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RELATIVE ABUNDANCE OF SMALL MAMMALS IN NEST CORE AREAS AND BURNED WINTERING AREAS OF MEXICAN SPOTTED OWLS IN THE SACRAMENTO MOUNTAINS, NEW MEXICO

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ABSTRACT.—Mexican Spotted Owls (*Strix occidentalis lucida*) are common in older forests within their range but also persist in many areas burned by wildfire and may selectively forage in these areas. One hypothesis explaining this pattern postulates that prey abundance increases in burned areas following wildfire. We observed movement to wintering areas within areas burned by wildfire by four radio-marked Mexican Spotted Owls in the Sacramento Mountains, New Mexico. These movements occurred during the winters of 2004–2005 and 2005–2006, with some owls migrating in both winters and others in only one. Wintering areas of these owls occurred within the perimeters of two wildfires that burned in May 2000 and April 2002, respectively. We estimated relative prey abundance and biomass during December 2006 within paired burned wintering areas and nest core areas used by these owls. Species richness and relative abundance of small mammals were greater in the burned wintering areas than in the associated nest core areas for all four owls, and estimated prey biomass ranged from 2–6 times greater in burned wintering areas relative to the paired nest core areas. Burned wintering areas used by these owls were similar in elevation to their nest core areas, and likely experienced similar weather conditions during winter. These results suggest that wintering owls moved to areas with greater food resources, rather than to areas with milder weather. They further suggest that relative prey abundance was greater in burned wintering areas than in the nest core areas >5 years post-fire, and that these burned wintering areas provided important habitat for Mexican Spotted Owls in our study area during an energetically stressful season. *Received 29 July 2013. Accepted 2 November 2013.*

Key words: Mexican woodrat, migration, prey abundance, prey biomass, species richness, voles, wildfire effects.

The Mexican Spotted Owl (*Strix occidentalis lucida*) occurs in canyonlands and forested mountains throughout the southwestern United States and the Republic of Mexico (Gutiérrez et al. 1995, Ward et al. 1995, U.S. Department of the Interior 2012). It frequently occupies older forests or forests with late-seral characteristics (Ganey and Dick 1995, U.S. Department of the Interior 2012), and was listed as Threatened under the Endangered Species Act in 1993, primarily because of concerns over the loss of older forest habitat to timber harvest (U.S. Department of the Interior 1993). Since that time, a number of large wildfires have burned within the range of the Mexican Spotted Owl, and many of these fires have impacted areas that were known to be occupied by Spotted Owls. As a result, wildfire has now supplanted timber harvest as the greatest perceived threat to the owl and its habitat (U.S. Department of the Interior 2012). Thus, understanding the impact of wildfires on population dynamics and habitat use of Mexican Spotted Owls is an area of growing interest (U.S. Department of the Interior 2012).

Wildfire can alter structure in or eliminate the older forests used by Mexican Spotted Owls over large areas, leading many observers to assume that wildfires routinely result in complete loss of habitat for Mexican Spotted Owls (e.g., Sheppard and Farnsworth 1995). However, available evidence suggests that these owls often persist in burned areas, at least in the short term (Bond et al. 2002; Jenness et al. 2004). Similar evidence exists for the California Spotted Owl (*S. o. occidentalis*; Bond et al. 2002, 2009, 2010, 2013; Roberts et al. 2011; Lee et al. 2012), and California Spotted Owls have been observed to selectively forage in burned areas (Bond et al. 2009).

One potential explanation for the continued use of burned areas by Mexican Spotted Owls postulates that abundance of the small mammals that dominate their diet (Ganey 1992, Ward and Block 1995, Seamans and Gutiérrez 1999, Block

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et al. 2005) may increase following fire, at least in the short term, and that owls thus may find favorable foraging habitat in burned areas (Bond et al. 2002, 2009, 2010; US Department of the Interior 2012). Studies within the range of Mexican Spotted Owls suggested increases in some species of small mammals following wildfire (Kyle and Block 2000, Converse et al. 2006), but data on this subject generally are sparse and short term. Thus, it is unknown whether or not increased prey abundance following fire is a general pattern, or how long such increases persist if they do occur.

In conjunction with a study on demography of Mexican Spotted Owls in the Sacramento Mountains, New Mexico, we observed movement by four radio-marked owls during winter from nest core areas in closed-canopy mixed-conifer forests to areas burned in two large wildfires. Because winter is suspected to be a time of food shortage for Mexican Spotted Owls (Block et al. 2005, Ganey et al. 2005) and prey abundance is hypothesized to increase post-fire, these moves might indicate a shift to areas of richer food resources. We examined species richness, relative abundance, and biomass of prey at potential foraging areas around winter roost sites for owls within the burned wintering areas and at paired nest core areas used by these owls. Thus, we provide data on potential differences between burned wintering areas and nesting areas in prey abundance and biomass during an energetically stressful season for Spotted Owls.

STUDY AREA

Our study area was approximately 50,000 ha in the Sacramento Mountains, south-central New Mexico, USA. This area encompassed much of the central portion of the Sacramento Ranger District, Lincoln National Forest, including the village of Cloudcroft, New Mexico. Elevation ranged from 2,000–2,800 m. Terrain consisted of heavily forested montane slopes and minor tributaries, with interspersed meadows in the larger valley bottoms. The predominant forest type was mixed-conifer, singularly or co-dominated by white fir (*Abies concolor*) and Douglas-fir (*Pseudotsuga menziesii*). Other common tree species included southwestern white pine (*Pinus strobiformis*), ponderosa pine (*P. ponderosa*), and quaking aspen (*Populus tremuloides*) (Kaufmann et al. 1998, Ward 2001). Precipitation averaged 65 cm/yr at Cloudcroft (2,652 m) with summer thunderstorms providing more than 60% of annual precipitation and most of the remainder occurring as winter snowfall (Kaufmann et al. 1998).

Two large wildfires burned within this study area in 2000 and 2002. The Scott Able fire ignited on 11 May 2000, and burned 6,213 ha, with approximately 16 and 25% of this area burned at moderate and high severity, respectively (Monitoring Trends in Burn Severity 2013). The Peñasco fire ignited on 30 April, 2002, and burned 6,073 ha, with approximately 29 and 17% of this area burned at moderate and high severity, respectively (Monitoring Trends in Burn Severity 2013).

METHODS

We located general areas occupied by Mexican Spotted Owls within the study area using nocturnal calling surveys (Forsman 1983). We captured owls during daytime follow-up surveys, using snare poles and baited mist nets, and attached radio transmitters using a backpack harness constructed of Teflon ribbon. All owls discussed here were captured during the summers of 2004 or 2005, and were radio-tracked though fall 2006. Radio-marked owls were not located frequently during the winter months because of constraints in funding and personnel availability, as well as access issues. Most locations recorded for Mexican Spotted Owls were from visual observations obtained during the day. Consequently, we defined movement to a wintering area as occurring when a radio-marked owl was located roosting during the day in an area >2 km from their nest/roost core (after Ganey and Block 2005) on multiple occasions between 1 November–15 April, with the roost locations separated by <300 m and occurring over a period of >18 days.

Five radio-marked owls satisfied these criteria, with four of these owls using areas burned by wildfires. We established two trapping grids for each of these four radio-marked owls. One grid was established within their nest core area (see below) and the second within their burned wintering area. We used the nest core area for comparative purposes, because these areas represented activity centers used during the breeding season and available foraging habitat which these owls, by moving to geographically distinct wintering areas, were not selecting. All nest core and burned wintering areas were located within the same forest cover type (mixed-conifer forest).

TABLE 1. Summary of migratory movements observed during the winter by five radio-marked Mexican Spotted Owls in the Sacramento Mountains, New Mexico, 2004–2006.

Owl territory	Owl sex	Fire area used	Winters in which owl migrated to winter area	Years post-fire	Distance from nest to winter area (km)	Elevation difference (m)[a]
010	M	Scott Able	2004–2005	4+	2.1	0
027	F[b]	Scott Able	2004–2005	4+	12.0	0
027	M[b]	Peñasco	2004–2005, 2005–2006	2–3+	7.1	180
104	F	Scott Able	2004–2005, 2005–2006	4–5+	14.0	35
067	F	NA[c]	2005–2006	NA	9.8	600

[a] Elevation difference computed as nest elevation – burned wintering area elevation.
[b] Burned wintering areas used by these mated owls were separated from each other by 8.3 km.
[c] This wintering area was not included within a fire perimeter. We considered this an example of altitudinal migration, and did not include nest core or wintering areas of this owl in small mammal trapping operations.

Nest core areas (40-ha each) were defined following Ward and Salas (2000). Wintering areas were defined by placing a 200-m buffer around all observed roost locations for each owl using Arcview 3.2 (ESRI Inc. 1999) then merging these buffers to create a single unique polygon for each owl. The 200-m buffers used were arbitrary, but were intended to define an area close to the observed roost sites and therefore readily available for foraging owls. We observed these owls foraging near their roosts during the day on several occasions.

Trapping grids were established at a randomly generated location in both nest core and burned wintering areas. At each grid location, we set 20 traps in two parallel lines (10 traps/line), with 20-m spacing between traps. We placed 1 extra-large ($10 \times 18 \times 60$ cm) Sherman live trap at each trap station. We baited traps with a mixture of peanut butter, rolled oats, and bird seed, supplied abundant cotton batting in traps to provide bedding material for captured animals during cold winter nights, and covered traps with 1–3 cedar shingles to provide additional insulation.

We trapped all grids over a 2-week period from 4–15 December 2006. We checked traps in each grid each morning for 4 days ($n = 80$ potential trap nights/grid). We noted any cases where traps were sprung without capturing an animal and subtracted such traps from available trap occasions. We marked each animal captured with a single numbered ear tag (Monel-1005s1, National Band and Tag, Newport, Kentucky), to allow identification of new versus recaptured individuals, and recorded species (or genus for white-footed mice [*Peromyscus* spp.]) of the captured animal. All captured animals were released unharmed at the point of capture.

For each transect, we report the number of unique individuals captured by species and total biomass of all species. We used the number of unique individuals captured as an index of abundance, because this index often outperforms model-based estimators of abundance when data are sparse (McKelvey and Pearson 2001). Biomass (g) was calculated as the summed biomass of all unique individuals captured. We used values presented in Ward (2001; Table 2.8) to generate mass estimates for individual prey species. Ward (2001; Table 2.8) presented means for small mammals trapped in each of four cover types in the Sacramento Mountains. We averaged these mean values across the four cover types to generate our mass estimates. Because capture data were sparse, we did not conduct formal statistical analyses and simply present summary information here.

RESULTS

Five radio-marked owls from four unique owl territories moved from their breeding area to geographically distinct wintering areas, based on our movement criteria (Table 1). One owl moved to a wintering area 600 m lower in elevation than the nest core area and located outside of the fire perimeters. We considered this an example of altitudinal migration (Ganey and Block 2005) and did not trap small mammals in this wintering area.

Only two species of small mammals (white-footed mice and Mexican woodrats [*Neotoma mexicana*]) were captured in nest core areas, with white-footed mice accounting for 85% of individuals captured (Table 2). In contrast, four species were captured in burned wintering areas (white-footed mice [72% of individuals captured], Mexican woodrats, and both long-tailed [*Microtus*

TABLE 2. Numbers of small mammals captured by species and estimated biomass of small mammals trapped in nest core and burned wintering areas used by four radio-marked Mexican Spotted Owls in the Sacramento Mountains, New Mexico, 2004–2006.

				Number of unique individuals captured				
Territory	Owl sex	Grid type	Trap occasions[a]	White-footed mouse	Mexican woodrat	Long-tailed vole	Mogollon vole	Biomass (g)[b]
010	M	Nest core	78	4	2	0	0	306.8
		Winter area	74	4	4	1	0	577.9
027	F[c]	Nest core	76	5	0	0	0	86.0
		Winter area	75	18	1	0	3	507.2
027	M[c]	Nest core	76	5	0	0	0	86.0
		Winter area	72	4	1	0	0	187.8
104	F	Nest core	73	2	0	0	0	34.4
		Winter area	77	11	0	0	0	189.2

[a] Calculated as (number of traps ×4 occasions) minus number of sprung or otherwise unavailable traps.
[b] Biomass estimates used were derived by averaging estimates from Ward (2001: table 2.8) across four cover types. Estimates used here were: white-footed mouse = 17.2 g, Mexican woodrat = 119.0 g, long-tailed vole = 33.1 g, and Mogollon vole = 26.2 g.
[c] The same nest core area was used for both the male and female from territory 027.

longicaudus] and Mogollon [*M. mogollonensis*] voles; Table 2).

Relative prey abundance in winter was low in all areas, but was greater in burned wintering areas than in the paired nest core areas (Table 2). In addition, estimated prey biomass ranged from approximately double to almost six times greater in burned wintering areas relative to the paired nest core areas. Total biomass of individuals captured in burned wintering areas was 237.2 g greater than biomass captured in nest core areas, on average (95% CI = 12.0–462.5 g), despite having more trap occasions in the nest core area in three of four cases (Table 2).

DISCUSSION

Our results support the hypothesis that prey resources were greater in the burned wintering areas than in the paired nest core areas. Species richness, relative abundance, and biomass of small mammals during the trapping period all were greater within the burned wintering areas than within the paired nest cores of the radio-marked owls. Because the Scott Able fire burned in May 2000 and we trapped small mammals in that area during December 2006, our results suggest that prey abundance in the burned wintering areas was greater than in the nest core areas even where those burned wintering areas were >6 years post-fire.

Although many radio-marked Mexican Spotted Owls in previous studies remained in their breeding areas during winter, some individuals in all populations studied migrated to wintering areas at lower elevations (Ganey and Block 2005: Table 2). Such movements typically allowed migrating owls to winter in areas featuring warmer temperatures below the level of persistent snow, but also could be driven by relative prey availability. Only one study (Block et al. 2005), involving two radio-marked owls from a single territory, quantified differences in prey abundance between lower elevation wintering areas and nest core areas. These owls moved ~40 km from their nesting area in ponderosa pine – Gambel oak (*Quercus gambelii*) forest to a wintering area in pinyon (*Pinus* spp.) – juniper (*Juniperus* spp.) woodland, ~920 m lower in elevation than the nest area. Prey biomass during the winter was approximately seven times greater in the wintering area than in the nesting area of these owls (Block et al. 2005). Thus, these owls moved a relatively long distance to a wintering area at lower elevation in a completely different forest cover type, which featured both milder weather and higher prey abundance.

In contrast, the burned wintering areas used by owls in our study were similar in elevation to the paired nest core areas, <15 km from those nest core areas in all cases, and located in the same forest cover type. Consequently, these owls did not appear to be moving to areas with more favorable weather conditions, such as warmer temperatures or reduced snow cover. The fact that they moved to areas with richer food resources suggests that they may have been seeking greater prey abundance during a season when prey for Mexican Spotted Owls are suspected to be scarce

(Ward 2001, Block et al. 2005, Ganey et al. 2005). Bond et al. (2010) also documented expanded winter movements and use of burned areas by radio-marked California Spotted Owls, and Irwin et al. (2013) documented preferential use of harvested areas by Northern Spotted Owls (*S. o. caurina*) during winter. Irwin et al. (2013) suggested that such use may have been a response to greater prey abundance in these areas.

Clearly, our data were sparse, and involved a limited trapping effort in one time period and in burned wintering and nest core areas of only four owls. We were not able to estimate detection probabilities, and so cannot rule out the possibility that trappability of small mammals differed between nest cores and burned wintering areas, although we have no biological reason to suspect such a difference. We also were not able to generate estimates of precision around abundance estimates, which limits the strength of our comparisons between paired nest core and burned wintering areas (McKelvey and Pearson 2001). The observed differences between paired nest core and burned wintering areas were both relatively large and consistent in direction, and the index of abundance that we used has been shown to perform well in many situations (McKelvey and Pearson 2001).

Finally, because our study was opportunistic and observational rather than experimental, we cannot conclusively attribute differences in prey abundance between paired nest core and burned wintering areas to the effects of wildfire. Paired nest and burned wintering areas sampled were separated in all cases by <15 km, and were similar in elevation and located in the same forest cover type. Thus, the primary difference between these paired areas was that wintering areas were burned and nest cores were not. Consequently, it seems likely that fire effects at least partly explained the observed differences in prey abundance between these paired sites.

It would be desirable to confirm our results with additional and more intensive trapping over longer time frames and on more than one occasion, in multiple seasons, and in more geographic areas throughout the range of Mexican Spotted Owls. In the meantime, however, our results suggest that the burned wintering areas used supported greater species richness, relative abundance, and biomass of prey than the paired nest core areas, that these differences were observed as much as >6 yrs post-fire, and that in our study area these burned wintering areas provided important habitat for Mexican Spotted Owls during an energetically stressful time of year.

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