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EFFECTS OF BARRED OWLS ON SPOTTED OWLS: THE NEED FOR MORE THAN INCIDENTAL DETECTIONS AND CORRELATIONAL ANALYSES

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The Northern Spotted Owl (*Strix occidentalis caurina*; hereafter, Spotted Owl) was listed as federally endangered in Canada (Campbell and Campbell 1984, Government of Canada 2002) and federally threatened in the United States (U.S. Fish and Wildlife Service 1990) due to population declines primarily attributed to destruction of its habitat, which is mature and old-growth forest. The Spotted Owl has been described as ''one of the most-studied and best-known owls in the world'' (Gutiérrez et al. 1995) and ''one of the most intensively studied birds in the world'' (Anthony et al. 2006). As the basis of the ten million-ha Northwest Forest Plan (USDA and USDI 1994), the Spotted Owl has affected land-use planning at the landscape scale more than any other species of wildlife in the United States (Noon and Blakesley 2006). Authors of the habitat-based Northwest Forest Plan expected continued declines in populations of Spotted Owls until sufficient amounts of previously harvested forests within the reserves mature into suitable habitat (Lint et al. 1999, Thomas et al. 2006). However, declines of Spotted Owl populations in the northern part of their range (Anthony et al. 2006) have been greater than expected, and these declines have been ascribed to competition with recently colonizing Barred Owls (*S. varia*; Thomas et al. 2006). There is little doubt that the Barred Owl now poses ''a significantly greater threat to the Northern Spotted Owl than originally envisaged at the time of listing'' the Spotted Owl as a threatened species (Gutiérrez et al. 2004).

Barred Owls and Spotted Owls are similar in several ways. They are congeners that have similar plumage, dark eyes, and no ear tufts. They occasionally hybridize and produce fertile hybrids (Hamer et al. 1994, Kelly and Forsman 2004), but this behavior is considered to be an ''inconsequential'' phenomenon that occurs mostly when Barred Owls move into new areas, and declines as the Barred Owl population becomes more established (Kelly and Forsman 2004). Like Spotted Owls, Barred Owls choose old or mature forests (McGarigal and Fraser 1984, Mazur et al. 1998, Hinam 2001) and nest in cavities and platforms in trees (Mazur et al. 1997, Buchanan et al. 2004, Livezey 2007). They prey upon the same species of small mammals (e.g., northern flying squirrel [*Glaucomys sabrinus*], snowshoe hare [*Lepus americanus*], deer mouse [*Peromyscus maniculatus*]) that are the primary prey species of Spotted Owls (Forsman et al. 2001, Hamer et al. 2001). However, Barred Owls differ from Spotted Owls in a number of ways. Barred Owls measure approximately 10% longer and weigh 10–20% more than Spotted Owls (Johnsgard 1998). They physically attack (E. Forsman, J. Mowdy, T. Snetsinger, G. Stagner pers. comm.) and may kill (Leskiw and Gutiérrez 1998) Spotted Owls. Barred Owls are opportunistic foragers (Johnsgard 1988) that consume a much wider variety of non-mammalian prey (Elderkin 1987, Bosakowski and Smith 1992, Hamer et al. 2001, Livezey 2007) than do Spotted Owls, which may allow Barred Owls to be more independent of fluctuations in small-mammal populations. Barred Owls in the Pacific Northwest have smaller territories (Hamer 1988, Singleton et al. 2005), breed more regularly, and have consistently larger broods (T. Fleming unpubl. data, J. Acker pers. comm.) than do Spotted Owls, indicating that they are capable of obtaining sufficient food in smaller areas. It is conceivable that, in higher densities and areas of sympatry with Spotted Owls, Barred Owls may be a factor in depletion of the small mammals Spotted Owls require, although these same mammals might not be primary prey for the Barred Owls. Barred Owls exploit some forests in the Pacific Northwest (e.g., younger forest stands, semi-forested urban and suburban landscapes) in the range of the Spotted Owl that are seldom used by Spotted Owls (T. Fleming unpubl. data). Barred Owls also use forests outside of the range of the Spotted Owl in the Pacific Northwest (Marshall et al. 2003, Buchanan 2005) and have a greater dispersal capability than do Spotted Owls (Gutiérrez et al. 2004, T. Fleming and K. Livezey unpubl. data); consequently, they have large source populations that can supplement numbers of Barred Owls within the range of the Spotted Owl. The combination of these similarities and differences may give Barred Owls a competitive advantage over Spotted Owls.

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Virtually all information specific to Barred Owls in British Columbia, Washington, Oregon, and northern California in areas where they are not sympatric with Spotted Owls is limited to detections obtained from a variety of opportunistic sources, primarily bird-watchers (T. Fleming and K. Livezey unpubl. data). In areas of Spotted Owl sympatry, only one study analyzed Barred Owl nests (N = 10; Buchanan et al. 2004), one examined Barred Owl diet (Hamer et al. 2001), and two analyzed Barred Owl habitat use via radiotelemetry. Of the radiotelemetry studies, one was conducted in the western Washington Cascades almost 20 yr ago (N = 23; Hamer 1988) and the other took place in a peripheral part of the range of the Spotted Owl in the eastern Washington Cascades (N = 15; Singleton et al. 2005, P. Singleton pers. comm.).

Most of the published information on Barred Owls in areas of Spotted Owl sympatry has relied on data gathered incidentally to Spotted Owl surveys using Spotted Owl calls to solicit responses. However, it is not known how effectively Barred Owls are detected with Spotted Owl calls. In addition, unlike Spotted Owl surveys, Barred Owl surveys rarely include follow-up site visits to determine occupancy status, find nests, and document reproduction (Forsman 1983, USFWS 1992, Hobbs et al. 2004), primarily because of the need to comply with study designs based on funding directed explicitly toward Spotted Owl surveys, the difficulty in collecting Barred Owl data relative to Spotted Owl data (see below), and the very recent recognition of the threat Barred Owls may pose to Spotted Owls. From incidentally collected data, correlational analyses implied negative effects of Barred Owls on Spotted Owl site occupancy, reproduction, and survival. Effects on nest-site occupancy were analyzed relative to distances of Barred Owl detections to Spotted Owl site-centers (based on location of nest trees, fledged young, or multiple detections of owls; Kelly et al. 2003), numbers of Barred Owl site-centers within certain distances of Spotted Owl site-centers (Pearson and Livezey 2003), distances of Barred Owl site-centers to Spotted Owl site-centers (Gremel 2005), and whether a Barred Owl was detected on a Spotted Owl site (Olson et al. 2005). Effects on reproduction were measured relative to whether a Barred Owl was detected on a Spotted Owl site (Olson et al. 2004), and effects on survival were estimated relative to the proportion of Spotted Owl territories in which Barred Owls were detected (Anthony et al. 2006). Increasingly larger densities of Barred Owls than Spotted Owls in reserves set aside for Spotted Owls in the Northwest Forest Plan (Pearson and Livezey 2003, 2007) have led some to question whether populations of Spotted Owls can be increased by the current management techniques. Many studies also noted correlational decreases in numbers of Spotted Owls and increases in numbers of Barred Owls (e.g., Anthony and Ackers 2005, Forsman et al. 2006, Schmidt 2006, S. Ackers pers. comm., R. Pearson pers. comm., D. Rock pers. comm.). Franklin (2004) was concerned that some studies were based on cumulative Barred Owl sites over years rather than on annually occupied Barred Owl sites. In addition, some studies were based on one-time presence of individual Barred Owls rather than on established territorial pairs of Barred Owls.

Such dependence on incidental detections for analysis of effects apparently is unique among bird species in the United States (J. Sauer pers. comm.), and is especially unfortunate due to the relevance of these analyses to the long-term persistence of Spotted Owls. Use of incidental detections when surveying for Spotted Owls not only confines analyses to correlations, but could result in underdetection of Barred Owls (Gutiérrez et al. 2004). In addition, exclusive dependence on incidental detections limits surveys to areas in which Spotted Owls are being surveyed, resulting in the failure to detect Barred Owls in other areas.

Noon and Blakesley (2006) recommended that an assessment of the effects of colonizing Barred Owls on Spotted Owls become a part of the monitoring program of the Northwest Forest Plan. While we heartily support such monitoring, we do not recommend continued collection of Barred Owl data in the manner that has occurred previously. Here we present potential biases resulting from use of these incidental data and recommend solutions to improve analyses of the effects of Barred Owls on Spotted Owls.

Recommended Research Focused on Barred Owls. Analyses of the effects of Barred Owls on Spotted Owls would greatly benefit from research focused on (1) detecting Barred Owls; (2) gathering basic ecological data (e.g., habitat use, home-range size, density, reproduction, food habits) for Barred Owls; (3) studying interactions between Spotted and Barred owls; and (4) conducting experiments to reduce reproduction or numbers of Barred Owls in areas occupied by Spotted Owls (Table 1). The biases and inadequacies in Barred Owl data within the range of the Spotted Owl may be partially addressed by focusing on adequately surveying for Barred Owls throughout the Pacific Northwest and accurately mapping Barred Owl site-centers (Table 1). The differences in behavior of these two *Strix* species (Table 1) and the apparent reluctance of Spotted Owls to respond when Barred Owls are present (Olson et al. 2005, Crozier et al. 2006) should be considered when designing effective techniques for surveying both species simultaneously. Managing forests to benefit Spotted Owls and deter Barred Owls may be possible if Spotted Owls select forest structures, forest ages, resources, or landscape conditions that are not used by Barred Owls; determining this requires understanding and comparing resources (e.g., prey, space, nest sites) and constraints on the use of those resources (e.g., predation, competition, activity time; Morrison 2001) for both species isolated from, and in contact with, each other. Estimation of densities of Barred Owls, coupled with assessment of the other factors described here, could indicate the relative concentrations at which these two species may be able to coexist and could be a crucial component to any management of Barred Owls or Spotted Owls. Analyzing interactions between the two species through long-term observational studies, as suggested by Noon and Franklin (2002), and

Table 1. Potential biases in Barred Owl (BDOW) information resulting from survey methods focused on monitoring Spotted Owls (SPOWs) or from differences in behavior between BDOWs and SPOWs, and proposed solutions to rectify these biases.[a]

SURVEY METHOD OR OWL BEHAVIOR	POTENTIAL BIAS IN BDOW INFORMATION	PROPOSED SOLUTION
Method and emphasis of research		
Use of SPOW calls to solicit responses (6, 13, 23)	BDOWs may respond less to SPOW calls than to BDOW calls (9), resulting in underdetection of BDOWs	Test whether BDOWs respond less to SPOW calls than to BDOW calls; if so, use BDOW calls in surveys
Limitation of SPOW survey periods to 10 min in U.S. (6, 23) and 15 min in British Columbia (13, 14)	BDOWs appear to respond less than SPOWs do during 10- or 15-min stations (4, 5, 8, 21, 22), resulting in underdetection of BDOWs	Test whether BDOWs respond less than SPOWs do during 10- or 15-min stations; if so, increase length of time at survey stations accordingly
Reduction of SPOW survey effort adjacent to known SPOW sites in forests thought to be unsuitable SPOW habitat to minimize costs (5, 9, 15)	BDOWs may use such habitats, resulting in underdetection of BDOWs and lack of data concerning the complete range of habitats used by BDOWs	Conduct BDOW surveys adjacent to SPOW sites in areas thought to be unsuitable SPOW habitat
Limitation of SPOW survey effort in known SPOW sites to only that needed to determine presence and breeding status of SPOWs to minimize cost and disturbance to SPOWs (5, 7, 15)	Underdetection of BDOWs, especially during years of good SPOW reproduction when SPOW site status is determined quickly and adjacent areas are subsequently not surveyed (5, 7, 15)	Maintain consistent survey effort of SPOW sites among years relative to ability to detect BDOWs
Less effort to retain BDOW survey data, especially if not associated with SPOW data (5)	Loss of BDOW data	Retain BDOW data
Lower priority given to determining locations of BDOW site-centers from detections (5, 12)	Less-accurate mapping of site-centers and habitat of BDOWs	Determine locations of BDOW site-centers with the same level of effort as that devoted to SPOW site-centers
Less effort to find BDOW nests and young, and to band or radio-tag BDOWs	Fewer BDOW nests located, and little information on movements, survival, site fidelity, and habitat use of BDOWs	Devote same level of effort finding BDOW nests and young as that given to SPOWs; conduct leg-banding and radio-tagging studies of BDOWs, especially when sympatric with SPOWs
Less effort to collect diet data for BDOWs	Little information on BDOW diet	Conduct studies of BDOW diet, especially when sympatric with SPOWs
Few or no owl surveys in Pacific Northwest in areas outside of SPOW distribution	BDOWs use forests throughout the Pacific Northwest that SPOWs do not use (3, 18), resulting in underdetection of BDOWs	Survey for BDOWs in the Pacific Northwest in areas outside of SPOW distribution
Analysis based on cumulative BDOW sites when all sites were not surveyed each year (20)	Overestimation of BDOWs due to inclusion of unoccupied BDOW sites; underestimation of effects from BDOWs due to inclusion of sites in which BDOWs were not present during all years	Analyze effects to SPOWs relative to annually occupied BDOW sites

Table 1. Continued.

SURVEY METHOD OR OWL BEHAVIOR	POTENTIAL BIAS IN BDOW INFORMATION	PROPOSED SOLUTION
Analysis based on presence of BDOWs in SPOW territories (16, 19) or proportion of territories (2)	Underestimation of effects from BDOWs due to inclusion of sites with only transient BDOWs; inadequate analysis of effects due to various densities of BDOWs and proximities of BDOW site-centers to SPOW site-centers	Analyze effects on SPOWs relative to distances between site-centers of established, territorial pairs of BDOWs and SPOWs
Behavior of BDOWs relative to behavior of SPOWs		
More variation in response rate among nights (5, 12, 21, 22)	Underdetection of BDOWs when they are not responding	Ensure that survey effort is sufficient to include nights when high percentages of BDOWs respond
Similarity in some alternate calls (5, 17, 21)	Underdetection of BDOWs and of BDOW/SPOW hybrids, especially by inexperienced surveyors (8)	Train SPOW and BDOW surveyors with extensive variety of recorded calls and conduct fieldwork with experienced BDOW surveyors
Less responsive during the day (5, 12, 15, 22)	Underdetection of BDOWs during SPOW daytime surveys	Ensure that nighttime survey effort is sufficient to detect BDOWs
More tendency to approach SPOW-calling surveyors quickly and quietly (1, 4, 5, 8, 9, 15, 21, 22), possibly to improve their ability to successfully confront the supposed Spotted Owls	Underdetection of BDOWs when BDOWs do not respond vocally; inability of surveyors to make triangulations when BDOWs approach surveyors, resulting in inaccurate locations of site-centers	Scan for BDOWs with high-powered lights and listen for sound of BDOWs landing on nearby branches or contacting nearby branches with their wings (15, 21); consider silent arrivals as evidence of presence within a territory but not necessarily of location of site-centers
More reluctance to allow close approaches by humans; more wild (5, 6, 7, 12, 15, 17, 21, 22)	Increased difficulty of visual observation, location of nests using live-mouse baiting, capture, and seeing leg bands, resulting in underdetection of BDOWs and less information concerning nest sites, reproduction, diet, etc.	Devote more time to visual observations, live-mouse baiting, etc.
Smaller home-ranges (10) and higher population densities (1, 5, 15, 21)	Attribution of multiple BDOW pairs to one site, so underestimation of BDOWs and inaccurate location of BDOW site-centers	Determine locations of BDOW site-centers with the recognition they can be much closer together than those of SPOWs

[a] References: (1) J. Acker (pers. comm.), (2) Anthony et al. (2006), (3) Buchanan (2005), (4) L. Diller (pers. comm.), (5) T. Fleming (pers. obs.), (6) Forsman (1983), (7) E. Forsman (pers. comm.), (8) S. Gremel (pers. comm.), (9) Gutiérrez et al. (2004), (10) Hamer (1988), (11) Herter and Hicks (2000), (12) D. Herter (pers. comm.), (13) Hobbs et al. (2004), (14) Hobbs (2005), (15) J. Hobbs (pers. comm.), (16) Kelly et al. (2003), (17) K. Livezey (unpubl. data), (18) Marshall et al. (2003), (19) Olson et al. (2004, 2005), (20) Pearson and Livezey (2003), (21) R. Pearson (pers. comm.), (22) D. Rock (pers. comm.), (23) USFWS (1992).

radio-tracking of sympatric Barred Owls and Spotted Owls may provide insights concerning niche partitioning, the extent to which the species interact, and the mechanisms by which they compete. Conducting experiments using management or removal of Barred Owls (Courtney and Franklin 2004, Buchanan et al. 2007) may be the best way to determine the degree to which Barred Owls negatively affect Spotted Owls (Gutiérrez et al. 2007).

Conducting this research would be more costly than collecting data incidentally to Spotted Owl research, but many of these gaps in knowledge about Barred Owls could be addressed in concert with Spotted Owl research, thereby minimizing costs. However, given the fact that several long-term Spotted Owl demography studies recently have been discontinued or greatly curtailed due to lack of funding, priorities would need to change before funds would be available to research Barred Owls or their effects on Spotted Owls. As Barred Owls continue to increase in numbers and expand in distribution, we are very concerned that any negative effects of Barred Owls on Spotted Owl site occupancy, reproduction, and survival may outstrip the pace at which we can learn about these effects and manage

identified problems. At this time, there are just a few studies beginning to address some of these research needs. We strongly encourage a much more active and rapid approach to quickly identify potential management options and, hopefully, find ways to increase the chances that Spotted Owls can coexist with Barred Owls.

EFECTOS DE *STRIX VARIA* SOBRE *S. OCCIDENTALIS*: NECESIDAD DE ALGO MÁS QUE DETECCIONES CASUALES Y ANÁLISIS DE CORRELACIÓN

RESUMEN.—Prácticamente todos los datos usados en los análisis de los efectos de *Strix varia* sobre *S. occidentalis caurina* han sido recolectados de modo casual durante censos de *S. occidentalis*, usando protocolos de censos para detectar a *S. occidentalis*. Estos métodos han resultado en la subestimación de *S. varia* y han limitado a los investigadores a utilizar sólo análisis de correlación para determinar los efectos de *S. varia* sobre *S. occidentalis*. Recomendamos realizar estudios enfocados en *S. varia* y estudios experimentales de control para examinar de manera más rigurosa los efectos de *S. varia* sobre *S. occidentalis*.

[Traducción del equipo editorial]

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