population scenarios, for a total of 84 scenarios analyzed. These scenarios, described below, enabled us to establish broad sideboards of population risk and to evaluate network performance within the individual modeling regions. Results of Phase 1 modeling were then used to develop two new alternative habitat network scenarios, representing relatively lower and higher levels of risk.

**Network, Habitat and Barred Owl Scenarios**

For Phase 1 modeling, we used the six Zonation and the NWFP reserve scenarios as articulated in Appendix C (USFWS 2011) and above.

***Habitat Change Scenarios***
We used three habitat change scenarios for Phase 1 modeling:

- HAB1 consisted of maintaining the RHS value within potential habitat network areas at their currently-estimated values, and reducing all non-network lands with RHS values >35 to a value of 34. This is the Round 2 scenario described in Appendix C (USFWS 2011, p. C-82). This scenario was intended to simulate an "isolated" habitat network by only allowing territory establishment within the potential critical habitat network. In HexSim, territory establishment was only allowed to happen when hexagon RHS values were ≥ 35 for three adjacent hexagons (USFWS 2011, p. C-62). Areas outside of the network could still contribute resources to owls, but nest sites were restricted to the habitat network in this scenario.

- In HAB2 we maintained the RHS value within potential habitat network areas at their currently-estimated values, and reduced all non-network areas with RHS values >35 to a value of 34, but maintained RHS >50 on *non-network areas on public lands* at their currently-estimated values. This is identical to the Round 3 Scenario described in Appendix C (USFWS 2011, p. C-82). This scenario is intended to emulate the management approach of maintaining occupied spotted owl habitat outside of the potential critical habitat network (full implementation of Recovery Action 10 (USFWS 2011) on public ownerships).

- The HAB3 scenario was identical to HAB2, except that RHS > 50 was maintained on all non-network lands. This scenario simulated full implementation of Recovery Action 10 (USFWS 2011) on both public and non-public ownerships).

For the purposes of developing habitat scenarios in Phase 1, Congressionally Reserved lands (e.g., Wilderness Areas and National Parks) were treated as if they were within the network, regardless of whether Zonation had selected these areas. This was done because such areas were set aside by acts of Congress, and we assumed that habitat quality would continue to be retained as in the potential critical habitat network.

***Barred Owl Scenarios***
Barred owl impacts were included in HexSim using variations of their currently-estimated encounter probability (i.e., the probability that a territorial spotted owl will have a barred owl on its territory) among modeling regions. See USFWS (2011, Appendix C) for a discussion of how barred owl encounter probabilities and impacts were developed and implemented. The barred owl scenarios used for Phase 1 included:

- STVA1) assumed no barred owls existed (i.e., that the barred owl encounter probability was set to zero for all individual spotted owls in all places);
- STVA2) barred owl encounter probabilities were held constant at their currently-estimated rates within each of the 11 modeling regions;
- STVA3) barred owl encounter probabilities were held constant at 0.25 everywhere in the spotted owl's range; and
- STVA4) barred owl encounter probabilities were held constant at 0.5 everywhere in the spotted owl's range.

In sum, Phase 1 modeling included 12 combinations of RHS scenarios and barred owl scenarios evaluated in HexSim for each of seven habitat network scenarios. For Phase 1 modeling, barred owl impacts (encounter probabilities) were inserted at time-step 40, and RHS changes were inserted at time-step 50.

**HexSim Population Performance Metrics**

For Phase 1 modeling, we had not yet included environmental stochasticity into HexSim. Because Phase 1 model runs had less variation among replicates than models with environmental stochasticity included, we ran five replicates of each scenario, and ran each replicate for 250 time-steps. Population performance metrics were evaluated range-wide and for each modeling region.

The following range-wide population performance metrics were used to compare and rank the various Phase 1 reserve networks by habitat and barred owl scenarios: 1) mean percentage population change among the five replicates between time-steps 50 and 250; 2) percentage of time-steps during which lambda ($\lambda$; mean of five replicates ± 95% CI) was ≥1.0 between time-steps 50 and 250; and 3) the first year that $\lambda$ (mean ± 95% CI) was ≥1.0. Because we were interested in longer-term trends, we calculated $\lambda$ as $N_t/N_{t-10}$ rather than by successive time-steps.

For each of the 11 modeling regions we evaluated the following population performance metrics of Phase 1 models: 1) percentage of time-steps during which population growth rate ($\lambda$) (mean of five replicates ± 95% CI) was ≥1.0 between time-steps 50 and 250; 2) the first year that $\lambda$ (mean ± 95% CI) was ≥1.0; 3) the percentage of replicates during which the population fell below 250 individuals; 4) the percentage of replicates during which the population fell below 100 individuals; and 5) the percentage of replicates during which the population went to extinction. The "thresholds" of 250 and 100 individuals were considered to be quasi-extinction thresholds, or population sizes that we believed to be at relatively high risk of extinction.

During Phase 1 modeling we had not yet included environmental stochasticity into HexSim. This, in addition to other assumptions we made (USFWS 2011, Appendix C), suggested to us that the model was more likely to provide optimistic results, or that it would be predisposed to underestimate extinction risk. Because of this we chose the two quasi-extinction thresholds. It is important to recognize that during Phase 1 modeling only five replicates were run. Thus, two scenarios that were identical in all ways other than one falling below 100 individuals one more time than another would differ in that metric by 20%.

We recognized that five replicates were likely too few to support strong conclusions. However, Phase 1 modeling was understood from the start as providing coarse-level information that would be used to refine and create subsequent reserve scenarios which would be subjected to more thorough evaluations. Therefore, the evaluation of Phase 1 modeling included comparing the quantitative measures articulated above, as well as using professional judgment. For example, we carefully considered the fact that only five replicates were run for each of the 84 combinations of habitat network design, RHS change, and barred owl rates in Phase 1. Small differences were generally ignored. Furthermore, we did not weigh each performance metric equally. For example, one of the 84 combinations might have had a population that was the first with $\lambda$ ≥1.0, but subsequently declined rapidly or became very unstable over the longer-term. Longer-term stability was considered more important in such circumstances. There were also circumstances where some of the quantitative information did not make intuitive sense, such that we felt that more replicates would likely produce different results. Effectively, we used the quantitative information and professional judgment to transition from Phase 1's 84 combinations of habitat network design, RHS change, and barred owl effects to Phase 2 modeling.

**Phase 1 Results**

In general, among similar barred owl and RHS scenarios, the NWFP performed worse than any of the Zonation habitat network scenarios, whereas the Z70all and Z70pub scenarios performed best. Barred owl impacts were substantial, especially STVA4 when all areas had an encounter probability of 0.5 (an encounter probability that is currently observed or exceeded in some parts of the owl's range). For example, when non-network lands had RHS<35 and barred owl encounter rates were 0.5, the range-wide spotted owl population was estimated to decline by 87% (Z70all) to 94% (NWFP) between time-steps 50 and 250. This is in contrast to estimated population declines of between 16% (Z70all) and 54% (NWFP) for the same habitat scenario when barred owl encounter probabilities were 0.25 in all modeling regions.

For individual modeling regions, Phase 1 modeling suggested that spotted owls in the Interior California Coast (ICC), Klamath East (KLE), Klamath West (KLW), and West Cascades South (WCS), and Redwood Coast (RDC) modeling regions were the most stable and least prone to fall below either quasi-extinction threshold or go to extinction. In contrast, the West Cascades Central (WCC), West Cascades North (WCN), and East Cascades South modeling regions most frequently fell below quasi-extinction thresholds (especially 250), even under scenarios with no barred owls and in which RHS was maintained in networks and only truncated to below 35 (for those areas that were estimated to be >35) outside of network lands. There were general differences in owl performance metrics among the various habitat network scenarios, again with the Z70 scenarios generally performing well and NWFP and Z30 scenarios performing more poorly.

In general, ranking of the seven habitat network scenarios by various RHS and barred owl assumptions revealed that the largest networks (Z70all and Z70 public) ranked highest, and the NWFP ranked lowest (Table 1). However, the NWFP was larger in area than Z30all and ranked much lower, overall, than Z30all did. This result highlights the potential value of NWFP 'matrix' lands to spotted owls, as well as the existence of lower-quality habitat within NWFP reserves.

**Table 1. Rankings of the seven reserve scenarios used in Phase 1 relative to habitat change and barred owl scenarios. Rankings are presented for both range-wide and modeling region evaluations. Rankings of 1 are the best and rankings of 7 are the worst.**

| RHS by STVA scenario | Ranking Focus | NWFP | Z30all | Z50all | Z70all | Z30pub | Z50pub | Z70pub |
|---|---|---|---|---|---|---|---|---|
| HAB1-STVA1 | Range-wide | 7 | 5 | 3 | 1 | 5 | 3 | 1 |
| | Modeling Region | 7 | 5 | 2 | 2 | 6 | 4 | 1 |
| HAB1-STVA2 | Range-wide | 6 | 5 | 3 | 2 | 7 | 4 | 1 |
| | Modeling Region | 7 | 5 | 2 | 2 | 6 | 4 | 1 |
| HAB2-STVA1 | Range-wide | 7 | 4 | 3 | 1 | 4 | 4 | 1 |
| | Modeling Region | 7 | 3 | 3 | 1 | 6 | 5 | 2 |
| HAB2-STVA2 | Range-wide | 6 | 4 | 1 | 3 | 6 | 5 | 1 |
| | Modeling Region | 7 | 4 | 1 | 2 | 4 | 3 | 6 |
| HAB3-STVA1 | Range-wide | 5 | 5 | 1 | 1 | 5 | 1 | 1 |
| | Modeling Region | 5 | 2 | 7 | 4 | 5 | 1 | 3 |
| HAB3-STVA2 | Range-wide | 4 | 4 | 4 | 2 | 4 | 2 | 1 |
| | Modeling Region | 2 | 4 | 3 | 4 | 6 | 7 | 1 |
| HAB1-STVA3 | Range-wide | 7 | 5 | 4 | 1 | 5 | 1 | 1 |
| | Modeling Region | 7 | 5 | 2 | 3 | 6 | 3 | 1 |
| HAB1-STVA4 | Range-wide | 4 | 4 | 1 | 1 | 4 | 4 | 1 |
| | Modeling Region | 7 | 5 | 3 | 2 | 6 | 4 | 1 |
| HAB2-STVA3 | Range-wide | 6 | 4 | 2 | 1 | 7 | 4 | 2 |
| | Modeling Region | 7 | 3 | 2 | 1 | 6 | 4 | 5 |
| HAB2-STVA4 | Range-wide | 3 | 1 | 3 | 1 | 3 | 3 | 3 |
| | Modeling Region | 4 | 2 | 3 | 1 | 4 | 7 | 4 |
| HAB3-STVA3 | Range-wide | 2 | 7 | 5 | 3 | 5 | 3 | 1 |
| | Modeling Region | 7 | 1 | 4 | 3 | 2 | 4 | 4 |
| HAB3-STVA4 | Range-wide | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Modeling Region | 6 | 2 | 3 | 5 | 3 | 1 | 6 |
| | MEAN Rank | 5.5 | 3.8 | 2.8 | 2.0 | 4.8 | 3.4 | 2.1 |

*Phase 1 modeling conclusions*

In Phase 1, we were not trying to create the "best" configuration, but rather to evaluate population performance across a broad range of scenarios.

Rather than choose the overall (rangewide) best performing Phase 1 habitat network scenarios to continue with to Phase 2, we evaluated the performance of various habitat scenarios among the individual modeling regions. This evaluation led us to create two scenarios to carry forward to Phase 2 called "composite" scenarios. These composite scenarios were composed of various Phase 1 modeling region-specific habitat scenarios depending largely on how simulated owl populations in each modeling region performed in Phase 1. That is, Phase 2 composite scenarios were a mixture of various Zonation or NWFP scenarios by modeling region. For example, the Phase 1 Z30pub scenario may have performed quite well in a particular modeling region, and thus for that modeling region we chose Z30pub, whereas for another modeling region we may have chosen Z50all or Z50pub. The two composite scenarios that became the Phase 2 scenarios were developed with the intent that one was expected to be of lower population risk (Composite 1) and the other was expected to be of higher risk (Composite 2) although still meeting the goals of our Guiding Principles. We also carried the NWFP scenario forward in Phase 2 modeling. Composites 1 and 2, along with our assumed modeling region-specific barred owl encounter rates, are fully articulated in Table 2.

## PHASE 2 MODELING

This phase represents a more detailed and rigorous evaluation of a reduced number of habitat network scenarios (NWFP, and Composites 1 and 2), habitat change, and barred owl scenarios. The primary objective of Phase 2 modeling was to develop and evaluate a single potential critical habitat network design for subsequent refinement.

### Phase 2 modeling: Initial Network, Habitat and Barred Owl Scenarios

#### *Habitat Change Scenarios*

We used habitat change scenarios to evaluate the influence of future habitat conditions on spotted owl populations in the HexSim model. We recognized that a wide range of methods and assumptions could be employed to simulate or predict future habitat conditions for use in population modeling, including forest growth models and wildfire risk models. However, we also recognized the great complexity involved in using such models across the geographic range of the spotted owl, and the high degree of uncertainty surrounding future climate, forest growth rates, harvest rates, and other important determinants of habitat trends. In addition, we understood that it would be extremely challenging to translate these other models into our relative habitat suitability (RHS) model that forms the base habitat layers for Zonation and HexSim modeling. Because our goal was to evaluate relative population performance among a range of habitat network designs, we elected instead to develop two contrasting “what if” scenarios that directly project RHS values into future conditions. The two RHS change scenarios used in Phase 2 and 3 modeling were dubbed “optimistic” and “pessimistic.”

These “what if” scenarios were not intended to be predictions, forecasts, or recommendations of future habitat conditions. The goal of these futuring scenarios was to evaluate how different the various population outcomes were as a function of different habitat change scenarios, not to obtain an (HexSim) estimate of what spotted owl populations will do under expected conditions. We chose the optimistic and pessimistic scenarios to reflect our belief that they were plausible, not that they were the most extreme case we could imagine. The team believed that the future reality on the ground would likely fall somewhere between the optimistic and pessimistic RHS scenarios we developed.

Our objective for the **optimistic scenario** was to evaluate spotted owl population response to future habitat conditions that resembled current conditions and habitat trends. We used estimates of habitat (RHS) change that were measured between 1996 and 2006, and projected these conditions and rates into the future. We calculated the change in mean RHS at the hexagon (86.6 ha) scale between 1996 and 2006 (two time periods during which the base GNN data existed – see Appendix C of USFWS 2011) in each modeling region for five classes of RHS, and the direction of change. The five RHS categories for which we estimated RHS change were: 0-0.2, 0.2-0.4, 0.4-0.6, 0.6-0.8, and >0.8. We also created six categories of RHS percentage change between 1996 and 2006: <1%, 1-2%, 2-3%, 3-4%, 4-5%, and >5%. We estimated the percentage of the modeling region within each RHS category that increased in RHS, by each RHS percentage change class, and that decreased in RHS. Stratification of RHS change by modeling region, direction of change, RHS categories and RHS percent-change classes resulted in 1,320 change-classification strata that were derived from the range-wide map.

For the optimistic habitat change scenario, we applied the "observed" gains and losses in RHS as follows: *within habitat networks*, future gains and losses in RHS occurred as estimated from 1996-2006, whereas *outside of habitat networks* gains were reduced by 50 percent and losses occurred as observed. In most circumstances the outside-of-network RHS changes resulted in a small net decrease of RHS. For the six percentage change classes, we projected the midpoint of each of the first five classes, but for the >5% class we estimated the mean amount of change that was estimated between 1996 and 2006, for each RHS category for each modeling region, and projected that value. The optimistic scenario were implemented as two 20-year change increments (RHS changes inserted at time steps 70 and 90), compounded (= two steps at 10% each, not one step at 20%). Hexagons to change were randomly selected, with replacement.

Because the primary goal of this evaluation was to compare simulated spotted owl population performance across a range of network designs, the objective of the **pessimistic scenario** was to "isolate" the habitat networks by increasing contrast between network and non-network areas. The pessimistic scenario used in Phase 2 modeling was identical to HAB1 scenario used in Phase 1. In this scenario we held RHS *within* network areas constant at its 2006 estimated level, whereas *outside* of network areas we truncated all RHS values that were >35 to a value of 34 − *just below the value needed for territory establishment*. All other non-network areas (already <35) remained constant. Through time (HexSim time-steps), this scenario resulted in the distribution of occupied spotted owl territories to be almost exclusively limited to identified habitat network areas and Congressionally Reserved (Wilderness, National Parks) lands.

During our evaluations of population modeling results among modeling regions and habitat change scenarios, we recognized that the pessimistic scenario did not reflect a plausible scenario for the RDC (Redwood Coast), where privately owned lands continue to support large numbers of spotted owls despite a long history of intensive timber management. To address this, we modified the pessimistic scenario as follows. Habitat suitability (RHS) *within* *network areas* remained constant at its estimated 2006 level, whereas RHS *outside of network areas* was reduced by 5 percent in each of two 20 year time-steps (not compounded).

The optimistic scenario generally resulted in future RHS values remaining near their currently-estimated values. Habitat change was much more pronounced in pessimistic scenarios, resulting in more variability in population results among the various network scenarios. Therefore, the team put more emphasis on population results from pessimistic scenarios, and the optimistic minus pessimistic evaluations. As noted above, network scenarios in which simulated owl populations performed well under the pessimistic RHS scenarios represent those that are more resilient to potential future changes in RHS. That is, if a habitat network scenario performed well under pessimistic RHS conditions, it would perform even better under more optimistic conditions.

***Establishing an 'assumed' Barred Owl Encounter Rate***

For Phase 2 HexSim modeling we used a constant barred owl encounter rate (see Table 2). Phase 1 modeling revealed the strong impact that barred owl encounter probability had on population performance metrics. Modeling regions with high barred owl encounter probabilities, particularly in Washington and coastal Oregon, required nearly all suitable habitat be included in order to sustain spotted owl populations through time. Because critical habitat cannot be expected to ameliorate all non-habitat based stressors to spotted owl populations, it was necessary to establish reasonable assumptions regarding barred owl encounter probabilities that we believed could, along with critical habitat designation, lead to recovery of the northern spotted owl. Controlling for the effect of barred owls in a reasonable way (in HexSim) in the course of evaluating various habitat scenarios was necessary in order to identify those specific areas that provide the physical or biological features essential for the conservation of the northern spotted owl, by segregating the negative effects of barred owls from the positive effects of habitat on spotted owl population viability. The designation of critical habitat requires that we identify those areas that are essential to the conservation and recovery of the species, and is intended to assist in addressing threats faced by the species due to the loss or degradation of its habitat. Critical habitat is not intended to single-handedly achieve the recovery of the species and address all existing threats, whether habitat-based or not. We used various metrics of population viability to determine the habitat network – the amount and configuration of habitat –that is essential to the conservation of the northern spotted owl. However, the overwhelming negative influence of barred owls on those measures of population viability confound those results, unless we make some reasonable assumptions that the barred owl threat will be addressed to some degree in the course of recovery implementation. We could have assumed no barred owl presence at all, which would result in an entirely independent determination of essential habitat. However, as barred owls are likely already present throughout the entire range of the northern spotted owl, such an assumption was deemed unreasonable and unrealistic. Therefore, we chose a middle ground between the extremes of no barred owl management (barred owl encounter rates at present levels or greater in the future) and complete theoretical eradication (no barred owl influence), and did so on a modeling region by modeling region basis, because the current barred owl encounter rate varies among modeling regions.

We made modeling region-specific decisions about reasonable barred owl encounter rates based on the HexSim results from Phase 1 and barred owl encounter probabilities estimated from long-term demographic study areas (Forsman et al. 2011) within each modeling region. We established a maximum encounter probability of 0.375 for the modeling process because population performance ranged from marginal to poor at higher barred owl encounter probabilities. For some modeling regions with currently-estimated barred owl encounter probabilities greater than 0.375, this resulted in a substantial reduction in the barred owl encounter rates through time. For modeling regions with currently-estimated barred owl encounter probabilities less than 0.375, we generally assumed that barred owl encounter probabilities would remain similar to current estimates or would increase slightly over time and could potentially be maintained at those levels through management actions. Table 2 shows the comparison of currently-estimated and assumed barred owl encounter rates we used in Phase 2 modeling. In HexSim simulations, currently-estimated modeling region-specific barred owl encounter rates were inserted at time-step 40; the final rates were inserted at time-step 60.

The barred owl encounter probabilities we established for modeling purposes do not represent predictions about conditions that will be achieved through management actions, nor are they estimates of what is likely to occur in the future. Instead, the assumed barred owl encounter probabilities were used to evaluate the critical habitat essential to recovery of the northern spotted owl, assuming that other, non-habitat based threats to the species have been addressed.

**Table 2. Composites 1 and 2 that resulted from Phase 1 modeling. These composites include both the modeling region-specific habitat network scenario from Phase 1 as well as the assumed barred owl encounter rate for Phase 2 modeling. Composite 1 was considered to be lower risk and Composite 2 was considered higher risk.**

| | | Habitat Network Scenario | | |
|---|---|---|---|---|
| **Modeling region** | **Barred owl encounter rate for HexSim models after Phase 1 (currently estimated encounter rate)** | **Composite 1 (lower risk)** | **Composite 2 (higher risk)** | **NWFP** |
| OCR | 0.375 (0.710) | Z50Pub | NWFP+Elliott State Forest | NWFP |
| KLW | 0.25 (0.315) | Z50Pub | Z30Pub | NWFP |
| RDC | 0.25 (0.205) | Z30Pub+HCPs | All public lands | NWFP |
| KLE | 0.25 (0.245) | Z50Pub | Z30Pub | NWFP |
| ICC | 0.25 (0.213) | Z50Pub | Z30Pub | NWFP |
| WCS | 0.375 (0.364) | Z50Pub | Z30Pub | NWFP |
| WCC | 0.375 (0.320) | Z70Pub | Z50Pub | NWFP |
| WCN | 0.375 (0.320) | Z70Pub | Z50Pub | NWFP |
| NCO | 0.375 (0.505) | Z70PUB-- with addition of SOSEAs/1 plus Satsop stepping stone/2 (private land). RHS artificially inflated to =0.4 at step 1 within Satsop but not SOSEAs | NWFP with the addition of Satsop, Capitol State Forest, Lower Chehalis, and SOSEAs. RHS artificially inflated to =0.4 at step 1within all additions except SOSEAs. | NWFP |
| ECN | 0.375 (0.296) | Z70all | Z70Pub | NWFP |
| ECS | 0.25 (0.180) | Z70Pub | Z50Pub | NWFP |

/1: SOSEA (Spotted Owl Special Emphasis Areas) are geographic areas as mapped in Washington State's Forest Practices Rules (WAC 222-16-086). Each delimited SOSEA polygon contains the specified goal for that area to provide for demographic and/or dispersal support as necessary to complement the northern spotted owl protection strategies on federal land within or adjacent to the SOSEA. These are private lands that have special protections for owl circles.

/2: "Satsop stepping stone" – a portion of the Satsop River watershed selected for evaluation of population response to increased connectivity that would potentially be provided by the inclusion of this area.

## Environmental Stochasticity

The HexSim spotted owl model described in Appendix C of the Recovery Strategy (USFWS 2011) uses 24 separate survival rates, distributed across 4 stage classes x 3 resources classes x 2 barred owl conditions (present / absent). For reproduction, the model uses 4 fecundity values, one for each stage class. Environmental stochasticity was added to the HexSim model by allowing survival rates to vary by up to 2.5 percent per year, and fecundity to vary by 50 percent per year. Stochastic survival and reproductive rates were selected independently (e.g. a good year for survival did not imply a good year for reproduction). From Forsman et al. (2011, Table 12) we calculated the mean variation as the ratio of 2*SE of adult survival divided by the mean adult survival. For each of the study areas for which data was presented mean variation 2.59% (range = 1.64 – 4.52%). We decided to use 2.5% as being quite close to this estimate. We allowed for this level of variation for each age class, even though separate calculations for younger age classes would have been much greater. Sample sizes were, however, much lower for younger age classes (3,545 adults, 903 2-yr old subadults, and 796 1-yr subadults; Forsman et al. 2011, p. 28). The 50% variation in fecundity was an attempt to allow for the wide variation in annual reproduction that is observed in many spotted owl population studies (Forsman et al. 2011).

The survival rates used in the HexSim simulations prior to adding environmental stochasticity are shown in Table 3. If the collection of survival rates shown in Table 3 are placed into a vector S, then the family of survival rates used in the stochastic simulations could be represented as the set { 0.975 * S, 0.980 * S, 0.985 * S, 0.990 * S, 0.995 * S, S, 1.005 * S, 1.010 * S, 1.015 * S, 1.020 * S, 1.025 * S }. This set has 11 members, five of which represent survival rates lower than those in S, and five that represent survival rates higher than those in S. When the stochastic simulations were run, one member from this set was selected at random each year, and used to drive the survival decisions for that year.

**Table 3. Spotted Owl Survival Rates**

| Without Barred Owls | | | With Barred Owls | | |
|---|---|---|---|---|---|
| **Stage Class** | **Resource Class** | **Survival Rate** | **Stage Class** | **Resource Class** | **Survival Rate** |
| Stage 0 | Low | 0.366 | Stage 0 | Low | 0.28 |
| | Medium | 0.499 | | Medium | 0.413 |
| | High | 0.632 | | High | 0.546 |
| Stage 1 | Low | 0.544 | Stage 1 | Low | 0.458 |
| | Medium | 0.718 | | Medium | 0.632 |
| | High | 0.795 | | High | 0.709 |
| Stage 2 | Low | 0.676 | Stage 2 | Low | 0.590 |
| | Medium | 0.811 | | Medium | 0.725 |
| | High | 0.866 | | High | 0.780 |
| Stage 3 | Low | 0.819 | Stage 3 | Low | 0.733 |
| | Medium | 0.849 | | Medium | 0.763 |
| | High | 0.865 | | High | 0.779 |

The reproductive rates used in the HexSim simulations prior to adding environmental stochasticity are shown in Table 4. If the collection of fecundities shown in Table 4 are placed into a vector F, then the family of reproductive rates used in the stochastic simulations could be represented as the set { 0.5 * F, F, 1.5 * F }. When the stochastic simulations were run, one member from this set of 3 elements was selected at random each year, and used to drive the reproductive decisions for that year.

**Table 4. Spotted Owl Fecundity Rates**

| Stage Class | Fecundity |
|---|---|
| Stage 0 | 0 |
| Stage 1 | 0.070 |
| Stage 2 | 0.202 |
| Stage 3 | 0.330 |

Adding stochasticity increases variability within and among HexSim replicates. In order to adequately assess these more variable results, we ran 100 replicates of each of the three network scenarios by two habitat change scenarios. Each replicate was run for 350 time-steps. The habitat network scenarios for Phase 2 were Composites 1 and 2, and the NWFP.

### HexSim Population Performance Metrics and Criteria

#### *Range-wide Comparisons*

We evaluated the following population performance metrics: 1) total (mean of 100 replicates) population size at time-step 350; 2) percent population change between time-step 50 and time-step 350; 3) percentage of simulations during which the range-wide population fell to below 1,250 individuals; 4) percentage of simulations during which the range-wide population fell below 1,000 individuals; 5) percentage of simulations during which the range-wide population fell below 750 individuals; and 6) the grand mean of the population between time-steps 150 and 350. Except for the second metric (percent change between time-steps 50 and 350) all other metrics were derived from time-steps 150 through 350. In most cases, our stochastic HexSim simulations had achieved steady-state by time step 150, and thus all but one of these metrics could be used to quantify the relative steady-state population size and distribution that should be associated with a proposed critical habitat network.

The "threshold" population sizes of 1,250, 1,000, and 750 represented population sizes that the team believed to represent overall risk thresholds (Table 5). Connectivity/isolation, demographic stochasticity, competition, and other factors are more likely to have deleterious impacts on small populations. Furthermore, such population sizes would likely result in large areas of the currently-occupied range becoming unoccupied by owls. Although arbitrary, these thresholds provide a consistent way to compare the relative risk of various reserve networks. The population size at time-step 350 and the grand mean produced very similar results (see below).

We interpreted the percentage of simulations during which the population fell below each of the threshold range-wide population sizes (described above) to be equivalent to the probability of moderate population risk (1,250 females), high population risk (1,000 females) and extinction risk (750 females)(Table 5). We used these risk metrics to establish criteria for comparing range-wide population results among reserve designs.

**Table 5. Categories of population and extinction risk used in comparisons of population modeling results**

| Risk Category | Description | Criteria |
|---|---|---|
| **Range-wide Scale** | | |
| Moderate Population Risk | Probability of simulated population with < 1,250 females | < 20% |
| High Population Risk | Probability of simulated population with < 1,000 females | < 10% |
| Extinction Risk | Probability of simulated population with < 750 females | < 5% |
| **Modeling Region Scale** | | |
| Moderate Population Risk | Probability of simulated population with < 250 females | N/A |
| High Population Risk | Probability of simulated population with < 100 females | N/A |
| Extinction Risk | Probability of simulated population reaching zero | N/A |

***Comparisons by Modeling Region***

For each of the 11 modeling regions we evaluated the following population performance metrics of Phase 2 models: 1) percentage of replicates during which the population fell below 250 individuals; 2) percentage of replicates during which the population fell below 100 individuals; 3) percentage of replicates that went to extinction; 4) mean (of the 100 replicates) population size at time-step 350; and 5) grand mean of population size from time-steps 150 to 350.

We interpreted the percentage of simulations during which the population fell below each of the threshold modeling region population sizes (described above) to be equivalent to the probability of moderate population risk (250 females), high population risk (100 females) and extinction risk (0 females). We used these probability of population risk and extinction risk metrics to compare population results among habitat network designs; however, (unlike range-wide comparisons) we were unable to establish limits or *a priori* criteria for comparing modeling region-specific results because of the high variability in extent (area) and population sizes among modeling regions. Instead, we used the differences between risk probabilities to compare results among habitat network designs within modeling regions.

Because we introduced stochasticity into Phase 2, we ran 100 replicates of each potential network by habitat and barred owl scenario. Initial evaluations of 100 replicates showed that the grand population mean was relatively stable with 100 replicates and 350 time-steps.

As with Phase 1, we used a combination of quantitative output from HexSim and professional judgment to evaluate composite scenarios and the NWFP by "what if" RHS scenarios. We considered classifying HexSim output into categories representing the degree to which recovery goals were likely to be met. However, we did not carry through with this because there were circumstances when two results differed markedly, but both would be categorized as high risk (e.g., 33% vs. 78% of replicates falling below 250 individual females in a modeling region). In cases like this, the Service posited that 33% was much less risk than 78%. Therefore, we evaluated both the raw output data for each metric, as well as ranking each of the reserve scenarios. The rankings provided a relatively simple and consistent method to evaluate the performance of each scenario. We also estimated the difference in population performance between optimistic and pessimistic scenarios within each scenario and ranked the absolute value of the differences. This was done to evaluate how reliant a network's performance was on a particular habitat scenario – or its potential vulnerability to future uncertainty in habitat change. That is, if, within a habitat network scenario, population performance metrics were relatively similar (less variable) and relatively good in both optimistic and pessimistic scenarios, we might conclude that that network scenario was resilient to uncertainty in future habitat conditions. In contrast, if a habitat network scenario performed well under the optimistic scenario and poorly under the pessimistic, that would indicate that it was less resilient to the uncertainty of what will happen, regarding RHS change, in the future.

**Phase 2 Results**

In general, for most population metrics, and most modeling regions, the NWFP and Composite 2 performed worse than Composite 1 under the pessimistic habitat change scenario (Tables 6-8). Grand mean population size was greater in each modeling region and overall in Composite 1 (Tables 6-8). In modeling regions with small estimated owl populations (e.g., ECN, ECS, NCO, WCC, WCN) differences among habitat network designs were sometimes quite small (Tables 6-8).

**Table 6. Modeling region-specific spotted owl population metrics from HexSim model of the NWFP with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – NWFP | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 100 | 19 | 60 | 67 |
| OCR | 99 | 62 | 0 | 186 | 195 |
| ECN | 100 | 100 | 2 | 47 | 61 |
| ECS | 100 | 100 | 0 | 81 | 79 |
| WCN | 100 | 100 | 79 | 5 | 8 |
| WCC | 100 | 100 | 31 | 25 | 32 |
| WCS | 66 | 20 | 0 | 368 | 415 |
| KLE | 78 | 7 | 0 | 359 | 364 |
| KLW | 19 | 0 | 0 | 629 | 628 |
| ICC | 10 | 3 | 0 | 445 | 441 |
| RDC | 100 | 100 | 0 | 75 | 74 |
| Total | | | | 2088 | 2364 |

**Table 7. Modeling region-specific spotted owl population metrics from HexSim model of Composite 1 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 1 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 99 | 14 | 105 | 80 |
| OCR | 99 | 62 | 0 | 357 | 227 |
| ECN | 100 | 95 | 1 | 222 | 123 |
| ECS | 100 | 97 | 0 | 151 | 115 |
| WCN | 100 | 100 | 81 | 9 | 8 |
| WCC | 100 | 100 | 26 | 43 | 39 |
| WCS | 60 | 16 | 0 | 740 | 497 |
| KLE | 33 | 0 | 0 | 1016 | 554 |
| KLW | 7 | 0 | 0 | 1552 | 829 |
| ICC | 10 | 0 | 0 | 1212 | 650 |
| RDC | 65 | 0 | 0 | 766 | 421 |
| Total | | | | 3216 | 3543 |

**Table 8. Modeling region-specific spotted owl population metrics from HexSim model of Composite 2 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 2 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 100 | 20 | 84 | 69 |
| OCR | 100 | 58 | 0 | 340 | 211 |
| ECN | 100 | 100 | 3 | 225 | 116 |
| ECS | 100 | 99 | 0 | 120 | 98 |
| WCN | 100 | 100 | 83 | 6 | 8 |
| WCC | 100 | 100 | 28 | 41 | 36 |
| WCS | 79 | 20 | 0 | 620 | 406 |
| KLE | 47 | 2 | 0 | 859 | 462 |
| KLW | 20 | 0 | 0 | 1261 | 663 |
| ICC | 23 | 0 | 0 | 1034 | 548 |
| RDC | 100 | 89 | 0 | 255 | 136 |
| Total | | | | 2534 | 2753 |

***Ranking of Scenarios***

Not surprisingly, the optimistic RHS scenarios resulted in very minor differences among Composites 1 and 2, and the NWFP. All network scenarios performed quite well under the optimistic RHS scenarios, however, Composite 1 was consistently the best performing (Table 9).

The pessimistic RHS scenarios resulted in more dramatic differences among the network scenarios with Composite 1 performing much better than any other scenario and the NWFP performing poorest (Table 9). Furthermore, the optimistic minus pessimistic results showed that Composite 1 was least variable and the NWFP the most variable network scenario, with Composite 2 being intermediate (Table 9).

**Table 9. Comparison of the rankings (range-wide) of Phase 2 network scenarios (Composites 1 and 2, and the Northwest Forest Plan [NWFP]) between optimistic and pessimistic habitat scenarios as well as optimistic minus-pessimistic (in gray). The SUM (summation) is of 61 individual rankings, whereas the mean is the mean rank of the 61 individual ranks. Lower numbers are better ranking.**

| RHS Scenario | Metric | NWFP | Composite 1 | Composite 2 |
|---|---|---|---|---|
| Optimistic | Sum | 101 | 76 | 122 |
| | Mean | 1.7 | 1.2 | 2.0 |
| Pessimistic | Sum | 137 | 64 | 113 |
| | Mean | 2.2 | 1.0 | 1.9 |
| Optimistic - Pessimistic | Sum | 133 | 74 | 100 |
| | Mean | 2.2 | 1.2 | 1.6 |

***Conclusions from Phase 2***

Before moving on to Phase 3 comparisons, we assessed general patterns apparent in the population results from Phase 1 and 2 modeling. In combination with current demographic information (Forsman et al. 2011), past conservation planning efforts for the owl (ISC 1990, USFWS 2011), and numerous other sources of information, these results provided the foundation of our subsequent process for developing habitat network designs and making comparisons. In particular, regional differences in spotted owl populations and their environments influenced the subsequent network scenarios we created, and our ability to establish and apply rangewide *a priori* evaluation criteria to use in comparing habitat network designs. As importantly, we recognized the uncertainty surrounding future barred owl encounter rates and their effects on spotted owl recovery within the various habitat network designs.

Several modeling regions exhibited consistently poor population performance regardless of network design. Modeling regions with simulated owl populations that performed poorly in all network designs and under both optimistic and pessimistic scenarios included the ECN, ECS, NCO, WCC, and WCN. In these modeling regions, 100 % of the replicates had estimated population sizes that fell below 250 females under optimistic and pessimistic RHS scenarios; estimated population sizes fell to below 100 females in 95-100 % of simulations in these modeling regions. Extinction risk was estimated to be highest (>70% of replicates went to extinction under all designs by RHS scenarios) in the WCN under both RHS scenarios, followed by WCC and NCO modeling regions. Simulated populations went to extinction in 14 to 83 percent of simulations, regardless of network design, in NCO, WCN, and WCC. These results are consistent with past conservation planning efforts that identified the North Cascades, North Cascades East, Olympic Peninsula, and Southwestern Washington as Areas of Special Concern due to low population sizes, sparse distribution of suitable habitat due to high elevations, high proportions of private industrial timberlands (SW WA), and past management practices (ISC 1990, pp. 66-68). More recently, colonization by barred owls and expansion of their populations (as indicated by high encounter rates) has exacerbated spotted owl population concerns in these areas.

Phase 2 modeling identified the OCR as exhibiting poor population performance, regardless of network design or habitat change scenario. Estimated population size fell below 250 females in 100 percent of simulations under optimistic and pessimistic scenarios; 58 to 63 percent of simulations fell below 100 females. Due to past timber harvest on private industrial timberlands, State forests, and (to a lesser degree) Federal lands, this modeling region supports relatively low proportions of spotted owl habitat. In addition, the “checkerboard” ownership pattern of private and most BLM land in this area, combined with poor connectivity with larger spotted owl populations in the WCS, KLW and KLE, act to further constrain population performance. These results are consistent with the ISC’s (1990, pp. 66-68) description of the Oregon Coast Range Area of Special Concern.

Phase 2 modeling results also highlighted the ECS as an area with small population size and relatively high risk. Modeled populations fell to below 100 females in 87 to 100 % of simulations, regardless of network or habitat-change scenario. Spotted owl habitat is limited in portions of this modeling region due to natural conditions (extensive ponderosa pine forest, high elevations) combined with a long history of intensive timber management. The southern Deschutes and Shasta-McCloud Areas of Special Concern (ISC 1990, pp. 66-68) lie within the ECS. The Shasta-McCloud Area of Special Concern consists of the portion of the ECS that lies within California, along with a small portion of the KLE near Mount Shasta. This area has also been identified as providing poor connectivity between the southern ECS and larger spotted owl populations in the KLE and ICC.

The ISC (1990, pp 66-68) also identified North Coastal California, an area corresponding to RDC, to be of special concern due to the predominance of private ownership in this modeling region. This region was unique in that it supports a large population of spotted owls on privately owned industrial timberlands. This contrasts sharply with privately owned industrial timberlands in southwestern Washington and coastal Oregon, where commercial forest management has resulted in extremely low numbers of spotted owl territories. The fact that spotted owls in the RDC appear to respond very differently (compared to owls in other portions of their range) to intensive timber harvesting influenced the assumptions we used in developing habitat change scenarios and modeling population responses for this region. In Phase 2 modeling, RDC exhibited the largest differences in modeled population size and risk between optimistic and pessimistic habitat scenarios. This result was inconsistent with the current spotted owl location and demographic data available to us. To address this, we modified the pessimistic habitat change scenario to allow a proportion of RHS on private timberlands in RDC to remain above 35 (more closely resembling the estimated RHS changes from 1996 – 2006), resulting in a less pessimistic habitat change scenario and enabling simulated owls to establish territories and reproduce outside of the habitat network. In western Washington and the Oregon coast, on the other hand, we felt that the pessimistic scenario described for Phase 2 modeling was more reasonable.

In contrast to the northern modeling regions, the Klamath-Siskiyou region and southwestern Cascades supported relatively robust populations of spotted owls. Based on the grand population mean between time-steps 150 and 350, the ICC, KLE, KLW, RDC, and WCS modeling regions represented from 80-87% of the total range-wide population of spotted owls regardless of network or RHS scenario (though the percentage was larger in the optimistic scenario in all cases). These results were consistent with spotted owl location data available to us, as well as results from recent meta-analysis of demographic data (Forsman et al. 2011).

Uncertainty surrounding future barred owl encounter rates and their effects on spotted owl population performance within the various network designs also influenced our process for evaluating and comparing habitat network designs. Data from the spotted owl demographic study areas clearly indicate that barred owl densities (and subsequently estimated encounter rates) continue to increase. Studies of barred owl effects on territory occupancy by spotted owls (Dugger et al. 2011) suggest that increasing amounts of suitable habitat may act to ameliorate the effects of barred owl competition; however, it is unclear how long this benefit will operate iif barred owl densities continue to increase. While it was necessary to select an assumed barred owl encounter rate for population modeling, we understood that our population results would be somewhat optimistic if barred owl encounter rates continue to exceed the assumed rates described under Phase 2 modeling. We incorporated this unquantifiable potential 'bias' into our decision process by selecting conservatively among competing population risk metrics.

## PHASE 3 MODELING

Phase 3 modeling consisted of iterative refinement and testing of potential critical habitat scenarios. In contrast to the model-driven processes used in Phases 1 and 2, evaluation processes in Phase 3 were based on model results obtained in the previous steps *combined with* other sources of information such as spotted owl location data, ancillary sources of habitat data, information regarding ecological conditions and disturbance regimes, and expert opinion from Service and other Federal biologists. In addition, aspects of spotted owl conservation such as future population connectivity, disturbance regimes, genetic linkages, and land ownership patterns that were not explicitly addressed by our modeling framework were evaluated at this step.

Use of expert opinion to refine the modeling products is consistent with the guidance in Appendix C of the Revised Recovery Plan (p. C-2): "While this framework represents state-of-the-art science, it is not intended to represent absolute spotted owl population numbers or be a perfect reflection of reality. Instead, it provides a comparison of the relative spotted owl responses to a variety of potential conservation measures and habitat conservation networks. The implementation of spotted owl recovery actions should consider the results of the modeling framework as one of numerous sources of information to be incorporated into the decision-making process." Further, Wintle et al. (2005) recommended when evaluating model output that: "Expert opinion can (and should) be used…for corroboration of a model's ecological realism, for ad hoc evaluation of model prediction, and for preparation of predictive maps for use in decision making…Consequently, the role of experts should be thought of as complementary to other, more data-driven methods, rather than as a competing alternative." The modeling cannot reliably be applied to critical habitat revision without going through this type of evaluation. We adopted a relatively conservative conservation approach, consistent with the recommendations of Reed et al. (2006) and other conservation-oriented modeling approaches (e.g., Beissinger et al. 2006).

Each composite developed and tested in Phase 3 represented the Service's effort to ensure that the reserve network accurately and efficiently reflected where the physical and biological features in habitat occupied at the time of listing are essential for conservation of the spotted owl as well as essential areas that may have been unoccupied at the time of listing and, given the Endangered Species Act's direction to focus first on occupied habitat when identifying critical habitat, represents occupied habitat to the greatest degree possible. The Service additionally sought suggestions from U.S. Forest Service and Bureau of Land Management professionals on Phase 3 scenarios as well (see below).

During Phase 3, the Service used technical knowledge and on-the-ground experience to evaluate and modify the composite maps relative to the following considerations:

<u>Efficiency</u> – The Service reviewed each composite map and evaluated the extent to which the model-generated maps (Zonation) reflected efficient network designs. We found that under some circumstances the Zonation algorithm attempted to achieve preselected habitat objectives (e.g., 50%) by retaining relatively low RHS in some areas. In these cases we refined the boundaries to better match the distribution of habitat likely to support occupancy by spotted owls.

<u>Connectivity and Isolation</u> – We evaluated whether the model-based critical habitat networks incorporated adequate population connectivity and did not exclude smaller, isolated populations from consideration. In particular, we reviewed "areas of special concern" described by the ISC (1990), as well as areas identified in field studies (e.g., Stralberg et al. 2009). In some cases, we reconfigured boundaries or identified additional areas of habitat to ensure adequate population connectivity and representation of isolated populations.

<u>Population Distribution</u> – Because the modeling framework is based on current habitat conditions, we reviewed the composite maps to assess whether the habitat networks corresponded to the full ecological gradient of the historical range of the spotted owl. We

considered whether substantial areas of formerly occupied habitat, potentially capable of supporting spotted owl populations in the future, needed to be incorporated into the network design.

Disturbance Regimes and Spatial Redundancy – The Service assessed factors such as wildfire risk not directly addressed by the modeling framework. These factors are particularly important in the fire-prone Klamath and Eastern Cascades areas, where disturbances such as wildfire exert a strong influence on the distribution and quality of spotted owl habitat through time.

Land Ownership Patterns – Across most of the range the model-based network designs attempted to meet habitat and population objectives on public lands; however, we further attempted to focus the designs specifically onto Federal lands when the quality and distribution of habitat on Federal lands was adequate to meet spotted owl conservation objectives. In some areas where Federal lands were not adequate to achieve conservation goals, we identified non-federal lands as likely necessary for recovery of the spotted owl.

Logical Boundaries - Where possible, we sought to use existing boundaries of management units or other administrative or geographic lines.

Following each change, the resulting composite was evaluated in HexSim, and spotted owl population response metrics were compared to all other composites rangewide and per modeling region. The process was did not consist of successive refinements, however, because some composites contained suggestions or proposals from other Federal agencies which we evaluated in HexSim and either accepted, rejected, or modified based on the population modeling results. Our objective was to address the above considerations while simultaneously meeting the objectives described in the Critical Habitat Guiding Principles

## Composite 3

Our primary objective for Composite 3 was to develop a network design that incorporated recommendations from the US Forest Service to rely on the existing NWFP late-successional reserves in the mesic modeling regions (WCN, WCC, OCR, and the northern portion of the WCS), and retained (relatively low) levels of population risk similar to Composite 1. This proposal also included a suggestion, based on wildfire probability modeling conducted for the NWFP monitoring program (Davis et al. 2011), to consider the southern portion of the WCS as a fire-prone area and use a design approach similar to other fire-prone regions (KLW, KLE and ICC).

To accommodate wildfire-related changes in habitat quality and distribution through time, we retained the low-risk habitat network design from Composite 1 (Z50 PUB) in the fire-prone southern modeling regions (KLW, KLE, ICC and southern portion of WCS). In contrast to smaller areas with higher risk of habitat loss, this approach incorporated habitat redundancy and enables strategic landscape-level management to restore and maintain owl habitat through time.

In mesic modeling regions with limited habitat on Federal lands (WCN, OCR and portions of NCO), we added some State and private lands to evaluate their effect on population performance. In NCO and WCN, Spotted Owl Special Emphasis Areas (SOSEA; a mix of State and private lands) were added to the habitat network. In addition, we added two areas in SW Washington to evaluate their potential contribution to population connectivity between the Olympic National Forest and the western Cascades. In these areas, we increased future RHS to 0.4 to allow occupancy in HexSim. In the OCR, portions of the Elliott State Forest were included to decrease risk.

**Table 10. Habitat network design elements and spatial extent by ownership of Composite 3.**

| Model Region | Network Design | Area within Networks (acres) | | | | |
|---|---|---|---|---|---|---|
| | | MR Total | Federal/1 | Congr. Reserve/2 | State | Non-public/3 |
| NCO | Z70PUB with addition of SOSEAs and Satsop area 'stepping stone' | 3,682,647 | 821,944 | 889,635 | 1,350,290 | 620,778 |
| OCR | NWFP plus portion of Elliott State Forest | 930,005 | 801,801 | 34,858 | 93,211 | 136 |
| ECN | Z70PUB | 3,311,356 | 2,232,861 | 1,078,453 | 0 | 41 |
| ECS | Z70PUB | 1,036,306 | 785,911 | 250,383 | 0 | 12 |
| WCN | NWFP with addition of SOSEAs | 1,913,451 | 705,508 | 1,207,853 | 49 | 41 |
| WCC | NWFP | 1,358,312 | 634,244 | 724,017 | 13 | 38 |
| WCS | Z50PUB in fire-prone south, NWFP in mesic north | 1,883,660 | 1,663,046 | 220,578 | 1 | 35 |
| KLE | Z50PUB | 1,394,234 | 1,247,161 | 147,041 | 1 | 30 |
| KLW | Z50PUB | 1,556,809 | 1,349,495 | 207,217 | 4 | 93 |
| ICC | Z50PUB | 1,565,650 | 1,248,030 | 317,565 | 0 | 55 |
| RDC | Z30PUB plus HCPs | 1,450,282 | 118,015 | 177,287 | 169,861 | 985,119 |
| | Total | 20,082,712 | 11,608,016 | 5,254,887 | 1,613,429 | 1,606,380 |

/1 USFS and BLM lands, excluding Congressional Reserves (Wilderness, National Parks)
/2 Congressional Reserves (Wilderness, National Parks)
/3 Privately owned lands, tribal lands

Modeling regions with the NWFP as their basic habitat network design included all Congressionally Reserved lands as "reserve" lands, and our area calculations include these lands. In previous critical habitat rules for the northern spotted owl, these lands were not included in critical habitat.

***Composite 3 Population Results***

Population modeling results suggested that overall, Composite 3 performed better than Composite 2 and NWFP, but not as well as Composite 1. Range-wide, population size (grand mean at time-step 350) in Composite 3 was greater than Composite 2 (2,753) and NWFP (2,364), but less than Composite 1 (3,541). In most modeling regions, population sizes in Composite 3 were intermediate between Composites 1 and 2. However, in OCR, ECN, and WCC, Composite 3 populations were substantially less than Composites 1 and 2.

**Table 11. Modeling region-specific spotted owl population metrics from HexSim model of Composite 3 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 3 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 99 | 9 | 54 | 74 |
| OCR | 100 | 73 | 0 | 158 | 178 |
| ECN | 100 | 100 | 4 | 44 | 63 |
| ECS | 100 | 99 | 0 | 118 | 116 |
| WCN | 100 | 100 | 75 | 5 | 8 |
| WCC | 100 | 100 | 35 | 17 | 27 |
| WCS | 59 | 21 | 0 | 372 | 481 |
| KLE | 39 | 3 | 0 | 509 | 507 |
| KLW | 12 | 0 | 0 | 777 | 761 |
| ICC | 18 | 1 | 0 | 616 | 606 |
| RDC | 73 | 2 | 0 | 404 | 396 |
| Total | | | | 3074 | 3217 |

Regardless of reserve design, five modeling regions (NCO, WCN, WCC, ECN and ECS) exhibited uniformly high (greater than 95 percent) probability of high population risk (Table 11). In the OCR, however, population risk was higher in Composite 3 (73%) than in the other networks (58 to 62%). Probability of high population risk in WCS was moderate (16 to 21%) in all four habitat networks. Four modeling regions (NCO, ECN, WCN and WCC) had relatively high extinction risk. Four southern regions (KLE, KLW, and ICC) exhibited relatively low probability of high population risk (0 to 7%), with no simulations going to zero.

One objective of Composite 3 was to evaluate owl population response to increased connectivity between the Olympic Peninsula and populations in the western Cascades. Increased connectivity, provided by a series of hypothetical habitat areas ("stepping stones") on private and State lands in NCO , was associated with a decreased probability of extinction in Composite 3 (9 percent versus 14, 19 and 20 percent in NWFP and Composites 1 and 2, respectively).

## Composite 4

Composite 4 was developed using Composite 3 as a starting point. In developing Composite 4, we sought to simultaneously improve the efficiency of potential critical habitat networks and reduce the level of population risk in NCO, OCR, ECN, ECS, WCN and WCC modeling regions, and to refine the networks in modeling regions with more robust population results. In some modeling regions, this involved reverting to modified versions of networks from Composite 1 or 2.

In Composite 4, the Composite 3 habitat network design for NCO was enhanced by the addition of Capitol State Forest, Joint Base Lewis-McChord (JBLM), and areas of Washington Department of Natural Resources (WA DNR) lands with existing habitat retention agreements. WA DNR lands with existing habitat retention agreements were also added to WCN and WCC (regions in which the NWFP rather than a Zonation network was the basis of Composite 3). We increased the habitat area in the OCR by reinstating Z50PUB (from Composite 1; instead of the NWFP area that had been used in Composite 3), and adding in mapped 'connectivity support areas' provided by BLM.

Within the Shasta-McCloud Area of Special Concern (ISC 1990) portion of ECS, we refined the habitat network (Z70PUB) to better reflect the distribution of RHS and areas capable of developing into spotted owl habitat.

We identified two populations at the extreme southern end of the spotted owl's range that were not included in the Zonation-based (Z30PUB, Z50PUB) networks for RDC and ICC. Based on mapped owl locations, RHS, and similar habitat modeling by Stralberg et al. (2009), we delineated two potential critical habitat units to conserve these isolated populations.

In all modeling regions in OR and CA, we trimmed areas of low RHS from identified habitat so that the boundaries conformed more closely with contiguous areas of moderate to high RHS, and small fragments were removed.

In general, the habitat networks within the fire-prone southern modeling regions (KLE, KLW and ICC), as well as RDC, did not change from Composite 3.

**Table 12. Habitat network composition and spatial extent by ownership of Composite 4.**

| Model Region | Habitat Network | Area within Networks (acres) | | | | |
|---|---|---|---|---|---|---|
| | | MR Total | Federal/1 | Congr. Reserve/2 | State | Non-public/3 |
| NCO | Z70PUB with addition of SOSEAs, Fort Lewis, Capitol State Forest, Satsop removed, RHS trimmed | 2,682,070 | 806,747 | 889,561 | 874,756 | 111,006 |
| OCR | Z50PUB (=Comp1), RHS trimmed, connectivity additions | 912,424 | 810,124 | 22,773 | 79,527 | 0 |
| ECN | Z70PUB plus some WA State lands, RHS trimmed | 3,741,864 | 2,359,240 | 1,046,819 | 82,115 | 253,690 |
| ECS | Z70PUB (=Comp1), revised reserves in Shasta-McCloud AOC | 763,619 | 596,620 | 166,987 | 0 | 12 |
| WCN | NWFP plus SOSEAs, additional WA State lands | 2,039,187 | 705,843 | 1,207,853 | 121,736 | 3,756 |
| WCC | NWFP plus SOSEAs, additional WA State lands | 1,525,920 | 634,273 | 724,017 | 165,639 | 1,992 |
| WCS | Z50PUB (=Comp1), RHS trimmed | 1,884,020 | 1,662,364 | 220,572 | 929 | 155 |
| KLE | Z50PUB (=Comp3), RHS trimmed | 1,393,595 | 1,246,482 | 147,041 | 41 | 30 |
| KLW | Z50PUB (=Comp3), RHS trimmed | 1,566,682 | 1,357,579 | 207,211 | 1,799 | 93 |
| ICC | Z50PUB (=Comp3), added in isolated population in Napa Co, RHS trimmed | 1,656,444 | 1,247,996 | 317,140 | 4,119 | 87,188 |
| RDC | Z30PUB plus HCPs (=Comp3), added in isolated population in Sonoma Co., RHS trimmed | 1,530,783 | 118,309 | 174,024 | 170,169 | 1,068,281 |
| | **Rangewide Total** | 19,696,609 | 11,545,577 | 5,123,998 | 1,500,830 | 1,526,203 |

/1 USFS and BLM lands, excluding Congressional Reserves (Wilderness, National Parks)
/2 Congressional Reserves (Wilderness, National Parks)
/3 Privately owned lands, tribal lands. Small acreage (<1,000 acres) of non-public land within a modeling region are the result of map errors and are not included in networks.

### *Composite 4 Population Results*

Population modeling results for Composite 4 indicate that the reduction of risk we sought was realized in some modeling regions (OCR, ECN, WCC), whereas risk remained unchanged (ECS) or increased (NCO, WCN) in others. In OCR, risk (quasi-extinction100) decreased by 18 percent, and population size (grand mean years 150-350) in Composite 4 increased by 19 percent from Composite 3. Conversely, extinction risk (percent of simulations going to zero) in NCO and WCN increased by 120 percent and 20 percent, respectively, in Composite 4; population size declined by 33 percent in WCN.

**Table 13. Modeling region-specific spotted owl population metrics from HexSim model of Composite 4 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 4 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 100 | 20 | 50 | 74 |
| OCR | 100 | 62 | 0 | 190 | 212 |
| ECN | 100 | 98 | 2 | 72 | 101 |
| ECS | 100 | 97 | 0 | 120 | 124 |
| WCN | 100 | 100 | 90 | 3 | 6 |
| WCC | 100 | 100 | 21 | 22 | 31 |
| WCS | 41 | 14 | 0 | 450 | 547 |
| KLE | 28 | 2 | 0 | 552 | 552 |
| KLW | 9 | 0 | 0 | 827 | 806 |
| ICC | 17 | 0 | 0 | 669 | 662 |
| RDC | 50 | 3 | 0 | 434 | 435 |
| **Total** | | | | 3390 | 3550 |

Relative to Composite 3, population sizes in Composite 4 increased (and risk levels decreased) in 8 of 11 modeling regions. Modeled population increases in modeling regions whose habitat area did not change from Composite 3 (KLE, KLW, ICC and RDC) likely resulted from increased dispersal and recruitment from populations in modeling regions that improved in Composite 4 (OCR, WCS).

**Composite 5**

This composite was primarily intended to evaluate an alternative habitat network suggested by the Bureau of Land Management for their lands in western Oregon. The BLM provided shapefiles for proposed areas in the NCO, OCR, WCS, ECS and the northern portions of KLW and KLE. Their objectives were to incorporate the results of their forest growth modeling into the habitat network, reduce the extent of NWFP matrix lands in potential critical habitat (relative to Composites 3 and 4), and to improve connectivity.

In addition, we incorporated revisions to the Composite 4 habitat network in the NCO, OCR and WCS suggested by the Forest Service. Specifically, the USFS requested that we evaluate a habitat network that included only NWFP late-successional reserves on the Mount Hood, Siuslaw, and Olympic National Forests. Yakima Tribal lands were removed from reserves in ECN, WCC.

To evaluate the potential effect on connectivity and population size at the southern extreme of ICC, RDC, we removed the areas associated with the Napa and Sonoma County isolated populations for this comparison.

**Table 14. Habitat network elements and spatial extent by ownership of Composite 5.**

| Model Region | Habitat Network | Area within Networks (acres) | | | | |
|---|---|---|---|---|---|---|
| | | MR | Federal/1 | Congr. | State | Non- |

| | | Total | | Reserve/2 | | public/3 |
|---|---|---|---|---|---|---|
| NCO | Z70PUB with addition of SOSEAs, Fort Lewis, Capitol State Forest, removed NWFP matrix lands on Olympic NF, Satsop removed, BLM proposal substituted on BLM lands (minor) | 2,446,749 | 571,455 | 889,560 | 874,755 | 110,978 |
| OCR | Z50PUB (=Comp1), BLM proposal substituted on BLM lands, removed NWFP matrix lands on Siuslaw NF, RHS trimmed | 742,404 | 640,108 | 22,754 | 79,527 | 15 |
| ECN | Composite 4, removed NWFP matrix lands on Mt Hood NF, removed Yakima tribal lands (test) | 3,373,540 | 2,220,748 | 1,046,819 | 82,115 | 23,858 |
| ECS | Composite 4 | 696,765 | 529,768 | 166,987 | 0 | 9 |
| WCN | Composite 4 | 2,039,187 | 705,843 | 1,207,853 | 121,736 | 3,756 |
| WCC | Composite 4, removed NWFP matrix lands on Mt Hood NF | 1,525,914 | 634,273 | 724,017 | 165,639 | 1,986 |
| WCS | Composite 4, BLM proposal substituted on BLM lands, RHS trimmed | 1,648,427 | 1,429,283 | 218,055 | 929 | 160 |
| KLE | Composite 4, BLM proposal substituted on BLM lands | 1,200,672 | 1,053,407 | 147,041 | 41 | 184 |
| KLW | Composite 4, BLM proposal substituted on BLM lands, RHS trimmed | 1,606,227 | 1,396,351 | 207,210 | 1,798 | 868 |
| ICC | Composite 4, removed Napa reserve (test) | 1,566,400 | 1,247,446 | 317,140 | 1,757 | 57 |
| RDC | Composite 4, removed Sonoma reserve (test) | 1,445,198 | 118,290 | 174,024 | 169,862 | 983,021 |
| | **Rangewide Total** | 18,291,483 | 10,546,974 | 5,121,459 | 1,498,157 | 1,124,893 |

/1 USFS and BLM lands, excluding Congressional Reserves (Wilderness, National Parks)
/2 Congressional Reserves (Wilderness, National Parks)
/3 Privately owned lands, tribal lands. Small acreage (<1,000 acres) of non-public land within a modeling region are the result of map errors and are not included in networks.

### *Composite 5 Population Results*

Rangewide mean population size at time 350 in Composite 5 was greater than Composite 2 and the NWFP, but lower than all other composites. Extinction risk was fairly low overall; however, specific modeling regions (NCO, OCR, ECN, ECS, WCN, WCC) exhibited higher extinction risk.

**Table 15. Modeling region-specific spotted owl population metrics from HexSim model of Composite 5 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model | Population Metrics – Composite5 |
|---|---|

| Region | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 50 - 350 |
|---|---|---|---|---|---|
| NCO | 100 | 98 | 26 | 46 | 67 |
| OCR | 100 | 78 | 0 | 143 | 165 |
| ECN | 100 | 100 | 1 | 53 | 78 |
| ECS | 100 | 99 | 0 | 99 | 104 |
| WCN | 100 | 100 | 78 | 4 | 8 |
| WCC | 100 | 100 | 30 | 18 | 28 |
| WCS | 63 | 9 | 0 | 376 | 505 |
| KLE | 55 | 3 | 0 | 424 | 452 |
| KLW | 9 | 0 | 0 | 783 | 798 |
| ICC | 12 | 1 | 0 | 636 | 645 |
| RDC | 60 | 1 | 0 | 417 | 420 |
| **Total** | | | | 2999 | 3270 |

Because the primary changes made between Composite 4 and 5 involved BLM lands in four modeling regions (OCR, WCS, KLE and KLW) in western Oregon, population differences between Composites 4 and 5 were largely confined to that area. Probability of moderate risk increased by 96 percent in KLE and 54 percent in WCS. In Composite 5, probability of high population risk increased by 26 percent in OCR. Grand mean population sizes in OCR, KLE, and WCS declined by 22 percent, 18 percent, and 8 percent, respectively.

Changes in the habitat network associated with the Mount Hood (ECN and WCC), Siuslaw (OCR), and Olympic (NCO) National Forests between Composites 4 and 5 also appeared to have influenced population results. Reduction of areas identified in NWFP matrix lands on the Siuslaw NF likely contributed to the previously-described increase in risk exhibited in OCR. Extinction risk in the NCO and WCC increased by 30 percent and 43 percent, respectively. Grand mean population sizes were reduced by 16 percent, and 23 percent in NCO and ECN, respectively.

**Composite 6**

In general, Composite 6 represented further refinement of Composite 4, based on comparison of population modeling results for Composites 3 through 5.

In Composite 6 we sought to develop and evaluate a more efficient habitat network for WCN, WCC, and ECN that remedied the overly broad network resulting from Zonation-based designs. Spotted owl habitat in those modeling regions tends to be sparsely distributed, its occurrence conforming with river drainages and lower elevations. When this pattern occurs, the Zonation algorithm appeared to aggregate some areas of low RHS to as it attempted to reach the cumulative habitat objective (e.g., 30%, 50%). To remedy this, we used the RHS maps directly to delineate potential critical habitat boundaries that more closely conformed to the distribution of moderate-high RHS and mapped spotted owl locations. We used a GIS-based elevation mask from the NWFP Monitoring Program (Davis et al. 2011) to further eliminate high-elevation areas unlikely to be occupied by spotted owls.

Composite 4 was reinstated as the basic habitat network in OCR. Based on expert opinion from BLM biologists, we revised the habitat areas identified in OCR and northern portions of KLW and KLE to more closely reflect lands most likely to support owls, and further refined by removal small isolated habitat patches.

To address connectivity issues resulting from a partial habitat gap in the area affected by the 2005 Biscuit Fire Area, we added in some areas that supported moderate to high RHS and occupied spotted owl locations in 1996.

In the RDC, we evaluated the population response to using only public lands and private lands with Habitat Conservation Plans or other formal agreements intended to conserve spotted owl habitat. In addition, we refined the habitat change scenario for RDC, based on estimated changes in RHS between 1996 and 2006, to better reflect habitat suitability in intensively managed redwood forests. We modified the pessimistic scenario as follows. Habitat suitability (RHS) within networks remained constant at its estimated 2006 level, whereas RHS outside of networks was reduced by 5 percent in each of two 20 year time-steps (not compounded).

In RDC and ICC, we reinserted slightly modified versions of the lands in Sonoma and Napa Counties intended to conserve specific isolated populations.

**Table 16. Habitat network elements and spatial extent by ownership of Composite 6.**

| Model Region | Habitat Network | Area within Networks (acres) | | | | |
|---|---|---|---|---|---|---|
| | | MR Total | Federal/1 | Congr. Reserve/2 | State | Non-public/3 |
| NCO | Removed low RHS | 1,765,443 | 734,119 | 723,445 | 306,918 | 961 |
| OCR | Composite 4, some low-RHS BLM lands removed | 891,166 | 790,443 | 22,782 | 77,941 | 0 |
| ECN | Removed low RHS | 1,936,625 | 1,356,593 | 368,903 | 57,589 | 153,540 |
| ECS | Composite 4, minor trimming | 526,815 | 417,763 | 109,040 | 2 | 11 |
| WCN | Removed low RHS | 760,955 | 543,603 | 165,419 | 49,645 | 2,288 |
| WCC | Composite 4 (NWFP), added high RHS matrix lands, | 1,336,694 | 923,740 | 324,970 | 38,342 | 49,642 |
| WCS | Composite 4, some low-RHS BLM lands removed | 1,869,525 | 1,593,297 | 275,889 | 183 | 156 |
| KLE | Composite 4 | 1,357,354 | 1,214,381 | 142,912 | 40 | 20 |
| KLW | Composite 4, modified | 1,695,874 | 1,396,892 | 296,127 | 2,383 | 472 |
| ICC | Composite 4, Napa reserve reinstated | 1,576,186 | 1,195,969 | 318,031 | 2,359 | 59,826 |
| RDC | Public lands and HCPs only, Sonoma reserve reinstated | 1,561,575 | 114,531 | 185,046 | 201,099 | 1,060,900 |
| | **Rangewide Total** | 15,278,211 | 10,281,331 | 2,932,564 | 736,499 | 1,327,816 |

/1 USFS and BLM lands, excluding Congressional Reserves (Wilderness, National Parks)
/2 Congressional Reserves (Wilderness, National Parks)
/3 Privately owned lands, tribal lands. Small acreage (<500 acres) of non-public land within a modeling region are the result of map errors and are not included in networks.

***Composite 6 Population Results***

At range-wide scales, population risk results for Composite 6 were very similar to Composite 5. All range-wide population size metrics were slightly larger for Composite 6; grand mean population size was 3,533 (7% larger) in Composite 6 versus 3,270 in Composite 5.

**Table 17. Modeling region-specific spotted owl population metrics from HexSim model of Composite 6 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 6 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 50 - 350 |
| NCO | 100 | 100 | 18 | 39 | 64 |
| OCR | 98 | 66 | 0 | 167 | 205 |
| ECN | 100 | 99 | 2 | 65 | 98 |
| ECS | 100 | 99 | 0 | 117 | 122 |
| WCN | 100 | 100 | 86 | 4 | 8 |
| WCC | 100 | 100 | 21 | 23 | 39 |
| WCS | 56 | 12 | 0 | 392 | 529 |
| KLE | 28 | 3 | 0 | 513 | 539 |
| KLW | 8 | 0 | 0 | 797 | 820 |
| ICC | 14 | 2 | 0 | 620 | 644 |
| RDC | 45 | 4 | 0 | 452 | 464 |
| **Total** | | | | 3190 | 3533 |

Population modeling results for most individual modeling regions were similar to Composite 5. Population sizes increased somewhat in eight modeling regions and were unchanged in three.

In northern modeling regions with small spotted owl populations, substantial refinement and reduction of the habitat network area either resulted in improved population results or did not influence population results (Table 17). By removing areas of low RHS, the area in the network was reduced by 28 percent and 12 percent in NCO and WCC, respectively, whereas extinction risk declined by 31 percent and 30 percent because we added in some areas of higher RHS not included in the Zonation networks. Levels of population or extinction risk were not appreciably influenced by 43 percent and 24 percent reductions of habitat network area in ECN and ECS, respectively. However, extinction risk in WCN increased 10 percent in response to a 63 percent reduction in network area.

In Composite 6 we used habitat networks from Composite 4 in OCR, KLE, KLW, and WCS, resulting in improved population performance relative to Composite 5. Probability of moderate population risk was reduced 49 percent in KLE and 11 percent in WCS; population sizes (grand mean) in KLE, KLW, and WCS increased 3 percent, 5 percent, and 19 percent, respectively. More importantly, probability of high population risk in OCR was reduced 15 percent, and population size increased by 24 percent

## Composite 7

The primary objective of Composite 7 was to evaluate the effect of relatively large refinements of habitat networks in the southern fire-prone modeling regions (KLE, KLW, ICC, and WCS). In this exercise, we used topographic features (major ridges, elevation), RHS maps, and administrative boundaries on Federal lands to subdivide the larger areas into separate units more closely corresponding to higher-quality habitat (RHS) and the distribution of occupied spotted owl sites. This refinement resulted in 18 percent, 24 percent, 19 percent and 13 percent reductions of habitat area in these four modeling regions, respectively.

At the extreme south end of RDC and ICC, we revised the Sonoma and Napa areas to more closely match the distribution of higher RHS and to reduce the amount of high-density subdivisions (parcels < 40 acres) within the identified network area.

Based on new information regarding Habitat Conservation Plans and other habitat management strategies in the State of Washington, we made a number of changes to State (WA DNR) and private lands in SOSEAs in NCO, WCN, WCC and ECN so that the habitat network better reflected State lands managed for spotted owl habitat.

**Table 18. Habitat network elements and spatial extent by ownership of Composite 7.**

| Model Region | Habitat Network | Area within Networks (acres) | | | | |
|---|---|---|---|---|---|---|
| | | MR Total | Federal/1 | Congr. Reserve/2 | State | Non-public/3 |
| NCO | Composite 6, WA state/private lands refined | 1,595,821 | 734,119 | 723,445 | 137,318 | 939 |
| OCR | Composite 6, WA state/private lands refined | 891,154 | 790,433 | 22,782 | 77,939 | 0 |
| ECN | Composite 6, WA state/private lands refined | 1,919,469 | 1,656,601 | 68,890 | 58,911 | 135,067 |
| ECS | Composite 6, | 526,810 | 417,770 | 109,040 | 0 | 0 |
| WCN | Composite 6, WA state/private lands refined | 820,832 | 543,615 | 165,407 | 111,222 | 588 |
| WCC | Composite 6, WA state/private lands refined | 1,353,045 | 923,742 | 324,966 | 57,400 | 46,937 |
| WCS | Composite 6, modified | 1,624,836 | 1,371,170 | 253,666 | 0 | 0 |
| KLE | Composite 6, modified | 1,111,679 | 1,018,352 | 90,487 | 2,840 | 0 |
| KLW | Composite 6, modified | 1,291,606 | 1,128,755 | 152,390 | 10,461 | 0 |
| ICC | Composite 6, modified, refined Napa unit | 1,276,450 | 978,599 | 250,575 | 12,123 | 35,153 |
| RDC | Composite 6, refined Sonoma unit | 1,550,747 | 114,523 | 185,025 | 203,102 | 1,048,097 |
| | **Rangewide Total** | 13,962,449 | | 2,646,671 | | |

/1 USFS and BLM lands, excluding Congressional Reserves (Wilderness, National Parks)
/2 Congressional Reserves (Wilderness, National Parks)
/3 Privately owned lands, tribal lands.

## *Composite 7 Population Results*

Although Composite 7 was 8.6 percent smaller in area than Composite 6, range-wide population results for the two composites were very similar (Table 20). Probability of high population risk and extinction risk were very low in both composites; population size (grand mean) for Composite 7 was 1.9 percent lower than Composite 6. Composite 7 was 30.5 percent smaller in area than the largest reserve design (Composite 3), but exhibited consistently lower risk metrics and similar population sizes (Figures 2 and 3).

**Table 19. Modeling region-specific spotted owl population metrics from HexSim model of Composite 7 with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Model Region | Population Metrics – Composite 7 | | | | |
|---|---|---|---|---|---|
| | Percent of simulations with <250 females | Percent of simulations with <100 females | Percent of simulations that go to extinction | Mean population size at time-step 350 | Grand mean population size time steps 150-350 |
| NCO | 100 | 99 | 21 | 52 | 74 |
| OCR | 99 | 58 | 0 | 173 | 212 |
| ECN | 100 | 95 | 3 | 66 | 97 |
| ECS | 100 | 95 | 0 | 112 | 120 |
| WCN | 100 | 100 | 80 | 4 | 8 |
| WCC | 100 | 100 | 28 | 25 | 38 |
| WCS | 59 | 14 | 0 | 375 | 501 |
| KLE | 38 | 0 | 0 | 473 | 522 |
| KLW | 9 | 0 | 0 | 732 | 776 |
| ICC | 12 | 0 | 0 | 596 | 641 |
| RDC | 46 | 2 | 0 | 442 | 475 |
| **Total** | | | | 3051 | 3464 |

The **North Coast and Olympic Peninsula modeling region (NCO)** consistently exhibited small population sizes and high extinction risk, with probability of extinction ranging from 9 percent (Composite 3) to 26 percent (Composite 5) under pessimistic habitat scenarios. Probability of extinction under Composite 7 was 21 percent; more than double that of Composite 3. Lower extinction probabilities in Composites 1 and 3 were correlated with large amounts of State and private land added to those networks to evaluate population effects of increased connectivity to the Olympic Peninsula. Because most of the hypothetical State and private habitat areas ("stepping stones") evaluated in Composite 3 did not meet criteria for critical habitat (no currently-suitable habitat and no records of occupancy by spotted owls), they were not incorporated into subsequent composites. Composite 7 therefore contains roughly 95 percent less State and private land than Composite 3. Grand mean population size was less than 100 females (range 64 to 80; 74 in Composite 7) in all networks and under both optimistic and pessimistic habitat change scenarios, suggesting that populations are limited by habitat availability and population isolation, as well as the moderate influence of barred owl (0.375 encounter rate) used in HexSim simulations. Most of the suitable spotted owl habitat within the NCO occurs on Federal lands at relatively low elevations in the Olympic National

Park and adjacent Olympic National Forest; suitable habitat is extremely limited on State and private lands in the coast ranges of Washington and northern Oregon.

In the **Oregon Coast Range modeling region (OCR)**, probability of high population risk (less than 100 females) was consistently high (58 to 78 percent of simulations) among habitat networks. Probability of high population risk under Composite 7 was 58 percent. Extinction risk was zero in all networks. Grand mean population size ranged from 178 to 222 females among networks (212 in Composite 7). The relatively small variation in population size among networks and between optimistic/pessimistic scenarios suggests that spotted owl populations in the OCR are limited by the amount and distribution of suitable habitat. Most of the habitat networks for OCR contained a large proportion of the available suitable habitat (RHS > 35) and known spotted owl locations on Federal lands, limiting our ability to improve risk metrics or substantially increase population size by increasing area within networks.

Climate and elevation in the **Eastern Cascades North (ECN) modeling region** act to limit the amount and distribution of forest types suitable for spotted owls. Probability of high population risk ranged from 91 percent to 100 percent among networks and between optimistic and pessimistic habitat scenarios. Under pessimistic habitat change scenarios, probability of extinction ranged from zero (Composite 7) to 4 percent (Composite 3). Population size under Composite 7 (97 females) was slightly less than Composite 4 (101 females), despite Composite 7 being roughly half the area of Composite 4.

Similar to ECN, the **Eastern Cascades South (ECS) modeling region** supports limited amounts and distribution of suitable spotted owl habitat. Probability of high population risk in Composite 7 was 99 percent for pessimistic habitat scenarios (79 percent for optimistic); overall among habitat networks in ECS, probability of high population risk ranged from 73 to 89 percent for optimistic habitat scenarios and 95-100 percent in pessimistic habitat scenarios. Extinction risk was zero for all reserve designs. Population size for Composite 7 (120 females) was similar to Composites 1, 4 and 6 (123, 124 and 122 females); but Composite 7 was approximately 50 percent smaller than Composite 1.

Although much of the **Western Cascades North modeling region (WCN)** is comprised of National Park and wilderness areas, the amount and distribution of forest types suitable for spotted owls is strongly limited by elevation and climate. The WCN supports the smallest and most at-risk spotted owl population within the species' range; probability of high population risk was 100 percent for all reserve designs and both optimistic and pessimistic habitat scenarios. Extinction risk (percent of simulations going to zero) ranged from 75 to 90 percent for optimistic habitat scenarios, and 77 to 89 percent for pessimistic scenarios. Population sizes among all reserve designs and habitat change scenarios ranged from 6 to 8 females; however, Composite 7 was 60 percent smaller than Composites 4 and 5. The high degree of similarity among population results for different reserve designs suggests that most suitable habitat is contained within reserves and few options exist for improving population outcomes, given the assumed level of barred owl effects.

Habitat availability and population metrics for spotted owls in the **Western Cascades Central (WCC) modeling region** were similar to the WCN. The WCC exhibited a 100 percent probability of moderate and high population risk under all networks and habitat change scenarios. Probability of extinction among habitat networks ranged from 12 to 26 percent under optimistic habitat scenarios and 21 to 35 percent under pessimistic habitat scenarios. While population sizes (grand mean at time-step 350) for Composite 7 were small (44 and 38 females for optimistic and pessimistic habitat scenarios), they were the largest among all networks and habitat scenarios (range 27 to 44 females).

The **Western Cascades South (WCS) modeling region** is dominated by Federal lands and supports extensive areas of suitable spotted owl habitat. Probability of moderate population risk for pessimistic habitat scenarios under Composite 7 was 50 percent; other networks ranged from 41 to 79 percent. Probability of high population risk for Composite 7 under pessimistic habitat scenarios was 14 percent; other networks ranged from 9 to 21 percent. Probability of extinction risk was zero for all habitat networks. Population size (grand mean at time-step 350) for Composite 7 was 648 and 501 females for optimistic and pessimistic habitat scenarios, respectively.

Habitat network and population characteristics were similar among the fire-prone **Eastern Klamath (KLE), Western Klamath (KLW) and Northern California Interior Coast Ranges (ICC)** modeling regions in the southern portion of the spotted owl's geographic range. Probability of moderate population risk under Composite 7 was 2 percent (ICC), 8 percent (KLE) and 5 percent (KLW) for optimistic habitat scenarios, and 12, 38 and 9 percent, respectively, for pessimistic habitat scenarios. Probability of high population risk was zero for Composite 7, as was extinction risk. Population sizes (grand mean at time-step 350) for Composite 7 were 973 (ICC), 770 (KLE) and 901 (KLW) under optimistic habitat scenarios and 641 (ICC), 522 (KLE) and 776 (KLW) under pessimistic scenarios.

Because private timberlands constitute a large majority of the **Redwood Coast (RDC) modeling region**, population modeling results varied widely among networks and habitat change scenarios applied to public versus non-public lands. A pessimistic habitat change scenario specific to RDC was used in population modeling for Composites 6 and 7 (see Composite 6 description); therefore pessimistic scenario results from these composites were not directly comparable to earlier networks identified. Probability of moderate population risk for Composite 7 was 3 percent and 46 percent under optimistic and pessimistic scenarios, respectively. Probability of high population risk was consistently low under optimistic habitat scenarios, but ranged from 100 percent to 1 percent under pessimistic habitat scenarios. This variation was the result of differing assumptions regarding habitat quality on private timberlands through time. Probability of high population risk under Composite 7 and pessimistic habitat change scenarios was 2 percent. Extinction risk was zero for all networks and habitat change scenarios. Population size for Composite 7 was 781 females and 475 females for optimistic and pessimistic scenarios, respectively.

## OVERVIEW OF PHASE 3 RANGEWIDE HABITAT NETWORK COMPARISONS

In this section we present an overview of our comparisons of population performance (HexSim results) across all seven composites and also with NWFP. We sought efficient potential critical habitat networks based (to the maximum extent feasible) on public lands, with a particular emphasis on Federal lands, that met the conservation objectives described in the Guiding Principles presented earlier in this document. While larger habitat networks had highest overall population performance, we were able to develop smaller, more efficient networks of critical habitat that supported similar population performance and thus meet the goal of providing for the conservation of the northern spotted owl (Table 20; Figures 2 and 3).

**Table 20. Range-wide spotted owl population metrics from HexSim model of Composites 1-7 and NWFP with 'pessimistic' habitat change scenario and barred owl encounter rates from Table 2.**

| Population Metric | Conservation Habitat Network Design | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | NWFP | Comp1 | Comp2 | Comp3 | Comp4 | Comp5 | Comp6 | Comp7 |
| N (time-step 50) /1 | 6861 | 6760 | 7193 | 6879 | 7012 | 7204 | 7268 | 6077 |
| N (time-step350) | 2088 | 3216 | 2534 | 3074 | 3390 | 2999 | 3190 | 3051 |
| N350/N50 x 100/2 | 30 | 48 | 35 | 45 | 48 | 42 | 44 | 50 |
| % of simulations N <1250 | 43 | 11 | 26 | 20 | 14 | 11 | 10 | 12 |
| % of simulations N <1000 | 24 | 5 | 15 | 11 | 8 | 5 | 6 | 3 |
| % of simulations N <750 | 11 | 0 | 2 | 1 | 0 | 2 | 3 | 1 |

/1 : N = number of female individuals

/2 : Percent of time-step 50 population at time-step 350

As noted above, efficiency of the habitat network was was one of the Service's goals. One method of evaluating efficiency is to compare habitat scenario area to owl population size. Figure 2 shows this relationship for each of the seven Composite network scenarios and the NWFP.

**Figure 2. Total area and number of female owls present in population at time-step 350 for Composites 1-7 and the Northwest Forest Plan (NWFP) using the pessimistic habitat scenario.**

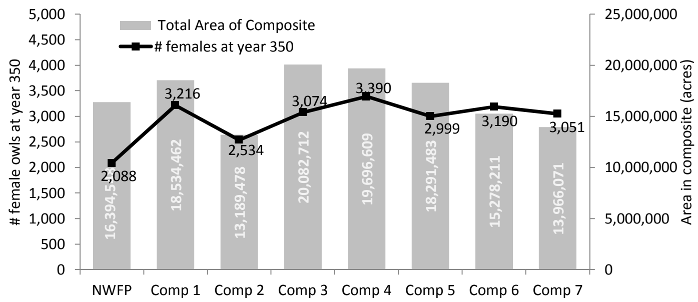
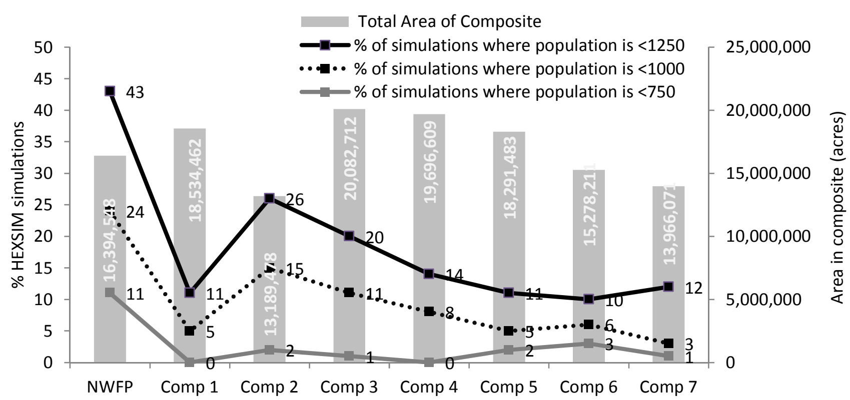



**Figure 3. Total area and percent of HexSim simulations (pessimistic habitat scenario) where spotted owl populations fell below 1250, 1000, and 750 total owls for Composites 1-7 and the Northwest Forest Plan (NWFP).**




Levels of population risk (Figure 3) followed a pattern similar to that shown in Figure 2; with Composite 7 as the most efficient of the scenarios we evaluated.

## SUMMARY AND CONCLUSION

The Service employed a 3-phase modeling process to evaluate potential critical habitat networks for the northern spotted owl. Phase 1 began with a coarse-filter comparison of 84 habitat network, habitat change, and barred owl scenarios. Based on the results of these comparisons, we created two composite scenarios for more detailed and rigorous evaluation in Phase 2. In Phase 3, we used an iterative process of developing and testing alternative potential critical habitat networks, evaluating spotted owl population performance in 176 modeling region-specific scenarios, including the Northwest Forest Plan reserve network. Each composite scenario represented the Service's effort to maximize efficiency and realism by reducing the potential critical habitat designation, focusing on well-connected high quality habitat while maintaining the best possible population performance. The last scenario in this process (Composite 7) performed substantially better than the NWFP and other composites nearly twice its size (area), and represents a robust potential critical habitat network that conforms with the statutory definition of critical habitat.

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# Appendix C

Included in this appendix is Appendix C of the 2011 Revised Recovery Plan for the northern spotted owl.

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

## Appendix C: Development of a Modeling Framework to Support Recovery Implementation and Habitat Conservation Planning

### Introduction by U.S. Fish and Wildlife Service

The Service believes a spatially explicit demographic model would greatly improve recovery planning and implementation for the spotted owl. Peer reviewers were critical of the 2008 Recovery Plan's habitat conservation network strategy and the general lack of updated habitat modeling capacity. The Service considered this criticism and concluded that a spatially explicit demographic model would greatly improve recovery implementation for the spotted owl, as well as other land use management decisions.

For this Revised Recovery Plan, the Service appointed a team of experts to develop and test a modeling framework that can be used in numerous spotted owl management decisions. This spatially-explicit approach is designed to allow for a more in-depth evaluation of various factors that affect spotted owl distribution and populations**.** This approach also allows for a unique opportunity to integrate new data sets, such as information from the NWFP 15-year Monitoring Report (Davis and Dugger in press) and the recent spotted owl population meta-analysis (Forsman *et al.* 2011).

The Service expects this modeling framework will be applied by Federal, State, and private scientists to make better informed decisions concerning what areas should be conserved or managed to achieve spotted owl recovery. Specifically, the modeling framework can be applied to various spotted owl management challenges, such as to:

1) Inform evaluations of meeting population goals and Recovery Criteria.
2) Develop reliable analysis and modeling tools to enable evaluation of the influence of habitat suitability and barred owls on spotted owl demographics.
3) Support future implementation and evaluation of the efficacy of spotted owl conservation measures described in various recovery actions.
4) Provide a framework for landscape-scale planning by both Federal and non-federal land managers that enables evaluation of potential demographic responses to various habitat conservation scenarios, including information that could be used in developing a proposed critical habitat rule.

These and other potential applications of the modeling framework described herein represent a significant advancement in spotted owl recovery planning. Although the completed model framework will be included in the Revised Recovery Plan, the Service hopes that future application of this modeling approach will lead to refinement and improvements, such as incorporation of population connectivity and source-sink dynamics, over time as experience and new scientific insights are realized.

To meet these objectives, the Service established the Spotted Owl Modeling Team (hereafter the "modeling team") to develop and apply modeling tools for the Service's use in designing and evaluating various conservation options for achieving spotted owl recovery. The modeling team was informally organized along lines of function and level of participation. Jeffrey Dunk (Humboldt State University), Brian Woodbridge (USFWS), Bruce Marcot (USFS, Pacific Northwest Research Station), Nathan Schumaker (USEPA), and Dave LaPlante (a contractor with Natural Resource Geospatial) composed the primary group which was responsible for conducting the data analyses and modeling. They were assisted by spotted owl researchers, agency staff and modeling specialists who individually provided data sets and advice on particular issues within their areas of expertise, and reviewed modeling processes and outputs. These experts were: Robert Anthony (Oregon State University), Katie Dugger (Oregon State University), Marty Raphael (USFS, Pacific Northwest Research Station), Jim Thrailkill (USFWS), Ray Davis (USFS, Northwest Forest Plan Monitoring Group), Eric Greenquist (BLM), and Brendan White (USFWS). Additionally, technical specialists—Craig Ducey (BLM), Karen West (USFWS) and Dan Hansen and M.J. Mazurek (contractors with Humboldt State University Foundation) conducted literature reviews and assisted with data collection and analyses.

To ensure that the modeling effort was based on the most current information, scientific knowledge and opinion, the modeling team also sought the assistance of numerous individual scientists and habitat managers from government, industry and a non-profit conservation organization (listed in acknowledgements) in development of habitat descriptions, modeling regions and many other aspects of spotted owl and forest ecology. To facilitate this effort, the Service held a series of meetings with spotted owl experts (habitat expert panels) to obtain additional information, data sets, and expertise regarding spotted owl habitats.

Representatives of the modeling team have prepared this Appendix to provide a thorough description of the modeling framework developed by the team, the results of model development and testing, and examples of how the modeling process can be used to evaluate habitat conservation scenarios and their relative contribution to recovery.

While this framework represents state-of-the-art science, it is not intended to represent absolute spotted owl population numbers or be a perfect reflection of reality. Instead, it provides a comparison of the relative spotted owl responses to a variety of potential conservation measures and habitat conservation networks. The implementation of spotted owl recovery actions should consider the results of the modeling framework as one of numerous sources of information to be incorporated into the decision-making process.

## General Approach

The spotted owl modeling team (hereafter “modeling team“ or “we”) employed state-of–the-art modeling tools in a multi-step analysis similar to that proposed by Heinrichs *et al.* (2010) and Reed *et al.* (2006) for designing habitat conservation networks and evaluating their contributions to spotted owl recovery. In addition to this objective, the modeling tools in this framework, individually or in combination, are designed to enable evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls.

Our conservation planning framework integrates a spotted owl habitat model, a habitat conservation planning model, and a population simulation model. Collectively, these modeling tools allow comparison of estimated spotted owl population performance among alternative habitat conservation network scenarios under a variety of potential conditions. This will enable the Service and other interested managers to use relative population viability (timing and probability of population recovery) as a criterion for evaluating habitat conservation network scenarios and other conservation measures for the spotted owl.

The evaluation approach the modeling team developed consists of three main steps (Figure C1):

> **Step 1** – Create a map of spotted owl habitat suitability throughout the species’ U.S. range, based on a statistical model of spotted owl habitat associations.
>
> **Step 2** – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.

**Step 3** – Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be estimates of what will occur in the future, but provide information on trends predicted to occur under differing habitat conservation scenarios.

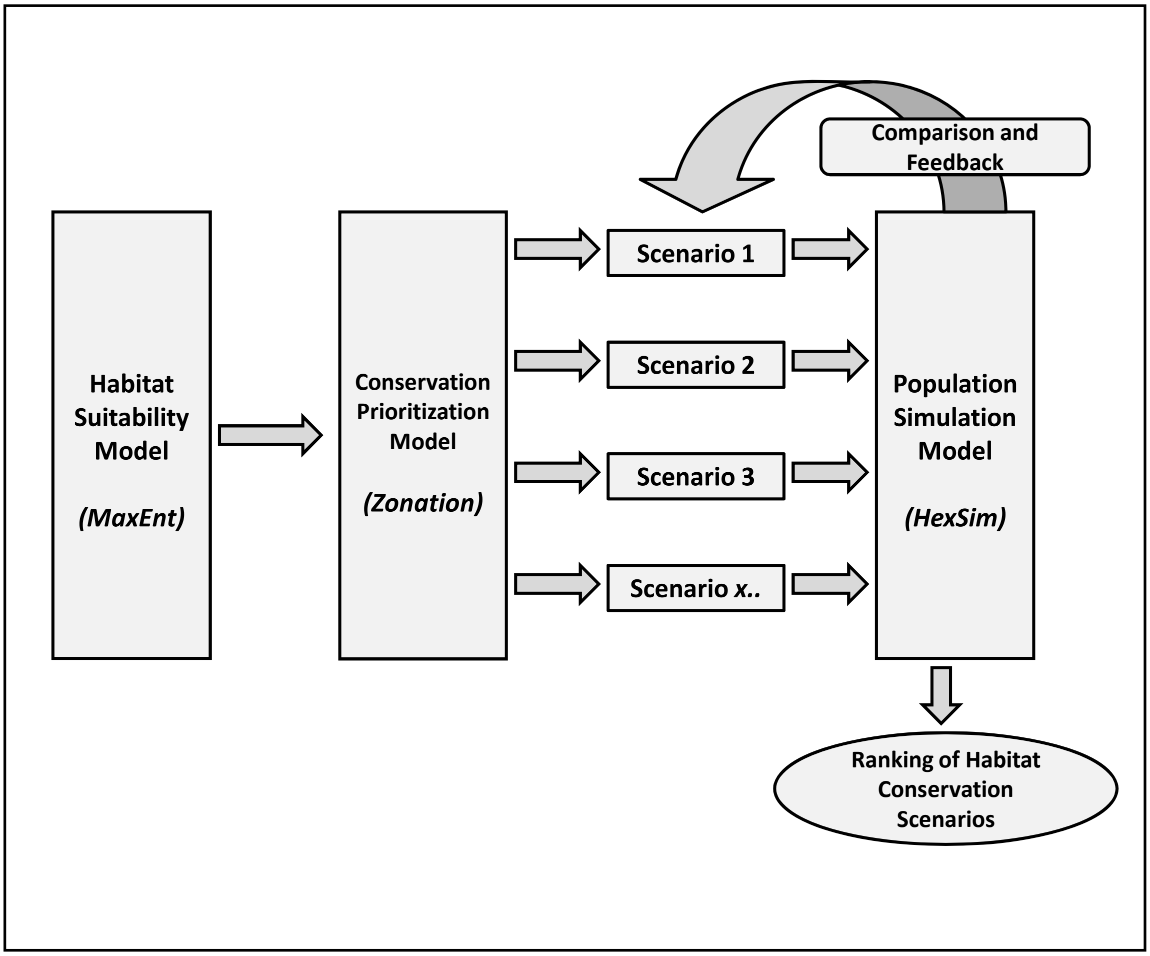
The Service or other practitioners can use the population simulation model developed in Step 3 to test the degree to which various recovery actions and habitat conservation network scenarios contribute to recovery of the spotted owl. For example, it can be used to evaluate relative population size and trend, as well as distribution and connectivity of modeled spotted owl populations through time.

Each of the steps noted above involved statistical and/or mathematical modeling and is not meant to be exact predictions of what currently exists or what will occur in the future, but represent our best estimates of current conditions and relationships. These models allow the use of powerful, up-to-date scientific tools in a repeatable and scientifically accepted manner to develop and evaluate habitat conservation networks and other conservation measures to recover the spotted owl. We view the benefit and utility of such models in the same way that Johnson (2001) articulated, "*A model has value if it provides better insight, predictions, or control than would be available without the model*." The modeling tools described herein meet this standard.

The overall framework and evaluations outlined in Figure C1 are somewhat similar to Raphael *et al.* (1998). Our modeling process differs fundamentally from the conservation planning approach used by the ISC (Thomas *et al*. 1990), 1992 Draft Recovery Plan (USFWS 1992b), FEMAT (1993), and the 2008 Recovery plan (USFWS 2008b), which were based on *a priori* rule sets derived from best expert judgment regarding the size of reserves or habitat conservation blocks, target number of spotted owl pairs per reserve or block, and targeted spacing between reserves or blocks. The new modeling framework we developed instead uses a series of spatially explicit modeling processes to develop habitat conservation networks (or "reserves") based on the distribution of habitat value. Issues of habitat connectivity and population isolation are identified within the population simulation model outputs.

The spotted owl modeling team has completed the development and evaluation of the overall modeling framework described in Steps 1 through 3 above. The *use* of the modeling framework, for example, to inform design and evaluation of various habitat conservation network scenarios (including potential effects of barred owl management), other conservation measures described in recovery actions, and evaluate potential effects of climate change will be completed as a part of recovery plan implementation or other analytical and regulatory processes.

**Figure 0-1**. **Diagram of stepwise modeling process for developing and evaluating habitat conservation scenarios for the spotted owl.**




# Modeling Process Step 1 – Create a spotted owl habitat suitability map covering the U.S. range of the subspecies based on a statistical model of spotted owl habitat associations.

## Habitat modeling objective and overall approach:

A variety of methods are available for modeling species-habitat relationships (Morrison *et al*. 1992, Elith *et al*. 2006), with divergent assumptions and underlying statistical bases (Breiman 2001). The selection of a modeling tool is influenced foremost by the objectives of the modeling exercise, and by the characteristics of data available for modeling. The primary objective of our recovery plan modeling was to develop a map that reliably predicts relative habitat suitability for the spotted owl. Our primary goals were to develop predictive models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. Our modeling was not an attempt to quantify or refine our understanding of the spotted owl's niche; but instead focused on predictions. Because we were primarily focused on obtaining reliable predictions, we were less concerned about covariates and their associated parameter estimates, or the relative importance of each habitat variable. This objective enabled us to consider newer algorithmic modeling approaches that emphasize prediction (Breiman 2001).

The nature of the spotted owl data available to us also influenced our choice of a modeling approach. We gathered several datasets which resulted in a large number of spotted owl locations, but only a relatively small subset of those data sets also had survey effort information (that could be used for occupancy modeling) and absence data (locations that were adequately sampled and where spotted owls were not detected). Because the majority of spotted owl data available was best characterized as 'presence-only' data, we elected not to employ occupancy modeling approaches.

Our objectives and the nature of the data available to us lead us to choose the species distribution model MaxEnt (Phillips *et al*. 2006, Phillips and Dudik 2008) to model spotted owl relative habitat suitability. MaxEnt is specifically designed for presence-only data. Moreover, MaxEnt has been thoroughly evaluated on a number of taxa, geographic regions, and sample sizes and has been found to perform extremely well (Elith *et al.* 2006, Wisz *et al*. 2008).

## Distributional Models and the Spotted Owl:

Species distributional models are used to evaluate species-habitat relationships, evaluate an area's suitability for the species, and to predict a species' presence (Elith and Leathwick 2009). These models, also called environmental (or ecological) niche models, correlate environmental conditions with species distribution and thereby predict the relative suitability of habitat within some geographic area (Warren and Seifert 2011). When translated into maps depicting the spatial distribution of predicted habitat suitability, these models have great utility for evaluating conservation reserve design and function (Zabel *et al.* 2002, Zabel *et al*. 2003, Carroll and Johnson 2008, Carroll *et al.* 2010). Because the spotted owl is one of the most studied raptors in the world; we had available hundreds of peer-reviewed papers on various aspects of the species' ecology, including habitat use and selection (see reviews by Gutiérrez *et al.* 1995, Blakesley 2004). Only a few range-wide (in the U.S.) evaluations of habitat association (Carroll and Johnson 2008) or habitat distribution (Davis and Lint 2005, Davis and Dugger in press) have been conducted. While we capitalized on this large body of literature and other information to build models for conservation planning purposes, we were primarily interested in using such models to map relative habitat suitability rather than to provide new ecological understanding of spotted owl habitat associations.

## Meetings with spotted owl habitat experts and review of literature and data sets:

Because the spotted owl is among the most-studied birds in the world, there is a wealth of information on its ecology and habitat associations. To ensure that the modeling effort was based on this scientific foundation, our first step was to conduct an extensive review of published and unpublished information on the species. Concurrent with this effort, team members travelled throughout the spotted owl's range and met with researchers and biologists with extensive experience studying spotted owls. Some of these meetings were one-on-one, and at other times we held meetings with several experts at one time to seek their individual advice. We have sometimes referred to these meetings as "expert panels." At these meetings, biologists were each asked to identify (1) the environmental factors to which spotted owls respond within particular physiographic provinces (*e.g.* Klamath Mountains of southern Oregon and northern California, Olympic Peninsula, Redwood Coast), and (2) regions believed to be distinct where spotted owls may be responding to conditions uniquely. In order to identify distinct modeling areas and definitions of spotted owl habitat (see below), we used both empirical findings (*i.e.*, published information) and the professional judgment of spotted owl experts.

## Modeling regions - Partitioning the species' range:

Several authors have noted that spotted owls exhibit different habitat associations in different portions of their range, which is often attributed to regional differences in forest environments and factors such as important prey species (Carey *et al.* 1992, Franklin *et al.* 2000, Noon and Franklin 2002, Zabel *et al.* 2003), or presence of Douglas-fir dwarf mistletoe (expert panels). The distribution of these features is likely influenced by relatively large east-west and north-south gradients in ecological conditions (*e.g.*, temperature, precipitation, net primary productivity) and subsequent variation in forest environments. Hence, we developed and evaluated region-specific habitat suitability models under the assumption that spotted owls *within* a modeling region respond to habitat conditions more similarly than do spotted owls *between* modeling regions where conditions differ.
For monitoring, management and regulatory purposes, the spotted owl's range has historically been divided into 12 physiographic provinces (USDI 1992, Davis and Lint 2005) based largely on the regional distribution of major forest types and state boundaries. Based on differences and similarities in spotted owl habitat, we combined some provinces (California and Oregon Klamath provinces), retained others, and divided some provinces into smaller modeling regions (see Figure C2). We did not establish modeling regions or develop models for the Puget Lowlands, Southwestern Washington, and Willamette Valley, where spotted owls are almost completely absent and sample sizes were too small to support for model development. Instead, we projected the models developed for the closest adjacent area to those areas. This decision had the influence of allowing those regions to have at least some potential value to simulated spotted owls as opposed to assuming zero value.

The predictive ability and accuracy of habitat suitability models are influenced by the range of environmental conditions that are incorporated into the training data used in model development. Models developed from data sets encompassing broad environmental gradients tend to be overly general; conversely, models developed with data representing a small subset of conditions have limited applicability across the species' larger distribution. The practice of partitioning a species' range into "modeling regions" that encompass relatively dissimilar subsets of species-habitat relationships and developing models specific to each region was used to reduce this source of variability. The challenge is balancing the high degree of variability within large regions against the tendency to create many small modeling regions (with potentially small sample sizes) based on locally unique environmental conditions.

We queried experts to suggest potential modeling region boundaries, and they provided input on broad-scale patterns in climate, topography, forest communities, spotted owl habitat relationships, and prey-base that supported delineation of the draft spotted owl modeling regions (Figure C2). Franklin and Dyrness (1973), Kuchler (1977) and other published sources of information on the distribution of major ecological boundaries were also consulted. Using information provided through our discussions with the expert panels and existing ecological section and subsection boundaries (McNab and Avers 1994), we delineated 11 spotted owl modeling regions (Figure C2).

In general, the spotted owl modeling regions varied in terms of these ecological features:

1) Degree of similarity between structural characteristics of habitats used by spotted owls primarily for nesting/roosting and habitats used for foraging and other nocturnal activities. This similarity is largely influenced by habitat characteristics of the spotted owl's dominant prey (proportion of flying squirrels versus woodrats).
2) Latitudinal patterns of topography and climate. For example, in the WA Cascades, spotted owls are rarely found at elevations above 1,219-1,372 m, whereas in southern Oregon and the Klamath province spotted owls commonly reside up to 1,830 m.
3) Regional patterns of topography, climate, and forest communities.
4) Geographic distributions of habitat elements that influence the range of conditions occupied by spotted owls. For example, several panelists pointed out that the distribution of dwarf mistletoe influences the range of stand structural values associated with spotted owl use. Other examples include the geographic distribution of elements such as evergreen hardwoods, Oregon white oak woodlands, and ponderosa pine-dominated forests.

## Modeling Region Descriptions:

**North Coast Ranges and Olympic Peninsula (NCO):** This region consists of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). This region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (448 to 750 m). High elevations and cold temperatures occur in the interior portions of the Olympic Peninsula, but spotted owls in this area are limited to the lower elevations (<900 m.). Forests in the NCO are dominated by western hemlock, Sitka spruce, Douglas-fir, and western red cedar. Hardwoods are limited in species diversity (consist mostly of bigleaf maple and red alder) and distribution within this region, and typically occur in riparian zones. Root pathogens like laminated root rot (*Phellinus weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat consists of stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. This region contains the Olympic Demographic Study Area (DSA).

**Oregon Coast Ranges (OCR):** This region consists of the southern 1/3 of the Oregon and Washington Coast Ranges Section M242A (McNab and Avers 1994). We split the section in the vicinity of Otter Rock, OR, based on gradients of increased temperature and decreased moisture that result in different patterns of vegetation to the south. Generally this region is characterized by high rainfall, cool to moderate temperatures, and generally low topography (300 to 750 m.). Forests in this region are dominated by western hemlock, Sitka spruce, and Douglas-fir; hardwoods are limited in species diversity (largely bigleaf maple and red alder) and distribution, and are typically limited to riparian zones. Douglas-fir and hardwood species associated with the California Floristic Province (tanoak, Pacific madrone, black oak, giant chinquapin) increase toward the southern end of the OCR. On the eastern side of the Coast Ranges crest, habitats tend to be drier and dominated by Douglas-fir. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple among others fills these gaps. Because Douglas-fir dwarf mistletoe is unusual in this region, spotted owl nesting habitat tends to be limited to stands providing very large trees with cavities or deformities. A few nests are associated with western hemlock dwarf mistletoe. Spotted owl diets are dominated by species associated with mature to late-successional forests (flying squirrels, red tree voles), resulting in similar definitions of habitats used for nesting/roosting and foraging by spotted owls. One significant difference between OCR and NCO is that woodrats comprise an increasing proportion of the diet in the southern portion of the modeling region. This region contains the Tyee and Oregon Coast Range DSAs.

**Redwood Coast (RDC):** This region consists of the Northern California Coast Ecological Section 263 (McNab and Avers 1994). This region is characterized by low-lying terrain (0 to 900 m.) with a maritime climate; generally mesic conditions and moderate temperatures. Climatic conditions are rarely limiting to spotted owls at all elevations. Forest communities are dominated by redwood, Douglas-fir-tanoak forest, coast liveoak, and tanoak series. The vast majority of the region is in private ownership, dominated by a few large industrial timberland holdings. The results of numerous studies of spotted owl habitat relationships suggest stump-sprouting and rapid growth rates of redwoods, combined with high availability of woodrats in patchy, intensively-managed forests, enables spotted owls to maintain high densities in a wide range of habitat conditions within the Redwood zone. This modeling region contains the Green Diamond and Marin DSAs.

**Western Cascades North (WCN):** This region generally coincides with the northern Western Cascades Section M242B (McNab and Avers 1994), combined with western portion of M242D

(Northern Cascades Section), extending from the U.S. - Canadian border south to Snoqualmie Pass in central Washington. It is similar to the Northern Cascades Province of Franklin and Dyrness (1974). This region is characterized by high mountainous terrain with extensive areas of glaciers and snowfields at higher elevation. The marine climate brings high precipitation (both annual and summer) but is modified by high elevations and low temperatures over much of this modeling region. The resulting distribution of forest vegetation is dominated by subalpine species, mountain hemlock and silver fir; the western hemlock and Douglas-fir forests typically used by spotted owls are more limited to lower elevations and river valleys (spotted owls are rarely found at elevations greater than 1,280 m. in this region) grading into the mesic Puget lowland to the west. Root pathogens like laminated root rot (*P. weirii*) are important gap formers, and vine maple, among others, fills these gaps. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nests sites are limited to defects in large trees, and occasionally nests of other raptors. Diets of spotted owls in this northern region contain higher proportions of red-backed voles and deer mice than in the region to the south, where flying squirrels are dominant (expert panels). There are no Demographic Study Areas in this modeling region.

**Western Cascades Central (WCC):** This region consists of the midsection of the Western Cascades Section M242B (McNab and Avers 1994), extending from Snoqualmie Pass in central Washington south to the Columbia River. It is similar to the Southern Washington Cascades Province of Franklin and Dyrness (1974). We separated this region from the northern section based on differences is spotted owl habitat due to relatively milder temperatures, lower elevations, and greater proportion of western hemlock/Douglas-fir forest and occurrence of noble fir to the south of Snoqualmie Pass. Because Douglas-fir dwarf mistletoe occurs rarely in this region, spotted owl nest sites are largely limited to defects in large trees, and occasionally nests of other raptors. This region contains the Rainier DSA and small portions of the Wenatchee and Cle Elum DSAs.

**Western Cascades South (WCS):** This region consists of the southern portion of the Western Cascades Section M242B (McNab and Avers 1994) and extends from the Columbia River south to the North Umpqua River. We separated this region from the northern section due to its relatively milder temperatures, reduced summer precipitation due to the influence of the Willamette Valley to the west, lower elevations, and greater proportion of western hemlock/Douglas-fir forest. The southern portion of this region exhibits a gradient between Douglas-fir/western hemlock and increasing Klamath-like vegetation (mixed conifer/evergreen hardwoods) which continues across the Umpqua divide area. The southern boundary of this region is novel and reflects a transition to mixed conifer sensu Franklin and Dyrness (1974). The importance of Douglas-fir dwarf mistletoe increases to the south in this region, but most spotted owl nest sites in defective large trees, and occasionally nests of other raptors. The HJ Andrews DSA occurs within this modeling region.

**Eastern Cascades North (ECN):** This region consists of the eastern slopes of the Cascade range, extending from the Canadian border south to the Deschutes National Forest near Bend, OR. Terrain in portions of this region is glaciated and steeply dissected. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Increased precipitation from marine air passing east through Snoqualmie Pass and the Columbia River results in extensions of moist forest conditions into this region (Hessburg *et al.* 2000b). Forest composition, particularly the presence of grand fir and western larch, distinguishes this modeling region from the southern section of the eastern Cascades. While ponderosa pine forest dominates lower and middle elevations in both this and the southern section, the northern section supports grand fir and Douglas fir habitat at middle elevations. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. This modeling region contains the Wenatchee and Cle Elum DSAs.

**Eastern Cascades South (ECS):** This region incorporates the Southern Cascades Ecological Section M261D (McNab and Avers 1994) and the eastern slopes of the Cascades from the Crescent Ranger District of the Deschutes National Forest south to the Shasta area. Topography is gentler and less dissected than the glaciated northern section of the eastern Cascades. A large expanse of recent volcanic soils (pumice region: Franklin and Dyrness 1974), large areas of lodgepole pine, and increasing presence of red fir and white fir (and decreasing grand fir) along a south-trending gradient further supported separation of this region from the northern portion of the eastern Cascades. This region is characterized by a continental climate (cold, snowy winters and dry summers) and a high-frequency/low-mixed severity fire regime. Ponderosa pine is a dominant forest type at mid-to lower elevations, with a narrow band of Douglas-fir and white fir at middle elevations providing the majority of spotted owl habitat. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, smaller trees. The Warm Springs DSA and eastern half of the South Cascades DSA occur in this modeling region.

**Western Klamath Region (KLW):** This region consists of the western portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994). A long north-south trending system of mountains (particularly South Fork Mountain) creates a rainshadow effect that separates this region from more mesic conditions to the west. This region is characterized by very high climatic and vegetative diversity resulting from steep gradients of elevation, dissected topography, and the influence of marine air (relatively high potential precipitation). These conditions support a highly diverse mix of mesic forest communities such as Pacific Douglas-fir, Douglas-fir tanoak, and mixed evergreen forest interspersed with more xeric forest types. Overall, the distribution of tanoak is a dominant factor distinguishing the Western Klamath Region. Douglas-fir dwarf mistletoe is uncommon and seldom used for nesting platforms by spotted owls. The prey base of spotted owls within the Western Klamath is diverse, but dominated by woodrats and flying squirrels. This region contains the Willow Creek, Hoopa, and the western half of the Oregon Klamath DSAs.

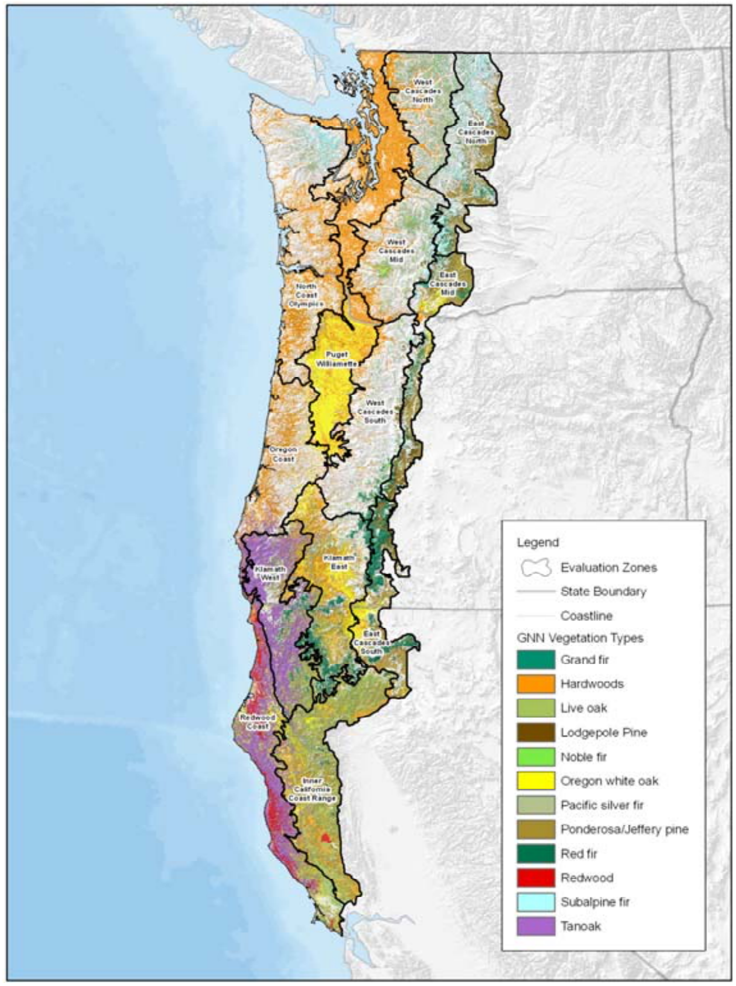
**Eastern Klamath Region (KLE):** This composite region consists of the eastern portion of the Klamath Mountains Ecological Section M261A (McNab and Avers 1994) and portions of the Southern Cascades Ecological Section M261D in Oregon. This region is characterized by a Mediterranean climate, greatly reduced influence of marine air, and steep, dissected terrain. Franklin and Dyrness (1974) differentiate the mixed conifer forest occurring on the "Cascade side of the Klamath from the more mesic mixed evergreen forests on the western portion (Siskiyou Mountains), and Kuchler (1977) separates out the eastern Klamath based on increased occurrence of ponderosa pine. The mixed conifer/evergreen hardwood forest types typical of the Klamath region extend into the southern Cascades in the vicinity of Roseburg and the North Umpqua River, where they grade into the western hemlock forest typical of the Cascades. High summer temperatures and a mosaic of open forest conditions and Oregon white oak woodlands act to influence spotted owl distribution in this region. Spotted owls occur at elevations up to 1,768 m. Dwarf mistletoe provides an important component of nesting habitat, enabling spotted owls to nest within stands of relatively younger, small trees. The western half of the South Cascades DSA and the eastern half of the Klamath DSA are located within this modeling region.

**Northern California Interior Coast Ranges Region (ICC):** This region consists of the Northern California Coast Ranges ecological Section M261B (McNab and Avers 1994), and differs markedly from the adjacent redwood coast region. Marine air moderates winter climate, but precipitation is limited by rainshadow effects from steep elevational gradients (100 to 2,400 m.) along a series of north-south trending mountain ridges. Due to the influence of the adjacent Central Valley, summer temperatures in the interior portions of this region are among the highest within the spotted owl's range. Forest communities tend to be relatively dry mixed conifer, blue and Oregon white oak, and the Douglas-fir-tanoak series. Spotted owl habitat within this region is poorly known; there are no DSAs and few studies have been conducted here. Spotted owl habitat data obtained during this project suggests that some spotted owls occupy steep canyons dominated by liveoak and Douglas-fir; the distribution of dense conifer habitats is limited to higher-elevations on the Mendocino National Forest.

**Figure 0-2**. Modeling regions used in development of relative habitat suitability models for the spotted owl.

# Modeling Regions

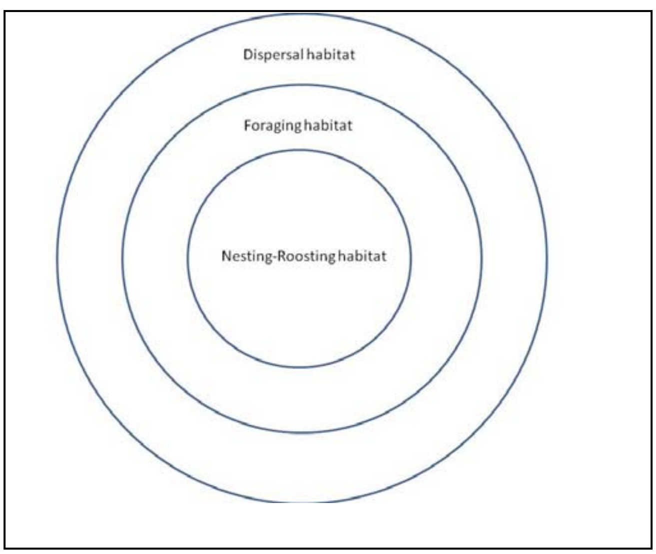
| CODE | Description |
|---|---|
| NCO | North Coast and Olympic |
| OCR | Oregon Coast |
| RDC | Redwood Coast |
| WCN | Western Cascades - North |
| WCC | Western Cascades - Central |
| WCS | Western Cascades - South |
| ECN | Eastern Cascades - North |
| ECS | Eastern Cascades - South |
| KLW | Klamath-Siskiyou - West |
| KLE | Klamath-Siskiyou - East |
| ICC | Interior California Coast |



## Habitat Modeling Process

Because spotted owl habitat use is influenced by factors occurring at different spatial scales, we developed habitat suitability models in two stages. In the first stage we used information from our literature review and experts to develop a series of alternative models of forest conditions corresponding to nesting-roosting habitat and foraging habitat within each modeling region. We used statistical modeling to test the effectiveness of these models and identify the forest structural models that best predicted the relative likelihood of a spotted owl territory being present. Spotted owl habitat is often subdivided into distinct components including: nesting habitat, roosting habitat, foraging habitat, and dispersal habitat. Habitats used for nesting and roosting are very similar, and so we combined them into nesting-roosting. Such areas are used for nesting, roosting, foraging, and dispersal by spotted owls, and are usually forests with more late-seral forest characteristics than "foraging" or "dispersal" habitat. Foraging habitat is thought to be largely used for foraging and other nocturnal activities, but also for dispersal (USFWS 1992; see Figure C3). Dispersal habitat is thought to largely have value for dispersal, to lack nest/roost sites and to provide few foraging opportunities. These categories are not absolutes, but instead represent generalizations (*e.g.*, one should not infer that spotted owls never roost in "foraging" habitat). That said, it is important to understand that

**Figure 0-3**. Venn diagram of relationships among spotted owl nesting-roosting, foraging, and dispersal habitats.




nesting-roosting habitat is generally considered to provide all or most habitat requirements, whereas foraging and dispersal habitats are considered to provide only a subset of the spotted owl's habitat requirements. For this effort, we attempted to accurately model the suitability of breeding habitat for spotted owls. Thus, we evaluated and modeled nesting-roosting and foraging habitat, but not dispersal habitat. While we recognized that dispersal plays an important role in population performance, we elected not to formally model dispersal habitat. This is because relatively little is known about habitat selection during dispersal and, more importantly, the likely influences of habitat conditions on dispersal success. The influence of habitat on dispersal and population performance is treated within the HexSim portion of the modeling framework (see Overview of HexSim Spotted Owl Scenario, page C-56).

**Spatial scale for developing and evaluating models:**

To determine the spatial scale at which to develop habitat models, the modeling team sought a uniform analysis area size that generally corresponded to large differences between use and availability. Spotted owls have been found to respond to habitats at a variety of spatial scales (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Franklin *et al*. 2000, Swindle *et al.* 1999, Thome *et al*. 1999, Zabel *et al*. 2003). Spotted owls do not build their own nests, but primarily utilize broken-top snags, tree cavities, dwarf mistletoe witch's brooms, or nests made by other species (Gutiérrez *et al.* 1995). Spotted owl habitat selection in the immediate vicinity of the nest (tens of meters around the nest tree) has been found to be strongly non-random, and largely associated with late-seral forest characteristics (Solis and Gutiérrez 1990, Meyer *et al.* 1998, Swindle *et al.* 1999). Areas at this small spatial scale are necessary, but often not sufficient to be selected by spotted owls because areas at larger spatial scales around the nest-site must contain attributes that also contribute to their survival and reproductive success (*e.g.*, Franklin *et al*. 2000, Olson *et al.* 2004, Dugger *et al.* 2005).
Ripple *et al.* (1991), Carey *et al.* (1992), Hunter *et al.* (1995), Thome *et al.* (1999), Meyer *et al.* (1998), and Zabel *et al.* (2003) all evaluated spotted owl habitat selection at a variety of spatial scales beyond the nest site itself. Spatial scales evaluated in these studies were based on the distribution of radio telemetry locations, presumed territorial behavior (nearest-neighbor distances), or various 'nested rings'. All studies found differences between spotted owl-centered (nest or activity center) locations and random or unoccupied locations across the range of spatial scales examined. However, the largest differences were often found in areas approximately the size of what Bingham and Noon (1997) defined as "core areas" (areas of the home range that received disproportionately more use than would be expected). An area of 158 to 200-ha has been used to describe/define spotted owl 'territory core areas', in western Oregon and the Klamath region (Hunter *et al.* 1995, Meyer *et al.* 1998, Franklin *et al*. 2000, Zabel *et al*. 2003, Olson *et al.* 2004, and Dugger *et al.* 2005). In northwestern Oregon, Glenn *et al.* (2005) found mean cumulative core areas to be 94 ha (SE = 14.9; n = 24). For the northern portion of the range we found little information directly comparable to the abovementioned studies, but estimated home range and core areas sizes and nearest-neighbor distances are larger in the extreme northern portion of the spotted owl's range (Forsman *et al*. 2005, Hamer *et al.* 2007, Davis and Dugger in press). Based on this review, we felt a 200-ha analysis area represented an area that is disproportionately used (more than expected) surrounding nest sites. We deal explicitly with geographic variation in home range size in HexSim (see below).

**Data Used for Model Development and Testing**

**Vegetation data – the GNN-LT Database:**

To develop rangewide models of relative habitat suitability for spotted owls, we required maps of forest composition and structure of sufficient accuracy to allow discrimination of attributes used for nesting, roosting and foraging by spotted owls. Past efforts to model, map and quantify habitat selection by spotted owls at regional scales have often suffered from lack of important vegetation variables, inadequate spatial coverage, and/or coarse resolution of available vegetation databases (Davis and Lint 2005). However, recent development of vegetation mapping products for the NWFP's Effectiveness Monitoring program (Hemstrom *et* *al*. 1998, Lint *et al.* 1999) provided detailed maps of forest composition and structural attributes for all lands within the NWFP area (coextensive with the range of the spotted owl). These maps were developed using Gradient Nearest Neighbor (GNN) imputation (Ohmann and Gregory 2002) and LandTrendr algorithms (Kennedy *et al.* 2007, 2010) and were available for two "bookend" dates (1996 and 2006 in Oregon and Washington, 1994 and 2007 in California). The GNN approach is a method for predictive vegetation mapping that uses direct gradient analysis and nearest-neighbor imputation to ascribe detailed attributes of vegetation to each pixel in a digital landscape map (Ohmann and Gregory 2002). Forest attributes from inventory plots (Forest Inventory and Analysis, Current Vegetation Surveys, etc.) are imputed to map pixels based on modeled relationships between plots and predictor variables from Landsat thematic mapper imagery, climatic variables, topographic variables, and soil parent materials. The assumption behind GNN methods is that two locations with similar combined spatial "signatures" should also have similar forest structure and composition. The GNN models were developed for habitat modeling regions used for the NWFP northern spotted owl effectiveness monitoring modeling (Davis and Dugger in press). For the NWFP Effectiveness Monitoring program, GNN maps were created for the two bookend time periods mentioned above to 'frame' their analysis period for habitat status and trends. This novel bookend mapping approach presents challenges associated with spectral differences due to different satellite image dates, which might produce false vegetation changes. To minimize the potential for this, the bookend models were based on Landsat imagery that was geometrically rectified and radiometrically normalized using the LandTrendr process (Kennedy *et al.* 2007, 2010).

The large list of forest species composition and structure variables provided by GNN vegetation maps constitute an improvement in vegetation data for modeling and evaluating spotted owl habitat. For our modeling, we selected from a set of 163 variables, including basal area and tree density by size class and species, canopy cover of conifers and/or hardwoods, stand height, age, mean diameter and quadratic mean diameter by dominance class, stand density index, and measures of snags and coarse woody debris. Additional variables pertaining to stand structural diversity and variability proved particularly useful for modeling spotted owl habitat.

The reliability or accuracy of vegetation databases poses a primary concern for wildlife habitat evaluation and modeling. The GNN maps come with a large suite of diagnostics detailing map quality and accuracy; these are contained in model region-specific accuracy assessment reports available at the LEMMA website (http://www.fsl.orst.edu/lemma/). For developing *a priori* models of spotted owl nesting/roosting habitat and foraging habitat, we generally selected GNN structural variables with plot correlation coefficients > 0.5 for an individual modeling region (42% were >0.7). On a few occasions when expert opinion or research results suggested a particular variable might be important, we used variables with plot correlations from 0.31 to 0.5 (Table C-1). For species composition variables, we attempted to use only variables with Kappas > 0.3. However, because we combined species variables into groups that expert opinion and research results suggested may represent influential community types, we occasionally accepted variables with Kappas > 0.2 and < 0.3 for individual variables within a group (Table C-2).

The GNN vegetation database was specifically developed for mid- to large-scale spatial analysis (Ohmann and Gregory 2002), suggesting that accuracies at the 30-m pixel scale may be less influential to results obtained at larger scales. Because we were interested in the utility of GNN at our analysis area (200 ha) spatial scale, we conducted less formal assessments where we compared the distribution of GNN variable values at a large sample of actual locations (known spotted owl nest sites and foraging sites) to published estimates of those variables at the same scale. In addition, we received comparisons of GNN maps to a number of local plot-based vegetation maps prepared by various field personnel. Based on these informal evaluations, we determined that GNN represents a dramatic improvement over past vegetation databases used for modeling and evaluating spotted owl habitat, and used the GNN-LandTrendr maps as the vegetation data for our habitat modeling.

**Table 0-1**. Pearson correlation coefficients for GNN structural variables used in modeling relative habitat suitability models for spotted owls.

| Variable | Modeling region | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ECN | ECS | ICC | KLE | KLW | NCO | ORC | RDC | WCC | WCN | WCS | AVG | STD |
| **BAA_75_100** | | | 0.42 | | | | | | | | | 0.49 | 0.09 |
| **BAA_GE_100** | | | 0.37 | | | | | | | | | 0.46 | 0.12 |
| **BAA_GE_3** | 0.75 | | | | | 0.71 | | | 0.71 | 0.71 | | 0.70 | 0.06 |
| **BAC_50_75** | | | | | | | | 0.46 | | | | 0.45 | 0.06 |
| **BAC_75_100** | | | | | | | | 0.31 | | | | 0.50 | 0.09 |
| **BAC_GE_100** | | | | | | | | 0.57 | | | | 0.47 | 0.12 |
| **BAC_GE_3** | | | | | 0.65 | | | | | | | 0.73 | 0.06 |
| **BAH_3_25** | | | 0.50 | | | | | | | | | 0.50 | 0.07 |
| **BAH_PROP** | | | | | 0.67 | | | | | | | 0.66 | 0.03 |
| **CANCOV** | 0.76 | 0.80 | 0.71 | 0.71 | 0.71 | | | 0.70 | 0.74 | 0.74 | 0.80 | 0.74 | 0.04 |
| **CANCOV_CON** | | | | 0.67 | | | 0.73 | | | | | 0.74 | 0.07 |
| **DDI** | 0.65 | 0.73 | 0.65 | 0.65 | 0.65 | 0.77 | 0.74 | | 0.77 | 0.77 | 0.73 | 0.69 | 0.08 |
| **QMDC_DOM** | 0.44 | 0.64 | 0.52 | 0.52 | 0.52 | | | | | | 0.64 | 0.59 | 0.11 |
| **TPH_50_75** | | | | 0.35 | | | 0.52 | | 0.44 | 0.44 | | 0.42 | 0.06 |
| **TPH_75_100** | | 0.52 | | 0.41 | | 0.56 | 0.58 | | 0.56 | 0.56 | 0.52 | 0.48 | 0.09 |
| **TPH_GE_100** | | 0.48 | | 0.45 | | 0.57 | 0.63 | | 0.57 | 0.57 | 0.48 | 0.49 | 0.10 |
| **TPHC_GE_100** | | | | | | | | | 0.57 | 0.57 | | 0.50 | 0.10 |

**Table 0-2**. Local scale accuracy assessments (kappa coefficients) for individual species variables within stand species composition variable groupings used in applicable modeling regions. N/A = variable not in best models for modeling region.

| | GNN DOM SPP | Common Name | East Cascades North | East Cascades South | Inner California Coast Ranges | Klamath East | Klamath West | North Coast Olympics | Oregon Coast | Redwood Coast | West Cascades Central | West Cascades North | West Cascades South | Average Kappa |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Evergreen hardwoods** | ARME | Pacific madrone | n/a | n/a | 0.43 | n/a | 0.43 | n/a | 0.49 | n/a | n/a | n/a | n/a | 0.45 |
| | LIDE3 | tanoak | n/a | n/a | 0.58 | n/a | 0.58 | n/a | 0.72 | n/a | n/a | n/a | n/a | 0.63 |
| | QUCH2 | canyon live oak | n/a | n/a | 0.35 | n/a | 0.35 | n/a | 0.46 | n/a | n/a | n/a | n/a | 0.39 |
| | UMCA | California laurel | n/a | n/a | 0.29 | n/a | 0.29 | n/a | 0.43 | n/a | n/a | n/a | n/a | 0.34 |
| **Northern Hardwoods** | ACMA3 | bigleaf maple | n/a | n/a | n/a | n/a | n/a | 0.41 | 0.30 | n/a | 0.41 | 0.41 | n/a | 0.38 |
| | ALRU2 | red alder | n/a | n/a | n/a | n/a | n/a | 0.44 | 0.33 | n/a | 0.44 | 0.44 | n/a | 0.41 |
| **Oak woodlands** | QUDO | blue oak | n/a | n/a | 0.68 | 0.68 | 0.68 | n/a | n/a | 0.41 | n/a | n/a | n/a | 0.62 |
| | QUGA4 | Oregon white oak | n/a | n/a | 0.35 | 0.35 | 0.35 | n/a | n/a | 0.34 | n/a | n/a | 0.52 | 0.38 |
| **Pines** | PICO | lodgepole pine | 0.26 | 0.57 | 0.28 | 0.28 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.35 |
| | PIJE | Jeffrey pine | n/a | 0.27 | 0.28 | 0.28 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.28 |
| | PIMU | Bishop pine | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | PIPO | ponderosa pine | 0.62 | 0.58 | 0.34 | 0.34 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.47 |
| **Douglas-fir** | PSME | Douglas-fir | 0.47 | 0.65 | n/a | 0.31 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.48 |
| **Subalpine** | ABAM | Pacific silver fir | 0.66 | 0.59 | n/a | n/a | n/a | 0.53 | n/a | n/a | 0.53 | 0.53 | 0.59 | 0.57 |
| | ABLA | subalpine fir | 0.58 | 0.39 | n/a | n/a | n/a | 0.48 | n/a | n/a | 0.48 | 0.48 | 0.39 | 0.47 |
| | ABMA | California red fir | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | ABPR | noble fir | 0.29 | n/a | n/a | n/a | n/a | 0.32 | n/a | n/a | 0.32 | 0.32 | n/a | 0.31 |
| | ABSH | Shasta red fir | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | |
| | CHNO | Alaska cedar | 0.29 | 0.19 | n/a | n/a | n/a | 0.28 | n/a | n/a | 0.28 | 0.28 | 0.19 | 0.25 |
| **Redwood** | SESE3 | redwood | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 0.59 | n/a | n/a | n/a | 0.59 |

## Spotted owl location data:

Spotted owl data used in model development consisted of site center locations documented within three years (plus or minus) of the date of the GNN vegetation data. Site centers are the location of spotted owl nests or daytime roosts containing paired spotted owls. Site center data for the habitat suitability modeling was made available through the cooperation of a variety of sources throughout the spotted owl's range. Data come from long-term demographic studies as well as locations from other research projects, public, private, and tribal sources.

Substantial effort was expended on verification of both the spatial accuracy and territory status of each site center in the data set. We specifically requested and received very high-quality data from spotted owl demography study areas (DSAs). For areas outside of DSAs, we obtained a large set of additional locations from NWFP Effectiveness Monitoring program (Davis and Dugger in press); the majority of these site centers had been evaluated for spatial accuracy. We also obtained and verified data sets from private timber companies, USFS Region 5 NRIS database and a number of research and monitoring projects across the species' range.

Because of the spatial extent of our analysis area (>23 million ha), we do not have the luxury of having equal survey effort throughout the region. Instead we have data from research studies, monitoring of demographic rates, management efforts, and other sources. While spotted owl demographic study areas have been intensively and extensively studied for long periods of time (see Anthony *et al.* 2006 and Forsman *et al.* 2011) and provide the highest- quality data sets, they comprise ~12% of the spotted owl's geographic range (based on our masked modeling regions). As importantly, for some modeling regions the proportion of total area and/or spotted owl locations within DSAs is very low. Given the DSAs represent nearly the only areas within the spotted owl's range that have consistently been surveyed over long periods of time and that they represent a smaller portion of the species' geographic range, the data from them (at the scale of a modeling region) is generally spatially aggregated. Spotted owl site location data from the DSAs represent a much smaller portion of the spotted owl's range than the full data set we used (Table C-3), and the larger data set represents more fully the spectrum or gradient of biotic and abiotic features that spotted owls select for nesting and roosting. For example, the total number of spotted owl site locations inside DSAs was 1,199, and when thinned by 3 km was 755. In contrast, the total number of site locations outside of DSAs was 2,591, and when thinned was 2,110. With our 200-ha analysis area, if we would have sampled from only the DSAs we would have sampled ~151,000 ha around thinned DSA sites versus the 573,000 ha sampled around all thinned sites.

**Table 0-3**. Comparison of area and spotted owl location data within modeling regions and demographic study areas (DSAs).

| Modeling Region | Acronym | Percentage of Region in DSA | Number of NSO Sites in DSA | Number of NSO Sites Outside DSA |
|---|---|---|---|---|
| ALL MODELING REGIONS | ALL | 12.34% | 1199 | 2591 |
| North Coast Olympics | NCO | 7.29% | 166 | 79 |
| Oregon Coast | ORC | 30.88% | 352 | 102 |
| East Cascades South | ECS | 20.49% | 78 | 45 |
| East Cascades North | ECN | 23.45% | 132 | 84 |
| West Cascades North | WCN | 0.92% | 3 | 77 |
| West Cascades Central | WCC | 19.21% | 57 | 157 |
| West Cascades South | WCS | 6.58% | 57 | 435 |
| Klamath East | KLE | 10.31% | 98 | 374 |
| Klamath West | KLW | 15.24% | 127 | 335 |
| Inner California Coast Ranges | ICC | 0.75% | 8 | 300 |
| Redwood Coast | RDC | 10.23% | 121 | 603 |

Outside of DSAs, the quantity and density of site center data varies widely. While we have attempted to compile a large sample of site centers that is broadly representative of the entire distribution of spotted owls, the overall distribution of sample sites is somewhat clumped. Areas with few nest locations are a result of: 1) few surveys being conducted, 2) the absence of spotted owls, or 3) data being unavailable. We did not want the modeling results to be a function of the intensity of spotted owl sampling throughout the region, but to be as close of an approximation as possible of spotted owl-habitat relationships. Phillips *et al*. (2009) noted that spatially biased survey data present major challenges to distributional modeling by over-weighting areas where intensive sampling has occurred. Therefore, within each modeling region we “thinned” the spotted owl nest locations such that the minimum distance between nest locations would be 3.0 km (thinning with a 3 km distance resulted in removing ~25% of the locations available to us). Carroll *et al.* (2010) used a similar approach in their modeling of other species whereby clusters of records were identified and one record from the cluster was randomly selected from the set. Using a 3 km thinning distance retained 75% of the total data, and did not have a large effect on those modeling regions with small initial sample sizes (<100) of site center locations (Table C4).

**Table 0-4**. Sample size of spotted owl site center locations (1993-1999) by modeling region and the impact of various thinning distances (minimum allowable distance between site centers) on sample size.

| | | Thinning Distance | | | | | |
|---|---|---|---|---|---|---|---|
| Modeling Region | Total Sites | 1 km | 1.5 km | 2 km | 2.5 km | 3 km | 4 KM |
| **NCO** | 241 | 236 | 229 | 221 | 209 | 196 | 162 |
| **OCR** | 454 | 430 | 414 | 371 | 325 | 281 | 202 |
| **RDC** | 724 | 716 | 670 | 547 | 461 | 392 | 284 |
| **WCN** | 80 | 80 | 79 | 78 | 77 | 77 | 74 |
| **WCC** | 214 | 211 | 205 | 195 | 182 | 173 | 144 |
| **WCS** | 489 | 489 | 487 | 482 | 477 | 470 | 342 |
| **ECN** | 216 | 215 | 209 | 203 | 195 | 184 | 155 |
| **ECS** | 123 | 122 | 119 | 112 | 104 | 93 | 67 |
| **KLW** | 462 | 460 | 454 | 440 | 414 | 358 | 275 |
| **KLE** | 472 | 468 | 463 | 455 | 434 | 381 | 285 |
| **ICC** | 308 | 308 | 307 | 300 | 286 | 253 | 199 |
| **Total** | **3783** | **3735** | **3636** | **3404** | **3164** | **2858** | **2189** |
| **Percentage of total** | **100** | **98.7** | **96.1** | **90.0** | **83.6** | **75.5** | **57.9** |

Due to the increased influence of the barred owl on spotted owls, we followed, in part, the modeling approach used by Davis and Dugger *(*in press) to reduce the influence of barred owls on apparent habitat associations of spotted owls. For our effort, we wanted our models to identify areas with more or less nesting suitability for spotted owls. Because barred owls have apparently displaced many spotted owls from previously-occupied nesting areas, sometimes into habitat types/conditions that spotted owls only rarely used prior to the barred owl's invasion (Gremel 2005, Gutiérrez *et al.* 2007), we did not want to evaluate their "displaced habitat use", but instead their use of habitat without the larger, current impact of barred owls. Although barred owls were known to be widely distributed in the northern portion of the spotted owl's range in 1996, Gremel (pers. comm. 2010) suggested barred owl densities were substantially lower in 1996 than in 2006. Pearson and Livezey (2003) reported that barred owls had increased by an average of 8.6% per year between 1982 and 2000 on parts of the Gifford Pinchot National Forest (GPNF), Washington. Subsequently, Livezey *et al.* (2007) reported that the 98 known barred owl sites on the GPNF in 2001 had increased to 143 sites in 2006. Thus, in an attempt to reduce the influence of barred owls on spotted owl habitat use, we developed and tested models using GNN vegetation data from 1996 (assumed to be the period with lower barred owl influence) along with spotted owl location information plus or minus three years from 1996. Those models were then projected to the most current (2006) GNN layer to predict contemporary relative habitat suitability (RHS). Each region's model was then tested by comparing with RHS values at independent sites from the 2006 spotted owl locations (only those that did not overlap with the 1996 locations).

## Developing Habitat Definitions:

### <u>Nesting and roosting habitat</u>

Prior to developing models, we attempted to synthesize both the literature and information from experts. From the literature, we emphasized studies evaluating habitat selection over those that described habitat features (associations) around spotted owl locations, but did not evaluate selection. This synthesis resulted in the development of a series of definitions of spotted owl nesting-roosting and foraging habitat. For example, several published studies concluded that nesting spotted owls strongly select for areas with canopy cover >70% and many large trees nearby and strongly select against areas with lower amounts of canopy cover and few or no large trees nearby. We therefore created definition "$NR_1$" (nesting-roosting definition number 1) based on canopy cover and density of large trees (*e.g.*, trees >75 cm dbh). Because experts and/or other published studies typically supported several (i) alternative NR definitions, we created roughly ten alternative NR habitat definitions ($NR_2$, $NR_3$, $NR_{i,}$ etc.) per modeling region. We used an identical process to develop a series of foraging (F) habitat definitions for each modeling region (Tables C5 and C6 provide an example of this process). It is important to recognize that these habitat definitions are binary for each pixel; either the pixel contained each of the features in the definition (and was therefore considered habitat), or it did not (it was considered non-habitat).

**Table 0-5**. Spotted owl nesting-roosting habitat variables for the northern Coast Ranges and Olympic Peninsula.

| Habitat characteristics from expert panel, literature | GNN Variable expression |
|---|---|
| Canopy cover of conifers is ≥ than 80% | CANCOV_CON_GE_80 |
| Mean stand diameter is ≥ than 50cm | MNDBHBA_CON_GE_50 |
| Structure should include ≥ 70 medium trees/ha | TPH_GE_50_GE_70 |
| Structure should include ≥ 20 larger trees/ha | TPH_GE_75_GE_20 |
| Very large remnant trees are important (≥5/ha) | TPH_GE_100_GE_5 |
| Canopy layering/diversity is important | DDI_GE_6 * |

*DDI = Diameter Diversity Index (ranges from 1-10)

**Table 0-6**. Sample definitions of spotted owl nesting-roosting habitat based on variables and values from Table 5.

| | Candidate nesting/roosting habitat definitions |
|---|---|
| $NR_1$ | CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + DDI_GE6 |
| $NR_2$ | CANCOV_CON_GE_80 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6 |
| $NR_3$ | CANCOV_CON_GE_80 + TPH_GE_50_GE_70 + TPH_GE_75_GE_20 + TPH_GE_100_GE_5 + DDI_GE_6 |
| $NR_4$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_50 + TPH_GE_75_GE_20 + DDI_GE_5 |

## Foraging habitat

Foraging habitat definitions were informed by published and unpublished literature and input from experts. In this process, foraging habitat was, by definition, different than nesting-roosting habitat. This is not to suggest that spotted owls do not forage in nesting-roosting habitat, but for the sake of being explicit in this process, foraging habitat was distinct from nesting-roosting habitat. In general, foraging habitat definitions had lower thresholds of canopy cover, tree size, and canopy layering than nesting-roosting definitions (Tables C7 and C8 provide an example of this process).

**Table 0-7**. Spotted owl foraging habitat variables for the northern Coast Ranges and Olympic Peninsula.

| Habitat characteristics from expert panel, literature | GNN Variable expression |
|---|---|
| Canopy cover of conifers is ≥ than 70% | CANCOV_CON_GE_70 |
| Mean stand diameter is ≥ than 40 cm | MNDBHBA_CON_GE_40 |
| Structure should include ≥ 50 medium trees/ha | TPH_GE_50_GE_50 |
| Structure should include ≥ 8 larger trees/ha | TPH_GE_75_GE_8 |
| Canopy layering/diversity is important | DDI_GE_4 * |

*DDI = Diameter Diversity Index (ranges from 1-10)

**Table 0-8**. Sample definitions of spotted owl foraging habitat based on variables and values from Table C7.

| | **Candidate nesting/roosting habitat definitions** |
|---|---|
| $F_1$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + DDI_GE_4 |
| $F_2$ | CANCOV_CON_GE_70 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_6 |
| $F_3$ | CANCOV_CON_GE_70 + TPH_GE_50_GE_50 + TPH_GE_75_GE_8 + DDI_GE_4 |
| $F_4$ | CANCOV_CON_GE_60 + MNDBHBA_CON_GE_40 + TPH_GE_75_GE_8 + DDI_GE_4 |

Because attributes of habitat such as amount of edge and core area have been shown to influence both habitat selection and fitness (Franklin *et al.* 2000) of spotted owls, we also included NR "core" and "edge" metrics.

## Abiotic variables

Because published literature and information from experts suggested that abiotic features might be important in determining spotted owl habitat use and selection, we evaluated a series of abiotic features known or suspected to influence spotted owl habitat selection and use (Table C9). Numerous studies have shown that local geographic features such as slope position, aspect, distance to water, and elevation have been found to influence spotted owl site selection (Stalberg *et al.* 2009, Clark 2007). Several authors (Blakesley *et al.* 1992, Hershey *et al.* 1998, LaHaye and Gutiérrez 1999) have noted the absence of spotted owls above particular elevational limits (whether this limit is due to forest structure, prey, competitors, parasites, diseases, and/or extremes of temperature or precipitation is not known). At broader scales, temporal variation in climate has been shown to be related to fitness (Franklin *et al.* 2000, Olson *et al.* 2004, Dugger *et al.* 2005, Glenn *et al.* 2010), suggesting that spatial variation in climate may also influence habitat suitability for spotted owls. Ganey *et al.* (1993) found that Mexican spotted owls (*S. o. lucida*) have a narrow thermal neutral zone and others (*e.g.*, Franklin *et al*. 2000) have assumed the northern spotted owl to be similar in this regard. Furthermore, the spotted owl's selection for areas with older-forest characteristics has been hypothesized to, in part, be related to its needing cooler areas in summer to avoid heat stress (Barrows and Barrows 1978). Temperature extremes (winter low and summer high) as well as potential breeding-season specific stressors (spring low temperature and high spring precipitation) are also considered potentially useful predictor variables for our purposes (Carroll 2010, Glenn *et al.* 2010). By including climate variables as candidate variables in our habitat suitability modeling, we evaluated whether climate effects on spotted owl fitness are translated into patterns of the species' distribution.

## Developing models:

MaxEnt compares the characteristics (variables included in the models) of the training data sites to a random selection of ~10,000 random "background" (available) locations. We only used the linear, quadratic, and threshold features within MaxEnt (*i.e.*, hinge and product features were not used).

**We used the following model-building and evaluation process within each modeling region**

1) Each nesting-roosting habitat definition is a single-variable model. Thus, if we developed 10 nesting-roosting habitat definitions for a region, we compared 10 nesting-roosting habitat models for that region. We used MaxEnt to determine the best nesting-roosting habitat definition within each region (see model evaluation, below).

2) Within each modeling region that has foraging habitat definitions, we combined the best nesting-roosting habitat definition(s) with each foraging habitat definition to evaluate whether the addition of foraging habitat improved model performance. Models were considered to have been improved if the addition of foraging habitat increases the ranking of the model. If the addition of foraging habitat improved the model's performance, we used the nesting-roosting + foraging habitat model for step 3 (below). If not, we used the best nesting-roosting model(s) for step 3.

3) For abiotic variables, we developed univariate or multivariate models using the variables in Table C9. Carroll (2010) found that mean January precipitation, mean July precipitation, mean January temperature, and mean July temperature were the variables in the best, of 30, climate models he evaluated. He found the two precipitation metrics were the most influential of the four. Franklin *et al.* (2000) also found climate variables to influence spotted owl survival and reproduction. We included three climate models: 1) the four variables Carroll (2010) reported, 2) mean January precipitation and mean July precipitation, 3) mean January precipitation and mean January temperature. We "challenged" the best model(s) after step 2 by adding each abiotic model to it (*sensu* Dunk *et al.* 2004), in an attempt to improve its predictive ability. The abiotic models were not compared to each other, but were compared in order to see if their addition to the best biotic (nesting-roosting or nesting-roosting + foraging) model resulted in an improved model (see step 2). If the biotic plus abiotic model was an improvement over the biotic-only model, we used the combination model, otherwise we used the biotic-only model. The reason abiotic-only models were not evaluated is that it is illogical to suggest that spotted owls (a species that nests in trees) might only respond to abiotic factors when selecting nesting areas. In contrast, we could develop a logical biological argument that spotted owls might respond only to biotic features when selecting nesting areas. We could also

develop logical biological arguments articulating how a combination of biotic and abiotic factors might influence the selection of nesting areas.

## Model-building hierarchy

The spatial distribution of spotted owl territories is influenced by a wide variety of environmental gradients operating at different spatial scales. At the smallest scale we evaluated, features such as the amount of nesting-roosting and/or foraging habitat within a core area, the amount of edge between spotted owl habitat and non-habitat, or amount of "core habitat" (*sensu* Franklin *et al*. 2000) have all be shown to influence spotted owl distribution, abundance, or fitness. Each of those variables, however, is a structural variable. That is, they are based on habitats comprised of various structural elements (*e.g.*, large trees, high canopy cover). However important and influential these variables are to spotted owls, other variables such as plant species composition (broadly speaking), topographic position, climate, and/or elevation are also likely to influence their distribution, abundance, and perhaps fitness (Franklin *et al.* 2000, Olson *et al*. 2004, Dugger *et al.* 2005, Glenn 2009).

In part, the partitioning of the spotted owl's geographic range into 11 modeling regions should act to reduce the influence of broad patterns in plant species composition, climate and/or elevation on the species. Nonetheless, we were interested in evaluating whether habitat suitability is influenced by local variation in these non-structural variables.

Stand structure and the spatial arrangement of forest patches have been found to influence spotted owl fitness (Franklin *et al*. 2000, Olson *et al*. 2004, Dugger *et al*. 2005). Edge between nesting-roosting habitat and other habitat types is thought to afford foraging spotted owl opportunities when habitats, but which are rarely used, are juxtaposed closely with habitats spotted owls use. "Core" habitat includes those areas of spotted owl nesting habitat not subjected to edge-effects. Franklin *et al*. (2000) estimated core habitat by buffering all spotted owl habitat (largely mature forest areas) by 100 m and estimating the size of the habitat excluding the 100 m buffer.

Spotted owl experts noted that mid-scale or landscape level patterns such as tree species composition and topography may also influence the local distribution and density of spotted owls. For example, within many of the modeling regions, there exists variation in tree species composition, but forests with different species compositions may still have similar structural attributes (*e.g.*, high canopy cover, multi-storied, large trees). Some forest types (regardless of their structural attributes) are rarely, if ever, used by spotted owls, so we attempted to account for this variation by evaluating models that include some compositional variables. Many of our 11 modeling regions contain high-elevation areas above the elevational extremes normally used by spotted owls. In some higher elevation areas there exist structurally complex, multi-storied forests with large trees – areas with similar structural characteristics to those used by spotted owls. However, spotted owls rarely if ever use such areas. Our intention was to attempt to account for this in our modeling.

We recognize the hierarchical nature of these environmental factors and their possible influence on spotted owl distribution. Our model building approach took this into consideration, by starting at the smallest scale and sequentially "challenging" models with variables from larger spatial scales. In order to focus on environmental features most directly linked to territory location, habitat selection, and individual fitness of spotted owls, we employed a bottom-up approach to building models (Table C9).

**Table 0-9**. Categories of candidate variables, variable names, and order of the entry of variables into modeling process.

| Category | Variable | Order |
|---|---|---|
| Best climate/elevation model | Mean July Precipitation | |
| | Mean July Temperature | |
| | Mean July Precipitation | |
| | Mean July Temperature | |
| | Mean Elevation | |
| | | |
| Topographic position | Curvature | |
| | Insolation | |
| | Slope Position | |
| | | |
| Compositional variables (percent of basal area) | Redwood | |
| | Oak Woodland | |
| | Pine-dominated | |
| | Northern Deciduous Hardwoods | |
| | Evergreen Hardwoods | |
| | Douglas-fir | |
| | Subalpine forest | |
| | | |
| Habitat pattern | Core of NR habitat | |
| | Edge of NR habitat | |
| | | |
| Habitat structure | Foraging Habitat Amount | |
| | Nesting/Roosting Habitat | |

## Goals of MaxEnt Modeling:

Our goals for the relative habitat suitability models were to find models that: 1) had good discriminatory ability, 2) were well calibrated, 3) were robust, and 4) had good generality. We sought models that were not over-fit, the consequences of which would be to have models that fit the developmental data very closely, but which would not have worked well on data that were not used in their development. That is we sought models with good generality (*i.e.*, models that worked well in the modeling regions in general, not simply at classifying the developmental/training data). MaxEnt attempts to balance model fit and complexity through the use of regularization (see Elith *et al.* 2011). Elith *et al.* (2011) noted that MaxEnt fits a penalized maximum likelihood model, closely related to other penalties for complexity such as Akaike's Information Criterion (AIC, Akaike 1974). In order to evaluate whether any model region's model was over-fit we conducted rigorous cross-validation on each model (see below), and, when available we evaluated how well models classified independent data (see below).

## Model discrimination

Once the best model was found for each region, we conducted a cross-validation of each model to evaluate how robust the model was. Each of 10 times we removed a random subset of 25% of the spotted owl locations, developed the model with the remaining 75% and classified using the withheld 25%. The area under the receiver operating characteristic curve (AUC) was evaluated for both training and test data within each region. AUC is a measure of a model's discrimination ability; in our case discrimination between spotted owl-presence locations and available locations (not discrimination of presence versus absence locations). AUC values, theoretically, range between 0 and 1.0, with values less than 0.5 having worse discriminatory ability than expected by chance, values closer to 0.5 suggesting no to poor discriminatory ability, and values closer to 1.0 suggesting excellent discriminatory ability.

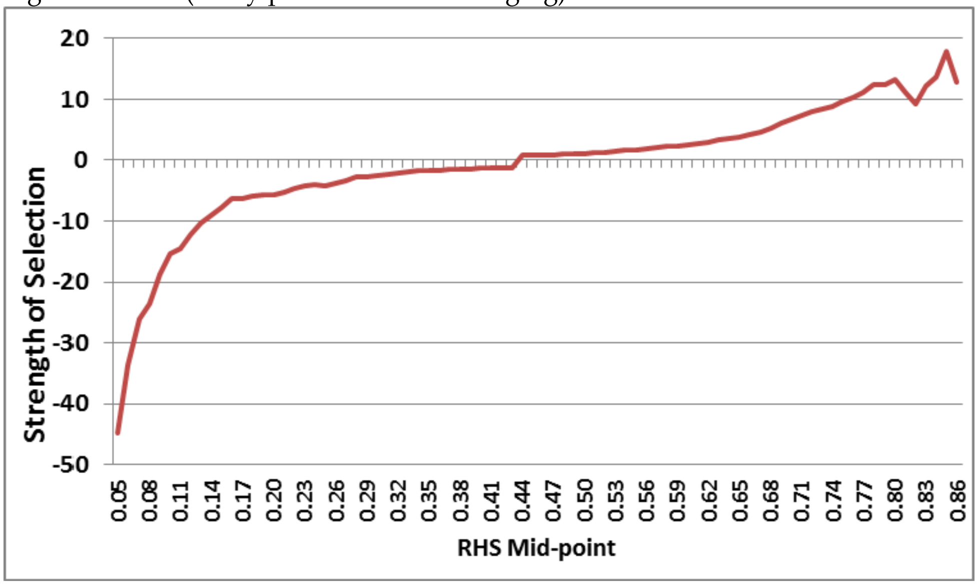
For these analyses, AUC values essentially describe the proportion of times one could expect a random selection of an actual spotted owl nest site location to have a larger relative habitat suitability value than a random selection from available locations. It is therefore a threshold-independent measure of model discriminatory ability. Because our evaluation represents use versus availability and not use versus non-use, AUC values have an upper limit somewhat less than 1.0 (because some of the available locations are actually used by spotted owls). Even for good (well-discriminating) models, AUC values should be lower in areas where the background areas contain larger amounts of suitable habitat. Two contrasting examples are provided to make this point: 1) a model estimating a riparian-dependent bird species' distribution in the Great Basin may have a very high AUC value because there is large contrast between riparian vegetation where the bird nests and the vast majority of background locations in sage-steppe, vs. 2) a model estimating the distribution of a generalist omnivore (like a black-bear) in a national forest may have a lower AUC because so much of the background habitat is suitable for the species. The point is that AUC is a measure of discrimination, but that a use-versus-availability model's ability to discriminate is a function of both the animal's habitat specificity and the abundance of the animal's habitat in the region of interest. To evaluate the degree to which AUC values from each modeling region's MaxEnt model were related to the abundance of suitable habitat we regressed AUC values against the proportion of each modeling region comprised of RHS values >30, >40, and >50 (the SOS values for all modeling regions showed selection for areas within this range – see Figure C-5 below). If the abundance of suitable habitat is high in areas with lower AUC values, and lower in areas with higher AUC values, the interpretation would be that the abundance of suitable habitat, not model discrimination ability, best explains this relationship.

In order to evaluate the degree to which AUC values were a function of the amount of suitable habitat in modeling regions, and thus help us interpret whether somewhat lower AUC values represented poor models versus a larger amount of suitable habitat in the modeling region, we evaluated the correlation between AUC values and the percentage of each modeling region with RHS scores above various thresholds corresponding to RHS values showing higher use than expected (see Model Calibration section below).

## Model Calibration

To assess model calibration we evaluated the agreement between RHS and observed proportions of sites occupied. Phillips and Elith (2010) noted that model discrimination and model calibration are independent measures. Model calibration refers to the agreement between predicted probabilities of occurrence (habitat suitability for our study) and observed proportions of sites occupied (Pearce and Ferrier 2000, Phillips and Elith 2010). Phillips and Elith (2010) note that model discrimination and model calibration are independent measures. Hirzel *et al.* (2006) (whose work Phillips and Elith [2010] expand upon), developed "strength of selection" metrics for species distribution models using a moving-window approach. Strength of selection (SOS) evaluations allow for an understanding of the use that areas with various habitat suitability values receive (by nesting spotted owls in our case) relative to the abundance of such areas in the study area (see Figure C4 below). Essentially, a well-calibrated model will show the species to use higher suitability areas disproportionately more and lower suitability areas disproportionately less. The shape of the relationship provides insights into the degree to which the species avoids or is attracted to areas with particular habitat suitability values.

**Figure 0-4**. This *example* of the strength of selection (SOS) evaluation shows a well-calibrated model. Areas with a mid-point RHS (*i.e.*, relative habitat suitability value) of 0.05 (the moving window size here was 0.1) were used ~45-times *less* than would be expected based on its extent in the study area. Similarly, areas with a mid-point RHS of 0.8 (window of 0.75-0.85) were used ~12-times *more* than expected based on its extent in the study area. This figure was developed from a model trained on >3,000 spotted owl night locations (many presumed to be foraging).




## Habitat Modeling Results:

The following section provides summary descriptions of the final "best" models for each modeling region; including information on the relative contribution of each covariate to the model, model evaluation metrics, and the results of validation against independent data sets conducted to date. Because the primary objective of this habitat modeling step was to provide accurate prediction of relative habitat suitability and subsequent likelihood of spotted owl occupancy, we focus on presenting evaluation of model performance, rather than description of spotted owl habitat associations. Tables and table series C10 to C17 provide descriptions of the best nesting-roosting habitat model, foraging habitat model, and full model for each modeling region, as well as model evaluation metrics (AUC and Gain) and the relative contribution of each variable to the full model (a heuristic estimate provided in the standard output from MaxEnt). AUC values were highly correlated with the percentage of each modeling region comprised of RHS values >30, >40, and >50 ($r^2$ = 0.9685, 0.9649, 0.9574, respectively). Hence, variation in AUC values among modeling regions (which ranged from 0.76 – 0.93) has less to do with model discrimination ability (*i.e.*, the quality of the model) and more to do with the quantity of suitably habitat in each modeling region.
See Table C18 for codes and descriptions of variables used in the models.

**Table Series 0-10**. Highest-ranking (best) Nesting/Roosting habitat (NR), foraging habitat (F), and full models for coastal Washington, Oregon and California modeling regions.

### North Coast and Olympics Modeling Region (N= 196 training sites):

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR06** | DDI (≥6) + TPH ≥ (>25/ha) + BAA GE3 (≥ 55 $m^2$/ha) | 0.8365 | 0.7667 |
| **F04** | MNDBHBA_CON (≥40); TPH_GE75 (≥10) | 0.8619 | 0.8817 |
| **Full Model** | NR06 + NR06EDGE + F04 + SLOPE POSITION+ ELEVATION + CURVATURE + SUBALPINE FOREST+JULY MAX TEMP+JANUARY PRECIP + JULY PRECP + INSOLATION + JANUARY MIN TEMP + NORTHERN HARDWOODS | 0.8989 | 1.057 |

### Oregon Coast Ranges Modeling Region (N = 281training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR08** | CANCOV_CON (≥55) + DDI (≥6) + TPH_GE75 (≥20) | 0.7683 | 0.4498 |
| **F04** | DDI (≥4) + TPH_GE50 (≥30) | 0.7787 | 0.467 |
| **Full Model** | NR08 + NR08 EDGE + SLOPE POSITION + JULY MAX TEMP + JANUARY MIN TEMP + F04 + CURVATURE + INSOLATION + JULY PRECIP + JANUARY PRECIP + ELEVATION + NR08 CORE + NORTHERN HARDWOODS + EVERGREEN HARDWOODS | 0.864 | 0.811 |

### Redwood Coast Modeling Region (N = 389 training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR03** | CANCOV (≥70) + MNDBHBA_CON (≥44) | 0.5928 | 0.0509 |
| **F05** | CANCOV (≥65) + BAC_GE50 (≥3) | 0.6256 | 0.0785 |
| **Full Model** | SLOPE POSITION + CURVATURE + NR03 EDGE + F05 + NR03 + REDWOOD + ELEVATION + JANUARY PRECIP + OAK WOODLAND + JULY MAX TEMP + INSOLATION + JANUARY MIN TEMP + NR03 CORE + JULY PRECIP | 0.760 | 0.335 |

**Table 0-11**. Individual covariates and their contribution to full model.

| North Coast / Olympics | | Oregon Coast Ranges | | Redwood Coast | |
|---|---|---|---|---|---|
| **Full Model** | **%** | **Full Model** | **%** | **Full Model** | **%** |
| NR 06 | 42.4 | NR 08 | 29.4 | Slope Position | 48.2 |
| NR06Edge | 21.5 | NR08 Edge | 24.2 | Curvature | 11.2 |
| NR06+F04 | 20.1 | Slope position | 11.9 | NR03 Edge | 10.3 |
| Slope position | 6.0 | July Max Temp | 10.1 | NR03 + F05 | 6.1 |
| Elevation | 3.6 | Jan Min Temp | 8 | NR 03 | 5.7 |
| Curvature | 1.8 | NR08 + F04 | 5.5 | Redwood (%BA) | 4.8 |
| Subalpine | 1.1 | Curvature | 4.1 | Elevation | 4.1 |
| July Max Temp. | 0.9 | Insolation | 3.1 | January Precip | 3.2 |
| Jan Precip. | 0.9 | July Precip | 1.5 | Oak Woodland | 2.6 |
| July Precip. | 0.8 | Jan Precip | 1.3 | July Max Temp | 1.3 |
| Insolation | 0.6 | Elevation | 0.4 | Insolation | 0.9 |
| Jan Min Temp | 0.3 | NR08 Core | 0.2 | Jan Min Temp | 0.7 |
| Northern Hdwd | 0.1 | Northern Hdwd | 0.2 | NR03 Core | 0.7 |
| | | Evergreen Hdwd | 0.1 | July precip | 0.4 |

**Table Series 0-12**. Nesting/Roosting habitat, foraging habitat, and full models for Western Cascades modeling regions.

### Western Cascades Modeling Region (Northern Section) (N = 76 training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR05** | CANCOV (≥80) + MNDBHBA_CON (≥60) + TPHC_GE100 (≥7) | 0.8377 | 0.7555 |
| **F01** | CANCOV (≥70); DDI (≥5); TPH_GE50 (≥42); BAA_GE3 (≥40) | 0.8417 | 0.7698 |
| **Full Model** | NR05 EDGE + NR05 + SLOPE POSITION + CURVATURE + ELEVATION + JANUARY PRECIP + NORTHERN HARDWOODS + JULY MAX TEMP + SUBALPINE FOREST + INSOLATION + JULY PRECIP + F01 + JANUARY MIN TEMP + NR05 CORE | 0.931 | 1.393 |

### Western Cascades Modeling Region (Central Section) (N = 171 training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR09** | TPH_GE50 (≥ 64) + TPH_GE75 (≥ 16) + TPHC_GE100 (≥ 4) | 0.7965 | 0.5825 |
| **F01** | CANCOV (≥70) + DDI (≥4) + TPH_GE50 (≥37) + BAA_GE3 (≥ 37) | 0.816 | 0.6575 |

| | | | |
|---|---|---|---|
| **Full Model** | NR09 EDGE + F01 + CURVATURE + ELEVATION + NORTHERN HARDWOODS + SUBALPINE + SLOPE POSITION + JANUARY MIN TEMP + NR09 + JULY PRECIP + JULY MAX TEMP + INSOLATION + NR09 CORE + JANUARY PRECIP | 0.892 | 1.024 |

**Western Cascades Modeling Region (Southern Section) (N = 470 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR02** | CANCOV (≥ 70) + MNDBHBA_CON (≥ 50) + TPH_GE75 (≥ 22) | **0.6877** | **0.2343** |
| **F01** | CANCOV (≥ 60) + DDI (≥ 4) + QMDC_DOM (≥ 37) | **0.6931** | **0.2385** |
| **Full Model** | NR02 + SLOPE POSITION + CURVATURE + F01 + JANUARY MIN TEMP + NORTHERN HARDWOODS + INSOLATION + JULY PRECIP + JANUARY PRECIP + JULY MAX TEMP + ELEVATION | **0.762** | **0.355** |

**Table 0-13**. Individual covariates and their contribution to full model.

| **Western Cascades North** | | **Western Cascades Mid** | | **Western Cascades South** | |
|---|---|---|---|---|---|
| **Full Model** | **%** | **Full Model** | **%** | **Full Model** | **%** |
| NR05 Edge | 34.4 | NR09 Edge | 44.8 | NR 02 | 62.9 |
| NR 05 | 17.2 | NR09 + F01 | 13.9 | Slope Position | 17.8 |
| Slope Position | 13.0 | Curvature | 8.5 | Curvature | 4.7 |
| Curvature | 12.6 | Elevation | 7.6 | NR02 + F01 | 3.9 |
| Elevation | 8.0 | Northern Hdwd | 7.4 | Jan Min Temp | 3.9 |
| Jan Precip | 4.3 | Subalpine | 4.2 | Northern Hdwd | 1.9 |
| Northern Hdwd | 3.7 | Slope Position | 4.1 | Insolation | 1.5 |
| July Max Temp | 2.2 | Jan Min Temp | 2.4 | July Precip | 1.5 |
| Subalpine | 1.4 | NR 09 | 1.8 | January Precip | 0.9 |
| Insolation | 0.9 | July Precip | 1.5 | July Max Temp | 0.5 |
| July Precip | 0.9 | July Max Temp | 1.4 | Elevation | 0.5 |
| NR05 + F01 | 0.8 | Insolation | 1.0 | | |
| Jan Min Temp | 0.5 | NR09 Core | 0.7 | | |
| NR05 Core | 0.2 | Jan Precip | 0.7 | | |
| NR05 Edge | 34.4 | | | | |

**Table Series 0-14**: Nesting/Roosting habitat, foraging habitat, and full models for Eastern Cascades modeling regions.

**Eastern Cascades Modeling Region (Northern Section) (n = 182 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR06** | CANCOV (≥ 70) + DDI (≥ 5) + MNDBHBA_CON (≥ 42) | 0.685 | 0.2263 |
| **F03** | CANCOV (≥52) + QMDC_DOM (≥30) + BAA_GE3 (≥23) | 0.7347 | 0.3114 |
| **Full Model** | NR06 + SLOPE POSITION + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + F03 + NR06 | 0.879 | 0.843 |

| | | | |
|---|---|---|---|
| | EDGE + JULY MAX TEMP + SUBALPINE FOREST + JANUARY PRECIP + CURVATURE + INSOLATION + JULY PRECIP + PINE | | |

### Eastern Cascades Modeling Region (Southern Section) (N = training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR07** | CANCOV (≥ 70) + MNDBHBA_CON (≥ 45) + TPH_GE75 (≥ 9) | 0.7263 | 0.2912 |
| **F03** | MNDBHBA_CON(≥ 38) + DDI(≥ 4) + QMDC_DOM(≥ 32) | 0.7868 | 0.4797 |
| **Full Model** | (F03 + NR07) + NR07 + NR07 EDGE + PINE + DOUGLAS-FIR + JANUARY MIN TEMP + ELEVATION + SLOPE POSITION + NR07 CORE + JULY MAX TEMP + INSOLATION + JANUARY PRECIP + CURVATURE + SUBALPINE FOREST + JULY PRECIP | 0.889 | 0.957 |

**Table 0-15**. Individual covariates and their contribution to full model.

| **Eastern Cascades South** | | **Eastern Cascades North** | |
|---|---|---|---|
| **Full Model** | % | **Full Model** | % |
| NR07 + F03 | 18.4 | NR06 | 20 |
| NR 07 | 13.9 | Slope Position | 14.6 |
| NR07 Edge | 11.7 | Douglas-fir | 13.6 |
| Pine | 10.7 | Jan Min Temp | 10.6 |
| Douglas-fir | 10.7 | Elevation | 8.3 |
| Jan Min Temp | 9.5 | NR06 + F03 | 6.8 |
| Elevation | 5.4 | NR06 Edge | 5.7 |
| Slope Position | 4.6 | July Max Temp | 4.1 |
| NR07 Core | 4.5 | Subalpine | 4.0 |
| July Max Temp | 3.3 | January Precip | 3.3 |
| Insolation | 3.2 | Curvature | 2.9 |
| January Precip | 1.6 | Insolation | 2.7 |
| Curvature | 1.5 | July Precip | 2.1 |
| Subalpine | 0.6 | Pine | 1.5 |
| July Precip | 0.4 | | |

**Table Series 0-16**. Nesting/Roosting habitat, foraging habitat, and full models for Klamath-Siskiyou Mountains and Interior California modeling regions.

### Western Klamath Mountains (N = 357 training sites)

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR01** | CANCOV (≥75) + DDI (≥6) + QMDC_DOM (≥50) | 0.6608 | 0.1677 |
| **F03** | DDI (≥4) + BAH_PROP (0.25 - 0.70) + BAC_GE3 (≥18) | 0.6751 | 0.1886 |
| **Full Model** | SLOPE POSITION + NR01 EDGE + NR01 + CURVATURE + JANUARY PRECIP + JULY PRECIP + NR01 CORE + JANUARY MIN TEMP + ELEVATION + INSOLATION + JULY MAX TEMP + F03 + OAK WOODLAND + EVERGREEN HARDWOODS | 0.769 | 0.396 |

**Eastern Klamath Mountains Modeling Region (N = 378 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR01** | CANCOV (≥65) + DDI (≥5.5) + QMDC_DOM (≥42) | 0.7052 | 0.2601 |
| **F05** | CANCOV_CON (≥45) + TPH_GE50 (≥23) + QMDC_DOM (≥30) | 0.7075 | 0.2613 |
| **Full Model** | NR01 + SLOPE POSITION+ DOUGLAS-FIR+ ELEVATION + NR01 EDGE + INSOLATION + JAN PRECIP+ F05 + CURVATURE + JULY MAX TEMP+ JAN MIN TEMP+ NR01 CORE + OAK WOODLAND+ PINE + SUBALPINE | 0.830 | 0.605 |

**Interior California Coast Ranges (N = 251 training sites)**

| Model | | AUC | GAIN |
|---|---|---|---|
| **NR02** | CANCOV (≥65) + MNDBHBA_CON (≥46) + BAA_GE ≥75) | 0.7136 | 0.2975 |
| **F04** | DDI (≥3.5) + QMDC_DOM (≥30) + BAH_3_25 (≥5) | 0.7296 | 0.3286 |
| **Full Model** | NR02 + NR02 EDGE + SLOPE POSITION + JULY MAX TEMP + CURVATURE + F04 + NR02 CORE + JULY PRECIP + JAN PRECIP + INSOLATION + JAN MIN TEMP + EVERGRN HDWD + PINE +OAK WOODLAND + ELEVATION | 0.820 | 0.540 |

**Table 0-17**. Individual covariates and their contribution to full model.

| **Western Klamath** | | **Eastern Klamath** | | **Interior CA Coast Ranges** | |
|---|---|---|---|---|---|
| **Full Model** | % | **Full Model** | % | **Full Model** | % |
| Slope Position | 33.0 | NR01 | 28.3 | NR02 | 29.9 |
| NR01 Edge | 32.2 | Slope Position | 24.6 | NR02 Edge | 19.8 |
| NR01 | 10.9 | Douglas-fir | 12.1 | Slope Position | 12.4 |
| Curvature | 6.6 | Elevation | 9.2 | July Max Temp | 11.1 |
| January Precip | 6.1 | NR01 Edge | 6.8 | Curvature | 5.6 |
| July Precip | 4.4 | Insolation | 5.4 | NR02 + F04 | 4.9 |
| NR01 Core | 1.6 | Jan Precip | 4.9 | NR02 Core | 3.3 |
| Jan Min Temp | 1.3 | NR01 + F05 | 3.3 | July Precip | 2.6 |
| Elevation | 1.1 | Curvature | 2.2 | Jan. Precip | 2.4 |
| Insolation | 1.0 | July Max Temp | 1.2 | Insolation | 2.0 |
| July Max Temp | 0.8 | Jan Min Temp | 0.8 | Jan. Min Temp | 1.8 |
| NR01 + F03 | 0.5 | NR01 Core | 0.5 | Evergrn Hdwd | 1.7 |
| Oak Woodland | 0.2 | Oak Woodland | 0.2 | Pine | 1.3 |
| Evergrn Hrdwd | 0.2 | Pine | 0.2 | Oak Woodland | 0.7 |
| | | Subalpine | 0.1 | Elevation | 0.5 |

**Table 0-18**. Codes and descriptions of stand structural variables from GNN and compositional variables used in relative habitat suitability models.

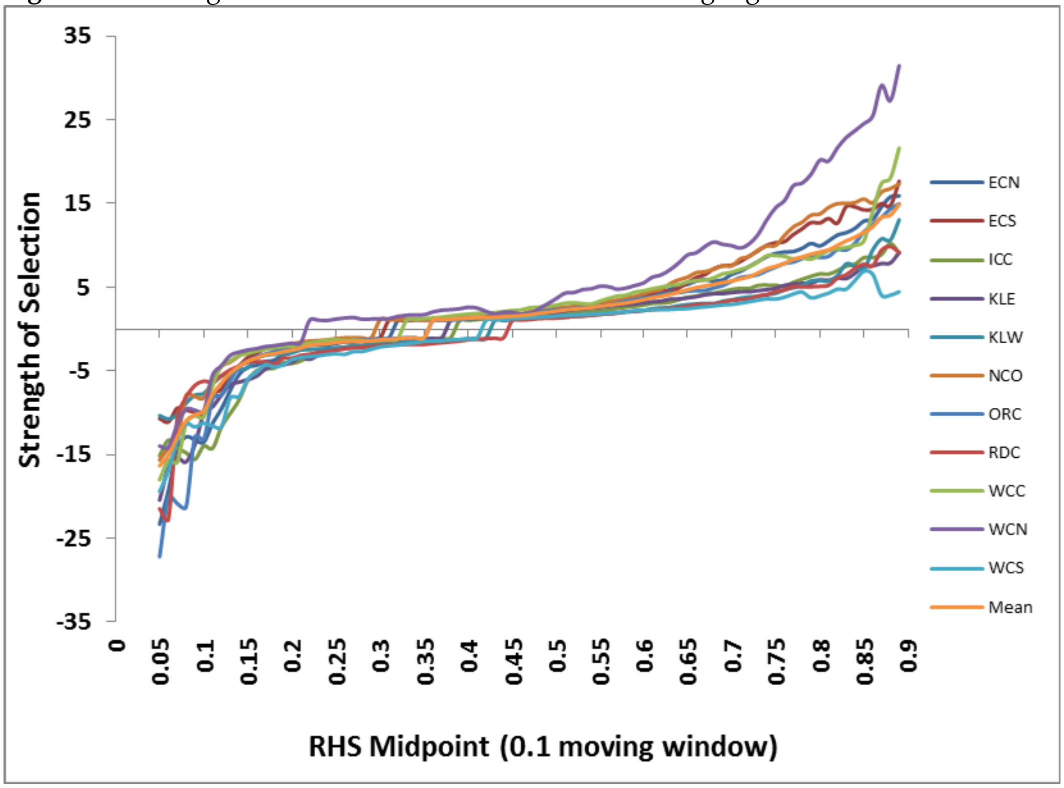
| Variable | Definition |
|---|---|
| CANCOV | Canopy cover of all live trees |
| CANCOV_CON | Canopy cover of all conifers |
| DDI | Diameter diversity index (structural diversity within a stand, based on tree densities within different DBH classes) |
| SDDBH | Standard deviation of DBH of all live trees |
| MNDBHBA_CON | Basal area weighted mean diameter of all live conifers |
| TPH_GE_50 | Live trees per hectare greater than or equal to 50 cm DBH |
| TPHC_GE_50 | Conifers per hectare greater than or equal to 50 cm DBH |
| TPH_GE_75 | Live trees per hectare greater than or equal to 75 cm DBH |
| TPHC_GE_75 | Conifers per hectare greater than or equal to 75 cm DBH |
| TPHC_GE_100 | Conifers per hectare greater than or equal to 100 cm DBH |
| QMDC_DOM | Quadratic mean diameter of all dominant and co-dominant conifers |
| BAA_GE_3 | Basal area of all live trees greater than or equal to 2.5 cm DBH |
| BAA_3_25 | Basal area of all live trees 2.5 to 25 cm DBH |
| BAA_GE_75 | Basal area of all live trees greater than or equal to 75 cm DBH |
| BAC_GE_3 | Basal area of conifers greater than or equal to 2.5 cm DBH |
| BAC_GE_50 | Basal area of conifers greater than or equal to 50 cm DBH |
| BAH_PROP | Proportion of BAA_GE_3 that is hardwood |
| BAH_3_25 | Basal area of all live hardwoods 2.5 to 25 cm DBH |
| **Compositional Variables** | |
| Evergreen Hardwoods | Basal area of tanoak, canyon, coast and interior live oaks, giant chinquapin, California bay and Pacific madrone |
| Subalpine | Basal area of silver fir, mountain hemlock, subalpine fir, red fir, Englemann spruce, |
| Pine | Basal area of ponderosa pine, Jeffrey pine, lodgepole pine, and Bishop pine |
| Northern Hardwoods | Basal area of red alder and bigleaf maple |
| Oak Woodland | Oregon white oak and blue oak |

## Results of Model Evaluation and Testing:

### Strength of selection results

We plotted the observed use that areas with various RHS values receive (by nesting spotted owls in our case) relative to the abundance of such areas in each modeling region. Figure C5 shows the SOS curves for all 11 modeling regions. Although the degree of calibration varies among modeling regions, the RHS models are generally well-calibrated, with strong selection for areas of RHS > 0.6 to 0.7, and avoidance of RHS <0.15 to 0.25.

**Figure 0-5**. Strength of Selection evaluation for all modeling regions.




## Results of Model Cross-Validation

Overall, each modeling region's model proved to be fairly robust, and thus gave us confidence in the model's generality. When we evaluated the differences in the percentages of spotted owl sites classified among 10 equally-sized RHS bins between the full model (using all of the spotted owl locations – thinned by 3 km) and the cross-validated (CV) models (*i.e.*, the 25% of observations that were withheld from the developmental model, each of 10-times for each modeling region) there were generally very small differences (Table C19). The maximum percentage point difference (percentage of observations from the full model minus percentage of observations CV model) was 11.1 (see Table C19). The mean difference of the absolute values among modeling regions ranged from 1.6 (for the Klamath West) to 4.5 (for the West Cascades North). Absolute values were used for calculating means because without doing so, the positive and negative values within a modeling region will always have a mean of 0, and thus don't accurately represent overall differences between full and cross-validated models. There was an inverse (negative logarithmic) relationship between sample size of spotted owl sites and mean difference in absolute value ($r^2 = 0.537$, $P = 0.01$).

Nonetheless, the magnitude of differences was generally quite low. For example, 39% of the differences were <2.0, 81% of the differences were <5.0, and only 7% of the differences were >7.0 (absolute value in each case). These findings suggest that none of the modeling region's full models were over-fit, and that all full models have good generality.

**Table 0-19**. Results from cross-validation tests, showing absolute values of differences (% classified by full model - % classified in cross-validated model) among modeling regions.

| | Absolute value of differences | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Po Bin** | **ECN** | **ECS** | **ICC** | **KLE** | **KLW** | **NCO** | **ORC** | **RDC** | **WCC** | **WCN** | **WCS** |
| **0-0.099** | 5.2 | 4.8 | 3.9 | 3.0 | 0.9 | 5.2 | 3.3 | 1.9 | 7.9 | 11.1 | 1.7 |
| **0.1-0.199** | 4.4 | 4.6 | 6.1 | 1.1 | 5.0 | 0.2 | 3.3 | 3.1 | 1.9 | 4.2 | 1.7 |
| **0.2-0.299** | 3.3 | 1.0 | 3.1 | 4.6 | 1.4 | 1.1 | 0.2 | 1.4 | 4.0 | 3.4 | 2.6 |
| **0.3-0.399** | 2.8 | 4.5 | 0.9 | 3.7 | 2.8 | 0.5 | 3.0 | 3.5 | 0.9 | 1.3 | 2.6 |
| **0.4-0.499** | 2.8 | 7.9 | 2.5 | 2.4 | 0.0 | 4.5 | 0.7 | 5.2 | 3.7 | 1.3 | 0.8 |
| **0.5-0.599** | 3.1 | 1.0 | 3.6 | 4.4 | 0.8 | 0.1 | 6.2 | 6.1 | 4.4 | 4.5 | 5.5 |
| **0.6-0.699** | 5.2 | 3.1 | 7.0 | 7.3 | 0.3 | 1.4 | 1.9 | 3.3 | 9.9 | 5.3 | 8.1 |
| **0.7-0.799** | 3.5 | 9.7 | 3.4 | 0.6 | 4.0 | 10.2 | 3.4 | 6.8 | 1.7 | 5.8 | 2.9 |
| **0.8-0.899** | 1.5 | 2.5 | 2.1 | 1.0 | 1.1 | 0.2 | 2.0 | 2.2 | 4.0 | 6.8 | 1.2 |
| **0.9-1.0** | 0.3 | 2.4 | 0.4 | 0.3 | 0.1 | 0.8 | 0.4 | 0.5 | 1.0 | 1.1 | 0.1 |
| **Mean** | **3.2** | **4.1** | **3.3** | **2.8** | **1.6** | **2.4** | **2.4** | **3.4** | **3.9** | **4.5** | **2.7** |

## Results of comparisons with independent data sets

To further evaluate the reliability of the models' predictions, we obtained independent (*i.e.* not used in model development) samples of spotted owl territory locations that represented the period 1993 to 1999 (Test96) and 2003 to 2009 (Test06) and compared their associated RHS values to corresponding values for spotted owl sites used in model development. All test sites were greater than 0.8 km from a training site. Because the RHS models were developed using spotted owl territories from the 1996 time period, comparison with Test96 most directly addresses model accuracy. Comparison with independent spotted owl locations from 2006, however, enabled us to evaluate accuracy of the models when projected to a new time period (model transferability), and to investigate systematic shifts in RHS at spotted owl sites. These shifts may occur, for example, in areas where densities of barred owls have increased during the 1996 to 2006 period, and are displacing spotted owls from favorable habitat. If this is the case (as has been hypothesized), we might expect to see reduced use of RHS area at 2006 spotted owl sites, relative to 1996 values (see Methods: Spotted owl location data).

We obtained adequate (N ≥ 100) test samples for 2006 in four modeling regions. As data for additional modeling regions and Test96 become available, further evaluation of model accuracy should be conducted. Table C20 shows the proportions of spotted owl sites in each of five RHS "bins" for the training data (Train), and Test06. Because they allow comparison of RHS values across a gradient of relative habitat suitability, these comparisons are more informative than binary "correct classification" analyses.

**Table 0-20.** Comparison of percentage of 1996 training sites versus test samples of 2006 spotted owl locations in 5 categories of Relative Habitat Suitability.

| | Oregon Coast | | Western Klamath | | Eastern Klamath | | Redwood Coast | | Rangewide | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Train | Test | Train | Test | Train | Test | Train | Test | Train | Test |
| N | 247 | 169 | 358 | 136 | 375 | 108 | 392 | 284 | 2742 | 916 |
| RHS bin | | | | | | | | | | |
| 0 – 0.2 | 7.3 | 7.1 | 8.7 | 2.2 | 6.1 | 4.6 | 4.8 | 3.2 | 6.1 | 4.6 |
| 0.2 – 0.4 | 19.0 | 23.1 | 18.2 | 19.8 | 14.1 | 20.4 | 13.8 | 12.7 | 16.5 | 17.8 |
| 0.4 – 0.6 | 35.6 | 35.5 | 38.5 | 46.3 | 38.4 | 39.8 | 42.1 | 44.7 | 36.7 | 41.8 |
| 0.6 – 0.8 | 32.8 | 30.2 | 33.5 | 30.8 | 38.7 | 35.2 | 37.2 | 37.7 | 36.7 | 33.8 |
| 0.8 – 1.0 | 5.3 | 4.1 | 1.1 | 0.74 | 2.7 | 0 | 2.0 | 1.8 | 4.0 | 1.2 |

**Model evaluation summary:**

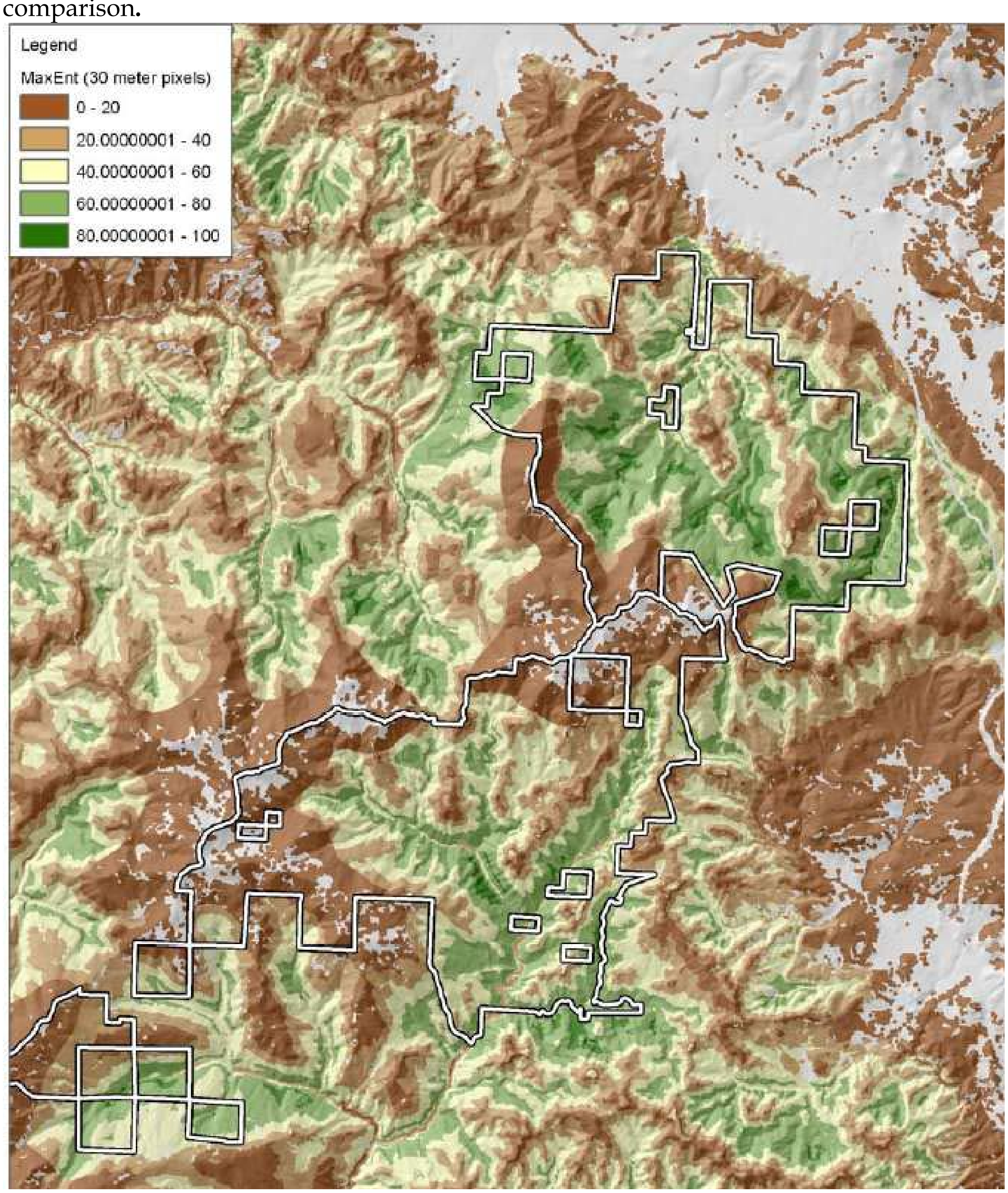
All modeling regions' models were well calibrated and showed a quite similar pattern in terms of strength of selection (see Figure C5). Cross-validation results by modeling region showed that all models were relatively robust to the 25% iterative reduction in sample size (see Table C19). Lastly, comparison of model results with independent test data showed the models had good ability to predict spotted owl locations (Table C20), and performed well when projected to 2006 vegetation conditions. Overall, these evaluations suggest that our RHS models were robust and have good generality. Subsequently, we used the full dataset models.

**Interpretation of model output:**

Elith *et al.* (2011) state that the MaxEnt logistic output is an attempt to estimate the probability that a species is present, given the environment (*i.e.*, the environmental conditions). For our purposes, we have taken a more conservative interpretation of the MaxEnt logistic output and interpret it to represent the relative habitat suitability (RHS) for nesting spotted owls within each modeling region. The map below (Figure C6) is the result of running each modeling region's best RHS model on each 30-m pixel within the region. That is, MaxEnt estimates a RHS value for each pixel based on the biotic and abiotic features within the 200-ha (~800 m radius) area around it (*i.e.*, based only on the variables in the best MaxEnt model for that modeling region). It is important to understand that a high RHS value is possible for a pixel that has little inherent value (*e.g.*, there are no trees in the 30x30 m focal pixel). It may, however, be that the surrounding 200-ha has many of the attributes associated with high RHS. Similarly, a focal pixel could have many of the positive characteristics that spotted owls generally select for, but it receives a low RHS value owing to the surrounding 200-ha having few or none of the attributes associated with high RHS values.

As noted above the RHS map is designed to facilitate and enable a wide variety of processes, discussions and analyses, including section 7 consultation, implementation and evaluation of the efficacy of spotted owl conservation measures such as Recovery Action 10 and management of barred owls. This model likely has utility for a wider variety of uses and processes than we currently envision, and it can be refined by future advances in the understanding of spotted owl habitat associations.
Maps depicting the RHS model outputs for the range of the spotted owl are available at:
http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner. The RHS values are the base layer on this map.

**Figure 0-6**. Map depicting Relative Habitat Suitability from MaxEnt model. Higher suitability habitat conditions are indicated by darker green areas; brown colors denote lower suitability. Outline of the Mount Ashland Late-successional Reserve is shown for comparison**.**



# Modeling Process Step 2 – Develop a spotted owl conservation planning model, based on the habitat suitability model developed in Step 1, and use it to design an array of habitat conservation network scenarios.

Because the RHS maps from Step 1 consisted of finely-distributed patterns of habitat suitability across the spotted owl's geographic range, we also wanted to provide a rigorous, repeatable method for aggregating habitat value into habitat conservation networks. We used the conservation planning model "Zonation" (Moilanen and Kujala 2008) to develop a spotted owl conservation planning model which can be used to design an array of habitat conservation network scenarios. To test this model we mapped a series of alternative spotted owl conservation network scenarios based on a series of rule-sets (*e.g.*, varying land ownership categories, the inclusion of existing reserves, identifying a specific amount of "habitat value" to include). The primary output of a Zonation analysis of the landscape is a "hierarchical ranking" of conservation priority of all cells or pixels in the landscape. Zonation allows analysts to incorporate species-specific factors such as dispersal capabilities and response to habitat fragmentation into the ranking of cells, and also allows the inclusion of factors such as land ownership and status into various evaluations. It is important to recognize that the maps produced by Zonation represent user-defined scenarios that were evaluated and compared in subsequent population modeling to test this modeling process; they do not represent decisions about the size or distribution of habitat conservation areas. While Zonation uses the term "reserve" to describe the conservation areas it identifies, this term does not dictate the types of management actions that could occur in those areas.

Zonation produces a hierarchical prioritization of the landscape based on the conservation value or "habitat value" of cells. A cell's habitat value is a function of its "base" value (*i.e.*, its RHS value) as well as the value of cells surrounding it. Thus, two cells of identical RHS may have different habitat value depending on how many other high, medium, and low value cells are nearby. The term habitat value therefore incorporates a larger spatial context than does RHS. Hierarchical, in this case, means that the most valuable five percent is also within the most valuable 10 percent; the top two percent is within the top five percent, and so on. Zonation uses minimization of marginal loss as the criterion to decide which cell is removed, and iteratively removes the least valuable cells from the landscape until no cells remain. The order of cell removal and its proportion of the total habitat value are recorded and can later be used to select any top fraction of cells or habitat value, the best 10 percent of cells or the top 10 percent of habitat value, for example, of the landscape.

To ensure that spotted owls and their habitat would be well-distributed throughout their range (one of the goals for recovery), Zonation analyses were conducted separately for each modeling region. This modeling region decision also had the impact of ensuring that conservation areas would be better distributed across the range of the species.

Zonation allows analysts to identify specific areas of the landscape that represent a particular percentage of the total estimated habitat value to the species. An important attribute of the Zonation algorithm is that it attempts to produce "efficient" solutions. That is, it prioritizes cells into units that maximize the habitat value per unit area within the solution (Figure C7). For example, in one Zonation scenario, 70% of the habitat value existed on ~40% of the landscape.

**Figure 0-7**. *Hypothetical* relationship between total size of habitat conservation system (x-axis) and percentage of habitat value "captured" (y-axis). Theoretically, the only way to capture 100% of the habitat value is to have the entire area to be considered reserve (or all areas with value >0). For this example, the entire area is ~ 19 million ha. In this example, a reserve system that is ~4 million ha "captures" ~50% of the habitat value, one that is ~9 million ha captures ~75% of the habitat value, etc.


Because Zonation is spatially explicit, in a GIS environment the user can control several aspects of how the program evaluates the distribution of habitat value. This enables the program to emulate important aspects of the species' life history, landscape pattern of habitat, and desired attributes of a habitat conservation network.

Zonation's **Distribution Smoothing** function is a species-specific aggregation method that retains high-value areas (pixels) that are better-connected to others, resulting in a more compact solution. The user specifies the area or "smoothing kernel" within which Zonation averages or smooths habitat values, based on a two-dimensional habitat density calculation, in accordance with attributes of an organism's movement patterns or abilities, such as home range area. We compared kernel sizes corresponding to the core use area (800 m radius), median home range (2100 m), and median dispersal distance (27.7 km; Forsman *et al.* 2002). The main difference in the resulting solutions from these three different settings is that the results from the kernel estimated from dispersal distance or home range were less fine-grained than the results from the kernel value estimated from a core area. Given that we are estimating habitat conservation network scenarios at relatively large scales, the coarser-grained (home range-derived kernel values) maps provided more discrete areas as estimated networks, and thus we used the home range scale kernel size.

Zonation's **Cell Removal Method** function allows users to control the spatial pattern or "grain" of priority areas by specifying whether cell removal begins around the edges of the analysis area or at cells scattered across the analysis area. The idea behind the "Edge Removal" setting is that it is more likely to result in connectivity of higher-value areas within the more central areas of the landscape. However, because cell removal is limited to the perimeters of large landscapes, the Edge Removal option can result in large blocks containing extensive areas of unsuitable habitat such as interior valleys and high mountain peaks. The "Edge Removal with Add Edge Points" option allows the user to randomly distribute a specified number of edge points where cell removal occurs within large landscapes. This setting allows more flexibility than edge removal and provides a greater chance that interior areas of poor-suitability habitat will be removed from the solution, and results in more finely-grained pattern of priority areas. The "No Edge Removal" option does not predispose Zonation to start cell removal from any particular area or region, but removes the lowest value cells in the landscape first, then the next lowest, and so on. This results in very finely-grained prioritized areas (and very long computer run times). We conducted side-by-side comparisons and found that Add Edge Points and No Edge Removal end up with nearly identical solutions (~95% overlap in identifying the top 25% habitat value areas in the landscape). To develop a series of alternative habitat conservation networks, we selected Add Edge Points, distributing 2,000 edge points into each modeling region.

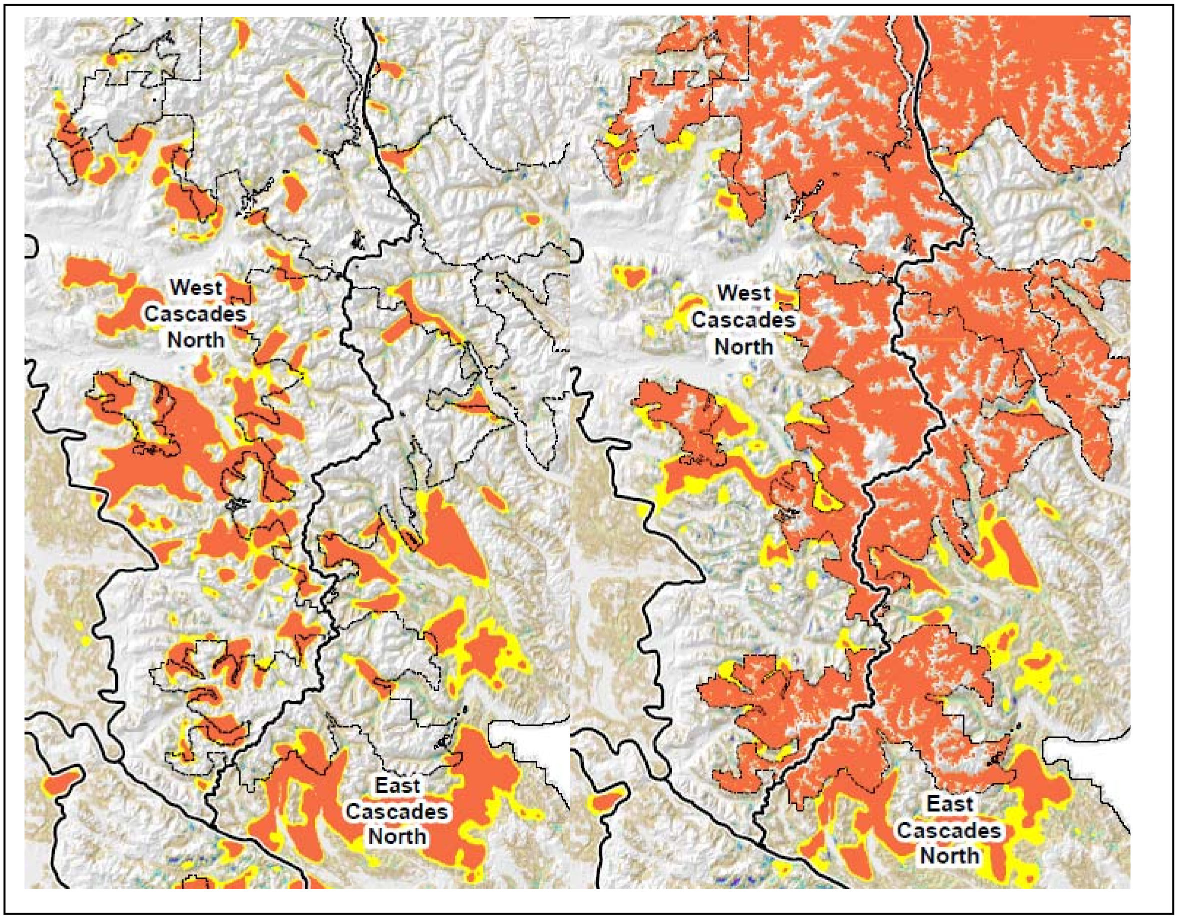
**Exclusion Areas** are areas that were excluded from the habitat suitability base maps prior to running Zonation. Examples are areas such as high elevation alpine areas as well as generally low elevation valley areas (*e.g.*, the Willamette Valley) that are considered incapable of supporting spotted owls. Including these areas in Zonation runs would give a false impression of habitat conservation block efficiency. That is, the algorithm would be able to remove large amounts of area (high elevation and valley areas) with no impact on the loss of spotted owl habitat value. Thus, we believed these areas should be masked out from the start. The GIS layer used to represent exclusion areas is the same one (mask) developed for the NWFP Monitoring Group (Davis and Dugger in press) and used in our MaxEnt modeling.

**Selection of values for conservation value ranking:** Zonation enables the user to specify the proportion of habitat value to display as maps of habitat conservation networks. Selection of the quantity of habitat value has a large influence on the size and distribution of habitat conservation networks. Because there is a near-infinite number of values that could be selected for evaluation, we compared results across a broad gradient of habitat values (20%, 30% 40%, 50%, 60%, 70%, and 80%), with the objective of identifying a smaller subset of reasonably diverse habitat conservation network scenarios for testing with the population model (see below). In addition, we compared habitat conservation networks from the above habitat values to the habitat values contained in existing networks such as spotted owl critical habitat (1992 and 2008) and the NWFP reserve network.

**Precedence Masking** allows the analyst to identify areas that must be or must not be included in the habitat conservation network. For example, existing protected areas such as Wilderness Areas and National Parks can be "forced" into the priority areas, regardless of their habitat value. Similarly, various land ownership categories can be "forced" out of priority areas. To accomplish this, the user identifies zones (land ownership, existing reserves, etc.) and ranks them by conservation priority (Zone 1, Zone 2, and so on) into a 'precedence mask'. In processing, Zonation removes the lowest value cells in Zone 1 first, , and continues by removing the next lowest value cell until all cells are removed in Zone 1 before moving on to Zone 2 and any potentially subsequent zones. Because the cells in Zone 2 are assigned a higher ranking, in terms of removal order, than those in Zone 1, they are disproportionately included in the solution. This process is repeated until all zones defined by the precedence mask have been fully evaluated. Zonation does not re-calculate or otherwise change the habitat value of a cell according to which zone it is in. Instead, identifying zones identifies discrete areas of the landscape that are to be given higher or lower priority of consideration for reasons other than the cells' habitat value.

The basis for precedence masking in Zonation is to allow factors such as land status to be incorporated into the landscape prioritization. For example, forcing existing National Parks and Wilderness Areas into habitat conservation networks would recognize that these areas exist as protected areas, and thus should be included in a habitat conservation networks regardless of their value to spotted owls. However, because we used Zonation to *help identify* areas estimated to provide the most conservation value for the spotted owl, we proceeded by first conducting an evaluation based purely on habitat value (unforced), and *then* evaluated how much overlap the resulting habitat conservation networks had with existing protected areas and other land designations or ownerships. Forcing existing reserves into priority areas will likely predispose Zonation to not find optimal solutions (*i.e.*, because some non-optimal areas are forced into the solution). For example, in areas such as the northern Cascades where high-value spotted owl habitat is relatively sparsely distributed, forcing Congressionally Reserved land allocations into priority areas resulted in an extremely inefficient network design (Figure C8).

**Figure 0-8**. Comparison of Zonation 40% (orange) and 50% (yellow) solutions on all land ownerships (left) and with Congressional Reserves prioritized (right). Outlines of habitat conservation network solutions in the right frame correspond largely to National Park and National Forest boundaries.




**Selection of Zonation scenarios – summary:**

After evaluating Zonation results employing a range of values for distributional smoothing, cell removal methods, ranking values, and land status and ownership prioritization, we selected habitat conservation network scenarios comprised of 30 percent, 50 percent, and 70 percent of habitat value as reference points. These scenarios sample along a gradient from somewhat smaller than the current habitat conservation network (NWFP) to a habitat conservation network approximately twice as large as the LSR network (Table C21). We recognize that the results of population modeling may indicate other Zonation scenarios that should or could be developed and tested (feedback loop in Figure C1). ***Also, it is important to recognize these scenarios are not recommendations for the specific size or location of habitat conservation blocks – they are only scenarios for the purpose of comparing to other scenarios to evaluate how they***

***influence spotted owl population performance in the population simulation model.***

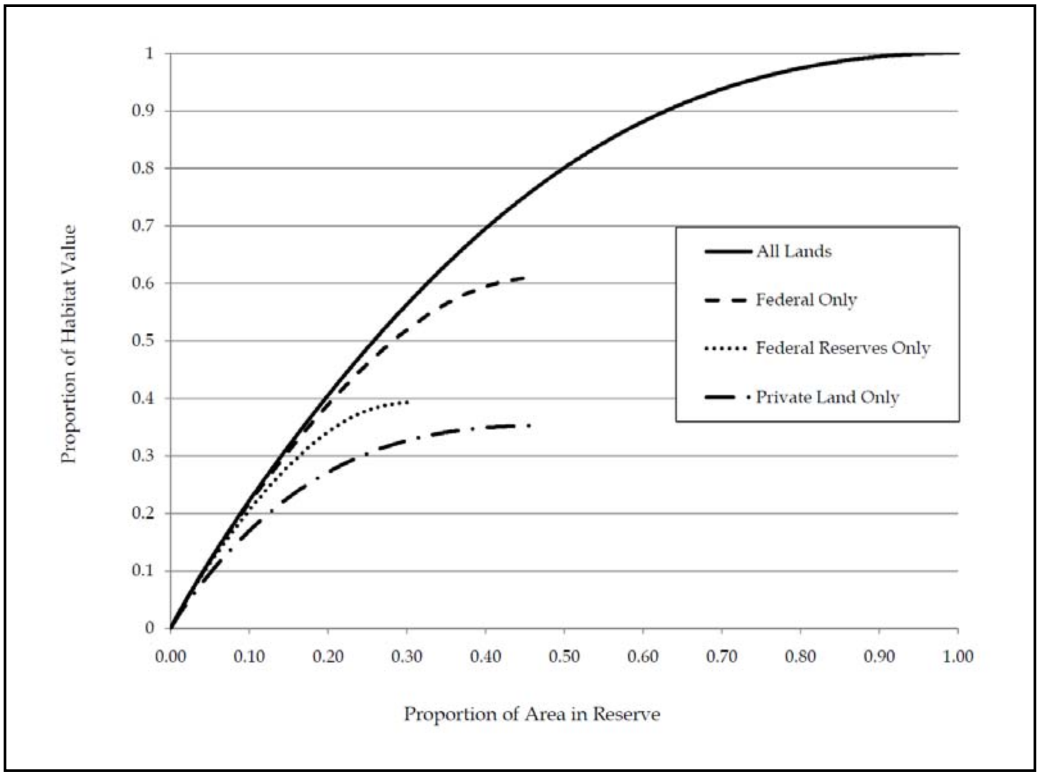
**Settings and Values Used in Zonation**
**Distribution Smoothing:** Home range area (2100 m radius)
**Cell Removal Method:** Add Edge points (2000 points/modeling region)
**Exclusion Areas:** Used NWFP non-capable habitat mask from NWFP Monitoring
**Ranking Values:** Used 30%, 50%, and 70% of habitat value
**Precedence Masking:** Land ownership scenarios evaluated include:

1) **No limit on inclusion** – No hierarchical masking - all land ownerships were allowed to be included and existing reserves were not forced into the priority areas. This scenario was chosen to represent the potential of the entire area to provide for spotted owls.

2) **Public lands only** – precedence masking was done such that non-public lands were removed first, and public lands were removed last. This had the effect of emphasizing reserves on public lands, but if the total amount of habitat value specified (*e.g.*, 50% or 70%) could not be acquired from cells in public lands, other lands could be included in the solution.

Maps depicting all of the initial Zonation scenarios are available at: http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.
Zonation outputs can be used to compare the contributions of different land classes (ownership, reserve status, etc.) based on the area and proportion of habitat value of each land class. Figure C9 depicts the relationship between area (proportion of the spotted owl's range) that could, hypothetically, be included in a habitat conservation network and the amount of spotted owl habitat value that various habitat conservation networks would contain among four categories: 1) all lands, which represents no limits on ownerships in the habitat conservation network; 2) Federal lands only, with no priority for currently existing reserves; 3) Federal reserves only, this scenario includes only NWFP reserves (Congressional Reserves and LSRs); and 4) private lands only; no reserves on Federal lands. These depictions are for demonstrative purposes only, not recommendations. They are essentially asking what would be the conservation value to spotted owls if habitat conservation areas were restricted to various land ownership categories. For example, private lands constitute about 45 percent of the spotted owl's range and provide roughly 35 percent of the rangewide habitat value (RHS), whereas the NWFP reserve network provides 40 percent of rangewide habitat value on 30 percent of the area (Figure C9).

**Figure 0-9**. Relationship between proportion of various land ownerships/categories (no restriction, Federal lands only, Federal reserves only, or private lands only) included in a habitat conservation network and proportion of spotted owl habitat value included in the habitat conservation network.




While Zonation outputs do not evaluate or predict potential spotted owl population sizes associated with different habitat conservation network scenarios, they nonetheless permit comparison of the sizes of existing reserve or conservation networks to possible habitat conservation areas, and enable additional comparisons to be made in a GIS environment. For example, Table C21 shows a comparison of network size, percent of spotted owl training locations from the habitat modeling that falls within various habitat conservation network scenarios, and percent of the top two Zonation habitat value ranks among 10 habitat conservation network scenarios. Table C22 shows the relationship the proportion of RHS bins within each of 20 Zonation and 4 non-Zonation habitat conservation network scenarios. The results show the efficiency with which Zonation selects high RHS areas.

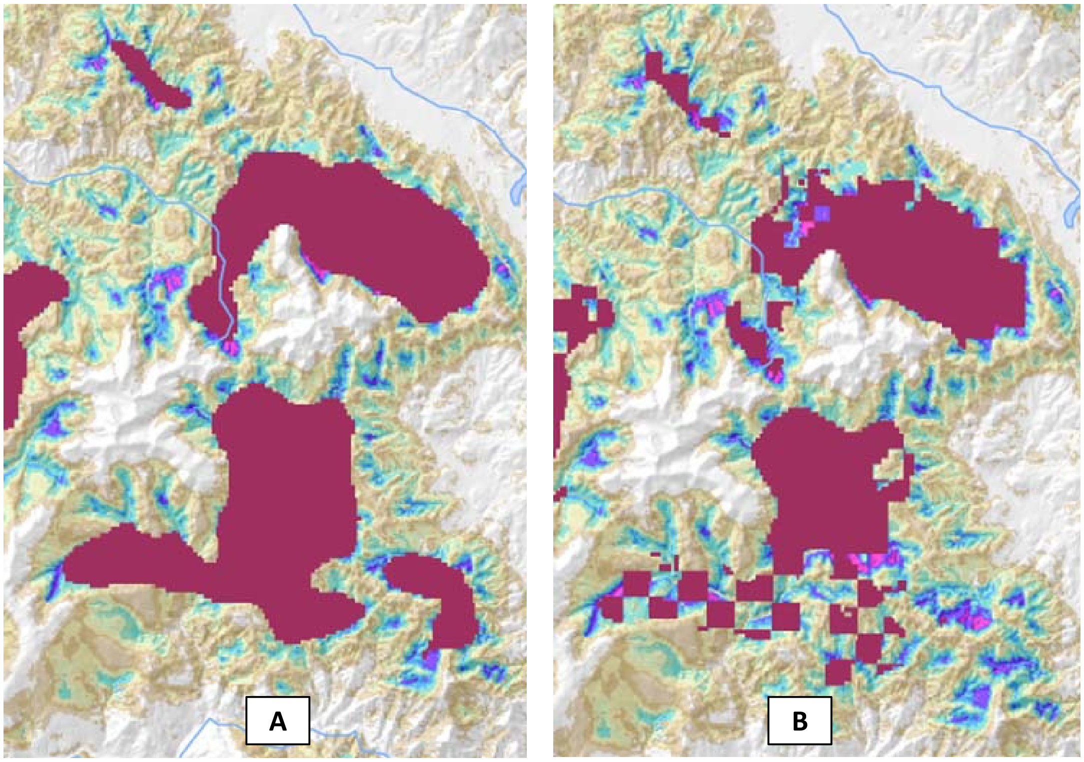
**Table 0-21**. Comparison of area, percent of 1996 spotted owl sites used in model development, and percent of top 10% and 20% Zonation ranked habitat value for 10 spotted owl reserve scenarios.

| Network scenario | Network scenario size (million hectares) | Percent of 1996 spotted owl sites | Percent of top 10% Zonation-ranked | Percent of top 25% Zonation-ranked |
|---|---|---|---|---|
| NWFP | 6.63 | 46 | 56.7 | 55.2 |
| MOCA | 4.77 | 33 | 46.3 | 43.8 |
| 1992 Critical Habitat | 5.75 | 44 | 57.3 | 55.4 |
| 2008 Critical Habitat | 5.17 | 37 | 49.6 | 47.7 |
| Z30 All lands | 5.61 | 50 | 100 | 100 |
| Z50 All lands | 7.80 | 71 | 100 | 100 |
| Z70 All lands | 10.55 | 87 | 100 | 100 |
| Z30 Public lands | 5.57 | 51 | 94.9 | 91.3 |
| Z50 Public lands | 7.82 | 73 | 95.0 | 93.0 |
| Z70 Public lands | 11.24 | 88 | 98.9 | 98.0 |

**Table 0-22**. Proportion of relative habitat suitability (RHS) bins represented among various habitat conservation network scenarios. Many more Zonation (Zall and Zpub) scenarios are presented in this table than in the remainder of the document. Zall = all lands available; public = Zpub lands prioritized in Zonation.

| | Relative Habitat Suitability Bin | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Habitat Conservation Network Scenario** | **0 - 10** | **10 - 20** | **20 - 30** | **30 - 40** | **40 - 50** | **50 - 60** | **60 - 70** | **70 - 80** | **80 - 90** | **90 - 100** |
| **NWFP** | 0.22 | 0.26 | 0.31 | 0.36 | 0.41 | 0.46 | 0.51 | 0.57 | 0.63 | 0.58 |
| **MOCA** | 0.16 | 0.18 | 0.22 | 0.25 | 0.30 | 0.34 | 0.40 | 0.46 | 0.49 | 0.31 |
| **1992 Critical Habitat** | 0.17 | 0.22 | 0.28 | 0.33 | 0.38 | 0.44 | 0.50 | 0.57 | 0.66 | 0.57 |
| **2008 Critical Habitat** | 0.16 | 0.20 | 0.24 | 0.28 | 0.32 | 0.37 | 0.43 | 0.51 | 0.60 | 0.51 |
| **Z10all** | 0.00 | 0.00 | 0.02 | 0.03 | 0.07 | 0.16 | 0.33 | 0.54 | 0.70 | 0.89 |
| **Z10pub** | 0.00 | 0.01 | 0.02 | 0.04 | 0.08 | 0.16 | 0.30 | 0.51 | 0.68 | 0.83 |
| **Z20all** | 0.00 | 0.02 | 0.05 | 0.10 | 0.19 | 0.35 | 0.57 | 0.77 | 0.89 | 0.99 |
| **Z20pub** | 0.00 | 0.03 | 0.06 | 0.11 | 0.20 | 0.34 | 0.54 | 0.73 | 0.85 | 0.90 |
| **Z30all** | 0.01 | 0.05 | 0.11 | 0.20 | 0.33 | 0.53 | 0.74 | 0.89 | 0.95 | 1.00 |
| **Z30pub** | 0.01 | 0.06 | 0.13 | 0.21 | 0.34 | 0.51 | 0.70 | 0.83 | 0.90 | 0.91 |
| **Z40all** | 0.01 | 0.09 | 0.19 | 0.32 | 0.49 | 0.69 | 0.85 | 0.94 | 0.98 | 1.00 |
| **Z40pub** | 0.02 | 0.11 | 0.22 | 0.34 | 0.48 | 0.66 | 0.80 | 0.88 | 0.92 | 0.91 |
| **Z50all** | 0.02 | 0.15 | 0.30 | 0.46 | 0.63 | 0.81 | 0.92 | 0.98 | 0.99 | 1.00 |
| **Z50pub** | 0.04 | 0.21 | 0.35 | 0.47 | 0.61 | 0.75 | 0.85 | 0.90 | 0.92 | 0.91 |
| **Z60all** | 0.04 | 0.24 | 0.43 | 0.61 | 0.77 | 0.90 | 0.96 | 0.99 | 1.00 | 1.00 |
| **Z60pub** | 0.12 | 0.37 | 0.48 | 0.58 | 0.70 | 0.82 | 0.89 | 0.92 | 0.93 | 0.92 |
| **Z70all** | 0.08 | 0.38 | 0.59 | 0.75 | 0.87 | 0.95 | 0.99 | 1.00 | 1.00 | 1.00 |
| **Z70pub** | 0.25 | 0.47 | 0.59 | 0.70 | 0.81 | 0.90 | 0.94 | 0.97 | 0.98 | 1.00 |
| **Z80all** | 0.15 | 0.57 | 0.75 | 0.87 | 0.95 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z80pub** | 0.32 | 0.61 | 0.73 | 0.83 | 0.91 | 0.96 | 0.98 | 0.99 | 1.00 | 1.00 |
| **Z90all** | 0.31 | 0.80 | 0.91 | 0.97 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z90pub** | 0.47 | 0.79 | 0.88 | 0.95 | 0.98 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z100all** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| **Z100pub** | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Figure 0-10**. Example Zonation output map of the Mount Ashland, OR, area, depicting 30 percent of habitat value in red on all lands (A) and on Federal lands only (B).




## Modeling Process Step 3 - Develop a spatially explicit spotted owl population model that reliably predicts relative responses of spotted owls to environmental conditions, and use it to test the effectiveness of habitat conservation network scenarios designed in step 2 in recovering the spotted owl. The simulations from this spotted owl population model are not meant to be precise estimates of what will occur in the future, but provide information on comparative trends predicted to occur under differing habitat conservation scenarios.

To meet this objective, the modeling team elected to use a spatially explicit, individual-based modeling approach. While other approaches such as population level population viability analysis (PVA) and metapopulation models have been used for evaluating spotted owl populations, we required an approach that enabled comparison of a wide range of spatially explicit conditions such as variation in habitat conservation networks. Dunning *et al.* (1995) wrote the following regarding spatially explicit population models:

> *"Spatial models, structured and parameterized according to a species' life history, allow one to explore the efficiency of various reserve designs. The*

> *models can be used to estimate the potential effects on a species' persistence by systematically varying factors such as the percentage of the landscape that is suitable habitat, and the size, shape, and spacing of habitat patches. The addition of marginal (i.e., sink) habitat to a reserve can be assessed for negative effects on a managed population (Pulliam and Danielson 1991). These exercises can be done on artificial landscape maps to explore general reserve design principles (Lamberson et al. 1992, 1994) or on GIS-based maps that incorporate land-use and ownership constraints (Murphy and Noon 1992, Noon and McKelvey 1992)."*

Individual-based models (IBMs) allow for the representation of ecological systems in a manner consistent with the way ecologists view such systems as operating. That is, emergent properties such as population increases or declines are the result of a series of effects and interactions operating at the scale of individuals. Individuals select habitat based on what is available to them, disperse as a function of their individual circumstance (age), compete for resources, etc. Grimm and Railsback (2005) noted that IBMs need to be simple enough to be practical, but have enough resolution to capture essential structures and processes. The spotted owl is perhaps the most studied raptor in the world, and thus there exists a tremendous quantity and quality of data (*e.g.*, vital rates are evaluated in a meta-analysis for several long-term demographic study areas every 5 years; *e.g.*, Anthony *et al.* 2006, Forsman *et al.* (2011)); habitat selection (see review by Blakesley 2004) has been thoroughly evaluated; large numbers of individuals have been followed during dispersal (Forsman *et al.* 2002); among many other aspects of the species' ecology. The spotted owl is therefore ideally suited for spatially explicit IBM. Bart (1995), however, noted that the question "Does the model improve our ability to make decisions?" needs to be explicitly considered. The modeling team believes that the spatially explicit IBM HexSim, which is parameterized largely with empirically-derived values from spotted owl studies, improves our ability to make land management decisions, and therefore we have decided to use this approach.

## The HexSim Model:

HexSim (Schumaker 2011) was designed to simulate a population's response to changing on-the-ground conditions by considering how those conditions influence an organism's survival, reproduction, and ability to move around a landscape. The modeling team developed a HexSim spotted owl scenario based on the most up-to-date demographic data available on spotted owls (Forsman *et al.* 2011), published information on spotted owl dispersal, and home range size as well as on parameters for which less empirical information was available (see below). Initially, the HexSim spotted owl model allows users to evaluate the efficacy of existing conservation strategies, under currently-estimated barred owl impacts and with currently-estimated habitat conditions, to meet recovery goals. Subsequently, the model serves as a consistent framework into which variation in spatial data layers (*e.g.*, reserve or conservation block boundaries, different assumptions about habitat conditions (RHS) inside and outside of reserves or blocks, different assumptions about RHS change on public versus private lands, and different assumptions about the impact of barred owls among modeling regions) can be introduced. Comparison of estimates of simulated spotted owl population performance estimates across the range of scenarios incorporating variation in habitat conservation network sizes, habitat trends, and barred owl influence, can inform evaluations of habitat conservation networks and other conservation measures designed to lead to spotted owl recovery.

In very general terms, we tried to design the model to answer the following questions: (1) Given current circumstances (reserves, habitat, barred owls, spotted owl demographic rates, etc.), is recovery of the spotted owl likely in the foreseeable future?; (2) Given current estimates of habitat, barred owls, and spotted owl demographics, is recovery of the spotted owl likely in the foreseeable future under different habitat conservation network scenarios?; and (3) To what degree would management of habitat and barred owls contribute to or detract from reaching spotted owl recovery goals under a range of habitat conservation networks and management scenarios? Evaluation and ranking of the population simulation results from the model obtained across a range of habitat conditions, barred owl effects, and conservation network scenarios, and comparison with established recovery criteria, should provide important insight into these questions. **The HexSim model is available at: www.epa.gov/hexsim.**

**HexSim Overview:**

HexSim is a spatially explicit, individual-based computer model designed for simulating terrestrial wildlife population dynamics and interactions. HexSim is a generic life history simulator; it is not specifically a spotted owl model. HexSim was designed to quantify the cumulative impacts to wildlife populations of multiple interacting stressors.

HexSim simulations are built around a user-defined life cycle. This life cycle is the principal mechanism driving all other model processing and data needs. Users develop the life cycle when initially setting up a simulation. The life cycle consists of a sequence of life history events that are selected from a list. This event list includes survival, reproduction, movement, resource acquisition, species interactions, and many other actions. Users can impose yearly, seasonal, daily, or other time cycles on the simulated population. Each event can work with all, or just a segment of a population, and events can be linked to static or dynamic spatial data layers. Each life cycle event has its own data requirements. Simple scenarios may use few events with minimal parameterization and little spatial data. When more complexity is warranted, HexSim allows a great deal of data and behavior to be added to its simulations.

HexSim scenarios include descriptions of one or more populations, spatial data needs, life cycle definitions, event data, and basic simulation criteria such as the number of replicates and time steps. Each population is composed of individuals, and individuals have traits that can change probabilistically, or based on age, resource availability, disturbance, competition, etc. HexSim also includes optional genetics and heritable traits (though these were not used for the spotted owl model). The use of traits allows members of the simulated population to have unique properties that change in time and space. Traits also allow populations to be segregated into classes, such as males and females, fitness categories, disease categories, etc. Combinations of trait values can be used to stratify events such as survival, reproduction, movement, etc.

Traits are a fundamental part of HexSim scenarios. Traits can be used to control most life cycle events because events can be stratified by trait combinations. For example, a movement event might be set up to operate only on a fledgling stage class. Or a survival event might assign mortalities based on the values of a trait that reflects resource acquisition. In addition, one trait's values can also be influenced by multiple other traits, which makes it possible to set up stressor interactions and complex feedback loops. Traits can also be used to capture interactions such as parasitism, competition, mutualism, breeding, etc.

## <u>Overview of the Spotted Owl Scenario</u>

Because females are the most influential sex in terms of population dynamics, the HexSim spotted owl scenario is a females-only model. The life cycle is simple except that the acquisition of resources by individual spotted owls is spatially stratified, and thus somewhat complex. The scenario depends on two static spatial data layers; one representing the distribution and relative suitability of habitat, and an "exclusion layer" to prevent spotted owls from moving out into the Pacific Ocean, or into areas outside of their geographic range .

An additional layer comprised of the boundaries of both the modeling regions and demographic study areas (DSAs were used to generate HexSim reports (*i.e.*, we extracted information about spotted owls in DSAs as well as within modeling regions and for all modeling regions overall), had no effect on the simulated population. All spatial data layers are converted to grids consisting of 86.6- ha hexagons. To the extent possible, simulation parameter values were estimated based on published empirical data.

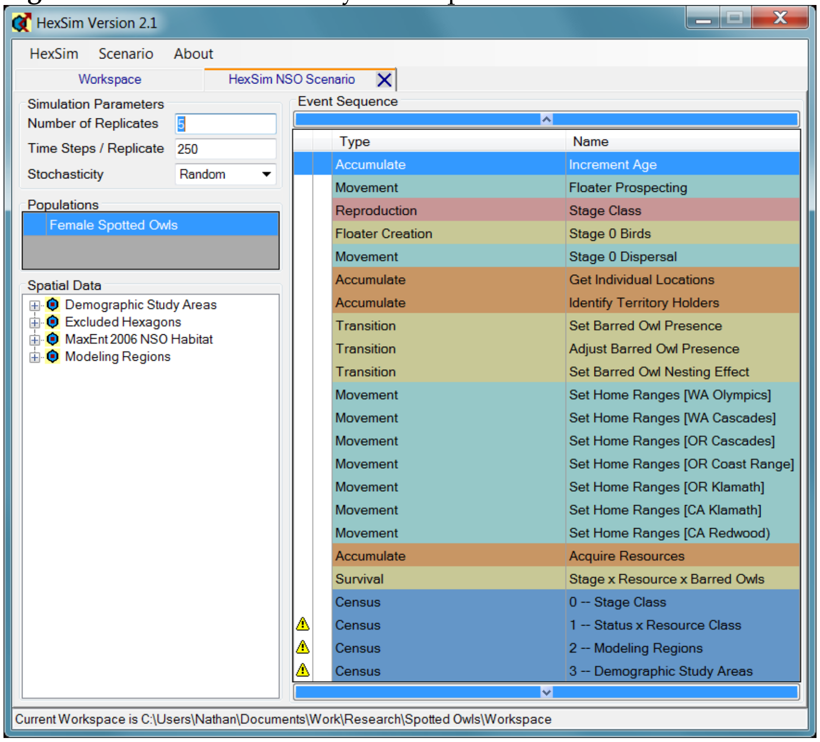
The HexSim simulations began with 10,000 spotted owls being virtually introduced into the study landscape. The initial population's ages were randomly distributed, and they were placed preferentially into areas of high RHS. Once initialization was complete, individual spotted owls were subjected to the event cycle shown in Figure C11. The year begins with each individual becoming a year older. Next, floaters (spotted owls without a territory) prospect for a territory. This is followed by reproduction and fledgling dispersal. Dispersing fledglings do not prospect for a territory.

We assumed that the RHS map developed in MaxEnt was a proxy for the amount of resources available to spotted owls within each hexagon. Because nesting spotted owls showed relatively strong selection for some RHS categories and against others (see Figure C5), we reasoned that this selection was based on a combination of factors (including, but not limited to, those we included as covariates in our models) that influence spotted owl natural selection. That is, spotted owls select some areas and avoid other areas in order to maximize their survival and reproductive success. Spatially-explicit data on competitors, prey, predators and other factors influencing spotted owls were unavailable, and thus we were unable to incorporate more direct measures of resource quantity and quality.

In the HexSim Spotted Owl Scenario, a primary influence of RHS on simulated spotted owl populations occurs in territory acquisition (occupancy). To the extent that some areas aren't selected by spotted owls (or disproportionately selected against), habitat suitability acts to limit survival and reproduction (*i.e.*, spotted owls don't survive or reproduce in areas that they don't occupy). Subsequent to territory establishment, resource acquisition (RHS values) determines the resource class a spotted owl is placed in, which influences survival rates. Reproduction was not influenced by resource acquisition, and thus was not influenced by habitat quality. Individual studies (*e.g.,* Franklin *et al*. 2000) and meta-analyses have reported influences of habitat on survival and in some cases fecundity (see Forsman *et al*. 2011).

We recognized the importance of dispersal and habitats used by dispersing spotted owls in developing habitat conservation planning models. However, relatively little is known about the characteristics of areas used by dispersing spotted owls. In the spotted owl modeling effort, the modeling team therefore elected not to define or attempt to model dispersal habitat, but instead to rely on reasonable assumptions about the influence of relative habitat suitability (for nesting) on successful dispersal. Success (survival) of spotted owls dispersing through variable landscapes may be influenced by factors similar to those affecting territorial spotted owls (*e.g.* availability of prey, cover from predation, thermal stress) albeit at a different scale. Because the RHS values generated by MaxEnt retain the full gradient of habitat suitability (*i.e.* not 'thresholded' or categorized), it is reasonable to assume that relative habitat suitability is correlated with relative success of dispersal occurring in those areas (pixels). In HexSim, dispersing spotted owls are allowed to disperse through the full range of RHS values, with some degree of repulsion to the lowest RHS values.

**Figure 0-11**. HexSim event cycle for spotted owls.




After floater spotted owls finish prospecting for territories, the modeling region they are in is recorded. Then the determination of whether each territorial spotted owl is in the presence of a barred owl is made probabilistically, with the probability of being in the presence of a barred owl dependent on the modeling region (Table C25). The region-specific probabilities for spotted owl exposure to barred owls were based on the proportion of spotted owl territories where barred owls were detected each year on the 11 DSAs (see Appendix B; Forsman *et al.* 2011). This decision is only made once per “bird-territory” (*i.e.*, once the decision is made for an individual spotted owl at a territory, the barred owl presence/absence is fixed for that territory until another spotted owl takes over the territory). All non-territorial spotted owls are placed in an ‘undetermined status’ category until they obtain a territory. A newly territorial spotted owl that has this undetermined status is assigned a "barred owl present" or "barred owl absent" status, based on the barred owl encounter probability for that modeling region. Next, spotted owls that have the “barred owl present” status are placed in either a "*nesting normal*" or "*nesting halted*" class. At present, every spotted owl is placed into the *nesting normal* class. If spotted owls were assigned to the *nesting halted* class, they would not reproduce. Unlike the barred owl presence/absence trait described above, the *nesting normal* vs. *nesting halted* decision could be revisited every year, for every territorial spotted owl. Spotted owl floaters do not reproduce, so although they are always assigned to the *nesting normal* category, this has no impact on the simulation results. We mention these features (even when they aren’t used) that were built into the HexSim Spotted Owl Scenario model to show how the model can adapt to and incorporate new information when it becomes available.

In the HexSim simulation, barred owls affect spotted owls through survival only. However, the simulation has been developed to facilitate a barred owl impact on spotted owl reproduction. This feature has not yet been used. It would also be possible to have barred owls impact habitat selection by spotted owls, or site fidelity. Neither of these processes has been implemented. Reproductive rates were obtained from Table 3 of Forsman *et al*. (2011). Those estimates were for time periods as long as 1985 to 2008 and as short as 1992 to 2008. It is generally agreed that barred owl populations have increased in most areas of the spotted owl's range over that time. Thus, to the degree that barred owls have an influence on fecundity, that influence is incorporated into these estimates.

Spotted owl reproduction is stratified by both stage class and nesting status (see above). Spotted owls that are in the *nesting halted* class have 100% probability of producing a clutch of size 0. Otherwise, the reproductive rates vary by stage class.

Spotted owl survival is stratified by barred owl presence, stage class, and resource class. Spotted owls in the barred owl present class have lower survival rates. Those in the barred owl absent, or undetermined classes, have higher survival rates.

At present, barred owls are not explicitly simulated, but are instead captured probabilistically. Accounting for barred owl impacts on spotted owl habitat selection or site fidelity would require that barred owls be actually located on the simulated landscape, and possibly even fully simulated within HexSim. The modeling team felt that sufficient data did not exist range-wide to permit either option to be incorporated into the current simulations. When such data become available, they can be integrated into the framework we have developed.

Next, each spotted owl establishes a home range. The simulated spotted owls have small defended territories, but large overlapping home ranges. Home range size varies with modeling region. The spotted owls extract resources from their home ranges, and thus they experience competition for resources from conspecifics. Finally, resource acquisition and survival are simulated. Survival varies based on stage class, resource acquisition class, and exposure to barred owls.

Home range sizes were set to the mean of the available regional-specific estimates (see summary in Schilling 2009). Spotted owl survival rates were based on study area-specific estimates from Forsman *et al.* (2011), with adjustment for the impact of barred owls across all study areas as calculated from the survival meta-analysis model containing an additive barred owl effect, also from Forsman *et al.* (2011).

## The Population Parameters

Three distinct component groups were involved in the specification of the HexSim spotted owl population. These involved a set of basic properties, the definition of several different population traits, and finally the establishment of rules for the spotted owl's use of space and resource needs. The basic properties were used to establish an initial population size of 10,000 spotted owls, and to define an exclusion layer. Individuals were initially placed into the best hexagons in the simulation landscape, but only one spotted owl was allowed per hexagon.

Seven traits were created as part of the spotted owl population definition. These traits track stage class, location (modeling region and possibly DSA), resource class, territory status (territorial vs. floater), exposure to barred owls, and barred owl impacts on spotted owl nesting. Table C23 shows each possible trait value.

The simulated spotted owls produced each year begin life at age zero, and stage class zero. Each year they transition into the next stage class. At age 3 they reach stage class three, which is the terminal stage class. The spotted owls always belong to one of three resource classes, depending on the amount of resources they are able to acquire from their home range. Resources are a function of the mean RHS of hexagons, derived from the MaxEnt models (see above). Spotted owls that acquire 2/3 or more of their resource target are placed in the high resource class. Those that attain less than 1/3 of their resource target are placed into the low resource class. All other spotted owls are placed into the medium resource class. Resource targets vary by modeling region, and are described below.

The territory status trait is used to record whether individual spotted owls own a territory, or are floaters. The barred owl presence trait categorizes individual spotted owls as being exposed, or unexposed, to a barred owl. This decision is made once for each territorial spotted owl. The barred owl nesting effect trait is used to assign a probability that exposure to a barred owl will cause a spotted owl to avoid nesting. This evaluation is repeated every year for every spotted owl.

**Table 0-23**. Spotted owl scenario traits and value categories.

| Trait | Values |
|---|---|
| Stage Class | Stage 0 |
| | Stage 1 |
| | Stage 2 |
| | Stage 3 |
| Resource Class | Low |
| | Medium |
| | High |
| Territory Status | Floater |
| | Territorial |
| Barred Owl Presence | Pending |
| | Absent |
| | Present |
| Barred Owl Nesting Effect | Normal |
| | Halted |

| Trait | Values |
|---|---|
| Modeling Region | North Coast Olympics |
| | Oregon Coast |
| | East Cascades South |
| | East Cascades North |
| | West Cascades North |
| | West Cascades Central |
| | West Cascades South |
| | Klamath East |
| | Klamath West |
| | Inner-California Coast Range |
| | Redwood Coast |

| Trait | Values |
|---|---|
| DSA | Cle Elum |
| | Coast Ranges |
| | HJ Andrews |
| | Klamath |
| | Olympic |
| | Rainier |
| | South Cascades |
| | Tyee |
| | Warm Springs |
| | Wenatchee |
| | Hoopa |
| | Marin |
| | NW California |
| | Simpson |

The modeling region and demographic study area traits are used to track individual spotted owl locations. The 11 modeling regions are space-filling and non-overlapping. Each individual spotted owl occupies one modeling region at any one time. If a spotted owl territory spanned multiple modeling regions, it was assigned to the region in which the majority of its territory hexagons fell. The demographic study areas (DSAs) take up just a fraction of the landscape. So at any moment most spotted owls will not be in a DSA. Resource targets (explained below) and home range size vary by modeling region.

The population parameters also control individual's use of space. The simulated spotted owls had territory sizes of no more than three 86.6-hectare hexagons. This territory size represents a reasonable approximation of a spotted owl core area (see discussion of spatial scale above). Hexagons had to have at least a score of 35 (out of 90 possible) to be usable in forming a territory. We decided on a minimum score of 35 after evaluating the scores of hexagons overlaid on 3,790 spotted owl nest sites. We evaluated the score for the focal hexagon (the one in which the nest resided), the second, and third closest hexagons, as well as the mean scores of the first, second, and third hexagons. More than 75% of the nest sites were in hexagons with scores >35. Similarly, 73% of the spotted owl sites had a mean score >35 for the focal, second, and third closest hexagons. Although other scores might be reasonable, we reasoned that increasing the score would unreasonably inhibit settlement on suitable areas, whereas decreasing the score would result in unrealistic densities in areas with relatively low RHS. Territory size had little significance for the simulated population dynamics, as the spotted owls derive resources from their home ranges. The territories served as a core area around which home ranges could be constructed. Territories, in the HexSim simulations, were exclusively used areas, whereas the remainder of the home range area could overlap with that of neighboring spotted owls.

Each simulated spotted owl has a resource target, which controlled how much resource it must have access to in order to be placed into the highest resource class. The resource targets vary by modeling region. Spotted owls that acquire 2/3 or more of their resource target are placed into the high resource acquisition class. Those that attain less than 1/3 of their resource acquisition target are placed into the low resource acquisition class. All other spotted owls end up in the medium resource acquisition class. The resource targets are listed in Table C24.

**Table 0-24.** Estimated resource targets based on RHS values at 3,790 spotted owl locations.

| Modeling Region | Home Range Size ha (# hexagons) | Resource Target |
|---|---|---|
| North Coast Olympics | 11,052 (128) | 1250 |
| East Cascades North | 7,258 (84) | 1000 |
| West Cascades North | 7,258 (84) | 1250 |
| West Cascades Central | 7,258 (84) | 1250 |
| Oregon Coast | 4,123 (48) | 375 |
| West Cascades South | 3,949 (46) | 375 |
| Inner CA Coast Range | 3,165 (37) | 375 |
| East Cascades South | 3,033 (35) | 750 |
| Klamath East | 3,033 (35) | 375 |
| Klamath West | 3,033 (35) | 375 |
| Redwood Coast | 1,173 (14) | 250 |

## The Event Sequence

There are 23 events in the HexSim spotted owl scenario. Not all of these events modify the population, and some have similar or related functions. These events are described in turn below. Each event is listed by type (*e.g.,* movement) and specific name (in square brackets).

Accumulate [Increment Age]

This event makes each individual one year older. As a result, stage 0 individuals will move into stage 1, stage 1 individuals will move into stage 2, and stage 2 individuals will move into stage 3.

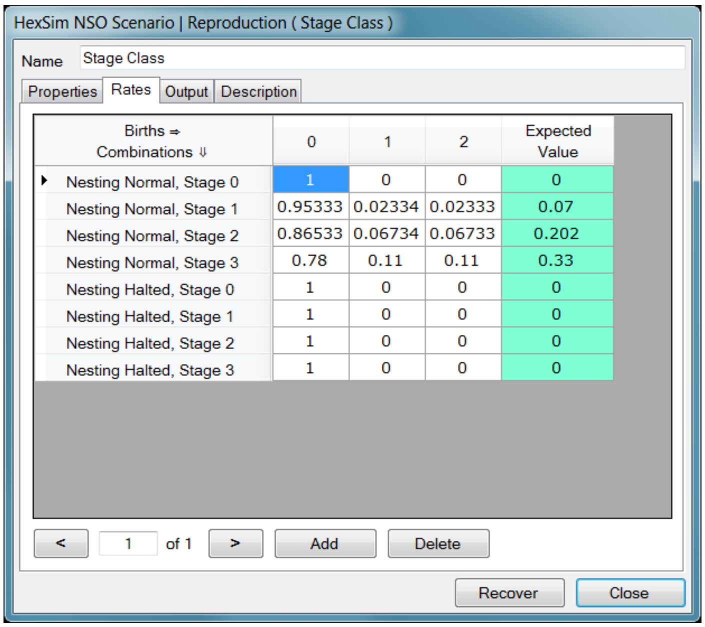
Movement [Floater Prospecting]

HexSim's movement event controls dispersal and prospecting behavior. But any one event may do either or both. This event only performs prospecting, but it does so for all spotted owls that are floaters (*i.e.,* those who do not own a territory). Individual floaters are allowed to search an area of up to 500 86.6 - hectare hexagons in search of a vacant area from which a territory could be constructed. The search strategy is imperfectly informed by resource availability. That is, spotted owls tended to construct home ranges from high RHS hexagons, but they did not select the best sites with certainty.

## Reproduction [Stage Class]

HexSim's reproduction module is parameterized by assigning probabilities to each possible clutch size. Reproduction is also stratified by traits. In this case, the maximum clutch size was set to 2, and reproduction rates were varied by stage class, and based on the Barred Owl Nesting Effect trait values. The reproductive rates used in the event are shown in Figure C12. The unperturbed (by barred owls) reproductive rates were obtained from Table 3 of Forsman *et al.* (2011).

**Figure 0-12**. Estimated spotted owl reproductive rates by stage class.




| Births ⇒ Combinations ⇓ | 0 | 1 | 2 | Expected Value |
|---|---|---|---|---|
| Nesting Normal, Stage 0 | 1 | 0 | 0 | 0 |
| Nesting Normal, Stage 1 | 0.95333 | 0.02334 | 0.02333 | 0.07 |
| Nesting Normal, Stage 2 | 0.86533 | 0.06734 | 0.06733 | 0.202 |
| Nesting Normal, Stage 3 | 0.78 | 0.11 | 0.11 | 0.33 |
| Nesting Halted, Stage 0 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 1 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 2 | 1 | 0 | 0 | 0 |
| Nesting Halted, Stage 3 | 1 | 0 | 0 | 0 |

The column headings in Figure C12 correspond to clutch sizes. The rows contain all of the permutations of the two trait values. The right-most column shows the expected values, which, in a females-only model, equal fecundities. Individuals whose nesting has been halted by a barred owl are assigned a 100% probability of having a clutch size of zero. The same is true for stage class 0 individuals. Otherwise, the probabilities of having clutches of size 1 and 2 were set as equal as possible, to whatever value was necessary to produce the fecundity values reported in Forsman *et al.* (2011). Finally, the probability of having a clutch of size zero was set so that each row summed to exactly 1.0.

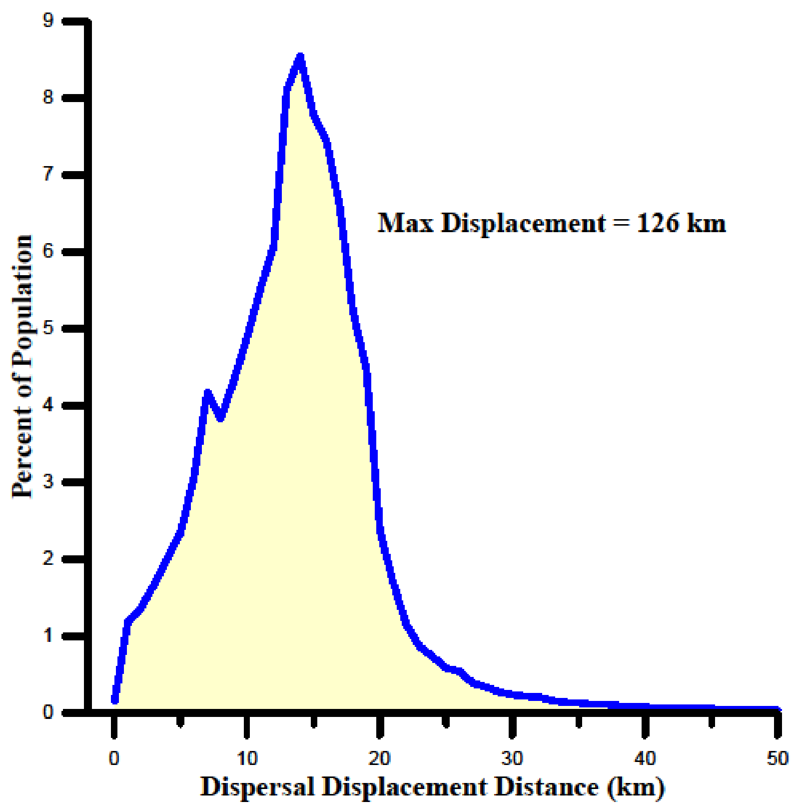
## Floater Creation [Stage 0 Birds]

In HexSim, recruits become a co-owner of their mother's territory. They will disperse from their natal territory when forced to by a floater creation event at the end of Year 1. This floater creation event removes all stage 0 birds from their natal groups. These animals disperse in the next event.

## Movement [Stage 0 Dispersal]

HexSim's movement event controls dispersal and prospecting behavior. Any one movement event may do either or both. This event strictly performs dispersal for stage class 0 spotted owls. The dispersing birds move with moderate auto-correlation until they encounter enough resource that a territory may be constructed (see above). Territory construction does not actually take place at this time. The dispersers are limited to moving 250 km total distance. The birds have a slight repulsion to lower RHS areas of the landscape, but are not prevented from moving into zero-valued hexagons. Figure C13 shows an example of the distribution of simulated dispersal displacement distances produced by this movement event. These data were gathered from five replicate simulations, for years 100-250. The total number of dispersal events in this period was approximately 852,000. The shape of this frequency distribution will change if either the rules for stopping (3 territory-quality hexagons encountered in succession) or the degree of autocorrelation (50%) are modified.

**Figure 0-13**. Distribution of 852,000 simulated Year 1 dispersal distances.



Accumulate [Get Individual Locations]

This event records which modeling region each spotted owl is in. If an individual falls within a demographic study area then this event will captures that information, as well.

Accumulate [Identify Territory Holders]

This event updates a trait that segregates into two classes: floaters and territory-holders.

Transition [Set Barred Owl Presence]

This transition event assigns values to the Barred Owl Presence trait. Each modeling region was assigned a separate barred owl encounter probability, based on field data illustrating the proportion of spotted owl territories on DSAs where a barred owl was documented each year (Appendix B; Forsman *et al.* 2011). Using these probabilities, this event places each territorial spotted owl into one of two classes. The classes indicate whether the spotted owl is exposed to a barred owl or not. Once this determination is made for a specific spotted owl, it is not changed until that spotted owl dies or otherwise leaves the territory. The probabilities that were used are shown in Table C25.

**Table 0-25.** Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

| Region | Encounter Probability |
|---|---|
| North Coast Olympics | 0.505 |
| East Cascades North | 0.296 |
| West Cascades North | 0.320 |
| West Cascades Central | 0.320 |
| Oregon Coast | 0.710 |
| West Cascades South | 0.364 |
| Inner CA Coast Range | 0.213 |
| East Cascades South | 0.180 |
| Klamath East | 0.245 |
| Klamath West | 0.315 |
| Redwood Coast | 0.205 |

Transition [Adjust Barred Owl Presence]

This transition event simply removes the barred owl presence designation from floater spotted owls. This way, if a spotted owl was to give up its territory and leave, it would not retain its barred owl presence / absence designation. In the present scenario territorial spotted owls have perfect site fidelity, so this event has no impact.

Transition [Set Barred Owl Nesting Effect]

This transition event uses the barred owl presence trait to set the value of a barred owl nesting effect trait. This allows spotted owls that are exposed to a barred owl to be placed into a non-nesting category with some probability. As this probability increases from zero, barred owls have an increasingly strong influence over spotted owl nesting rates, and hence reproductive output. In these simulations, the barred owl effect on spotted owl nesting was set to zero.

Movement [Set Home Ranges]

Eight different movement events are used to set home range sizes differently based on modeling region. These movement events only establish home ranges for territorial spotted owls. The home range sizes used are listed in Table C26. Spotted owls acquire resources from their home ranges, and the home ranges for different birds may overlap; territories however, cannot overlap. This results in competition among spotted owls for resources. Spotted owl home ranges were always contiguous, but their shapes were not constrained. The home range sizes used were developed from the published results of many field studies, and were compiled by the modeling team.

**Table 0-26.** Spotted owl home range sizes used in population modeling.

| Region | Home Range Size (in hexagons) |
|---|---|
| North Coast Olympics | 128 |
| East Cascades North | 84 |
| West Cascades North | 84 |
| West Cascades Central | 84 |
| Oregon Coast | 48 |
| West Cascades South | 46 |
| Inner CA Coast Range | 37 |
| East Cascades South | 35 |
| Klamath East | 35 |
| Klamath West | 35 |
| Redwood Coast | 14 |

Accumulate [Acquire Resources]

This "accumulate event" assigns individual spotted owls to a resource class, based on how much resource they acquire from their home ranges. Habitat suitability and quantity, plus competition with conspecifics will dictate what resource class individual spotted owls end up in.

Survival [Stage x Resource x Barred Owls]

The survival event is stratified by stage class, resource class, and exposure to barred owls (which is binary). The survival rates that were used are shown in Table C27. The derivation of these values is discussed in a separate section below.

Census [x 4]

Four census events are used to track the number of spotted owls by stage class, resource class, modeling region, and demographic study area.

**Table 0-27.** Estimated survival rates of spotted owl based on stage class, resource class, and barred owl effect.

| Without Barred Owls | | | With Barred Owls | | |
|---|---|---|---|---|---|
| Stage Class | Resource Class | Survival Rate | Stage Class | Resource Class | Survival Rate |
| Stage 0 | Low | 0.366 | Stage 0 | Low | 0.28 |
| | Medium | 0.499 | | Medium | 0.413 |
| | High | 0.632 | | High | 0.546 |
| Stage 1 | Low | 0.544 | Stage 1 | Low | 0.458 |
| | Medium | 0.718 | | Medium | 0.632 |
| | High | 0.795 | | High | 0.709 |
| Stage 2 | Low | 0.676 | Stage 2 | Low | 0.590 |
| | Medium | 0.811 | | Medium | 0.725 |
| | High | 0.866 | | High | 0.780 |
| Stage 3 | Low | 0.819 | Stage 3 | Low | 0.733 |
| | Medium | 0.849 | | Medium | 0.763 |
| | High | 0.865 | | High | 0.779 |

## Spatial Data

The Baseline HexSim spotted owl scenario uses four different map files. All four maps are static (they do not change with time), and each is made up from 538,395 hexagons arranged in 1430 rows and 377 columns. Individual hexagons are 1000 meters in diameter, and 86.6 hectares in area. The spatial data were developed by sampling raster imagery, using a tool that is built into the HexSim model. The sampling process involves intersecting a grid of hexagonal cells with a raster image, and then computing a per-hexagon mean from a series of weights assigned to the land cover classes present in the raster data.

The habitat map (*MaxEnt 2006 NSO Habitat)* depicts spotted owl RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each pixel was assigned a weight equal to its RHS score. Pixel scores ranged between zero and 97. Thus when the HexSim RHS map was constructed from this raster file, the largest possible hexagon score was 97.00; this upper limit was never realized because each hexagon’s value represented an average of the pixels underneath it. The hexagons in the HexSim RHS map vary between 0.00 and 90.37. Hexagon scores were assumed to be proxies for the value of resources available to NSOs within the hexagon.

The habitat map (*MaxEnt 2006 NSO Habitat)* captures spotted owl resource quality, and was derived from RHS values developed using MaxEnt in Step 1 (see above). In HexSim, each land cover class was assigned a weight equal to its category ID. The category IDs ranged between zero and 97. Thus when the HexSim resource quality map was constructed from this raster file, the best possible hexagon score was 97.00; this upper limit was never realized because each hexagon's value represented an average of the pixels underneath it. The hexagons in the HexSim resource quality map vary between 0.00 and 90.37.

A map delineating the study area (*Excluded Hexagons)* was binary, with ones being assigned to each hexagon within the range of the spotted owl, and zeros elsewhere. Simulated spotted owls were not allowed to move into hexagons that were zero-valued in this map. This map included boundaries to the study area, such as the Pacific Ocean and other areas outside of spotted owl's range, or outside our area of inquiry (*e.g.*, the spotted owl's range in British Columbia).

The final two maps depict the locations of the modeling regions and DSAs. The map called *Modeling Regions* breaks the range of the spotted owl up into 11 different regions. This map was used to identify which region individual spotted owls occupied, because each modeling region had different resource requirements and home range sizes. Similarly, a map called D*emographic Study Areas* indicates the locations of 14 different DSAs.

## <u>Survival Rates</u>

The survival event is stratified by stage class, resource class, and exposure to barred owls. To begin with, 9 survival rates (estimated apparent survival) were derived from Table 12 in Forsman *et al.* (2011). Because true adult survival is unknown we made the assumption that apparent adult survival is equal to, or a reliable surrogate for, true adult survival. These rates corresponded to the three oldest stage classes x 3 resource classes. Forsman *et al.* (2011) provided stage class-specific survival estimates for each of 11 DSAs. For each study area and stage class, mean apparent survival values for males and females were provided. We computed the mean of each pair and identified the smallest and largest of these mean values. For any given stage class, the smallest mean value was assigned to individuals in the low resource class. Likewise, the largest stage-specific mean value was assigned to individuals in the high resource class. The stage-specific survival rates for individuals in the medium resource class were set equal to the mean taken over all of the survival estimates present in Table 12 of Forsman *et. al* (2011) for that stage class. Through this process survival rates were obtained for stage 1-3 spotted owls in all three resource classes.

Stage class 0 survival estimates were taken from Franklin *et al*. (1999: 27-28). This is the final report titled "Range-wide status and trends in northern spotted owl populations" that was written after a major workshop held in Corvallis, Oregon, in 1999 to estimate demographic rates of the subspecies. The estimates of juvenile survival rates for three study areas from banding studies were adjusted to compensate for emigration rates, based on radio telemetry studies conducted by Eric Forsman (unpublished data). Mean, minimum and maximum juvenile survival rates were taken from this reference and used in the model. The mean value for Stage class zero was set to the midpoint between the minimum and maximum value.

Finally, survival rates were varied based on the presence or absence of barred owls, and the magnitude of their effect was based on the best meta-analysis model for survival with an additive barred owl covariate across all DSAs from Forsman *et al.* (2011). These values were stratified by both stage class and resource class.

## Evaluation of Model Calibration

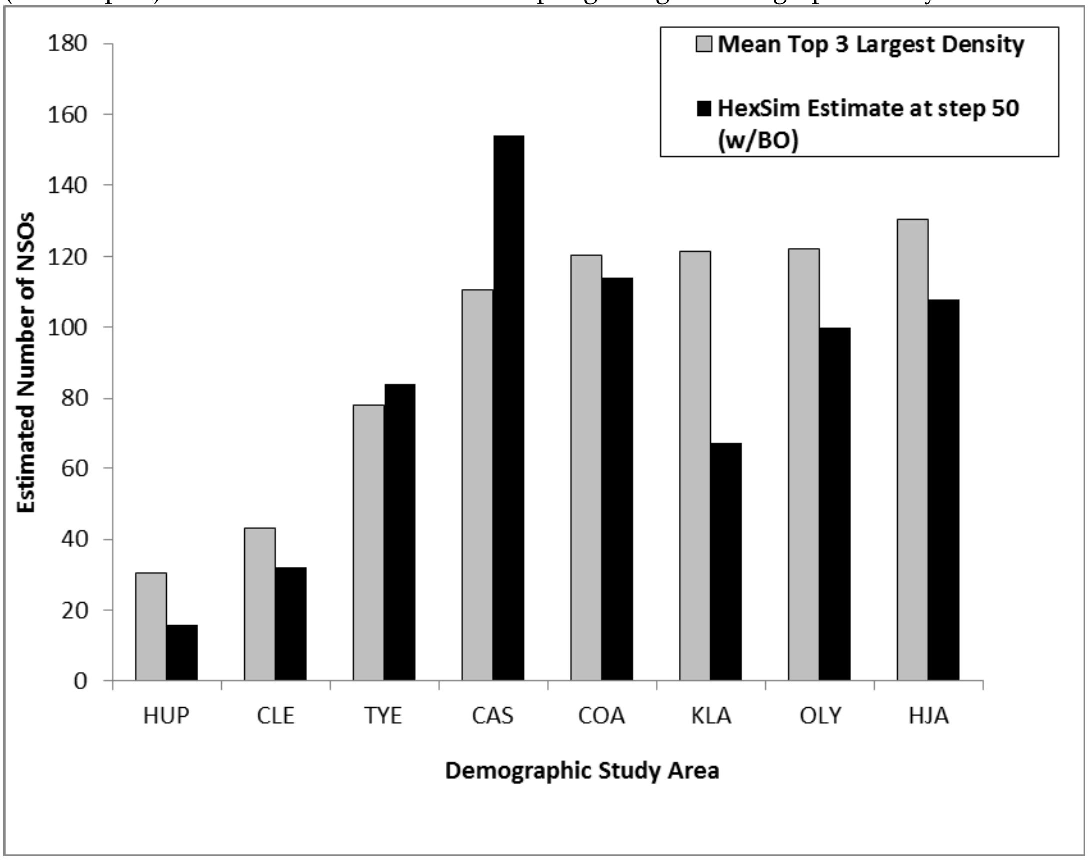
The HexSim model simulated a females-only population of spotted owls throughout their range. The principal metric used to evaluate the model was the simulated population size. The numbers of female spotted owls were tracked range-wide, per modeling region, and also per DSA. The model's performance was assessed by comparing all three measures of simulated population size to field data. We compared simulation year 50 HexSim estimates to field data for 8 DSAs. For this comparison, we used the HexSim simulations during which barred owl impacts were inserted during year (or time-step) 40. After barred owl impacts were incorporated at time-step 40, they remained constant for the remaining 210 time-steps. For these simulations we did not attempt to back-cast barred owl "invasion" dynamics. Our "scenario", therefore, predisposed barred owl impacts to occur all at once, not incremented. We determined by inspection that simulation year 50 most closely represented the present day.
HexSim simulations are stochastic, and to quantify population size, the mean was taken from 5 replicate simulations. Each simulation was 250 time-steps (years) in duration. This does not suggest that spotted owl population sizes were forecasted 250 years into the future. Doing so would at minimum require performing the simulations with a series of maps illustrating habitat changes through time. In contrast, these initial simulations were performed with static data from year 0 to year 40, then (if changes were introduced) changes in barred owl or RHS were introduced and remained static until year 250. The length of the simulations (250 years) simply allowed a steady-state population size and trend to be estimated.

Most, but not all DSAs had data that could be used to approximate density of female spotted owls. Additionally, not all DSAs functioned as "density study areas", and they did not always sample spotted owls identically, nor present data consistently (among DSAs at least). Nonetheless, most DSA annual reports contained tables of historic data which revealed trends. For calibration purposes data from the following DSAs were used: Cle-Elum, Olympic, Oregon Coast, HJ Andrews, Tyee, Klamath, Cascades, and Hoopa. Several calibration iterations were performed by varying resource requirements one modeling region at a time.

Discrepancies in the fit between simulated and observed population size were addressed by varying the resource targets (described above). The resource targets were specified on a modeling-region basis, and they indicated how much resource an individual spotted owl living in a specific region would attempt to acquire. The resource targets were a proxy for resource availability, which varied from region to region and was not fully captured in the RHS maps. As the resource targets increased, individual spotted owl's needs for resources increased. An inability to acquire sufficient resources could cause spotted owls to drop into the lower resource acquisition classes, which would then lower their survival rates.

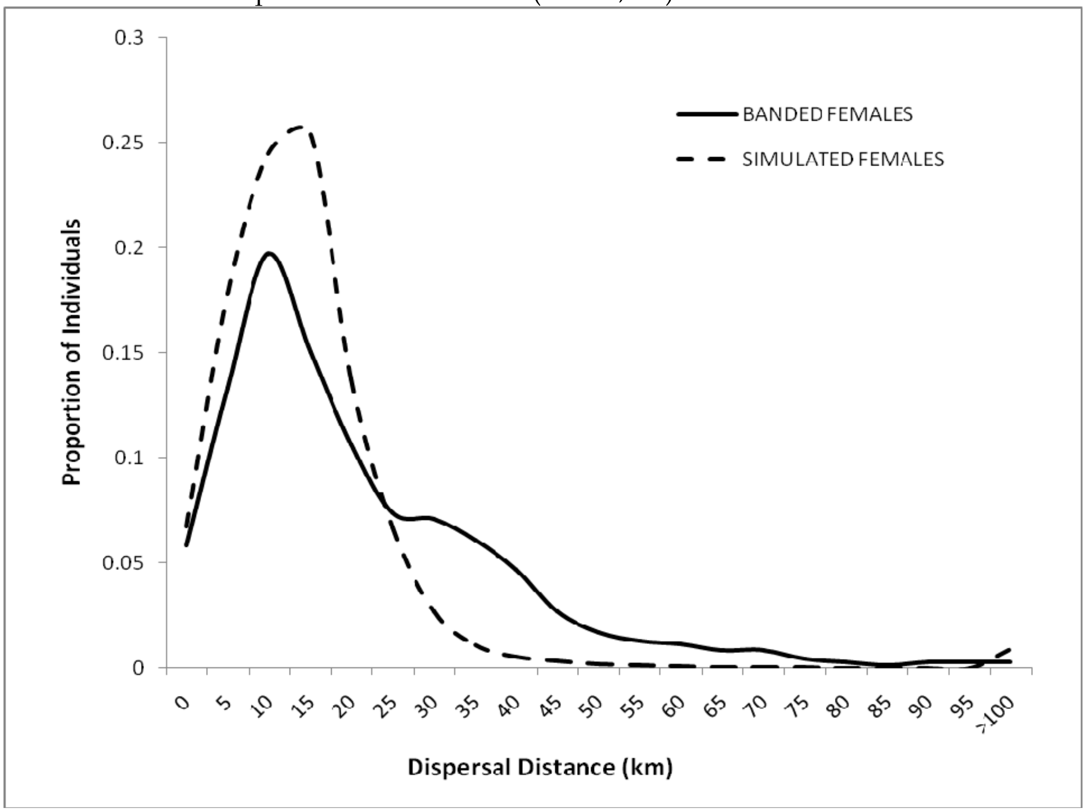
The Baseline HexSim simulations, in which barred owl impacts were introduced at time-step 40, then held static, produced an estimated total female spotted owl population size within the eight DSAs of 675. From field sampling, the total estimated female spotted owls in those DSAs based on the largest number recorded between 1996 and 2006 was 778. The average of the three highest density years from the annual reports (using only data from 1996-2006) for total estimated spotted owl females was 756. The mean of the highest three years (1996-2006) was selected instead of the highest single year in order to reduce the chance that a single year was uncharacteristic of the DSA (Figure C14). Differences in number of female spotted owls on the eight DSAs between those estimated from field sampling and those estimated from our HexSim runs ranged from 5% to 47%, with a mean absolute percentage difference of 26%. Subsequent changes to HexSim did not eliminate these differences.

**Figure 0-14.** Model calibration: Comparison of simulated spotted owl population size (time step 50) to estimates based on field sampling in eight Demographic Study Areas.




Dispersal is a critical process through which landscape structure impacts spotted owl population size and meta-population structure, and is a primary concern in habitat conservation network design (Murphy and Noon 1992). Of particular importance is natal dispersal; the movements of juvenile spotted owls between their natal site and the site where they eventually establish breeding territories. We evaluated the performance of HexSim relative to natal dispersal by comparing graphs of simulated versus observed natal dispersal displacement distances (Figure C15). HexSim generates reports of annual dispersal events by non-territorial (juvenile and floater) spotted owls. The dispersal behavior of the simulated spotted owls was affected principally by landscape structure, the dispersal stopping criteria, and the amount of autocorrelation (both discussed above). Observed natal dispersal distances were estimated from movements of banded spotted owls (Forsman *et al.* 2002).

**Figure 0-15.** Model calibration: Comparison of natal dispersal distances of banded female spotted owls (N= 328) from Forsman *et al.* (2002) to simulated natal dispersal distances for female spotted owls in HexSim (N=850,000).




Because our HexSim spotted owl scenario consists solely of females, we limited the comparison to banded female spotted owls. The distributions of natal dispersal distances for 328 banded female spotted owls were generally similar to 850,000 natal dispersal events recorded during a 250 time-step (years) HexSim simulation. The majority of both observed and simulated dispersal distances were between one and 25 km, however, about 10 % fewer simulated dispersal distances were greater than 10 km and 20% fewer were greater than 25 km.

## Uncertainties and Limitations

An important goal of the spatial population modeling effort is to provide a tool to evaluate and compare the suitability of suites of habitat conservation network scenarios. Each scenario represents a unique ensemble of conditions that could affect future spotted owl population size and trends. The overall amounts of spotted owl habitat, the arrangement of habitat conservation networks, and barred owl influences will vary from scenario to scenario.

Several conclusions about each scenario could be drawn from the HexSim spotted owl simulations. Very specific results, such as estimates of absolute population size, will be the most sensitive to parameter uncertainties. Less specific conclusions, such as the relative differences between scenarios, will be increasingly robust. The HexSim simulations provide, at a minimum, a repeatable methodology for qualitatively ranking the efficacy of the habitat conservation scenarios. This analysis might also extend further, to include a quantification of individual reserve or block carrying capacities, and attendant probabilities of extinction. The conclusions that are drawn from a simulation model must balance concern over uncertainties with the desire to preserve a threatened species.

The HexSim spotted owl simulation model resulted from an attempt to construct the simplest model that could do a credible job of ranking habitat conservation network scenarios. HexSim makes adding realism relatively simple. But more life history detail does not automatically translate into more accurate forecasts. Realism comes at a cost since complex models have larger numbers of parameters, and thus greater data requirements.

There are many details that could be added to the existing HexSim simulation model. Examples include environmental stochasticity, the explicit modeling of spotted owl males (including mate-finding and pairing) and barred owl populations, genetics, disturbance regimes such as fire, etc. Some of these "enhancements" might provide more accurate forecasts of future spotted owl population sizes and probabilities of extinction, and decisions whether to incorporate some of them can be made in the future by model users depending on their specific needs. These enhancements, however, are not necessary in order to reliably rank habitat conservation network scenarios based on their likelihood of facilitating recovery of the spotted owl.

The modeling team considered several enhancements that could be added to the current HexSim spotted owl model. Some enhancements that might be made to the HexSim model are listed below.

## Environmental Stochasticity

Incorporation of environmental stochasticity into HexSim scenarios will be necessary when estimates of population size or extinction probability need to be made. However, the addition of environmental stochasticity is unlikely to change the order in which habitat conservation network scenarios rank (*i.e.*, from least to most likely to recover the spotted owl). Developing a modeling process to determine the rank-ordering of scenarios was the modeling team's primary goal, and environmental stochasticity was left out of these simulations in order to limit the computational burden associated with that analysis. Environmental stochasticity should be added to the HexSim model before it is used to estimate population sizes or extinction rates. At that time, the more variable model could be used to test a subset of the rank-ordering results obtained without environmental stochasticity. Recent research into the effects of variability in climate on spotted owl demographic rates (Glenn *et al.* 2010) suggested adding realistic variation in annual temperature and precipitation would provide an important element of environmental stochasticity into HexSim simulations.

## Effect of relative habitat suitability on reproductive rates

The HexSim spotted owl model links habitat to survival rates through resource acquisition. Individual spotted owls acquire resources from their simulated home ranges, and home ranges with higher RHS values provide greater resources. But home ranges overlap, and competition between spotted owls will lower resource availability. Resource acquisition, because it links landscape structure and intra-specific competition, is a more realistic driver of survival rates than habitat would be on its own. Resource acquisition could easily influence reproduction in exactly the same way that it influences survival. Unfortunately, the most recent meta-analysis (Forsman *et al.* 2011) was inconclusive regarding the role that habitat played in determining reproductive rates. For this reason, the modeling team elected to not vary spotted owl reproductive rates as a function of resource acquisition.

## Effect of barred owls on reproductive rates

The HexSim spotted owl model includes the machinery necessary for barred owl influences to include a lowering of spotted owl reproductive rates. This is done by setting a probability that a spotted owl in the presence of a barred owl will nest. Each year, every affected territorial spotted owl will make an independent nesting decision, based on this probability. However, in the current model, the probability that a spotted owl in the presence of a barred owl will forgo nesting entirely is set to zero.
Modeling team members determined that range-wide empirical estimates were not sufficient to assign region-by-region probabilities for barred owl impacts on spotted owl reproduction. Such impacts could come in several forms. For example, the presence of a barred owl could cause a spotted owl to abandon its territory, to keep the territory but forgo nesting (or calling for a mate), or a barred owl could lower effective spotted owl reproductive rates by interfering with nest-tending or preying on spotted owl offspring.
In order to simulate territory abandonment, it would be necessary to explicitly model barred owl locations across the landscape. But sufficient data on barred owl locations and habitat associations were not available range-wide to permit doing more than setting region-by-region probabilities of barred owl occurrence. Simulating barred owl predation on spotted owl offspring runs the risk of double-counting this impact, since barred owl presence does lower survival rates in the HexSim spotted owl model. As described above, the model is able to simulate a lowering of spotted owl nesting rates (when in the presence of a barred owl). But sufficient data was not available range-wide to do more than speculate on the associated parameter values.

## Interaction between habitat and barred owl effect

By incorporating the barred owl into the spotted owl scenario as a dynamic spatially explicit stressor, the influence of habitat on barred owl presence and barred owls effects to spotted owl occupancy (extinction rates), recruitment and survival could be more realistically simulated. While there is new information suggesting that habitat and barred owl effects may interact, the data necessary to develop reliable models of barred owl habitat suitability (and subsequently, distribution) are not available. For this reason, the modeling team elected not to attempt this. Moreover, outcomes of modeling region-specific simulations suggest that the current barred owl parameterization is realistic; low to intermediate barred owl encounter probabilities act to depress spotted owl populations but do not result in extinction.

## Sensitivity analyses

When the HexSim spotted owl model is used to make estimates of population size, or probabilities of extinction, it will be necessary to also conduct a sensitivity analysis. The modeling team has conducted some work on a traditional sensitivity analysis. Whereas a traditional sensitivity analysis is focused on making small changes to individual parameter values, it would be instructive to complement this work with an assessment of the consequences of varying elements of the model structure itself. Examples of model design elements that might be varied include the lack of direct effects of resource acquisition on reproductive rates, the number of resource acquisition levels being simulated, and some of the behavioral features associated with dispersal and prospecting.

The most important parameters in any model of the spotted owl are going to be the survival and reproductive rates. The rates used in the HexSim survival and reproduction events have been derived from the most recent compendium of spotted owl field data (Forsman *et al.* 2011). Still, some uncertainty is introduced when these survival data are used to assign rates to spotted owls in three different resource acquisition classes, as that process involves extrapolation. We therefore elected not to use a larger number of resource acquisition classes. Likewise, the impact of barred owls on spotted owl reproduction is not perfectly understood, and certainly varies from region to region (as we represent in the HexSim scenarios).

One element of realism that the modeling team deemed necessary for this analysis was ensuring that the simulated spotted owls' home ranges and resource requirements varied by modeling region. The variation in home range size is supported by much published information (see review in Schilling 2009). The variation in resource requirements was used to account for regional differences in resource availability that were not captured in the MaxEnt resource map. In areas where the resource availability was known to be lower, spotted owls were assigned a higher resource requirement. The resource requirements were used as a fitting parameter that made it possible to adjust regional population sizes independently.

The HexSim spotted owl model described here is simple, but not overly so. It is likely the most realistic spatially-explicit individual-based spotted owl simulation that has been developed to-date. Its design and complexity mirror what is being asked of it. Additional complexity may be added at a future time as needed to meet the goals that accompany other planning exercises.

**Testing Modeling Process Applications – Using the HexSim Spotted Owl Scenario model to compare the demographic effectiveness of various habitat conservation network scenarios and other recovery strategies:**

For the Revised Recovery Plan, the modeling team's objective was to develop and test a modeling framework (Steps 1-3) that would support a wide variety of recovery actions, including evaluation of habitat conservation network scenarios. To facilitate the implementation of recovery actions contained in the Revised Recovery Plan, the modeling team established a process for developing scenarios and conducted preliminary population simulations to compare a sample of habitat conservation network scenarios in order to test the modeling framework's reliability. The results from these preliminary comparisons were necessary in order to obtain feedback on the overall framework and provided the basis for revisions to the HexSim model. This objective was completed as part of the recovery planning process. The following evaluation consists of the actual comparison of simulated spotted owl population responses among many alternative scenarios representing various recovery strategies and habitat conservation networks.

**Development of Scenarios for Evaluation and Comparison in HexSim**

An important use of the modeling framework is to simulate spotted owl population performance relative to three primary sources of variation: size (area) and distribution of habitat conservation networks; trends in habitat conditions inside and outside of the habitat conservation networks; and trends in the influence of barred owls. Considering the many possible variations in network designs, land ownership limitations, future habitat trends, and barred owl effects that could be evaluated, it is clear the number of scenarios needed to evaluate all of the possibilities could increase rapidly and become unfeasible. Instead, the modeling team developed an iterative process for evaluation of scenarios; establishing broad sideboards in earlier comparisons, then testing the models' sensitivity to habitat conditions and barred owl effects. The HexSim spotted owl model can also be used to evaluate the response of spotted owl populations to future climate scenarios.
To test the modeling framework's ability to evaluate the influence of habitat conservation network size (area) and spatial distribution on spotted owl population performance, we analyzed a subset of 10 habitat conservation network scenarios from Step 2 representing a wide range of

sizes (proportions of "habitat value"), as well as existing habitat conservation networks (Table C28).

**Table 0-28**. Initial set of habitat conservation networks evaluated in population modeling Rounds 1-3.

| Network **scenario** | **Code** |
|---|---|
| **Northwest Forest Plan Reserve Network** | **NWFP** |
| **Managed Owl Conservation Areas** | **MOCA** |
| **1992 Critical Habitat** | **1992CH** |
| **2008 Critical Habitat** | **2008CH** |
| **30% Zonation (All Lands Available)** | **Z30all** |
| **50% Zonation (All Lands Available)** | **Z50all** |
| **70% Zonation (All Lands Available)** | **Z70all** |
| **30% Zonation (Public Lands Only)** | **Z30pub** |
| **50% Zonation (Public Lands Only)** | **Z50pub** |
| **70% Zonation (Public Lands Only)** | **Z70pub** |

Maps depicting each of the network scenarios listed above are available at: http://www.fws.gov/oregonfwo/Species/Data/NorthernSpottedOwl/Recovery/Library/Default.aspx#Files
Once there, click on "maps" and "AppendixCMaps.pdf" The layers can be turned on and off using the "layers" button in the upper left-hand corner.
The habitat conservation networks listed in Table C28 form the basis for a series of comparisons in the population modeling environment (called Rounds) wherein different environmental conditions such as barred owl effects and habitat conditions are manipulated both spatially and temporally (scenarios). Each habitat conservation network that is subjected to different conditions is termed a habitat conservation network scenario. Rounds simply articulate the specific modifications that are made. The following paragraphs provide descriptions of the scenarios developed by the modeling team, and the results of HexSim runs for the scenarios in Rounds 1-3.

**Interpreting HexSim results:**

Each HexSim simulation run provides estimates of population size at any chosen time period as well as population trend over any range of time steps. Estimates are reported at both range-wide and regional scales. It is important to recognize that the results are intended to allow comparison of *relative population performance* among alternative habitat conservation network scenarios, not predictions of actual population size or trend in the future.

When a HexSim simulation starts, the number of individuals, age class distribution, spatial arrangement of territories, and other population attributes will have values that reflect the model's initial conditions. It takes many years for these artifacts to subside, and thus for the population's stable-state dynamics to become evident. Simulations were started with 10,000 female spotted owls, thus this initial period of transitory dynamics involved a period of rapid (apparent) population decline for the first 25 or 30 time-steps; typically subsiding by approximately time step 50. It is important not to confuse this decline with an observed or predicted loss in spotted owl numbers that has resulted from changing environmental conditions. We could have chosen to begin simulations with many fewer spotted owls than are known to currently exist in the landscape (say 250), and waited many time-steps for them to increase and reach some sort of equilibrium with their simulated landscape. That would have resulted in a rapid (apparent) population *increase*, but again would simply be the transitory dynamics involved with the starting population conditions. The point is that the first 25-30 time steps are not meant to be interpreted, but can be thought of as a "burn-in" period for the simulation whereby the simulated spotted owls equilibrate with the simulated environment.

## Round 1: Baseline (2006) conditions

This was the simple "Baseline" scenario that was used to evaluate parameterization of the HexSim spotted owl scenario. This scenario assumes no change in habitat through time (2006 RHS map); therefore the 10 habitat conservation networks listed above are not compared (because nothing different happens inside and outside of habitat blocks in this scenario). Also, barred owl effects remain constant over time (either at zero or constant at their currently-estimated impacts, beginning at time step 40).

Figures C16 through C18 highlight differences in the relative influence of barred owls among modeling regions. Rangewide, barred owls act to depress spotted owl populations to roughly 50 percent of potential population size without barred owls (Figure C16). However, spotted owl populations in modeling regions with high barred owl encounter rates such as the Oregon Coast Ranges ($P_{BO}$ = 0.710; figure C17) decline rapidly in comparison to modeling regions with low to intermediate barred owl encounter rates such as the Western Klamath ($P_{BO}$ = 0.315; figure C18).

**Figure 0-16**. Results of HexSim Round 1 model runs with five replicates each for "Without STVA" (barred owl) impacts and "With STVA" impacts for the spotted owl's entire geographic range in the U.S. The apparent within-year variation that appears in the figure is a function of an "even-odd" year effect on reproduction that was included in this version of the HexSim model.

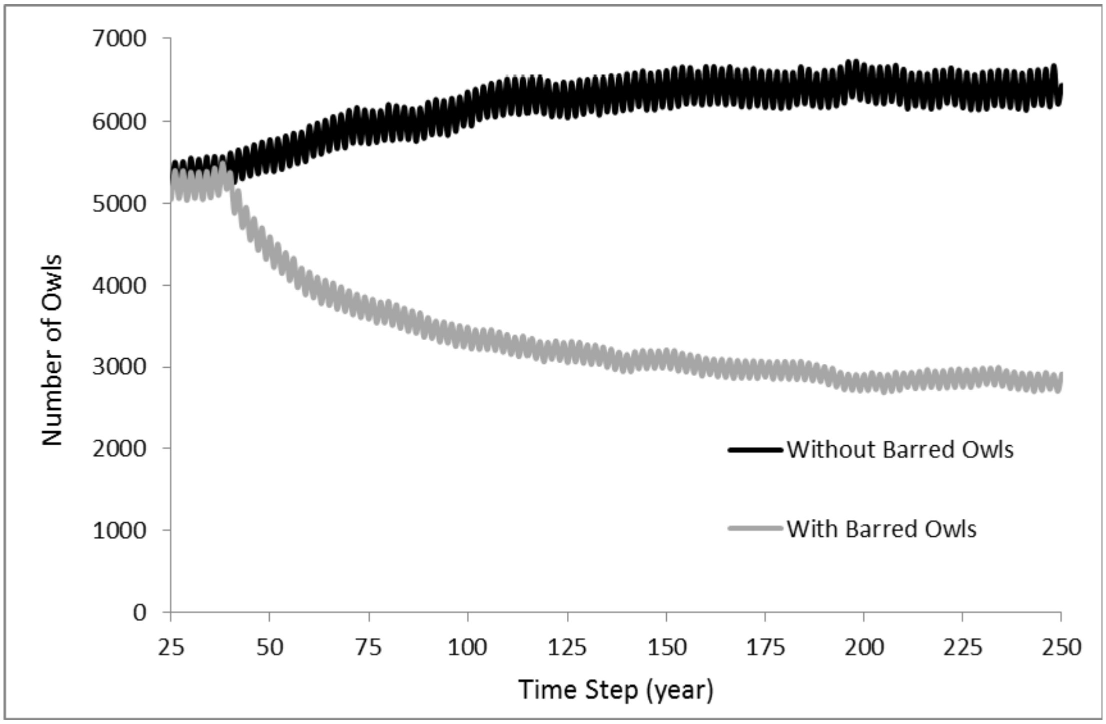



**Figure 0-17**. Simulated Round 1 spotted owl population sizes in the Oregon Coast Ranges modeling region showing 1) current barred owl influence and 2) barred owl influence removed.

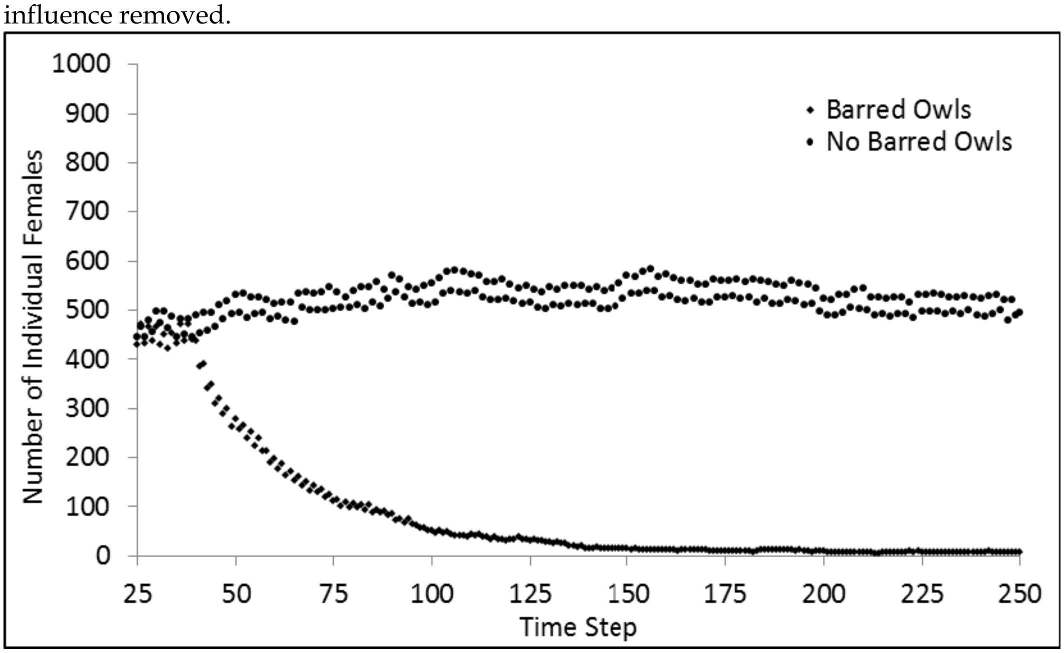
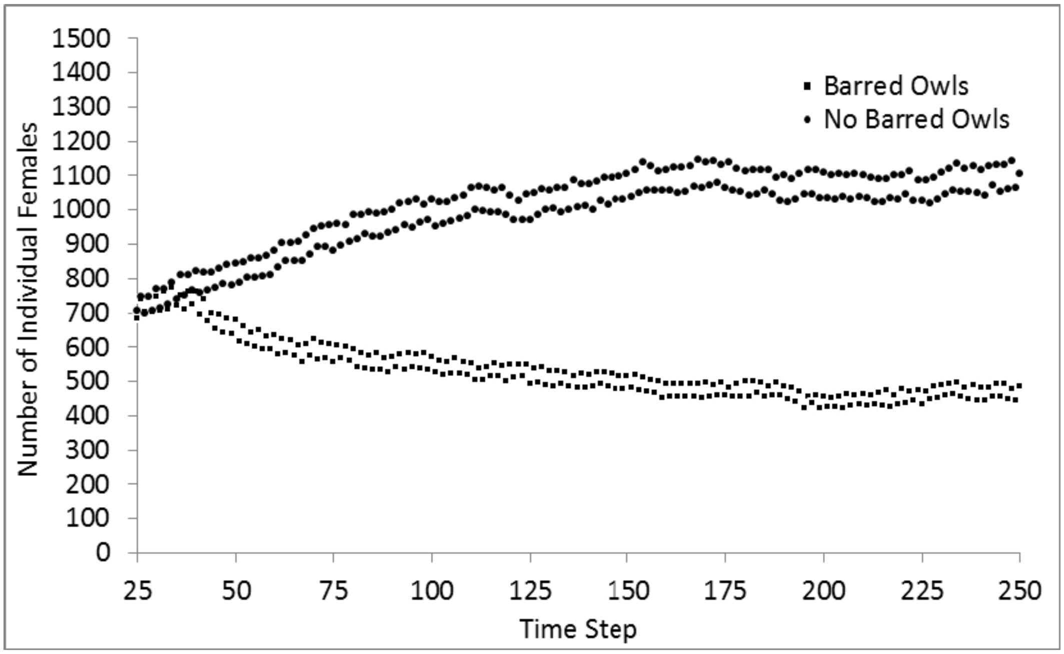


**Figure 0-18**. Simulated Round 1 spotted owl population sizes in the Western Klamath modeling region showing 1) current barred owl influence, and 2) barred owl influence removed.




## Round 2: Simulating a high degree of reliance on habitat conservation networks

Because the primary objective in this evaluation is to compare estimated spotted owl population performance across a range of habitat conservation network, the goal of Round 2 was to "isolate" the habitat conservation networks by devaluing non-network habitat suitability and holding habitat in networks at its 2006 estimated level throughout the simulation. In this scenario, we reduced relative habitat suitability (RHS) *outside* of habitat conservation networks to 34 (RHS=0.34); *just below* that needed for territory establishment; RHS within networks remained unchanged. The influence of barred owls was held to the currently-estimated encounter rates calculated from Forsman *et al.* (2011); the barred owl influence was slotted in at year 40. We repeated Round 2 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance. The results of the Round 2 simulations allow for an evaluation of the relative influence of habitat conservation network size and distribution (relying primarily on public versus both public and private lands) and barred owls on spotted owl population performance – when the habitat conservation network provides nearly all nesting and roosting habitat.

## Round 3: Simulating RA10 - retention of high-value habitat outside of habitat blocks

The goal of Round 3 was to evaluate the relative contribution of habitat conditions ***outside*** of habitat conservation networks to spotted owl populations; Scenarios R3S1 through R3S10 are intended to emulate the management approach of maintaining occupied spotted owl territories outside of network areas . RHS within habitat conservation networks was held constant, and areas of high RHS (>50) *outside* of networks (on public lands) were retained through time. Areas of RHS between 35 and 49 (outside of networks) were decremented to RHS 34. Scenarios R3S11 through R3S20 were similar but apply to *all* non-network lands (public and private). We repeated Round 3 with *No barred owl effect*, to evaluate the relative contribution of habitat and barred owl effects on simulated spotted owl population performance.
Figures C19 and C20 provide examples of different metrics that can be used to compare estimated spotted owl population outcomes among habitat conservation network scenarios, in this case Rounds 2 and 3 described above. Initial results using a wide range of population metrics can provide insights for meeting the recovery criteria established in the Revised Recovery Plan. Comparison of these estimates of spotted owl population performance across the range of scenarios can inform evaluation of habitat conservation networks designed to lead to spotted owl recovery.

Figure C19 provides results for the entire range of the spotted owl, but as described in Round 1 and evidenced in Figure C20, it is important to recognize that population outcomes may differ markedly among modeling regions.
**Figure 0-19**. Comparison of percent population change (rangewide) between year 25 and year 250 under the scenarios in Rounds 2 and 3, with and without barred owl influence. MOCAs and critical habitat were not compared for Round 3.

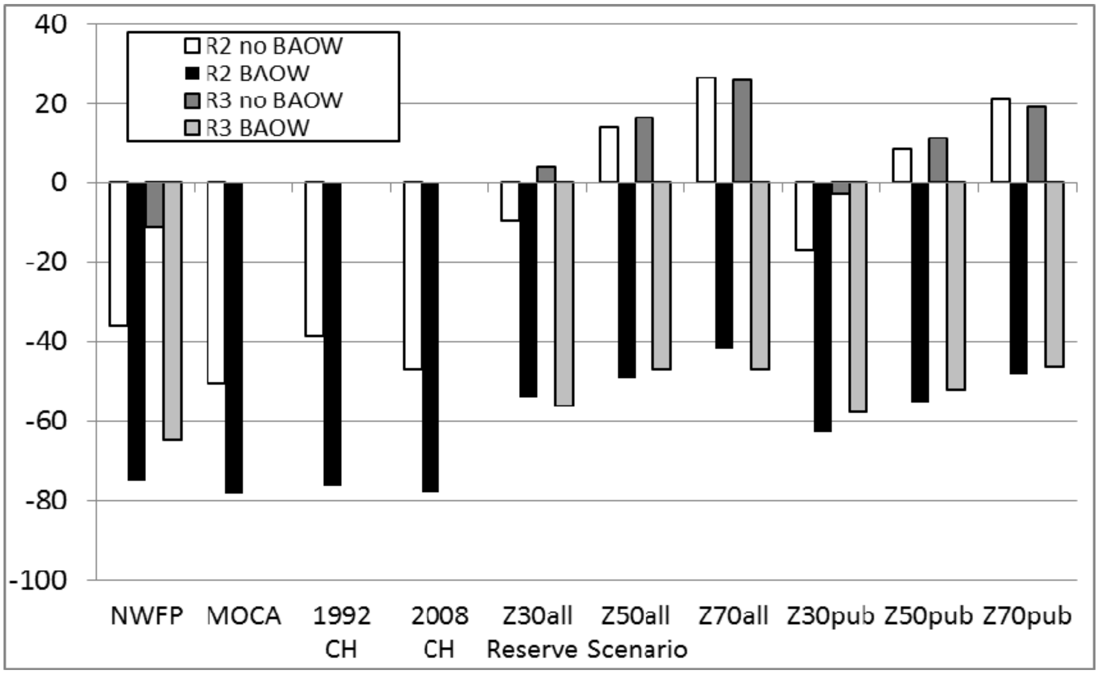
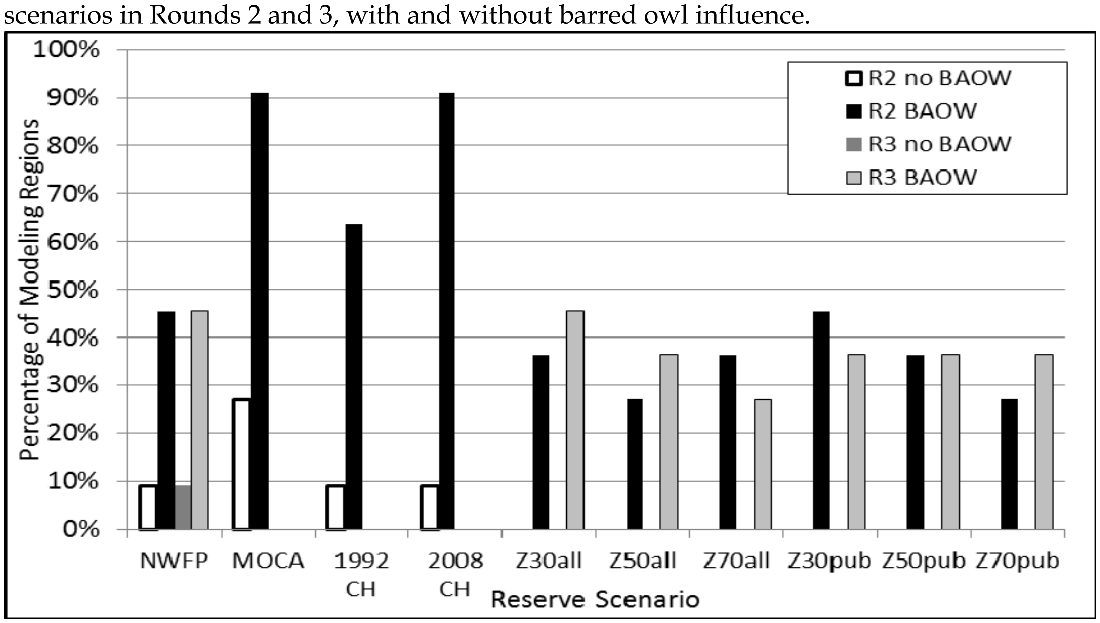



**Figure 0-20**. Percentage of modeling regions whose simulated populations declined by more than 75% between years 25 and 250 (indication of extinction risk) under the scenarios in Rounds 2 and 3, with and without barred owl influence.




The interaction of network size with other conservation measures is highlighted in Figures C19 and C20. In Round 3 (simulated RA10 - retention of likely occupied, high-value habitat with RHS>50 in non-network areas), the amount of habitat "retained" is inversely proportional to the size of area within habitat conservation networks Subsequently, RA 10's benefit to simulated spotted owl populations is relatively less for larger habitat conservation network scenarios such as Z50 and Z70.

## Conclusions:

The analysis presented in this appendix is intended to demonstrate how the three-part modeling framework can be used to evaluate spotted owl population response to a variety of environmental conditions such as habitat variation and barred owls. Although this initial analysis is intended to evaluate the modeling framework, it provides insight into factors influencing spotted owl populations and conservation planning for recovery of the spotted owl.

HexSim population simulations can be completed for the entire range of the spotted owl as well as for subsets of the species' range, such as individual modeling regions or DSAs. This capability enables evaluation of varying environmental conditions and subsequent population effects occurring in different parts of the species' range. For example, the relative effect of barred owls on spotted owl survival and subsequent population size varies among modeling regions, in accordance with different barred owl encounter rates (Table C29). Comparison of the relative differences between simulated spotted owl populations without barred owls and those resulting from different barred owl encounter rates among modeling regions (Figures C17 and C18) suggests there may be barred owl population levels (encounter rates) below which spotted owl populations remain stable (albeit at lower population sizes). Further evaluation of these relationships may inform planning of barred owl management scenarios.

**Table 0-29.** Barred owl encounter probabilities estimated from Forsman *et al.* (2011).

| Region | Encounter Probability |
|---|---|
| North Coast Olympics | 0.505 |
| East Cascades North | 0.296 |
| West Cascades North | 0.320 |
| West Cascades Central | 0.320 |
| Oregon Coast | 0.710 |
| West Cascades South | 0.364 |
| Inner CA Coast Range | 0.213 |
| East Cascades South | 0.180 |
| Klamath East | 0.245 |
| Klamath West | 0.315 |
| Redwood Coast | 0.205 |

As shown in Figure C1, the modeling framework contains feedback loops that facilitate an iterative process, with each iteration informed by the results of previous scenarios and simulated population outcomes. This process enables an adaptive approach to developing and testing conservation measures. As new information from monitoring or other research becomes available, its influence on spotted owl conservation can be incorporated into subsequent evaluations in a consistent manner.

In sum, our goal was to develop a modeling framework that can be applied by interested parties to make better informed decisions concerning spotted owl management and recovery. The analyses described in this appendix represent a small subset of possible scenarios and are presented to test the framework and to give potential users of this approach some preliminary exposure to the models' potential utility. Future conservation planning for spotted owls will require development and evaluation of additional scenarios that are relevant to the management questions of particular interest to various stakeholders. These future planning efforts will likely address temporal factors such as changing barred owl populations, climate change, and future habitat change. They might also apply to private land managers who are evaluating different options within a Habitat Conservation Planning scenario, or Federal land managers who are considering recommendations for amending long-term forest management plans. Whatever the use to which this framework is applied, our goal was to provide managers with tools that will ultimately result in better informed decisions for spotted owl conservation.

# Appendix D

# Preliminary Effects of Areas Considered for Exclusion or Exemption on the Northern Spotted Owl

As part of this draft EA, we must analyze the effects that may be incurred on the northern spotted owl if critical habitat were designated. We have identified certain lands to be considered for exclusion from critical habitat designation under section 4(b)(2) of the Endangered Species Act (ESA). We have also identified Joint Base Lewis McChord to be considered for exemption of critical habitat designation under section 4(a)(3)(B) of the ESA. This draft EA presents our evaluation of the effects on the northern spotted owl of the potential exclusion and exemption of lands identified in the proposed rule as proposed or under consideration for exclusion or exemption from the final designation. For this evaluation, we requested the following information from Fish and Wildlife Field Offices in Washington, Oregon, and California:

1. A summary of the provisions of the HCP, SHA, conservation easement, or other baseline condition in effect at present, specific to the northern spotted owl (e.g., what protections are already provided on the private lands within SOSEAs in Washington, or provided by California State Forest Practice Rules).

2. A description of baseline conditions: -- what are the effects, beneficial or detrimental, on the conservation of the northern spotted owl of the HCP, SHA, conservation easement, or other protection already in place.

3. A description of the additional beneficial or detrimental effects on the owl, if any, as a result of the designation of critical habitat in addition to the existing baseline conditions (what changes would be experienced by the owl as a result of the additional layering of CH on top of existing protections? E.g. would there be a Federal nexus so that there would be additional S7 protections or other regulatory protections? Are there additional education benefits?)

The results of this analysis are presented in the tables below. Tables are arranged by State.

This analysis does not substitute for the comprehensive 4(b)(2) analysis that must be done before deciding whether individual lands may be excluded from critical habitat designation.

## Summary of effects

Below we provide a brief description of conservation provisions for northern spotted owls that may be in place on lands being considered for exclusion or exemption from critical habitat designation (Tables D-1, D-2, and D-3). We further describe how those provisions may affect northern spotted owls, and how a potential critical habitat designation on these lands may further affect owl conservation. The possible effects of critical habitat designation on these lands are varied, but in general, on most lands proposed for exclusion or exemption, critical habitat designation is expected to have a limited to no effect, either beneficial or detrimental, on northern spotted owl conservation. For most lands with existing HCPs or SHAs, the benefit of critical habitat designation is expected to be limited because the property under the existing agreement is already managed with conservation benefits for the spotted owl. Specific benefits of critical habitat designation were described for one HCP (Regli Estates), where re-initiation of section 7 may yield more efficient conservation measures. For lands without an existing HCP or SHA, designation of critical habitat may afford additional benefits to the northern spotted owl, particularly where management is otherwise not directed towards spotted owl conservation. However, these benefits could only be incurred through an adverse modification analysis as part of section 7 consultation, which requires a Federal nexus; for most of these lands, there are limited opportunities for a Federal nexus to occur. Designation of critical habitat on these lands may also be an incentive to partner with the FWS in a conservation agreement. Our analysis suggests that designation of critical habitat, at least in Washington and California, is not an inducement to accelerate harvest because there are State regulations that require avoidance of take of listed species that would still be in place, regardless of critical habitat designation or whether formal conservation agreements are in place.

For the most part, detrimental effects to the owl of designating critical habitat were described as limited to none. For one HCP in Washington (Plum Creek-I-90), there is concern that designation may impede the level of partnership with the landowner. For another HCP that is currently being developed, adding an adverse modification analysis to the section 7 consultation may alter the ongoing negotiations. Some respondents also included information about possible detrimental effects of critical habitat designation on land use management; effects were mostly considered to be limited to none. This was primarily based on the very low likelihood that a Federal nexus would occur, resulting in the requirement to avoid destruction or adverse modification of critical habitat. For one HCP in Washington (Plum Creek – I-90) a concern was raised that a future designation would impose a restriction on the ability of the landowner to sell their property.

Table D-1. Summary of conservation provisions in effect for the northern spotted owl on lands considered for exemption or exclusion from critical habitat designation in the State of Washington. Possible effects of critical habitat designation on the northern spotted owl are also described.

| Area proposed or considered for exclusion or exemption | Summary of provisions specific to conservation of the northern spotted owl | Effects of existing conservation provisions on northern spotted owl | Additional effects, beneficial or detrimental, of critical habitat on northern spotted owl conservation |
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| Joint Base Lewis McChord Integrated Natural Resource Management Plan. Area considered for exemption. (14,330 ac) | The current INRMP identifies management objectives for the conservation of the northern spotted owl. Specifically, the INRMP specifies the objective of managing JBLM forests to develop spotted owl habitat characteristics, and indicates desired conditions of the forest to provide for nesting, roosting, foraging and dispersal habitat (INRMP 2007, p. 3-18). It is the only significant Federal ownership in this region of Washington, and it provides the largest contiguous block of forest in this area as well. The potential development of suitable owl habitat at JBLM provides one of the only feasible opportunities for establishing connectivity between owl populations in the Olympic Peninsula and the western Cascades Range. | Limited as northern spotted owls are not currently known to occupy JBLM. The plan is intended to produce conditions that will provide for nesting, roosting, foraging and dispersal of the northern spotted owl across JBLM. | **Detrimental Effect of CH Designation**: None. May require additional consultation for military and forest management activities. Base has previously been CH and gone through consultation process. No changes or effects to mission/training expected.<br><br>**Beneficial Effect of CH Designation**: Limited. The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No, all other Federal actions that may affect the listed species would still require consultation under section 7(a)(2) of the Act, and we would review these actions for possible significant habitat modification in accordance with the definition of harm referenced above. JBLM also has own regulations to protect listed species and their habitat. |

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| Port Blakely Tree Farms SHA, Landowner Option Plan, Cooperative Habitat Enhancement<br>(421 ac) | In the SHA, Port Blakely agrees to implement enhanced forest management measures that would create potential dispersal habitat for the northern spotted owl and marbled murrelet, such as longer harvest rotations, additional thinning to accelerate forest growth, a snag creation program, retaining more down wood than is required by Washington Forest Practices Rules, establishing special management areas and special set-aside areas, and monitoring. | Limited as NSOs do not currently nest on property. The terms of the agreement are intended to produce conditions that will facilitate the dispersal of the northern spotted owl across the Port Blakely ownership. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without SHA. |
| Cedar River Watershed (Seattle City) HCP<br>(3,367 ac) | Mitigation and minimization measures for the northern spotted owl are detailed in Section 4.2.6 of the HCP and summarized as follows: (1) protection of all existing old-growth forest; (2) elimination of timber harvest for commercial purposes in the watershed, including within the spotted owl CHU; (3) natural maturation of second-growth forests into mature and late-successional seral stages; (4) restoration thinning of about 11,000 acres, ecological thinning of about 2,000 acres, and restoration planting of about 1,400 acres designed to facilitate structural development of mature forest characteristics in second-growth forest in some areas; (5) removal of 38 percent of existing watershed roads; (6) monitoring and research; and (7) protection from human disturbance (within 1/4 mi) around reproductive site centers with actively nesting pairs. | (1) protection of all documented spotted owl nest sites, all suitable nesting habitat, and reproductive site centers in the watershed; (2) elimination of commercial logging activities (including virtually all log hauling) from the watershed; (3) avoidance of construction and other activities within 1/4 mile of active nests that could disrupt successful nesting; | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The plan supports existing NSO centers on ownership and provided habitat protection within these areas.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |

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| Tacoma Green River Water Supply HCP (3,175 ac) | The Plan sets aside 39 percent of Tacoma's ownership in a natural reserve where no active forest management will take place. Another 35 percent is designated as a conservation zone where limited harvest is used to accelerate development of late seral forest habitat. Roughly 78 percent of Tacoma's land is forested, and two-thirds of this (7,812 acres) is within the Natural and Conservation zones that will be managed specifically to protect, promote, and maintain late-seral forest habitat conditions for spotted owls. | At the time the HCP was approved, there were 16 spotted owl activity centers within 1.8 miles of the Upper HCP Area. These represented 15 pairs of spotted owls (10 with confirmed reproduction) and one single spotted owl of unknown status. Nine of these were within 0.7 mile of the Upper HCP Area and one was within the HCP Area. Restrict removal of habitat within 660 feet of the activity center of any known northern spotted owl pair or resident single. Protection from human disturbance (within 1/4 mi) around reproductive site centers with actively nesting pairs. Positive effect on spotted owls located in the upper portion of the HCP Area as a result of the seasonal and long-term protection of spotted owl nests; retention of late-successional forest in the Natural and Conservation Zones; 70-year rotation ages in the Commercial Zone; and increased retention of snags, recruitment trees, and logs. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The plan supports existing NSO centers on ownership and provided habitat protection within these areas.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| Plum Creek Timber I-90 HCP (33,764 ac) | Plum Creek will maintain target percentages for NRF habitat and maintain 6 - 8 percent of its ownership in the Planning Area as NRF habitat. NRF habitat was deferred from harvest for at least 20 years near key spotted owl sites. 1,300 - 2,300 acres of current NRF and FD habitat will be retained as FD corridors to facilitate dispersal and linkage to additional habitat on PC and Federal lands. 3,100 – 3,700 acres of forestland adjacent to perennial streams will be maintained as spotted owl habitat. Known sites with active spotted owl nests in the Planning Area will receive seasonal protection within a 0.25-mile radius. | Impacts will be minimized by: Plum Creek's Owl strategy, Riparian Management Strategy, and multi-species protection plans; by protecting habitat and deferring harvesting activities adjacent to productive spotted owl nest sites; by maintaining NRF and dispersal habitat outside and within Riparian habitat areas; and by incorporating a dispersal habitat management strategy to allow spotted owls and other wildlife species to disperse across Plum Creek's lands to the habitat available in LSRs and AMAs on Forest Service lands, particularly throughout the I-90 corridor. | **Detrimental Effect of CH Designation**: May impede our level of partnership with permit holder. In addition, CH designation may impose restrictions on their ability to sell property.<br><br>**Beneficial Effect of CH Designation**: Very Limited. The land is being managed to support existing owls and provide demographic support, dispersal, and connectivity to adjacent lands.<br><br>**CH Designation an Inducement to Harvest More?** NO. State take-avoidance measures still in effect, even without HCP. Timber harvest would ensure that additional habitat does not materialize through growth of stands. |

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| West Fork Timber HCP<br>(5,233 ac) | The HCP is designed to develop and maintain owl dispersal habitat across 43 percent of the tree farm. In addition, the HCP provides for leaving at least 10 percent of the tree farm in non-harvest reserves for the next 100 years. | HCP ensures that all forest habitat types and age classes currently on the tree farm are protected or enhanced. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| Scofield Corp. HCP<br>(40 ac) | Provided for mitigation and minimization measures by retaining a buffer of intact NSO habitat, implementing selective timber harvest practices, and placing a perpetual deed restriction on the property permanently prohibiting further timber harvest or tree removal without FWS approval. | Retained owl habitat and approximately 72 percent of the total number of trees after harvest. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited (40 acres). The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| SDS & Broughton Lumber proposed SHA<br>(16,031 ac) | In development. Within SOSEAs all suitable owl habitat within 0.7 mile radius is maintained and over long term further developed. Outside of 0.7 miles will remove some habitat in short term but will be developing habitat in long term. | None, other than those associated with Forest Practices Rule and SOSEAs. | Detrimental Effect of CH Designation: Limited, most will not have federal nexus.<br><br>Beneficial Effect of CH Designation: Supports adjacent identified important habitat.<br><br>CH Designation an Inducement to Harvest More? No. State take-avoidance measures still in effect. |

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| Private lands in SOSEAs<br>(133,895 ac) | The State finalized its owl rule in 1996, which identified ten SOSEAs to complement the protection provided by the Northwest Forest Plan. State and private landowners who do not have their own Habitat Conservation Plan must protect a circle of habitat around an owl site center. Within SOSEAs all suitable owl habitat within 0.7 mile radius is maintained. Within SOSEA's on the Olympic Peninsula, within a 2.7 mile radius, a total of 5,863 acres, if available is maintained. For all other SOSEAs, within a 1.8 mile radius, a total of 2,605 acres, if available, are maintained. | Currently this state designation helps support NSO habitat on non-federal lands. Without it, private lands with no federal nexus would not be restricted from removing NSO habitat based on federal regulations. | **Detrimental Effect of CH Designation**: Limited, most will not have federal nexus.<br><br>**Beneficial Effect of CH Designation**: Supports adjacent identified important habitat.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect. |
| Washington Dept. of Natural Resources State Lands (trust lands) HCP<br>(225,013 ac) | The conservation measures in the HCP for the northern spotted owl were developed to minimize and mitigate for incidental take by providing owl nesting, roosting and foraging (NRF) habitat and dispersal habitat in areas that complement the NWFP. | Covers 1.8 million acres. Provides habitat that makes a significant contribution to:<br><br>Demographic support<br>Maintenance of species distribution<br>Facilitation of dispersal | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| Washington State Parks<br>(104 ac) | No specific measures are available for NSOs. But as species is WA state listed proposed actions consider effects to the species as part of implementation. | Limited value but actions on State Park lands have very little effect. Typical management is compatible with long term conservation for species. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The land supports NSO on adjacent lands.<br>**CH Designation an Inducement to Harvest More?** No. State listed and State take-avoidance measures still in effect. |

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| Washington Dept. of Fish & Wildlife lands (1,752 ac) | No specific measures are available for NSOs. But as species is WA state listed proposed actions consider effects to the species as part of implementation. | Limited value but actions on State Park lands have very little effect. Typical management is compatible with long term conservation for species. | **Detrimental Effect of CH Designation**: None<br><br>**Beneficial Effect of CH Designation**: Limited. The land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State listed and State take-avoidance measures still in effect. |

Table D-2. Summary of conservation provisions in effect for the northern spotted owl on lands considered for exemption or exclusion from critical habitat designation in the State of Oregon. Possible effects of critical habitat designation on the northern spotted owl are also described.

| Area proposed or considered for exclusion | Summary of provisions specific to conservation of the northern spotted owl (examples more likely to come from existing HCPs SHAs) | Effects of existing conservation provisions on northern spotted owl | Additional effects, beneficial or detrimental, of critical habitat on northern spotted owl conservation |
|---|---|---|---|
| **Oregon State Forest Lands (228,733 ac)** | Management varies depending on forest unit and is guided by multi-year, forest management plans that can be modified prior to the designated term of the plan. Management requirements for all State forest lands include:<br>• requiring surveys for spotted owls at known sites prior to timber sale operations;<br>• Maintaining at least a 70-acre core of habitat around known spotted owl activity centers; and<br>• Employing seasonal restrictions for operations near known activity centers.<br>The intent is to have no incidental take of spotted owls by maintaining available habitat of 40 percent within the average home range around known activity centers.<br><br>Additional management for NW Forests including Clatsop, Tillamook, Santiam State Forests include structure based management with these planned landscape proportions:<br>Regeneration 15-25 percent<br>Closed Single Canopy 5-15 percent<br>Understory 30-40 percent<br>Layered 15-25 percent<br>Older Forest Structure 15-25 percent.<br><br>The Elliott State Forest, which is predominantly owned by the Department of State Lands but managed by the Oregon Department of Forestry, has a more simplified structure-based approach than the NW Forests. Landscape target structures include:<br>Advanced structure 30 to 50 percent;<br>Intermediate structure 30 to 60 percent; and<br>Early structure 10 to 20 percent.<br>Designated conservation areas include habitats utilized by northern spotted owls, riparian management areas, and steep, unique and visual lands. Management within conservation areas is aimed at maintaining desired habitat conditions. | Provides some nesting and dispersal habitat across the forested landscape. While limiting harvest at known sites, older forest patches can be redistributed across the ownership while maintaining landscape percentages. In northwestern Oregon, due to limited Federal lands, state lands contain the majority of suitable habitat. | Due to limited Federal nexus, critical habitat designation is not likely to provide any additional effects, beneficial or detrimental. |

Table D-3. Summary of conservation provisions in effect for the northern spotted owl on lands considered for exemption or exclusion from critical habitat designation in the State of California. Possible effects of critical habitat designation on the northern spotted owl are also described.

| Area proposed or considered for exclusion | Summary of provisions specific to conservation of the northern spotted owl | Effects of existing conservation provisions on northern spotted owl | Additional effects, beneficial or detrimental, of critical habitat on northern spotted owl conservation |
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| **California** | | | |
| Forster-Gill SHA (236 ac) | (1) No owls on property; SHA provisions designed to support two NSO activity sites on adjacent property. (2) All harvesting prohibited on a total of 11.2 acres for protection of nest sites on adjacent lands. (3) Remainder of covered land managed so that mean DBH is 12-24" and canopy closure is 60-100 percent. (4) Retention of all snags that do not present a safety hazard.<br>These provisions are also incorporated into a Non-Industrial Timber Management Plan (NTMP) (No. 1-97NTMP-017 HUM) filed with CA Department of Forestry and Fire Protection (Cal Fire). | (1) Harvest prohibitions will support and protect two NSO activity sites on adjacent lands. (2) Stand management provisions will provide long term source of foraging habitat, also in support of NSO on adjacent lands. | **Detrimental Effect of CH Designation**: Possible costs to the owner due of re-initiation of Sec 7 on the SHA.<br><br>**Beneficial Effect of CH Designation**: None. Due of the small size of the property, the only long term benefit that can reasonably be expected is that the land will support NSO on adjacent lands. The property is already being managed to that effect.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| Van Eck Forest Foundation SHA (2,163 ac) | The property is covered land under a Safe Harbor Agreement. The terms of the SHA are also recorded in the easement deed (2001-13236-37) held by the Pacific Forest Trust. Silvicultural systems to achieve land management goals are recorded in the NTMP (No. 1-96NTMP-012 HUM) filed with Cal Fire.<br><br>Specific long term management goals: (1) Mix of dominant conifer tree species. (2) Long term stocking target of 100,000 board feet per acre. (3) Multi-storied canopy, generally no less than 80% cover. (4) Long term age range 1-600 years with 20% over 200 years. (5) Long term average of 15 dominant conifers per acre >= 36" DBH. (6) Retention of all snags that do not present a safety hazard. | Property is currently advanced young-growth conifer forest, mostly dominated by redwood. As of 2008, two or more owls have been detected on the property, but no nesting activity has been observed. Long term implementation of this agreement will eventually provide very high quality nesting-roosting habitat that will support adjacent industrial and non-industrial forest lands. | **Detrimental Effect of CH Designation**: Probable costs to the owner due of re-initiation of Sec 7 on the SHA.<br><br>**Beneficial Effect of CH Designation**: None, this property is already being managed for maximum long term benefit to the NSO.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures are still in effect, even without HCP. |

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| Green Diamond Resource Company HCP (360,870 ac) | The key requirement of the HCP is that take would be contained within the company's estimate of annual displacement of owl pairs by direct and indirect causes. The combined rate was approximately 5 pairs per year. | Uncertain. The HCP was modified in 2007 to permit an additional quantity of incidental take, and that quantity is now nearly exhausted. Based on the company's 2010 HCP review, the company and FWS are re-negotiating the terms of the HCP. | **Detrimental Effect of CH Designation**: Likely substantial costs to the owner due to the increased complexity of the upcoming Sec 7 analysis associated with ongoing re-negotiation of the terms of the existing HCP.<br><br>**Beneficial Effect of CH Designation**: May be possible Federal nexus through water-quality permitting.<br><br>**CH Designation an Inducement to Harvest More?** Not likely. Without ITP coverage, State take-avoidance measures go into effect. In the near term, the current timber market would probably not sustain a substantial increase in harvest level. The company has over 20 years of time and investment in an NSO management program. |
| Humboldt Redwood Company HCP (211,700 ac) | (1) Maintains annual minimum of 108 NSO activity sites on covered land over the life of the HCP. (2) Maintains NSO pairs on 80% of activity sites, calculated by 5-year average. (3) Maintains target reproductive rate of 0.61 fledged young per pair. | HCP standards are designed to support a specified breeding population and breeding rate; i.e., the HCP standards are based on demographic performance. The company is responsible to find remedies if they fall below any HCP NSO standards. | **Detrimental Effect of CH Designation**: Likely costs to the owner due of re-initiation of Sec 7 on the SHA.<br><br>**Beneficial Effect of CH Designation**:<br>Likely no additional benefit. There is limited opportunity for a Federal nexus that would result in additional benefits to the owl that is not already covered under the HCP.<br><br>**CH Designation an Inducement to Harvest More?** Not likely. Without ITP coverage, State take-avoidance measures go into effect. The "light-handed" business model and reputation of the new ownership also argues against over-reaction to CH designation. In the near term, the current timber market would probably not sustain a substantial increase in the harvest level. |

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| Regli Estates HCP (500 ac) | HCP mitigates potential for incidental take of two owl sites on the property. Both owl home ranges extend onto adjacent lands. Measures include following land allocations. (1) Set-aside land for core areas. (2) Land allocated to selection harvest for maintenance of foraging habitat. (3) Grassland areas that were formerly conifer forest will be restored through tree planting. | Maintenance of long term function on two NSO activity sites. | **Detrimental Effect of CH Designation**: Possible costs to the owner due of re-initiation of Sec 7 on the HCP.<br><br>**Beneficial Effect of CH Designation**: Re-initiation of Sec 7 with requirement to avoid "adverse modification" may yield more efficient habitat conservation measures.<br><br>**CH Designation an Inducement to Harvest More?** No. State take-avoidance measures still in effect, even without HCP. |
| Terra Springs HCP (41 ac) | (1) HCP was enacted in connection to the conversion of mixed forest and grassland to a commercial vineyard. (2) Purpose of the HCP was to preserve a portion of the forested habitat near the property boundary that influences an NSO site, No. NP033, on adjacent land. (3) HCP requires retention of 30 acres of suitable nesting-roosting habitat, and 11 acres of suitable foraging habitat, which is accomplished. (4) HCP also requires a deed restriction, in perpetuity, on the retained habitat acreage, which is also accomplished. | Protection of 41 acres of suitable nesting-roosting and foraging habitat to support the off-property NSO activity site No. NP033. Terra Springs Co. has shown no interest in active management of the forest land on their property. | All HCP provisions are fulfilled as long as the landowner retains the currently forested land. We foresee no further effect of CH designation on this landownership. |

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| Big River, Salmon Creek, and Garcia River Forests (type of agreement?) (40,293 ac) | Provisions are found in Integrated Resources Management Plans (IRMPs) for Garcia River (2006) and Big River/Salmon Creek (2009). Measures in the IRMPs are recorded in binding arrangements with the following organizations: (a) the easement deed held by The Nature Conservancy; (b) "green" forest certification agreements with The Forest Stewardship Council and the Sustainable Forestry Initiative; and (c) access to carbon credit brokering through the California Climate Action Registry.<br>Primary focus and stated mission of the IRMPs and ownership (The Conservation Fund) is improvement of anadromous fisheries, aquatic resources and public access. Forest management measures include: (1) Near term 40-50% reduction in harvest levels, only generating sufficient revenue to repay State loans for land acquisition, cover annual operating costs and investments in restoration and enhancement programs. (2) Choice of silvicultural systems is heavily weighted to uneven-aged management and the restoration of understocked areas, with some use of thinnings and variable-retention cutting. (3) Build standing forest inventory by setting harvest levels significantly lower than current and future growth rates. (4) Retention of snags and other legacy forest features, subject to safety considerations. | Landbase of all three forests is heavily cutover former industry land, with standing forest inventory heavily skewed to younger age classes. NSO survey history on these lands is sketchy due to lax management by previous owners. The minimal information available suggests that the three properties combined only support on the order of 5-15 NSO activity sites. It appears that the primary mission of forest management is to build up their standing forest inventories. This management direction is highly compatible with long term improvement of existing NSO habitat and is likely to result in the eventual emergence of new habitat from developing forests over the next several decades. | **Detrimental Effect of CH Designation**: Possible costs to the owner from occasional Sec 7 actions on individual projects having federal nexus (e.g., water quality permits).<br><br>**Beneficial Effect of CH Designation**: Possible inducement to the owners to enter into a Conservation Agreement with FWS.<br><br>**CH Designation an Inducement to Harvest More?** Very unlikely. Consideration of adverse modification through infrequent Sec 7 actions not a significant inducement. State take-avoidance measures would still be in effect. The terms of the conservation easement, forest certification, access to carbon markets, and the conservation reputation of TCF all argue strongly against an over-reaction to CH designation. |

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| Usal Forest (type of agreement?) (50,000 ac) | The Usal Forest (owner is Redwood Forest Foundation, Inc.) land acquisition is very recent, but RFFI is on the same managerial trajectory as the TCF lands (Garcia River, Salmon Creek and Big River Forests). RFFI has sold a conservation easement to TCF. RFFI is also developing a management plan to obtain certification from the Forest Stewardship Council. We do not know RFFI's intent regarding carbon credit brokerage, but their developing plan could probably support entry into that market.<br>The in-progress version of the management plan (www.RFFI.org) points to the following forest management measures: (1) Build standing forest inventory by setting harvest levels at or below growth. (2) Transition to uneven-aged silviculture. (3) Retention snags and other legacy forest features, and long term recruitment of those features. | Landbase is cutover former industry land, but with more standing forest inventory of mid-seral age classes than found on TCF lands (Garcia River, Big River and Salmon Creek Forests). There is an extensive NSO survey history done by the previous owner (Campbell Forest Management Group) on up to 22 NSO activity sites. Current management direction to build up standing forest inventory is highly compatible with long term improvement of existing NSO habitat and is likely to result in the eventual emergence of new habitat from developing forests over the next several decades. | **Detrimental Effect of CH Designation**: Possible costs to the owner from occasional Sec 7 actions on individual projects having federal nexus (e.g., water quality permits).<br><br>**Beneficial Effect of CH Designation**: Possible inducement to the owners to enter into a Conservation Agreement with FWS.<br><br>**CH Designation an Inducement to Harvest More?** Very unlikely. Consideration of adverse modification through infrequent Sec 7 actions not a significant inducement. State take-avoidance measures would still be in effect. The terms of the conservation easement, the likely future terms of a future forest certification arrangement and the conservation reputation of RFFI all argue strongly against an over-reaction to CH designation. |

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| Mendocino Redwood Company proposed HCP (232,584 ac) | Multi-species HCP pending. Quantitative NSO objectives: (1) Maintain at least 28 Level-1 (higher breeding productivity) territories and 67 Level-2 (medium breeding productivity) territories during first 60 years of the plan. (2) Increase to 34 L-1 and 80 L-2 territories by year-75 of the plan. (3) Achieve by year-40 of the plan a distribution of NSO territories in each forest inventory block proportionate to potential nesting-roosting habitat. (4) Achieve by year-75 a distribution of territories that exceeds proportional distribution of potential nesting-roosting habitat. (5) Achieve by year-40 a landscape configuration in which 23% of all potential habitat is suitable for nesting-roosting, proportional to the availability of potential habitat in each inventory block. (6) Achieve by year-75 a landscape configuration in which 25% of all potential habitat and 25% of each inventory block is suitable nesting-roosting habitat. | HCP NSO standards operate on three levels: breeding population (objectives 1 and 2), maintenance of owl distribution (objectives 3 and 4), and habitat availability (objectives 5 and 6). The company is responsible to find remedies if they fall below any HCP NSO standards. | **Detrimental Effect of CH Designation**:<br>CH designation would add an adverse modification analysis to the HCP section 7 consultation, incurring additional costs to the landowner.<br><br>**Beneficial Effect of CH Designation:** Not likely. There is a potential for a Federal nexus through water quality permitting, but the typical projects in this category focus on in-stream activities and don't rise to the level of destruction or adverse modification of critical habitat. In the unlikely event of a Federal nexus associated with timber harvests, an adverse modification analysis is unlikely to result in additional conservation measures given existing measures being proposed in the HCP and the current condition of the landscape."<br><br>**CH Designation an Inducement to Harvest More?** Not likely. Without ITP coverage, State take-avoidance measures are in effect. The "light-handed" business model and reputation of the ownership also argues against over-reaction to CH designation. |
| Private lands subject to CA Forest Practice Rules | For each NSO activity site: (1) Administratively defined circular home range of 985.2 acres, 0.7 mile radius. (2) Minimum post-harvest retention of 200 acres of suitable nest-roost habitat in one or more polygons, of which at least 100 acres must be designated core area which encompasses the nest stand or nest site. (3) Minimum post-harvest retention of 300 acres of suitable foraging habitat. (4) Fish and Wildlife Service is designated by Cal Fire as "expert" entity on NSO matters, and reviews all proposed Timber Harvest Plans in the range of the NSO. (5) FWS review encompasses site-specific evaluation and mitigation of noise disturbance hazards. | The actual demographic effect of the take avoidance strategy is unknown, as it is confounded with the effects of the barred owl range expansion. The general impression among knowledgeable individuals is that take avoidance standards have somewhat slowed the rate of NSO population decline. | Private lands not already covered above under conservation agreements that are either existing or in progress occur only in critical habitat subunits RDC-4 and ICC-6. Residential subdivisions, commercially-zoned lands, and individually owned parcels less than 40 ac that are included in mapped subunits are not proposed as critical habitat.<br><br>Within subunits RDC-4 and ICC-6, timber harvesting does not appear to be a common economic activity, although there is the potential for loss of suitable habitat due to encroaching residential, commercial, and agricultural development. However, there is limited opportunity for a Federal nexus to occur to potentially employ additional conservation benefits. |

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| Jedediah Smith, Del Norte Redwoods, and Prairie Creek State Parks, Managed Cooperatively with Redwood National Park | (1) These three state parks do not have any conservation agreements with Fish and Wildlife Service (i.e., HCPs, SHAs), but they are managed cooperatively with Redwood National Park. Part of the co-op arrangement is that the three state parks consult with FWS on their projects. (2) All Sec 7 costs incurred by the state parks are cost-shared with Redwood National Park, but there is some cost to the state. | Undeveloped areas of the State parks may support NSO. Management is characterized by the terms "preservation" or "custodial" or "stewardship." | **Detrimental Effect of CH Designation**: Possible marginal costs to the state parks for additional Sec 7 work on park management projects.<br><br>**Beneficial Effect of CH Designation**: See response to "All Other California State Parks", below. |
| All Other California State Parks | No conservation agreements (i.e., HCP, SHA) with the Fish and Wildlife Service. | Undeveloped areas of the State parks may support NSO. Management is characterized by the terms "preservation" or "custodial" or "stewardship." | **Detrimental Effect of CH Designation**: None apparent.<br><br>**Beneficial Effect of CH Designation**: CH designation may induce the State Parks System to pursue a Conservation Agreement (i.e., HCP, SHA) with FWS for NSO management. This could be helpful for park management issues like trash collection and public education relating to trash disposal, where one underlying problem is corvid predation on NSO eggs and nestlings. |
| California State Forests, Jackson Demonstration State Forest | Sliding-scale habitat retention requirements at four radii around an activity site; 500', 1000', 0.7 mile, and 1.3 miles. At the 0.7 mile scale, similar to private lands in the redwood region that are regulated under state Forest Practice Rules. | The actual demographic effect of the take avoidance strategy is unknown, as it is confounded with the effects of the barred owl range expansion. The general impression among knowledgeable individuals is that take avoidance standards have somewhat slowed the rate of NSO population decline. | **Detrimental Effect of CH Designation**: None apparent.<br><br>**Beneficial Effect of CH Designation**: CH designation may induce Jackson Demonstration State Forest to pursue a Conservation Agreement (i.e., HCP, SHA) with FWS for NSO management. This could be helpful for forest management, and also for public access management issues like trash collection and public education relating to trash disposal, where one underlying problem is corvid predation on NSO eggs and nestlings. |

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| Marin Municipal Water District, Mt. Tamalpais Municipal Watershed (RDC-5) | We are aware of three separate management plans on the MMWD lands: fire management, invasive plants, and biodiversity. There is no timber harvesting in the municipal watershed, and that stands to reason because one of the primary management objectives for MMWD is to minimize sediment delivery to the five water storage reservoirs located within the watershed boundary. There is no public access into the watershed but existing roads receive administrative use. MMWD occasionally seeks water quality permits for road and stream crossing improvements designed to minimize sediment delivery to the reservoirs. | Undeveloped forest and woodland areas of the municipal watershed supports breeding NSOs. Management is characterized by the terms “preservation” or “custodial” or “stewardship.” | **Detrimental Effect of CH Designation**: Possible costs to the owner from occasional Sec 7 actions relating to water quality permits.<br><br>**Beneficial Effect of CH Designation**: In an urbanized county, CH designation may be seen in some quarters as a public benefit that will translate into more public support for the Water District. This might be an incentive for the District to enter into a Conservation Agreement with FWS.<br><br>**CH Designation an Inducement to Harvest More?** Not applicable. |
| Marin County Parks System, Open Space Preserves (RDC-5) | No agreements (i.e., HCP, SHA) with the Fish and Wildlife Service. | Undeveloped areas of the county parks may support NSO. Management is characterized by the terms “preservation” or “stewardship.” | **Detrimental Effect of CH Designation**: None apparent.<br><br>**Beneficial Effect of CH Designation**: CH designation may induce the county park system to pursue a Conservation Agreement with FWS for NSO management. This could be helpful for issues like trash collection and public education relating to trash disposal, where one underlying problem is corvid predation on NSO eggs and nestlings. As with Marin Muni Water District, CH designation could raise the image of the parks system and increase public support. |
| Sonoma County Regional Parks District, Hood Mountain Regional Park (Overlaps ICC-6) | No agreements (i.e., HCP, SHA) with the Fish and Wildlife Service. | Undeveloped areas of the county parks may support NSO. Management is characterized by the terms “preservation” or “stewardship.” | **Detrimental Effect of CH Designation**: None apparent.<br><br>**Beneficial Effect of CH Designation**: CH designation may induce the county park system to pursue a Conservation Agreement with FWS for NSO management. This could be helpful for issues like trash collection and public education relating to trash disposal, where one underlying problem is corvid predation on NSO eggs and nestlings. |