Threats

Loss of Habitat

Historical Levels of Old-Growth/Mature Forest and Rates of Loss

In 1990, the Service estimated spotted owl habitat had declined 60 to 88 percent since the early 1800s (USFWS 1990b). This loss, which was concentrated mostly at lower elevations and in the Coast Ranges, was attributed primarily to timber harvest and land-conversion activities, and to a lesser degree to natural perturbations (USFWS 1990a). Davis and Lint (2005) compared the current condition of forests throughout the range of the species to maps from the 1930s and 1940s and found that, in Oregon and Washington, fragmentation of forests had increased substantially; in some physiographic Provinces, the increase was more than five-fold. However, fragmentation in California decreased, which the authors speculate may be due to fire suppression in fire-dependent Provinces (Davis and Lint 2005).

Current Rates of Loss of Suitable Habitat as a Result of Timber Harvest

Until 1990, the annual rate of removal of spotted owl habitat on national forests as a result of logging was approximately 1 percent per year in California and 1.5 percent per year in Oregon and Washington. Anticipated future rates of habitat removal on BLM lands in Oregon at that time were projected to eliminate all suitable habitat on non-protected BLM lands (except the Medford District) within 26 years (USFWS 1990b).

Since 1990, there have been only a few efforts that have produced indices or more direct estimates of trends or change in the amount of suitable habitat for spotted owls. A recent study (Cohen *et al.* 2002) reported landscape-level changes in forest cover across the Pacific Northwest using remote sensing technology. According to the study, there was "a steep decline in harvest rates between the late 1980s and the early 1990s on State and Federal and private industrial forest lands" (Bigley and Franklin 2004:6-11). Not all forested land is necessarily suitable habitat for spotted owls, so the area of forest that is cut does not necessarily equate to the area of spotted owl habitat removed. However, although these estimates of harvest rates do not translate directly to changes in the amount of spotted owl habitat, they do provide some insight into harvest trends since 1980 (Bigley and Franklin 2004).

The trend analysis for habitat of the spotted owl conducted by the Service (USFWS 2004a) and reported in Bigley and Franklin (2004) indicated an overall decline of approximately 2.11 percent in the amount of suitable habitat on Federal lands as a result of range-wide management activities from 1994 to 2003 (Table B1). This rate of loss is lower than the 2.5 percent-per-decade estimate of habitat loss resulting from management activities that was predicted in the NWFP (USDA and USDI 1994a). The majority of management-related habitat loss was in Oregon, which contributed more than 75 percent of the habitat removed range-wide (121,735 acres). In particular, the amount of habitat in the Oregon Klamath Province has declined by 6.8 percent (53,468 acres) since 1994, which represents an average annual rate of 0.76 percent (Table B1). The California Cascades Province, where the amount of habitat has declined by 5.77 percent (5,091 acres, which represents an average annual decline of 0.64 percent), is the only other area that has shown a relatively high rate of habitat loss during the 9 years of record. Because this Province has a smaller habitat baseline, it contributes less to the range-wide rate.

Table B1. Summary of lost habitat acres and percent change in northern spotted owl habitat on Federal lands as a result of management activities from 1994 to 2003 (Bigley and Franklin 2004).

Physiographic Province	Forest Plan Baseline (acres)	Management Changes (acres)	Percent Change	Average Annual Rate of Change
Olympic Peninsula	560,217	-87	-0.02	-0.002
Eastern WA Cascades	706,849	-5,024	-0.71	-0.08
Western WA Cascades	1,112,480	-11,139	-1.00	-0.11
Western WA Lowlands	0	0	0	0
OR Coast Range	516,577	-3,278	-0.63	-0.07
OR Klamath	786,298	-53,468	-6.80	-0.76
Eastern OR Cascades	443,659	-13,867	-3.13	-0.35
Western OR Cascades	2,045,763	-51,122	-2.50	-0.28
Willamette Valley	5,658	0	0	0
CA Coast	51,494	-250	-0.49	-0.05
CA Cascades	88,237	-5,091	-5.77	-0.64
CA Klamath	1,079,866	-12,673	-1.17	-0.13
Range-wide total	7,397,098	-155,999	-2.11	-0.23

Raphael (2006) estimates that approximately 7.5 million acres of spotted owl habitat existed on non-Federal lands within California, Oregon, and Washington in 1994 (Table B2). Cohen *et al.* (2002) reported that, from the early 1970s through the mid-1990s, the harvest rates on private industrial lands were consistently about twice the average rate of harvest on public land. "In the late 1980s and early 1990s the harvest rate was estimated at 2.4 percent per year for private industrial land. An increase in non-industrial private landowner's harvest rates started in the 1970s when the rate was 0.2 percent per year and continued to increase to the early 1990s when the rate was similar to that of the private industrial lands" (Bigley and Franklin 2004:6-11). Again, these estimates can only be used to infer rates of forest removal on Federal and non-Federal lands and may or may not translate into the same comparisons with respect to habitat loss (*i.e.,* the harvest may not have removed spotted owl habitat). The estimates may also provide some insight into the potential differences in the rates of habitat loss on different land ownerships (Bigley and Franklin 2004). Raphael (2006) estimates that, since 1994, losses of spotted owl habitat from non-Federal timber harvest have far outpaced losses from Federal land, with the range-wide loss at 8.0 percent (12.0 percent in Washington, 10.7 percent in Oregon, and 2.2 percent in California).

Table B2. Estimated amount of spotted owl habitat[a] at the start of the Northwest Forest Plan (baseline) and losses owing to regeneration harvest from 1994 to 2004, by State and ownership (adapted from Raphael 2006).

Land class	Baseline (1994) (thousands of acres)	Harvest (thousands of acres)	Percent change 1994-2004
Federal reserved			
Washington	1964.5	0.4	0.02
Oregon	3002.5	1.6	0.05
California	1754.4	0.9	0.05
Range-wide total	6721.4	2.9	0.04
Federal non-reserved			
Washington	531.4	3.2	0.6
Oregon	1944.4	15.7	0.8
California	1104.8	4.1	0.4
Range-wide total	3580.6	23	0.6
Non-Federal			
Washington	1748.3	209.6	12.0
Oregon	2906.0	310.6	10.6
California	2910.7	63.3	2.2
Range-wide total	7565.0	583.5	7.7
Range-wide total	17,867	609.4	8.34

[a] See Davis and Lint (2005) for methods of defining habitat suitability (HS).

Raphael (2006) conducted a different analysis of habitat loss, this time looking solely at losses due to regeneration harvest. His analysis estimates that nearly

3,000 acres of higher-suitability spotted owl nesting habitat (see Davis and Lint 2005) were harvested on Federal reserved and nearly 26,000 acres of such habitat were harvested on non-reserved lands between 1994 and 2004. This represents less than 1 percent of the over 10 million acres of higher-suitability spotted owl nesting habitat believed to have existed in 1994.

Current Rates of Loss of Suitable Habitat as a Result of Natural Events

Habitat loss resulting from natural events in the 10-year period from 1994 to 2003 was 224,041 acres, which equates to a 3.03 percent decline in available habitat range-wide (USFWS 2004a). Most natural loss of habitat resulted from wildfires (75 percent of natural event losses), followed by insects and disease (25 percent). Very little loss from wind throw was reported (Table B3).

Table B3. Federal habitat lost resulting from natural disturbances from 1994 to 2002 (acres).

Physiographic Provinces	Fire	Wind	Insects and disease	Provincial total	Percent change	Annual rate of change
Olympic Peninsula	-299			-299	-0.05	-0.01
Eastern WA Cascades	-5,754			-5,754	-0.81	-0.09
Western WA Cascades			-250	-250	-0.02	-0.002
Western WA Lowlands				0	0	0
OR Coast Range	-66			-66	-0.01	0
OR Klamath	-117,622			-117,622	-14.96	-1.66
Eastern OR Cascades	-4,008		-55,000	-59,008	-13.30	-1.48
Western OR Cascades	-24,583			-24,583	-1.20	-0.13
Willamette Valley				0	0	0
CA Coast	-100			-100	-0.19	-0.02
CA Cascades				0	0	0
CA Klamath	-15,869	-100	-390	-16,359	-1.51	-0.17
Range-wide total	-168,301	-100	-55,640	-224,041	-3.03	-0.34

The effects of wildfire on spotted owls and their habitat vary by location and by fire intensity. Low-severity fires often result in habitat mosaics improving spotted owl habitat, while high-severity fires commonly result in the loss of spotted owl habitat. Mixed-severity fires vary in their impact to spotted owl habitat and may result in delayed mortality of trees, making impacts difficult to determine until well after the fire is over (USFWS 2004a).

Seventy different fires contributed to the loss of habitat as a result of natural disturbances, with the amount of loss from individual fires ranging from 66 to

113,667 acres. Only 14 of 70 fires resulted in losses of suitable nesting and roosting habitat that exceeded 1,000 acres. In general, the Oregon Klamath Province suffered the highest losses of habitat from natural events, all of which were due to wildfire. Ninety-six percent of habitat loss in this Province can be attributed to the Biscuit fire that burned approximately 113,667 acres of habitat on three administrative units of the Rogue River basin in 2002 (USFWS 2004a).

Information on the loss of spotted owl habitat as a result of natural disturbances on non-Federal lands was not available.

This approach estimated 600,000 acres of in-growth per decade on Federal lands, representing about an 8 percent decadal increase in forest over 80 years of age on Federal lands relative to the NWFP baseline.

Habitat Recruitment

As with habitat loss, development of suitable habitat contributes to overall trends in habitat availability and distribution. Estimates of late-successional habitat development were calculated at the regional scale using a modeled projection approach (USDA *et al.* 1993; USFWS 2004a). This approach estimated 600,000 acres of in-growth per decade on Federal lands, representing about an 8 percent decadal increase in forest over 80 years of age on Federal lands relative to the NWFP baseline. In reality, projecting the transition of a forest's age and size classes to different levels of habitat function requires extensive field verification. Estimates of late-successional habitat development are approximations to be used on range-wide scales. Given the uncertainty about the rate of complex forest structure development in the stands older than 80 years, it is likely that habitat development was overestimated, although the extent of overestimation cannot be determined (Bigley and Franklin 2004).

Moeur *et al.* (2005) measured the rate of forest stand change in medium and large older-forest classes (defined as containing trees at least 20 inches dbh) on BLM, USDA Forest Service, and National Park Service lands during the first decade following adoption of the NWFP. They estimated the net change in these types of forests (which includes the loss of these forest classes to regeneration harvest and stand-replacing fires) as a gain of 1.25 to 1.5 million acres.

Comparison of Current Rates of Habitat Loss Resulting from Management Activities to Rates in 1990

Average annual rates of the harvest of spotted owl habitat on Federal lands have declined substantially since 1990 (Table B4). Harvest rates on national forests in Oregon and Washington dropped from 1.5 percent (64,000 acres) per year at the time of listing to an average of 0.21 percent (10,341 acres) per year from 1994 to 2003. Harvest rates for spotted owl habitat on national forests in California dropped from 0.6 percent per year (calculated at approximately 4,700 acres) to an average of 0.14 percent (1,653 acres) per year. Harvest rates for spotted owl habitat on BLM lands in Oregon dropped from 3 percent (22,000 acres) per year in 1990 to 0.52 percent (4,911 acres) per year in 2003 (Table B4).

Table B4. Comparison of estimates of the amount of spotted owl habitat annually harvested on lands in the 10-year period prior to the listing of the northern spotted owl with the anticipated and actual rates of harvest of spotted owl habitat after the listing of the spotted owl. Values represent acres, with the average annual percentage in parentheses.

Management Agency and State	Final Listing Document[1]		5-Year Review[2]
	Pre-Listing Period (about 1981 to 1990)[3]	Anticipated Rates (about 1991 to 2000)[4]	Calculated Rates[5] (1994 to 2003)
Forest Service in WA and OR	64,000 (1.5)	39,400 (1)	10,341 (0.21)
Forest Service in CA	Not reported[6]	4,700 (0.6)	1,653 (0.14)
Bureau of Land Management in OR	22,000 (3)	23,400 (3)	4,911 (0.52)
	Total	67,500 (1)	16,905 (0.24)

[1] Habitat change values were presented in the listing document in units of acres per year, rather than as a percentage of total available habitat per year. We converted these values to annual percentage rates by dividing by the habitat amount in the Northwest Forest Plan's baseline for each management agency and geographic group and multiplying by 100 (annual percentage rates in parentheses, indicating negative changes).
[2] USFWS (2004b).
[3] Reported in USFWS (1990b) as observed trends from 1981 to 1990.
[4] Estimated in USFWS (1990b) as trends expected in the next decade (1991 to 2001).
[5] Annual acreage totals calculated as the sum of effects from 1994 to 2003 divided by 9 years of record. Annual percentage rates calculated as described above.
[6] The listing document references a rate of 12,000 acres of habitat loss per year in California, but it was unclear what time period this rate represented so it was not included here.

Disease

WNV has killed millions of wild birds in North America since it arrived in 1999 (McLean *et al.* 2001; Fitzgerald *et al.* 2003; Caffrey 2003; Marra *et al.* 2004). Although birds are the primary hosts of WNV, mosquitoes are the primary carriers of this virus that causes encephalitis in humans, horses, and birds. Mammalian prey may play a role in spreading WNV, if predators like spotted owls contract the disease by eating infected prey (Garmendia *et al.* 2000; Komar *et al.* 2001). One captive spotted owl in Ontario, Canada, is known to have contracted WNV and died (Gancz *et al.* 2004), but there are no documented cases of the virus in wild spotted owls.

Health officials expect that WNV eventually will spread throughout the range of the spotted owl (Blakesley *et al.* 2004), but it is unknown how the virus will ultimately affect spotted owl populations. Susceptibility to infection and the mortality rates of infected individuals vary among bird species (Blakesley *et al.* 2004), but most owls appear to be quite susceptible. For example, eastern screech-owls breeding in Ohio that were exposed to WNV experienced 100 percent mortality (T. Grubb pers. comm. in Blakesley *et al.* 2004). Barred owls, in contrast, showed lower susceptibility (B. Hunter pers. comm. in Blakesley *et al.* 2004). Wild birds may develop resistance to WNV through immune responses (Deubel *et al.* 2001).

Blakesley *et al.* (2004) offer competing scenarios for the likely outcome of spotted owl populations being infected by WNV. One scenario is that spotted owls can tolerate severe, short-term population reductions caused by the virus because spotted owl populations are widely distributed and number in the several thousands. An alternative scenario is that the virus will cause unsustainable mortality because of the frequency and/or magnitude of infection, thereby resulting in long-term population declines and extirpation from parts of the spotted owl's current range.

Inadequacy of Regulatory Mechanisms

The original listing document (USFWS 1990b), Franklin and Courtney (2004), and the 5-year review (USFWS 2004b) noted some inadequacies in existing regulatory mechanisms. The 1990 listing rule concluded that current State regulations and policies did not provide adequate protection for spotted owls; less than 1 percent of the non-Federal lands provided long-term protection for spotted owls (USFWS 1990b). The listing rule stated that the rate of harvest on Federal lands, the limited amount of permanently reserved habitat, and the management of spotted owls based on a network of individually protected spotted owl sites did not provide adequate protection for the spotted owl. If continued, these management practices would result in an estimated 60 percent decline in the remaining spotted owl habitat, and the resulting amount of habitat might not be sufficient to ensure long-term viability of the spotted owl.

When it was adopted in 1994, the NWFP significantly altered management of Federal lands (USDA and USDI 1994a, 1994b; Noon and Blakesley 2006; Thomas *et al.* 2006). The substantial increase in reserved areas and associated reduced harvest (ranging from approximately 1 percent per year to 0.24 percent per year) has substantially lowered the timber-harvest threat to spotted owls. However, the NWFP allows some loss of habitat and assumed some unspecified level of continued decline in spotted owls. Franklin and Courtney (2004) noted that many, but not all, of the scientific building blocks of the NWFP have been confirmed or validated in the decade since the plan was adopted. One major limitation appears to be the inability of the reserve strategy presented in the plan to deal with invasive species. However, this deficiency does not diminish the important contribution of the relevant LRMPs to spotted owl conservation (Franklin and Courtney 2004).

As the Federal agencies develop new LRMPs, they will consider the conservation needs of the northern spotted owl and the goals and objectives of the Recovery Plan. If needed, actions to implement Federal land use plans will be accompanied with either plan or project level consultations to assure management actions align with recovery goals.

Barred Owls

With its recent expansion to as far south as Marin County, California (Gutiérrez *et al.* 2004), the barred owl's range now completely overlaps that of their slightly smaller congener, the northern spotted owl. To what extent the barred owl range expansion is a result of humans altering the environment is unknown (Monahan and Hijmans 2007; Livezey *et al.* 2008). Barred owls appear to be competing with spotted owls for prey (Hamer *et al.* 2001) and habitat (Hamer *et al.* 1989, 2007; Dunbar *et al.* 1991; Herter and Hicks 2000; Pearson and Livezey 2003, 2007). In addition, barred owls have been observed physically attacking spotted owls (pers. comm's in Pearson and Livezey 2003) and circumstantial evidence indicated that a barred owl killed a spotted owl (Leskiw and Gutiérrez 1998).

Barred owls were thought by some to be more closely associated with early successional forests than spotted owls are, based on studies conducted on the west slope of the Cascades in Washington (Hamer 1988; Iverson 1993). However, barred owls throughout North America use, and in some cases, prefer older forest (Pearson and Livezey 2003; Gremel 2005; Schmidt 2006; Hamer *et al.* 2007; Livezey 2007).

The only study comparing food habits of sympatric spotted and barred owls reported that the diets of these two species overlapped by 76 percent (Hamer *et al.* 2001). However, barred owl diets (Livezey 2007; Livezey *et al.* In Press) are more diverse than spotted owl diets (Forsman *et al.* 2004) and include species associated with riparian and other moist habitats, along with more terrestrial and diurnal species (Hamer *et al.* 2001). The more-diverse food habits of barred owls appears to be the reason that barred owls have much smaller home-ranges than spotted owls do (Hamer *et al.* 2007). Gutiérrez *et al.* (2007:189) stated: "we predict that the barred owl will have negative impacts on the threatened spotted owl through competitive exclusion. **…**Dietary relationships suggest that interference competition would**…**be the mode of this relationship."

Barred owls reportedly have reduced spotted owl detectability (response behavior), site occupancy, reproduction, and survival.

- Olson *et al.* (2005) and Crozier *et al.* (2006) found that the presence of barred owls significantly reduced the detectability of spotted owls during surveys.
- Kelly *et al.* (2003:51) reported that the occupancy of historical territories by spotted owls in Washington and Oregon was significantly lower after barred owls were detected within 0.5 miles of the territory center but was "only marginally lower" if barred owls were located more than 0.5 miles from the spotted owl territory center. In Gifford Pinchot National Forest, Pearson and Livezey (2003) found there were significantly more barred owl site-centers in unoccupied spotted owl circles than in occupied spotted owl circles with radii of 0.5 miles, 1 mile, and 1.8 miles. In Olympic National Park, Gremel (2005) found a significant decline in spotted owl pair occupancy at sites where barred owls had been detected,

while pair occupancy remained stable at spotted owl sites without barred owls. In some areas at least, barred owls appear to be appropriating spotted owl sites in flatter, lower-elevation forests (Pearson and Livezey 2003, Gremel 2005, Hamer *et al.* 2007) and individual spotted owls, apparently in response to barred owls, have moved higher up slopes (Gremel 2005). According to one study, "the trade-off for living in high elevation forests could be reduced survival or fecundity in years with severe winters" (Hamer *et al.* 2007:764). In addition, In Washington State at least, NWFP reserves typically include large percentages of forests in flatter, lower-elevation areas, and these areas are supporting many barred owls. For example, throughout one Ranger District of the Gifford Pinchot National Forest in 2006, there were 34 percent more barred owl sites (n = 94) than spotted owl sites (n = 70) in reserves set aside by the NWFP, whereas in non-reserves there were 33 percent more spotted owl sites (n = 79) than barred owl sites (n = 53; Pearson and Livezey 2007). It is unknown: whether this slope/elevation tendency found in two study areas in Washington is prevalent throughout the range of the spotted owl, how long spotted owls can persist in landscapes where they are relegated to only steep, higher-elevation areas, and whether barred owls will continue to move upslope and eventually supplant the remaining spotted owls in these areas. Olson *et al.* (2005) found that the annual probability that a spotted owl territory would be occupied by a pair of spotted owls after barred owls were detected at the site declined by 5 percent in the HJ Andrews study area, 12 percent in the Coast Range study area, and 15 percent in the Tyee study area.

- Olson *et al.* (2004) found the presence of barred owls had a significant negative effect on the reproduction of spotted owls in the Roseburg study area located in the central Coast Range of Oregon.
- Anthony *et al.* (2006) found evidence for negative effects of barred owls on apparent survival of spotted owls in two of 14 study areas (Olympic and Wenatchee). They attributed the equivocal results for most of their study areas to the coarse nature of their barred owl covariate. It is likely that the above analyses underestimated the effects of barred owls on the reproduction of spotted owls because spotted owls often cannot be relocated after they are displaced by barred owls (E. Forsman 2006 pers. comm.). The conclusion by Iverson (2004) that barred owls had no significant effect on the reproduction of spotted owls in one study in the western Washington Cascades was unfounded because of small sample sizes (Livezey 2005).

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

Forsman 2004:808). However, at very small population sizes, hybridization between the two owl species could be come a significant issue.

Data indicating negative effects of barred owls on spotted owls are largely correlational and are almost exclusively gathered incidentally to data collected on spotted owls (Gutiérrez *et al.* 2004; Livezey and Fleming 2007). Because there has been no research to quantitatively evaluate the strength of different types of competitive interactions, such as resource partitioning and competitive interference, the particular mechanism by which the two owl species appear to be competing is not known. Competition theory predicts that barred owls will compete with spotted owls because they are similar in size and have overlapping diet and habitat requirements (Hamer *et al.* 2001, 2007; Gutiérrez *et al.* 2007). Limited experimental evidence (Olson *et al.* 2005; Crozier *et al.* 2006), an experiment controlling barred owls (L. Diller pers. comm.), correlational studies (Kelly *et al.* 2003; Pearson and Livezey 2003; Gremel 2005; Olson *et al.* 2005), and copious anecdotal information (Leskiw and Gutiérrez 1998; Gutiérrez *et al.* 2004) all strongly suggest competition through reduction of site occupancy by spotted owls, interference competition, and possible predation. The preponderance of evidence suggests barred owls are exacerbating the spotted owl population decline, particularly in Washington, portions of Oregon, and the northern coast of California (Gutiérrez *et al.* 2004; Olson *et al.* 2005). Although there are few efforts designed to track trends in barred owl abundance, there is no evidence that the increasing trend in barred owls has stabilized in any portion of the spotted owl's range (*e.g.*, Pearson and Livezey 2007; Herter *et al.* 2008), and "there are no grounds for optimistic views suggesting that barred owl impacts on northern spotted owls have been already fully realized" (Gutiérrez *et al.* 2004:7-38).

Loss of Genetic Variation

One possible threat to northern spotted owls is a loss of genetic variation from population bottlenecks which could lead to increased inbreeding depression and decreased adaptive potential. SEI (2008) reviewed a presentation and two unpublished manuscripts, provided by Dr. Susan Haig, on the evidence for genetic bottlenecks in northern spotted owl populations. Using microsatellite markers and a computer program called "Bottleneck," Haig provided evidence of recent genetic bottlenecks at several spatial scales (individual "populations" [demographic study areas], regions, and subspecies). Haig explicitly stated she could not conclude these bottlenecks were the cause for, nor were they necessarily related to, the recently documented declines in spotted owl populations. However, she did present a "cross-walk" of her results with a table depicting the status of northern spotted owl populations from Anthony *et al.* 2006.

SEI (2008) concluded Haig's observed bottlenecks are likely the result of population declines and not the cause of it; they are signatures of something that occurred in the past. SEI (2008) advises the population dynamics of the spotted owl likely will be more important to its short-term survival than will be its genetic makeup, regardless of the evidence for bottlenecks having occurred in the past (Barrowclough and Coats 1985). SEI (2008) stated the data and manuscript results presented by Dr. Haig did not currently warrant re-evaluation of genetic concerns as threats to the spotted owl. Based on this analysis by SEI (2008), this Recovery Plan does not list additional recovery actions to address genetic threats to the spotted owl, although a modification to this conclusion may be warranted at a later time.