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Spotted Owls, Barred Owls, and Late-Successional Reserves

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The conservation strategy for federally threatened Northern Spotted Owls (*Strix occidentalis caurina*, hereafter Spotted Owls) in the Northwest Forest Plan (NWFP) (USDA and USDI 1994, Thomas et al. 2006) was based on the assumptions that numbers of Spotted Owls would continue to decline in the short term, especially in areas subject to timber harvest outside of Late-Successional Reserves (LSRs; areas set aside for the conservation of Spotted Owls and other late-successional forest species), and that populations of Spotted Owls in LSRs would be self-sustaining in the long term as forests in LSRs mature (Lint et al. 1999). However, the habitat-based NWFP did not consider competition of Spotted Owls with Barred Owls (*S. varia*; Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005, Olson et al. 2005). In a previous study, we found more Spotted Owl site-centers (the centers of activity for territorial owls) than Barred Owl site-centers in areas with timber harvest and fewer Spotted Owl than Barred Owl site-centers in areas protected from timber harvest in Gifford Pinchot National Forest through 2001 (Pearson and Livezey 2003). Gutiérrez et al. (2004) referenced our results and stated: ''If late successional reserves fail to protect breeding populations of Spotted Owls, then the overall conservation strategy for the species is based on an untenable premise and may similarly fail.'' Noon and Blakesley (2006) also noted our results, stated their hope that Spotted Owls would find refuge from Barred Owls in LSRs, and concluded that it ''is clear that an assessment of Barred Owl effects on Spotted Owls should become a part of the NWFP monitoring program.'' Here we report additional findings through 2006 as an example of part of the monitoring requested by Noon and Blakesley (2006), suggest ways by which the remainder of such monitoring could be accomplished, identify environmental characteristics that may favor Barred Owls or Spotted Owls, and recommend solutions to mitigate potential negative impacts of Barred Owls on Spotted Owls.

Methods

Our study area was the 217 812-ha Cowlitz Valley Ranger District of the Gifford Pinchot National Forest, located on the west slope of the Cascade Mountains in southwestern Washington (Fig. 1). Forested vegetation on the study area was dominated by Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), mountain hemlock (*Tsuga mertensiana*), Pacific silver fir (*Abies amabilis*), noble fir (*Abies procera*), subalpine fir (*Abies lasiocarpa*) and western redcedar (*Thuja plicata*). Small, local areas of deciduous hardwoods (1146 ha) such as bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and black cottonwood (*Populus trichocarpa*) were primarily in riparian areas. The four main forest zones in the study area, with approximate elevation limits, were western hemlock (<914 m), Pacific silver fir (914–1372 m), mountain hemlock (1372–1707 m), and subalpine fir (1707 m–tree line). The study area was composed of 56% forest ≥80 yr old, 29% forest <80 yr old, and 15% non-forested areas (rock, wet-mesic, dry meadow/brush, or water). The NWFP (USDA and USDI 1994) placed all federally administered land within the range of the Spotted Owl into one of many land-use allocations. We categorized the land-use allocations in our study area as either ''reserves'' or ''non-reserves.'' Reserves were Congressionally Reserved Areas (e.g., wilderness areas; 19.7% of study area) and Administratively Withdrawn Areas (e.g., recreation areas; 12.5%), which did not allow any timber harvest, and LSRs (25.2%), which allowed timber harvest either in special circumstances (e.g., wildfire, disease) to maintain late-successional forest characteristics or in forest <80 yr old when conducted to accelerate the attainment of late-successional forest characteristics. Non-reserves were Matrix (22.6%) and an Adaptive Management Area (19.7%), for which timber harvest was planned to meet timber-sale goals, and private inholdings (0.3%). Four LSRs were situated entirely in our study area: Nisqually (20 779 ha), Packwood (18 267 ha), Woods (11 665 ha), and Quartz (3584 ha). In addition, a small part of Lewis LSR (872 ha) extended into the study area. Due to logging, 27.1% of the forested area of LSRs and 29.6% of that of non-reserves was forest <50 yr old as of 2006. In the Yellowjacket area (described below), 63.6% of the forest ≥80 yr old was in Matrix and 36.4% was in a high-elevation Administratively Withdrawn Area.

U.S. Forest Service personnel (1978–2002) and Robert Pearson (RP; 1992–2006) detected Spotted and Barred owls in our study area (Pearson and Livezey 2003) by soliciting responses via amplified tape recordings or voice imitations of calls of Spotted Owls following accepted protocols (Forsman 1983, USFWS 1992). Surveyors often followed detections with visits to locate Spotted Owls, their nests, and their young. We defined a ''site'' as the area currently or formerly occupied by a territorial individual

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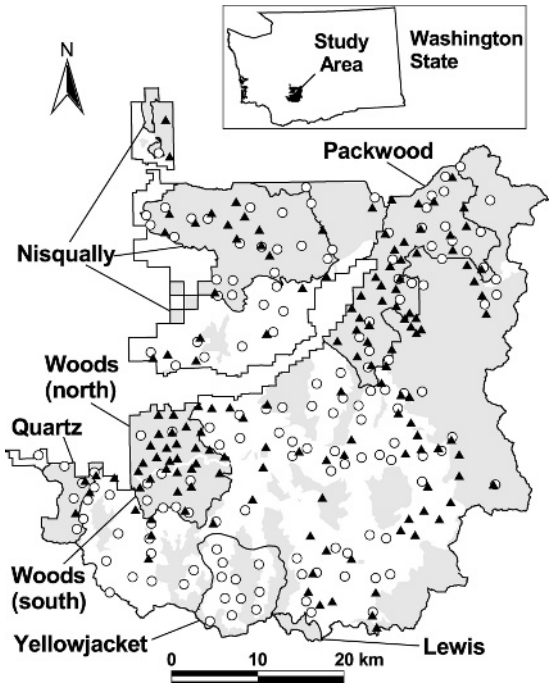

Figure 1. Location of study area (shaded) in southwestern Washington (inset); Spotted Owl sites (circles; $N = 149$) and Barred Owl sites (triangles; $N = 147$) in reserves (gray), LSRs (gray with boundaries), non-reserves (white), and the Yellowjacket area, Cowlitz Valley Ranger District, Gifford Pinchot National Forest, Washington, 1978–2006.

owl or pair of owls, with identification of a site for both species based on protocols for Spotted Owls (USFWS 1992). For each site, we determined a site-center, which was a mapped point based on locations of nests, young, or clusters of detections (USFWS 1992). We considered the area within 1.6 km of a Spotted Owl site-center, or 1.0 km of a Barred Owl site-center, to represent the area of a site where owls associated with that site generally would be found during the breeding season. From 2002–2006, RP conducted surveys for both species during the breeding season to detect presence at sites, locate new sites in areas with prior detections but no sites identified, and check for recent colonization in areas without prior detections. Surveys were conducted along roads or trails, or cross-country in areas without road or trail access. RP initially surveyed site core-areas (local areas around site-centers) which generally were within 0.8 km of site-centers for Spotted Owls and within 0.5 km for Barred Owls. If no owls were detected in a core-area, he expanded surveys to cover the entire site. Barred Owl calls were sometimes used in areas thought to contain no Spotted Owls. When Barred Owls were detected within a Spotted Owl site, survey of the Spotted Owl site continued outside the range of the Barred Owls. Road closures precluded survey of the entire study area in any 1 yr; however, from 2002–2006, all sites were surveyed in at least 3 of 5 yr, except 10 Spotted Owl and two Barred Owl sites that were considered to be ''status unknown.'' Sites with no detections from 2002–2006 and at least 10 survey visits in 5 yr were considered to be ''unoccupied.'' Survey effort for reserves vs. non-reserves was similar each year.

Because the distribution of Barred Owls in the Pacific Northwest was not well documented, RP conducted additional fieldwork to verify sites, including (1) locating owls for adjacent sites, and all adjacent sites within clusters of sites, on the same survey outing, (2) surveying individual site core-areas in densely populated areas rather than along transects, to avoid attracting an owl from one site to another, and (3) surveying stations 100–200 m apart near Barred Owl site-centers to detect juveniles. Barred Owl site persistence was documented by relocating Barred Owls within sites in successive years.

In our study area, forests typically begin to develop late-successional characteristics that support Spotted Owls when the forests are ≥80 yr old (USDA and USDI 1994); therefore, we compared densities of Spotted and Barred owl site-centers within land-use allocations according to the amount of forest that was ≥80 yr old in 2006. We excluded areas above 1524 m elevation from analyses because no Spotted or Barred owls have been detected above that elevation in our study area. Spotted Owls may respond less frequently to survey calling in areas where Barred Owls are present (Olson et al. 2005, Crozier et al. 2006), resulting in non-detection of resident Spotted Owls. Additionally, Spotted Owl sites may be vacant for a number of years but then recolonized (T. Fleming pers. comm.). Because of these uncertainties related to occupancy, we included all Spotted Owl sites in our analyses, even if Spotted Owls were not detected there during 2002–2006, to minimize the chance of incorrectly inflating the number of Barred Owl sites relative to the number of Spotted Owl sites. For comparison of elevation and slope, we generated one random location per 2 km^2, with a minimum distance of 1000 m between locations, in forested areas ≥80 yr old and ≤1524 m. We compared elevation and slope of the random locations that were in non-reserves ($N = 428$), LSRs ($N = 247$), Woods LSR ($N = 56$), and the Yellowjacket area ($N = 34$), using two-tailed Mann-Whitney U-tests (SYSTAT Version 10, SPSS Inc., Chicago, IL U.S.A.) with significance at the 0.05 level. We used ArcView version 3.1.1 (Environmental Systems Research Institute, Inc., Redlands, CA U.S.A.) to map survey detections, plot site-centers, and analyze data for vegetation and land-use allocations.

RESULTS

Based on 2673 Spotted Owl detections and 1176 Barred Owl detections from July 1978–September 2006, RP identified 149 Spotted Owl sites and 147 Barred Owl sites (Table 1, Fig. 1) in our study area. Sites included a nest or young at 91 (61%) of the Spotted Owl sites and 37 (25%) of the Barred Owl sites. Four Spotted Owl and 49 Barred Owl sites were identified during 2002–2006 in addition to those we reported through 2001 (Pearson and Livezey 2003); 32 (65%) of the newly detected Barred Owl sites and two (50%) of the newly detected Spotted Owl sites were in reserves. In 2006, there were 34% more Barred Owl sites than Spotted Owl sites in reserves, while in

Table 1. Number and density (sites/km²) of Spotted Owl (SPOW) and Barred Owl (BDOW) sites, and ratio of BDOW/SPOW sites, in forest ≥80 yr old and ≤1524 m by land-use allocation, Cowlitz Valley Ranger District, Gifford Pinchot National Forest, Washington, 1978–2006.

	SPOW		BDOW		
LAND-USE ALLOCATION[a]	NO. SITES	DENSITY	NO. SITES	DENSITY	BDOW/SPOW
Reserves					
LSR	53	0.162	72	0.220	1.36
CRA	14	0.073	19	0.099	1.36
AWA	3	0.024	3	0.024	1.00
All reserves	70	0.108	94	0.146	1.34
Non-reserves					
Matrix	42	0.167	23	0.092	0.55
AMA	37	0.161	30	0.130	0.81
All non-reserves	79	0.164	53	0.110	0.67

[a] LSR = Late-Successional Reserve; CRA = Congressionally Reserved Area; AWA = Administratively Withdrawn Area; AMA = Adaptive Management Area.

non-reserves the situation was reversed, with 33% more Spotted Owl sites than Barred Owl sites (Table 1). Excluding 38 Spotted Owl sites and four Barred Owl sites that were unoccupied by the criteria we used previously (i.e., sites that were occupied for ≥1 yr and were subsequently surveyed ≥10 times during the last 5 yr of the study with no detections; Pearson and Livezey 2003), there were 96% more Barred Owl sites ($N = 92$) than Spotted Owl sites ($N = 47$) in reserves and 25% more Spotted Owl sites ($N = 64$) than Barred Owl sites ($N = 51$) in non-reserves.

The 11 665-ha Woods LSR (Fig. 1) was significantly lower in elevation (634 ± 289 m) than non-reserve areas (998 ± 279 m; $P < 0.001$) and flatter in slope (29 ± 19%) than non-reserve areas (37 ± 20%; $P = 0.001$). This LSR also was significantly lower in elevation than the other four LSRs (993 ± 277 m; $P < 0.001$) and flatter in slope than the other four LSRs (39 ± 21%; $P = 0.001$). Woods LSR included 27 Barred Owl sites (13 with documented reproduction) and had the highest density of Barred Owl sites in forests ≥80 yr old (0.41 sites/km²) of the five LSRs. The northern half of this LSR, which was significantly lower in elevation (444 ± 73 m vs. 870 ± 282 m; $P < 0.001$) and flatter in slope (20 ± 13% vs. 40 ± 19%; $P < 0.001$) than the southern half, had 18 Barred Owl sites (0.50 sites/km²), and two Spotted Owl sites, while the southern half had nine Barred Owl and seven Spotted Owl sites. Only two of the nine Spotted Owl sites in this LSR had Spotted Owls detected from 1998–2006; both of these were in the southern half. The other seven sites either were unoccupied or had no responding Spotted Owls during scores of surveys during those 9 yr. Conversely, a nearby non-LSR area of 8736 ha in the Yellowjacket watershed (Fig. 1) which was significantly higher in elevation (1143 ± 210 m; $P < 0.001$) and steeper in slope (48 ± 16%; $P < 0.001$) than Woods LSR, included 11 Spotted Owl sites (nine with documented reproduction), no Barred Owl sites, and only three Barred Owl detections during this 29-yr study.

DISCUSSION

We assume many factors may influence where sympatric Spotted and Barred owls establish their territories and exist over time, including the relative densities of the two species, forest quality, forest age, elevation, slope, distance to water, and abundance and availability of prey. As a simple example using two variables, Barred Owls in many parts of North America are found in forests located in relatively flat, low-elevation areas (Fuller 1979, Yannielli 1988, Piorecky 2003, Gremel 2005). Pearson and Livezey (2003) reported that (1) occupied Spotted Owl sites were significantly steeper in slope and significantly higher in elevation than Barred Owl sites, (2) unoccupied Spotted Owl sites were not significantly different from Barred Owl sites in slope or elevation, and (3) there were significantly more Barred Owl site-centers in unoccupied than occupied Spotted Owl circles of 0.8-km, 1.6-km, and 2.9-km radii. In this analysis, the low-elevation, relatively flat Woods LSR was densely packed with Barred Owls, whereas the nearby higher-elevation, steeper Yellowjacket area remained free of Barred Owl sites. Although densities in the other LSRs and non-reserve areas in our study area lie somewhere between these extremes and are not as clearly explained by the parameters of elevation and slope, we believe that elevation and slope are important factors for the rest of our study area when combined with additional factors including forest quality, forest age, distance to water, and abundance and availability of prey.

Barred Owls have more diverse prey (Errington and McDonald 1937, Wilson 1938, Elderkin 1987) than Spotted Owls have (Hamer et al. 2001, Forsman et al. 2004),

which apparently allows Barred Owls to have smaller home ranges (Hamer et al. 1989) and reach higher densities in some areas. Although higher density *per se* is not a concern, we consider that large numbers of Barred Owls in areas with Spotted Owls result in frequent territorial encounters between species with the potential for aggressive interactions (Leskiw and Gutiérrez 1998, T. Fleming, E. Forsman, J. Mowdy, G. Stagner, and T. Snetsinger pers. comm.), more hybrids (Turner-Hane et al. 2005), loss of habitat available to Spotted Owls (Kelly et al. 2003, Pearson and Livezey 2003, Gremel 2005), and, due to the dietary overlap between Spotted and Barred owls (Hamer et al. 2001), loss of prey available to Spotted Owls. Such effects may be especially dire for Spotted Owls within reserves where the species is expected to survive in the long term.

To estimate the factors that influence the occupancy of these two species, the exact mechanisms by which Barred Owls negatively affect Spotted Owls, and the region-specific relative densities of Barred Owls at which these negative effects become significant, we recommend (1) extensive surveys specific to both species throughout the range of the Northern Spotted Owl; (2) studies employing radiotelemetry coupled with visual observations of both species; and (3) analyses of the effects of experimental control of Barred Owls on the demographics of Spotted Owls. However, exactly how these factors influence demographic rates of Spotted Owls alone is still relatively unknown (Franklin et al. 2000, Olson et al. 2004), so it is perhaps optimistic to assume that the above studies, if actually conducted throughout the range of the Spotted Owl, will provide conclusive answers. While we wait for those answers, Spotted Owls in our study area may be unable to persist due to the combination of expected loss of pairs in areas open to timber harvest and the unanticipated loss of pairs, particularly in reserves, due to increasing competition with Barred Owls. Of the 111 Spotted Owl sites potentially still active under the occupancy criteria described above, only 22.5% ($N = 25$) had 100% of the area within 1.6 km of their site-centers fully protected in reserves; 22.5% ($N = 25$) had 50–99% in reserves; 41.4% ($N = 46$) had 1–49% in reserves; and 13.5% ($N = 15$) were completely in nonreserves. With the combination of timber harvest and pressure from Barred Owls, there is no guarantee that Spotted Owls will be able to maintain their numbers in reserves, much less increase their numbers to foster recovery.

That Spotted Owls in the Yellowjacket area and other areas have persisted after so many years of Barred Owl colonization may indicate that there are local environmental factors such as elevation and slope that favor Spotted Owls over Barred Owls, and that a natural balance has been achieved which allows the coexistence of these species. Given this possibility, the presence of Spotted Owls at a site might be the best indicator that the site is important for persistence of Spotted Owls at the local level and, ultimately, for the entire population. Consequently, it seems prudent to reassess the effectiveness of the NWFP in areas such as Gifford Pinchot National Forest. Fortunately, such adaptive management was incorporated into the NWFP: ''To be successful, it [the NWFP] must have the flexibility to adapt and respond to new information …. This may result in the refinement of standards and guidelines, land-use allocations, or amendments to Forest and District Plans. Adaptive management decisions may vary in scale from individual watersheds, specific forest types, physiographic provinces, or the entire planning area or region'' (USDA and USDI 1994:E-12–E-13).

To address the concerns of Gutiérrez et al. (2004) and Noon and Blakesley (2006) and to protect Spotted Owls while information is gathered, we recommend for Gifford Pinchot National Forest and other areas with similar conditions that standards and guidelines for LSRs (USDA and USDI 1994) be adopted either for all stands considered suitable habitat for Spotted Owls or for forests where Spotted Owls still outnumber Barred Owls. Also, we recommend the placement of LSRs be evaluated and modified, if necessary, relative to the distributions of these two species. In addition, Barred Owls may need to be controlled within specific Spotted Owl territories or groups of territories. To optimize the chances of the continued existence of Spotted Owls, protection of forests should incorporate real-time distributions of these two species, and should include not only areas where Spotted Owls are located at any one time, but also sufficient amounts of suitable habitat free from negative effects from Barred Owls to permit Spotted Owl recovery.

STRIX OCCIDENTALIS, *S. VARIA* Y BOSQUES PROTEGIDOS EN SUCESIÓN TARDÍA

RESUMEN.—La estrategia de conservación de la lechuza amenazada a nivel federal *Strix occidentalis caurina*, trazada en el Plan de Bosques del Noroeste, se basó en los supuestos de que el número de lechuzas continuaría disminuyendo en el corto plazo, especialmente en las áreas sujetas a extracción de madera ubicadas por fuera de los Bosques Protegidos en Sucesión Tardía (BPST), y que las poblaciones de las lechuzas presentes en los BPST serían autosustentables a largo plazo a medida que dichos bosques madurasen. Sin embargo, el Plan de Bosques del Noroeste no consideró la competencia entre *S. occidentalis* y *S. varia*. Desde 1978 hasta 2006, identificamos 149 sitios con *S. occidentalis* y 147 sitios con *S. varia* en las 217 812 ha del Distrito Cowlitz Valley del Bosque Nacional Gifford Pinchot. En 2006, hubo un 34% más de sitios habitados por *S. varia* que por *S. occidentalis* en las reservas (áreas con muy escasa o sin tala de árboles en bosques sucesionales tardíos), mientras que en las no-reservas (áreas designadas para tala de árboles en bosques sucesionales tardíos), la situación fue al revés, con un 33% más de sitios habitados por *S. occidentalis* que por *S. varia*. Este contraste entre las densidades relativas en los bosques protegidos y no protegidos fue más evidente en la comparación entre las 11 665 ha del BPST Woods con las 8736 ha no protegidas del área Yellowjacket, lo cual apoya nuestros hallazgos

anteriores de que los sitios habitados por *S. varia* fueron mucho más numerosos en los bosques de elevaciones bajas y en áreas de poca pendiente (Pearson y Livezey 2003). El BPST Woods presentó una elevación y una pendiente significativamente menores que las de los otros BPST de nuestra área de estudio, y presentó 29 sitios habitados por *S. varia* y sólo dos sitios con presencia conocida de *S. occidentalis*. Por el contrario, la localidad cercana Yellowjacket, la cual fue significativamente mayor en elevación y pendiente que el BPTS Woods, no registró sitios habitados por *S. varia* y presentó 11 sitios habitados por *S. occidentalis*. Recomendamos investigar los mecanismos de competencia entre estas especies, realizar una evaluación de la efectividad de la ubicación de los BPST en relación con la distribución de estas dos especies, adoptar medidas de manejo de los BPST en las áreas donde la abundancia de *S. occidentalis* es aún mayor que la de *S. varia* y eventualmente modificar los límites de los BPST.

[Traducción del equipo editorial]

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