Conservation of the Northern Spotted Owl under the Northwest Forest Plan

BARRY R. NOON* AND JENNIFER A. BLAKESLEY†

*Department of Fishery and Wildlife Biology and Graduate Degree Program in Ecology, Colorado State University, Fort Collins, CO 80523, U.S.A., email brnoon@cnr.colostate.edu
†Department of Fishery and Wildlife Biology, Colorado State University, Fort Collins, CO 80523, U.S.A.

Abstract: Development of the Northwest Forest Plan (NWFP) was motivated by concerns about the overharvest of late-seral forests and the effects of intensive forest management on the long-term viability of the Northern Spotted Owl (Strix occidentalis caurina). Following several years of intense political and legal debates, the final NWFP was approved in 1994. Even though the plan evolved with a broad ecosystem perspective, it remained anchored in the Spotted Owl reserve design proposed in 1990. Based on a criterion of stable or increasing populations, a decade later it remains unclear whether the enactment of the NWFP has improved the conservation status of Spotted Owls. The results of intensive monitoring of several Spotted Owl populations for over a decade suggest a continuing range-wide decline even though rates of timber harvest have declined dramatically on federal lands. The cause of the decline is difficult to determine because the research needed to establish cause and effect relations has not been done. One plausible hypothesis is that the owl’s life history greatly constrains its rate of population growth even when habitat is no longer limiting. Since enactment of the NWFP, new threats have arisen, including the movement of Barred Owls (S. varia) into the range of the Spotted Owl, political pressure to increase levels of timber harvest, and recent changes to forest laws that eliminate the requirement to assess the viability of wildlife populations on U.S. Department of Agriculture Forest Service lands. At this time it appears that Spotted Owl conservation rests critically on continued implementation of the protections afforded by the NWFP and the U.S. Endangered Species Act.

Key Words: conservation planning, Northern Spotted Owl Strix occidentalis caurina, Endangered Species Act, timber harvest

Conservación de Strix occidentalis caurina bajo el Plan Forestal del Noroeste

Resumen: El desarrollo del Plan Forestal del Noroeste (PFN) fue motivado por las preocupaciones respecto a la sobreexplotación de bosques de sucesión tardía y los efectos de la gestión forestal intensiva sobre la viabilidad a largo plazo del búho Strix occidentalis caurina. Después de 10 años de intensos debates políticos y legales, el PFN fue aprobado en 1994. Aunque el plan evolucionó con un amplio enfoque de ecosistema, permaneció anclado en el diseño de la reserva para S. o. caurina propuesta en 1990. Con base en un criterio de poblaciones estables o crecientes, una década después no es claro si la promulgación del PFN ha mejorado el estatus de conservación del búho. Los resultados del monitoreo intensivo de varias poblaciones de búhos por más de una década sugieren una declinación continua aun cuando las tasas de aprovechamiento de madera en terrenos federales han declinado dramáticamente. Es difícil determinar la causa de esa declinación porque no se ha realizado investigación para establecer las relaciones de causa y efecto. Una hipótesis plausible es que la historia de vida del búho construye su tasa de crecimiento poblacional aun cuando el hábitat no sea limitante. Desde la promulgación del PFN han surgido nuevas amenazas, incluyendo el desplazamiento de S. varia hacia el área de distribución de S. o. caurina, presiones políticas para incrementar los niveles de cosecha de madera y cambios recientes en las leyes forestales que eliminan el requerimiento de evaluar la viabilidad de poblaciones de vida silvestre en terrenos del Servicio Forestal de E.U.A. En el momento actual, parece que la
conservación de S. o. caurina se basa críticamente en la implementación continua de protecciones otorgadas por el PEN y el Acta de Especies en Peligro de E.U.A.

Palabras Clave: acta de Especies en Peligro, cosecha de madera, planificación de la conservación, Strix occidentalis caurina

Introduction

The Northern Spotted Owl (Strix occidentalis caurina; hereafter, Spotted Owl) has near icon status in the field of conservation biology. No species in the United States has had a greater impact on land-use planning at the landscape scale. The Spotted Owl is the basis of the Northwest Forest Plan (NWFP), which changed management practices on nearly 10 million ha of forested land administered by the U.S. Department of Agriculture Forest Service (USFS) and Bureau of Land Management (BLM). The stage was initially set for a focus on Spotted Owls by the Multiple Use Sustained Yield Act (1960), which extended USFS management responsibilities to include wildlife conservation in addition to timber harvest and watershed protection. The planning emphasis on the Spotted Owl in the NWFP, however, was ultimately triggered by the species “viability” requirement (36 CFR §219.19) in the regulations that implement the National Forest Management Act of 1976 and subsequently by the U.S. Endangered Species Act (ESA) of 1973. The viability requirement specifies that the USFS must provide for viable populations of all native and desired nonnative vertebrate species in the planning area (usually considered the individual national forest).

The scientific, political, legal, and procedural history of Spotted Owl management in the context of the NWFP is reviewed in Marcot and Thomas (1997), Johnson et al. (1999; Thomas et al. 2006 [this issue]), and Thomas (2004). Therefore, we touch only on those components relevant to understanding the scientific basis of plan development for the Spotted Owl. In addition, the U.S. Fish and Wildlife Service (USFWS) recently completed a species status review as required under the ESA. This review relies heavily on a report by Courtney et al. (2004) and a recent meta-analysis of the demography and population trends of Spotted Owl populations within the region covered by the NWFP (Anthony et al. 2004). Our goals here were to review the evolution of conservation planning for the Spotted Owl and to draw from recent status and trend assessments to evaluate the effectiveness of the NWFP in achieving its conservation goals.

Role of the Interagency Scientific Committee

In 1989 the heads of the USFS, BLM, USFWS, and the National Park Service selected a team of biologists, the Interagency Scientific Committee (ISC), to propose a management strategy for the Spotted Owl. The ISC adopted a hypothesis-testing and iterative-map-revision process in the development of a conservation strategy (Murphy & Noon 1992). The process was spatially explicit and incorporated information on nonbiological factors, such as landownership patterns, that act as constraints on an idealized reserve design (Thomas et al. 1990; ISC 1991; Murphy & Noon 1992).

The ISC tested three hypotheses: (1) the finite rate of population change ($\lambda$) is $\geq 1.0$; (2) owls do not differentiate among forest types on the basis of age, structure, or composition; and (3) no decline has occurred in the areal extent of habitat types selected by Spotted Owls. Age-specific estimates of survival and reproduction were available from three demographic studies that allowed hypothesis 1 to be tested. Following an analysis of the stage-projection matrix (Caswell 2001), the first null hypothesis was rejected based on the observation that $\lambda$ was $< 1.0$ from two of the three demographic study areas (Thomas et al. 1990). A 1993 reanalysis of demographic data from 11 study areas resulted in a more convincing rejection of this hypothesis (Burnham et al. 1996). At the time of this reanalysis, however, concerns were being expressed that estimates of $\lambda$ were biased low because of an underestimate of juvenile survival rate (Bart 1995).

The second null hypothesis was that Spotted Owls use forest types in proportion to their availability on the landscape. At the time of listing, all the studies of Spotted Owl habitat use concluded that owls select old forests or younger forests that have retained characteristics of old forests. Studies published since the ESA listing decision provide additional support that habitat selection is significantly nonrandom (reviewed in FEMAT 1993; Noon & McKelvey 1996; Thome et al. 1999; Lint 2005).

Based on data from National Forest and BLM lands in Oregon and Washington, Thomas et al. (1990) tested the third hypothesis and found significant declines since 1940 in the extent of owl habitat. This trend was projected to continue for many decades (Murphy & Noon 1992) unless levels of timber harvest were reduced significantly. Additional data collected since 1990 provide evidence of declines in Spotted Owl habitat in California, and more regionally specific estimates of decline are reported in the draft Northern Spotted Owl Recovery Plan (USFWS 1992). Habitat loss is primarily attributable to timber harvest and wildfire (Courtney et al. 2004; Lint et al. 2005).

Rejection of these three hypotheses was fundamental to the listing of the Spotted Owl as a threatened species
under the ESA in 1990 and subsequent reserve design. Thomas et al. (1990) proposed a series of habitat conservation areas (HCAs) that collectively defined a reserve system for the Spotted Owl. The HCAs, many of which were not entirely suitable habitat, were selected to provide habitat for ≥ 20 pairs of owls (Lamberson et al. 1994) or serve as stepping stones between larger HCAs. Selection of HCAs was based on local population stability, connectivity to neighboring HCAs, redundancy as a form of risk spreading, and constraints of land ownership and natural vegetation patterns (Thomas et al. 1990, 2006; Murphy & Noon 1992). The pattern of land allocations served as the baseline for subsequent planning efforts under the NWFP (FEMAT 1993; Thomas et al. 1993; Thomas 2004).

Northwest Forest Plan

The NWFP applies to approximately 10 million ha of federal lands and includes approximately 90% of suitable habitat within the owl’s range. Of this federal land area, 77% was allocated to reserves with the remainder available for management and timber harvest (Marcot & Thomas 1997). Perhaps most significant for the eventual conservation of owl populations is that the NWFP reduced the projected timber harvest to 2.6 million m³/year from a high of approximately 32.1 million m³/year in the 1980s (Arabas & Bowersox 2004). Specific land allocations under the NWFP relevant to Spotted Owls are shown in Table 1 (USDA Forest Service & BLM 1994a, 1994b).

In one significant way the NWFP has not been fully implemented. The allowable level of timber harvest under the NWFP has not been achieved (Charnley 2006 [this issue]). Timber sales peaked in 1997 at approximately 2 million m³ and declined to approximately 726,000 m³ in 2001 (Thomas 2004). Reduced rates of harvest in the matrix would presumably slow the rate of population decline until some stable amount of suitable habitat remained. In contrast, some of the reserves assumed to contribute to population recovery are being managed for timber extraction more than old-growth recovery (Strittholt et al. 2006 [this issue]). Thus, whether full implementation of the NWFP will provide long-term viability of Spotted Owls under the projected level of timber harvest has not been fully tested and data do not exist to evaluate the functionality of the habitat reserves (see discussion in Lint et al. 2005).

Assessing Population Status and Trends

One requirement of the NWFP is development of a monitoring program to assess changes in population trend and demographic performance and the amount and distribution of nesting, roosting, and foraging habitat (Lint et al. 1999). To estimate demographic rates and the annual rate of population change (λ), standardized mark-recapture methods were implemented (Lint et al. 1999). The analytical methods adopted provide estimates of annual survival, reproduction, and turnover of territorial birds and spatially referenced information on nest site locations (see Franklin et al. [1996] and Raphael et al. [1996] for methods and rationale). Throughout the process of protocol development external peer reviews were solicited.

Age or stage-specific estimates of survival and fecundity are used to parameterize population projection matrices with two to four distinct age (stage) classes and to predict population trajectories assuming constant vital rates (e.g., Lande 1988; Noon & Biles 1990; Blakesley et al. 2001). Estimates of survival rates for Spotted Owls have been based on intensive capture-recapture studies and fecundity rates have been estimated by determining the reproductive outcomes of known-aged birds. For the past 20 years, all Spotted Owl researchers have used common methods of data collection and analysis, which allows comparison across populations and subspecies (Franklin et al. 1996; Raphael et al. 1996; Anthony et al. 2004).

To date, three demographic workshops including data from all researchers studying Spotted Owl demography have been conducted at which independent analysts guided data analyses and interpretation (Anderson et al. 1999). Workshops were held in 1993, with mark-recapture data from 12 study areas (Forsman et al. 1996); in 1998, with data from 15 study sites (Franklin et al. 1999); and in 2004, with data from 14 study sites (Anthony et al. 2004). In the 1993 and 1998 meta-analysis workshops, λ was estimated from the stage projection. Because of concerns over possibly biased estimates of juvenile survival rates, however, the assumption of a stationary population required using a stage projection matrix, a new analytical method based solely on the mark-recapture data (Pradel 1996) was adopted for estimating λ in 2004.

Table 1. Land allocations, area, and percentage of the Spotted Owl’s range included in the allocation under the Northwest Forest Plan (Option 9), including USDA Forest Service, BLM, and national park lands.

<table>
<thead>
<tr>
<th>Allocation</th>
<th>Acres (ha)</th>
<th>Owl range (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congressionally reserved areas</td>
<td>7,320,600 (2,963,000)</td>
<td>30</td>
</tr>
<tr>
<td>Late-successional reserves (LSRs)</td>
<td>7,430,800 (3,007,000)</td>
<td>31</td>
</tr>
<tr>
<td>Managed late-successional areas</td>
<td>102,200 (41,360)</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Administratively withdrawn</td>
<td>1,477,100 (598,000)</td>
<td>6</td>
</tr>
<tr>
<td>Adaptive management areas</td>
<td>1,521,800 (616,000)</td>
<td>6</td>
</tr>
<tr>
<td>Riparian reserves</td>
<td>2,627,500 (1,063,000)</td>
<td>11</td>
</tr>
<tr>
<td>Matrix</td>
<td>3,975,300 (1,609,000)</td>
<td>16</td>
</tr>
</tbody>
</table>
The two estimates of $\lambda$ have distinct interpretations. The projection matrix estimate assesses whether the population of territorial female owls within the study area is replacing itself, assuming the area is geographically closed (i.e., recruitment based only on in situ reproduction). The mark-recapture estimate reflects whether the population of territorial female owls is replacing itself over the period of study (includes both in situ recruitment and immigration). Because analyses were cumulative over time and later analyses supersede earlier analyses, the results reported by Anthony et al. (2004) are most relevant to an evaluation of the effectiveness of the NWFP.

**Current Population Status**

The 14 study areas represented in the 2004 meta-analysis (Anthony et al. 2004) constitute approximately 12% of the range of the Spotted Owl and include data from federal, tribal, private, and mixed private and federal lands. All major forest types occupied by Spotted Owls are represented in these analyses. Eight of the 14 study areas, some with a mix of federal and private lands, constitute the Effectiveness Monitoring Plan for the owl under the NWFP (Lint et al. 1999).

Anthony et al. (2004) used Pradel’s (1996) methods to estimate the annual rate of population change ($\lambda$) in 13 study areas. Values for $\lambda$ ranged from 0.896 to 1.005 and were $<1.0$ on 12 of the 13 study areas. The weighted mean value of $\lambda$ was 0.963 (SE = 0.009), suggesting that populations over all areas declined at about 3.7% per year during the period of study. The weighted mean $\lambda$ for the eight monitoring areas on federal lands was 0.976 (SE = 0.007) compared with a weighted mean of 0.942 for the other study areas. This suggests that Spotted Owls on federal lands within the area of the NWFP declined at a slower rate than elsewhere (Anthony et al. 2004).

The 2004 $\lambda$ estimates were generally lower than those reported in the 1998 meta-analysis. These results may indicate worsening conditions for Spotted Owls or simply reflect statistical variations inherent in population samples. The consistent finding of $\lambda$ values $<1.0$, however, indicates that owls are still declining 10 years after implementation of the NWFP. Continuing declines are not necessarily unexpected. The question remains, however, as to whether the rate of decline is than expected under the first 10 years of the NWFP.

**Causal Factors**

The causes of Spotted Owl declines from 1990 to 2003 are poorly known. Only recently have researchers begun to explore causal models to better understand cause-effect relationships and to seek mechanistic explanations for observed patterns (e.g., Franklin et al. 2000). Within the area covered by the NWFP possible factors contributing to population decline include loss and fragmentation of habitat due to fire and timber harvest on private and federal lands, competitive displacement from suitable habitat due to increasing populations of Barred Owl (*S. varia*), advancing forest succession toward climax fir communities in the absence of fire, and changing weather patterns.

**Habitat Loss and Fragmentation**

When the Spotted Owl was listed as a threatened subspecies, the primary causal factor for its decline was thought to be the loss and fragmentation of late-successional forest (USFWS 1990; Lamberson et al. 1992; McKelvey et al. 1993). In 1990 the USFWS estimated that Spotted Owl habitat had declined 60–80% from its amount in the early 1800s (Federal Register 55:26114). Since implementation of the NWFP estimates of habitat loss and fragmentation have been done by the USFWS (USFWS 2004) and the USFS and BLM (Lint et al. 2005). Precise estimates of habitat trends, however, are not currently available (Strittholt et al. 2006).

Between 1994 and 2003, the USFWS (2004) reported an overall habitat loss from all causes on federal lands within the range of the Spotted Owl of approximately 5% (0.57% per year). This estimate is derived from changes relative to the habitat baseline developed by the NWFP in 1993 (FEMAT 1993). (Similar estimates have recently been published by Lint et al. [2005].) Of this total, about 2% is attributable to timber harvest and 3% to natural disturbance events, mostly fire. The most extensive decline (0.76%/year) occurred in the Oregon Klamath Mountains, primarily because of a 40,000-ha fire in 2003. Timber harvest accounted for the removal of approximately 65,000 ha (7,200 ha/year) of suitable owl habitat on federal lands within the NWFP area between 1994 and 2003. This is in contrast to predicted rates of 27,000 ha/year under the projected timber harvest levels of the NWFP (USFWS 2004).

The amount of habitat lost from private lands within this time period is unknown but is estimated to be about twice the average rate of harvest from public lands (Cohen et al. 2002; Strittholt et al. 2006). Additionally, forest succession has occurred and some unknown amount of nesting and roosting habitat may have developed (USFWS 2004; Lint et al. 2005). All the estimates are imprecise, however, and should be interpreted cautiously (Bigley & Franklin 2004). Even given uncertain estimates, it is clear that annual rates of loss due to management activities on federal lands have been considerably less than the rates allowed under the NWFP. Although harvest levels on federal lands from 1994 to 2004 were well below allowable levels, it is unclear whether this pattern will continue.
Since 1993 important advances have been made in our understanding of the relationship between demography and forest habitat structure and landscape pattern. In northwestern forest California Franklin et al. (2000) found that annual survival of territorial owls is positively associated with both the amount of interior old-growth forest and the amount of edge between those forests and other vegetation types. A similar relationship between old-growth forest amount and increased survival has also been reported for the southern half of the Oregon Coast Range (Olson et al. 2004) and for the western Cascades and eastern Siskiyou Mountains of Oregon (Dugger et al. 2005). In contrast, both Franklin et al. (2000) and Olson et al. (2004) found reproductive output to be positively related to the amount of early successional edge habitat. Franklin et al. (2000) hypothesized that in areas where woodrats (Neotoma spp.) are a major component of the diet, the positive effects of edges may be due to increased food abundance. These results suggest that a mixture of early, mid-, and late-seral forests may be best for owl reproduction but that substantial amounts of old-growth forest are needed for high survival rates.

Some general demographic patterns have emerged from these detailed studies and the meta-analyses. That is, reproductive rates generally show extensive annual variation that is strongly related to climatic variation. In contrast, annual survival rate shows little temporal variation, but the spatial variance component is most strongly related to the amount of old-growth forest within the vicinity of the nest or primary roost sites.

**Barred Owl Invasion**

Before the twenty-first century, the range of the Barred Owl was restricted to eastern North America (Mazur & James 2000). For at least the last 80 years the Barred Owl has been expanding its range westward, and it has reached the Pacific Northwest. It is unknown whether the range expansion has been facilitated by anthropogenic landscape change or is a natural phenomenon. The potential impact of Barred Owls on Spotted Owl populations was recognized as early as 1976 (Taylor & Forsman 1976) and was specifically referenced in the Spotted Owl listing decision.

Mechanisms of competition between Barred and Spotted owls may be via aggressive displacement (Hamer 1988) or competition for similar prey species (Herter & Hicks 2000; Hamer et al. 2001; Kelly et al. 2003; Pearson & Livezey 2003). From 1990 through 2003 Anthony et al. (2004) found little evidence for an effect of Barred Owls on Spotted Owl fecundity but did find some indication of an adverse effect on Spotted Owl survival in three study areas in Washington where Barred Owls were most common.

The potential exists for Barred Owls to significantly affect future trends of Spotted Owl populations (Gutierrez et al. 2004). The current range of the Barred Owl almost completely overlaps the range of the Northern Spotted Owl, and recent sightings of Barred Owls in the central Sierra Nevada indicate that they are invading the range of the California Spotted Owl (S. o. occidentalis) as well. Because Barred Owls are thought to be habitat generalists, it has been widely assumed that even if their populations continue to increase, Spotted Owls would find refuge in late-successional forests within the late-successional reserves (LSRs). Pearson and Livezey (2003), however, found that Barred Owls in Washington reached their highest densities within LSRs and areas not subject to timber harvest. It is clear that an assessment of Barred Owl effects on Spotted Owls should become part of the NWFP monitoring program.

**Weather and Prey**

A few researchers have explored the relationship between weather variables (temperature and precipitation) and Spotted Owl demography during various life-history periods (reviewed in Blakesley et al. [2004]). Results have been variable but high precipitation during the early stages of the nesting cycle may depress reproductive success. Franklin et al. (2000) found that climate explains most of the annual variability in fecundity, which suggests habitat variation is weakly related to variation in fecundity. An important finding of this study is that higher-quality habitat may buffer the negative effect inclement weather has on fecundity.

Weather effects, unless they lead directly to physiological stress or mortality, are often mediated through other variables such as prey abundance and prey availability. Only two studies since the NWFP have investigated the relationship between prey abundance and variation in fecundity (Ward et al. 1998; Rosenberg et al. 2003). Neither of these studies found a strong relationship between owl reproductive success and prey abundance. This is in contrast to studies of other forest raptors that often show strong relationships between variations in prey abundance and variations in breeding success (e.g., Doyle & Smith 1994; Korpimäki & Norrdahl 1989; Steenhof et al. 1997).

**Forest Thinning**

Timber management practices that do not retain dominant canopy trees may have adverse effects on Spotted Owl populations. Changes in the amount of suitable habitat due to understory thinning cannot be estimated based solely on remotely sensed data. Extensive forest thinning is part of the Healthy Forest Restoration Act of 2003 and

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is being applied to many regions covered by the NWFP. Conventional thinning in some forest types can reduce the density of northern flying squirrels (*Glaucomys sabrinus*) (Carey 2000), the primary or secondary prey of Spotted Owls in many parts of their range (Forsman et al. 1984, 2001, 2004; Ward et al. 1998). Other thinning methods, however, may accelerate the development of Spotted Owl habitat and benefit prey populations, particularly if snags and large logs are left in the forest stand (e.g., Carey et al. 1999; Wilson & Carey 2000). Forest thinning is expected to increase in the future and is probably desirable in fire-prone forests on the east side of the Cascade Range (Spies et al. 2006 [this issue]). If thinning is restricted to small-diameter trees within 80- to 100-year-old stands, this may accelerate succession to suitable habitat. If, however, “thinning” is extended to include larger-diameter tree classes associated with Spotted Owl territories, habitat quality may be significantly reduced.

**Other Causal Factors**

Other influences on Spotted Owl populations may become more relevant in the future within the NWFP area, including predation by Great Horned Owls (*Bubo virginianus*), West Nile virus, and sudden oak death. At this time little is known about how these factors are affecting Spotted Owl population dynamics, but they are thought to be minor influences (Courtney & Gutierrez 2004).

**Perspectives on the Current Status and Trends**

Based on current status and trend assessments (Anthony et al. 2004; Courtney et al. 2004; Lint et al. 2005), hypotheses 1 and 2 tested by the ISC would still be rejected. The lack of validity of hypothesis 3 is less clear than in 1990. Since enactment of the NWFP, timber harvest rates on federal public lands have declined substantially from their peak in the 1980s, but some local declines are still occurring (e.g., salvage logging following fire in southwestern Oregon). Rates of harvest of owl habitat since 1994 averaged <1%/year (USFWS 2004), and timber harvest in general has been significantly less than that allowable under the NWFP. Harvest rates on private and state lands within the range of the Spotted Owl are poorly known, but they are probably greater than harvest rates on federal public lands (Strittholt et al. 2006). Thus ongoing habitat loss over the last decade on federal lands is largely excluded as a contemporary factor driving population decline on a range-wide scale, although it still may be important for some local populations. Because of life-history constraints that limit rates of population growth (Noon & Biles 1990), however, it is possible that past habitat loss and fragmentation may still be a dominant factor affecting Spotted Owl population dynamics (Anthony et al. 2004).

Based on current population trends alone, it appears that the listing of the Northern Spotted Owl as a threatened species under the ESA is still justified. This was the conclusion reached in November 2004 by the USFWS following their review of the recent meta-analysis (Anthony et al. 2004) and the 2004 status review (USFWS 2004). Given the status of the Spotted Owl and the decision by the USFWS, it is apparent that the management aspects of the NWFP—designated LSRs, riparian buffers, adaptive management areas, and constrained levels of timber harvest in the forest matrix—should remain in place.

Current population trends of Spotted Owls need to be considered in the context of expected trends one decade after enactment of the NWFP. Thomas et al. (1990) argued that populations would stabilize at a lower equilibrium size sometime with the next 100 years. In the interim the expectation was that the rate of decline would slowly decrease as habitat loss was arrested and new habitat regenerated in the HCAs. A substantial time lag was anticipated before population equilibrium would be achieved. Two critical assumptions of Thomas et al. (1990) were that a condition of “no net loss” of suitable habitat would be achieved before crossing an extinction threshold (Lande 1987; Lamberson et al. 1994) and that the conservation areas (HCAs) would eventually be fully occupied by owls (Murphy & Noon 1992). Current data on habitat trends suggest that the first assumption is approximately true on federal public lands (Lint et al. 2005). In addition, most LSRs have achieved approximately 60% suitable habitat (Lint et al. 2005), the target value suggested as necessary by Lint et al. (1999). The second assumption is probably false because of mixed ownership of many designated reserves and because of natural disturbance events.

It is possible that the populations are in the process of recovery. The life-history structure of the Spotted Owl, particularly its low reproductive potential and a delayed age to maximum reproduction, suggests that it would be slow to recover from small population size (Noon & Biles 1990). This interpretation, however, is highly uncertain. Even given multiple long-term studies, the most recent meta-analysis (Anthony et al. 2004) does not allow one to discriminate between the two key, opposing hypotheses: (1) owl populations are slowly declining to a new, positive equilibrium and (2) owl populations have crossed a threshold and are slowly declining to extinction.

**Conservation Implications**

Accelerating recovery of Spotted Owl populations will require a mechanistic understanding of the factors that affect population growth (\(\lambda\)). A key element missing from the NWFP Spotted Owl research and monitoring program is the use of manipulative experiments to better understand cause and effect relationships (e.g., the effects of various silvicultural methods on demography [Noon &
The 2003 BLM settlement agreement (American Forest Resource Council et al., V. Kathleen Clarke, Gale Norton, and Jack Ward Thomas 2005) and recent changes to the rules that implement the National Forest Management Act (Noon et al. 2003; USDA Forest Service 2005), bring into question the future of the NWFP and its role in Spotted Owl conservation. The new National Forest System Planning Rule (USDA Forest Service 2005) eliminates the requirement to maintain the viability of native plants and animals and mandatory requirements to monitor the effects of projects, such as timber harvest, on wildlife populations. The outcome of a recent lawsuit by the timber industry and a settlement agreement reached with the Bush administration could eliminate some protections for Spotted Owls. The agreement requires the BLM to include at least one option in their upcoming land-management plans that would change the objective from recovery of the owl on BLM lands to an objective that "... will not create any reserves on O and C [Oregon and California] Lands except as required to avoid jeopardy under the Endangered Species Act." (U.S District Court 2003:12). These are ominous tidings for Spotted Owls and for protection of species diversity on federal lands in general. Given the importance of the viability rule in the early stages of forest-plan development for Spotted Owls, its absence removes a significant legal requirement. However, NWFP management guidelines and actions affecting Spotted Owl viability remain subject to Section 7(a) of the ESA and, given continued listing, this requirement should assure continued efforts to recover Spotted Owl populations.

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