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SHORT COMMUNICATIONS

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DO CALIFORNIA SPOTTED OWLS SELECT NEST TREES CLOSE TO FOREST EDGES?

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KEY WORDS: *Spotted Owl*; *Strix occidentalis*; *California*; *habitat selection*; *nest-site selection*.

Throughout their range Spotted Owls (*Strix occidentalis*) typically select nest sites in mature and late-seral forests (Buchanan et al. 1993, Gutiérrez et al. 1995, Forsman and Geise 1997). Many factors probably affect selection and use of nest sites by Spotted Owls, including thermal properties of forest stands (Chen et al. 1990), presence of suitable nest trees (Buchanan et al. 1993, 1995, Forsman and Geise 1997), predation risk (Johnson 1993), and presence of nearby foraging habitat (Hunter et al. 1995, Gutiérrez et al. 1998, Ward et al. 1998, Forsman et al. 2005). Observations of the spatial location of nest sites relative either to ecotones (zones between forest cover types) or forest edges have been reported for Northern Spotted Owls (*S. o. caurina*). For example, Johnson (1993) found that Northern Spotted Owl nest sites were located further from a forest edge than random locations. No assessment of California Spotted Owl (*S. o. occidentalis*) nest-site placement relative to forest edge has been published, to our knowledge.

The question of nest site location relative to forest edge is of interest to forest managers because of its implication for logging management and design. Moreover, there is some public perception that California Spotted Owls are more likely to select nest sites that are near an edge rather than within the interior of a forest patch (e.g., stakeholder comments from the Sierra Nevada Adaptive Management Project public participation forum, 5 November 2008). If owls use nest sites closer to edges than expected by chance, nest locations might reflect factors such as proximity to foraging areas, responses to local thermal conditions, historic disturbance patterns, or some unknown factor (Thomas et al. 1990, Ward et al. 1998, Folliard et al. 2000). The causative mechanism for nest selection cannot be determined by observational studies, but field studies can elucidate patterns of nest locations. The location where owls choose to nest is significant; if owls select nest sites close to forest edges, that might provide some justification for logging regimes that create small or large

amounts of edge (e.g., group selection or clear-cutting, respectively) in areas where owls occur. However, if nest placement is random or farther from edges than expected by chance, such justification may not be warranted. Therefore, in this study we examined the hypothesis that California Spotted Owl nest trees are located closer to edges than would be expected by chance.

STUDY AREA

Our study area (925 km²) was located on the Eldorado and Tahoe National Forests in the central Sierra Nevada, California. The area was mountainous, with elevations ranging from 366 to 2257 m. Climate was Mediterranean with cool, wet winters and hot, dry summers (Olson and Helms 1996). Vegetation was typical of mixed-conifer forest of the mid-elevation Sierra Nevada. Dominant tree species were sugar pine (*Pinus lambertiana*), ponderosa pine (*P. ponderosa*), Douglas-fir (*Pseudotsuga menziesii*), incense cedar (*Calocedrus decurrens*), California black oak (*Quercus kelloggii*), and white fir (*Abies concolor*). Red fir (*A. magnifica*) was less abundant but common at higher elevations. Chaparral was a common vegetation type at lower elevations. Land ownership was 63% public and 37% private land.

METHODS

We used a Geographic Information System-based (GIS; ArcInfo Version 9.0, ESRI, Redlands, CA) vegetation map of our study area created using aerial photography from 1998 and 2000 (Chatfield 2005). Our GIS-based map consisted of eight cover types, elevation data, nest tree locations, and one random location within each nest stand. The seven cover types dominated by vegetation were consistent with the California Wildlife Habitat Relationships System, which designates cover types based on vegetation type, size class of dominant trees, and canopy cover (Table 1; Mayer and Laudenslayer 1988). Our map had an accuracy that averaged 83% with user's and producer's accuracy for individual cover types, ranging from 68% to 89% and from 47% to 97%, respectively (Chatfield 2005). We derived elevation data from a 1:250 000 U.S. Geological Survey (USGS) Digital Elevation Model (DEM; <http://ned.usgs.gov/>).

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Table 1. Landscape cover types used in the analysis of Spotted Owl nest-site location analysis on the Eldorado and Tahoe National Forests, California, from 1989–2007 (adapted from Chatfield 2005). We considered cover types 1–5 to be “high-contrast” edge relative to cover types 6–8.

COVER TYPE	DESCRIPTION
1	Hardwood forest (>10% hardwood canopy closure and <10% conifer canopy closure)
2	Clearcut or small tree (<15.24 cm DBH)
3	Pole (15.24–27.7 cm DBH) forest
4	Medium (27.94–60.7 cm DBH) conifer/mixed-conifer forest with low to medium canopy closure (30–69%)
5	Water
6	Medium (27.94–60.7 cm DBH) conifer/mixed-conifer forest with high canopy closure ($\geq 70\%$)
7	Mature (≥ 60.96 cm DBH) conifer/mixed-conifer forest with low to medium canopy closure (30–69%)
8	Mature (≥ 60.96 cm DBH) conifer/mixed-conifer forest with high canopy closure ($\geq 70\%$)

We located owl nests using standard survey protocols (Franklin et al. 1996). We found multiple nest trees in some territories over time, and some individual nest trees were used in multiple years. To avoid pseudoreplication, we randomly selected one nest tree from among all nest trees used in each territory for our analysis. We used ArcInfo Version 9.0 to generate one random point within each nest stand for comparison with the nest tree location in that stand. We used this paired-comparison study design to control for variation in patch size, shape, and local conditions at each site (e.g., elevation, aspect, or slope). We defined nest stand as that polygon on the cover-type map where the nest tree was located. We considered polygons contiguous even if they contained one or more areas connected by narrow corridors (e.g., dumbbell-shaped). In the event that owls were selecting nest sites for proximity to edge, these corridors provided a high edge-to-area ratio.

The two reference frames that we used for tests of our hypotheses were distance to the nearest edge with any other cover type and distance to the nearest high-contrast edge (see below). In addition, we examined the relationship between distance-to-edge of nest trees and elevation because owls inhabiting higher elevations forage on flying squirrels (*Glaucomys sabrinus*; Verner et al. 1992), which use closed-canopy forests (Waters and Zabel 1995). Closed-canopy forests are likely to be less fragmented and have a greater area per forest patch, so we predicted that distance-to-edge of nest sites and random points would increase with elevation. Higher-elevation forests in our area also experienced lower logging intensity because of slower tree growth and lower economic value of trees.

We used the Nearest Features extension (Jenness 2004) in ArcView Version 3.2 (ESRI, Redlands, CA) to estimate the distance from a nest tree or random point either to the closest edge or to the closest high-contrast edge. We defined the closest edge as the distance from the nest tree or random location to the closest point on the boundary between the nest stand and the nearest of seven adjacent cover types (Table 1). To delineate high-contrast edges, we first consolidated cover types 6, 7, or 8 (Table 1) be-

cause these were the only cover types used for nesting. We then considered the distance to the nearest cover type that was not cover types 6, 7, or 8 as the distance to a high-contrast edge.

We used a paired *t*-test to compare the distance-to-edge estimates of nest trees to their corresponding random points. We also used a Pearson Product Moment analysis to test the hypothesis that nest tree distance-to-edge increased with elevation for all comparisons. We used SigmaPlot 11.0 for our statistical analysis (Systat Software Inc., Chicago, IL).

RESULTS

We located 135 different nest trees in 49 different owl territories from 1989–2007. Mean area of cover-type polygons containing nest trees was 304.6 ha (SE = ± 45.5 , range 16.0–1116.7 ha, $n = 49$). The mean distance to the nearest edge with another cover type (regardless of contrast) was 130 m for nest trees (SE = ± 16 , range 4–504 m, $n = 49$) and 103 m for random points (SE = ± 14 , range 1–357 m, $n = 49$; paired *t*-test, $t = 1.246$, $P = 0.219$). The mean distance to the nearest high-contrast edge was 222 m for nest trees (SE = ± 22 , range 0–680 m, $n = 49$) and 173 m for random points (SE = ± 23 , range 1–860 m, $n = 49$; paired *t*-test, $t = 2.054$, $P = 0.045$). We found no relationship between distance-to-edge and elevation for either the nearest edge of any type (Pearson product moment correlation coefficient = -0.134 , $P = 0.36$) or the nearest high-contrast edge (Pearson product moment correlation coefficient = -0.07 , $P = 0.58$).

DISCUSSION

We found no evidence that California Spotted Owls used nest sites closer to edges than one would expect by chance, at least on our study area in the central Sierra Nevada. In fact, our analysis suggested that the owls nested further from high-contrast edges. Our results were consistent over a wide range of elevations, contrary to our predictions based on changes in forest types and primary prey. Further, our result for mean distance (222 m) to a high-contrast edge was within the range reported by Buchanan and

Irwin (1998; 203–565 m) for the distance from a nest site to an opening >1.0 ha. Although owls will forage in or near edge habitats (Ward et al. 1998, Folliard et al. 2000), the energetic savings gained by selecting nest sites close to edges may be insignificant or may not outweigh the risk of predation (Forsman et al. 1984). Alternatively, foraging by owls in or near edge habitat may not be sufficiently consistent to influence nest-site selection.

Habitat alteration (e.g., timber harvest, fire) may have occurred between the date of nest-site selection by owls and the date of aerial photography used to develop our vegetation map. In these cases, the distance-to-edge for nest locations could only have decreased. In addition, this effect would apply equally to the random points used for comparison. Thus, we believe that our findings were not an artifact of habitat change during the course of our study. We suggest that other factors, such as the spatial distribution of suitable nest trees within the nest stand, may be more important for nest-site selection than distance to an edge. We also suggest that owls would not benefit from increased forest fragmentation around nest stands, at least with respect to nest-site selection.

¿ SELECCIONA *STRIX OCCIDENTALIS* ÁRBOLES CERCA DE LOS BORDES DE BOSQUE PARA ANIDAR?

RESUMEN.—La selección de los sitios de anidación por parte de individuos de *Strix occidentalis* en ambientes de bosque tiene implicaciones importantes para el manejo de estas áreas, particularmente si las aves seleccionan áreas próximas a los bordes del bosque. Para probar la hipótesis de que *S. o. occidentalis* selecciona árboles de anidación ubicados cerca de los bordes de bosques en la Sierra Nevada central, California, comparamos las distancias de 49 nidos de *S. o. occidentalis* con la distancia a los bordes de 49 localidades pareadas seleccionadas al azar dentro del mismo lote forestal en que se encuentran los nidos. También examinamos algunas correlaciones entre estas distancias y la elevación porque tanto el tipo de bosque como la intensidad de corte variaron con la elevación. Encontramos que la distancia desde los árboles de anidación hasta el borde más próximo (media = 130 m) no difirió significativamente de las distancias desde los puntos escogidos al azar (media = 103 m; $P = 0.219$) cuando el borde de referencia era de cualquier tipo. Cuando el borde de referencia era de alto contraste (e.g., bosque primario/bosque secundario joven o bosque primario/área abierta), los nidos estuvieron localizados más lejos de los bordes (media = 222 m) que las localizaciones escogidas al azar (media = 173 m; $P = 0.045$). Estos resultados fueron consistentes, independientemente de la elevación. Por lo tanto, rechazamos nuestra hipótesis de que *S. o. occidentalis* utiliza sitios de anidación más cerca los bordes del bosque que lo esperado al azar en nuestra área de estudio.

[Traducción del equipo editorial]

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