Endangered Species

SPOTTED OWLS AND WILDFIRE

Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success

Monica L. Bond, R. J. Gutiérrez, Alan B. Franklin, William S. LaHaye, Christopher A. May, and Mark E. Souman

Abstract The effects of wildfire on wildlife are important considerations for resource managers because of recent interest in the role of fire in shaping forested landscapes in the western United States. This is particularly true of wildfire effects on spotted owls (Strix occidentalis) because of the uncertainty of impacts of controlled burning within spotted-owl habitat. Therefore, we documented minimum survival, site fidelity, mate fidelity, and reproductive success for 21 spotted owls after large (>540 ha) wildfires occurred within 11 owl territories in California, Arizona, and New Mexico. In each territory, fire burned through the next and primary roost sites. Eighteen owls (86%) were known to be alive at least 1 year after the fire, which was similar to reported annual adult survival probabilities for the species. Of 7 pairs of which both members were later sighted, all were located together on the same territories during the breeding season following fire, and 4 pairs produced a total of 7 fledglings. No pair separations were observed after fire. On 8 territories where fireseverity was mapped, 30% experienced predominantly low- to moderate-severity fire while 30% experienced high-severity fires that burned large (>30%) areas of the territories. We hypothesize that wildfires may have little short-term impact on survival, site fidelity, mate fidelity, and reproductive success of spotted owls. Further, prescribed burning could have an effective tool in restoring habitat to natural conditions with minimal short-term impact on resident spotted owls. While we do not advocate wholesale prescribed burning in spotted owl territories at this time, we believe our observations justify large-scale experiments on effects of prescribed burning on spotted owls to corroborate our observations and to establish cause-and-effect relationships.

Key words prescribed burning, spotted owl, Strix occidentalis, wildfire

Wildfire is a natural process that has shaped the character of western forests (Agnew 1990). In many areas, pre-settlement fire regimes consisted of frequent low-severity fires at 5-30-year intervals (Kilgore 1973), Hornon and Mannan 1998, Weatherpoon et al. 1992, MacCracken et al. 1996). In central and southern California, the Southwest, and eastern slopes of the Cascades, low-severity fires created a mosaic of uneven and engrailed forest stands (Kilgore 1973, Hornon and Mannan 1998).

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Peer reviewed
Spotted owls and wildfire • Bond et al. 1023

MacCracken et al. (1996). In northwestern California, the xeric end of the Pacific Northwest rainfor-
cest, fire frequency occurred at about 20-year inter-
vals and the fire regime was more similar to
southwestern than other northwestern regions
(Agave 1990, 1993). However, western forests were
not immune to high-severity wildfires, which
occurred infrequently and were patchy in nature
(Stephenson et al. 1991, MacCracken et al. 1996).
Therefore, both low- and high-severity fires have
had significant impacts on forest structure, compo-
sition, and distribution. Risk of high-severity wild-
fires associated with drought, insect and disease
demics, and global warming has increased sig-
nificantly in the western United States following
decades of fire suppression (Agave 1993).

Many studies have been conducted on indirect
impacts of wildfire on bird populations (e.g., Thrush
1963, Barlow 1989). Indirect impacts include
changes in vegetation type, canopy closure, and rel-
ative food abundance, which influence local densi-
ties of birds (Kilgore 1973, Hormann and Mannan
1980). In addition to indirect effects, direct mortal-
ity of birds due to fire has been assessed or sus-
pected (Robbins and Myers 1992; Smith 2000). Pur-
pose, avian lungs may be more susceptible to
damage from smoke exposure than mammalian lungs because of an apparent inability of the avian
respiratory tract to repair itself (Komatsu et al.
1991). While smoke destruction caused by fire has
been reported for some ground-nesting birds in
North Dakota (Robbins and Myers 1992), new stud-
ies have examined avian mortality and behavior
directly following fire (McKean and deSales
2000).

Some biologists assume that large wildfires nega-
tively impact long-term survival of the spotted owl
(S. s. occidentalis; e.g., Weatherpoon et al. 1992,
MacCracken et al. 1996), and believe catastrophic
or "stand-replacement" fires, which kill all vegeta-
tion within the fire boundary pose the greatest nat-
ural risk to spotted owl habitats (United States Fish
and Wildlife Service (USFWS) 1992, 1995; Vernier et
al. 1992). Management plans generally recommend
reducing risk of catastrophic fire in forests occu-
pied by spotted owls (e.g., Vernier et al. 1992). One
method of reducing risk of wildfire is the use of
prescribed fire to remove fuels that can facilitate
surface fires becoming crown fires (Bissell 1989).

Because northern (S. s. occidentalis) and Mexican-spot-
ted owls (S. s. lucidus) are federally listed as endan-
gered subspecies, prescribed fires within owl areas
require consultation with the USFWS. USFWS
smoke and wildfire guidelines for prescribed burn-
ing currently exist for site-preparation of clearcut
units located near northern spotted owl Habitat
Conservation Areas (HCAs), but some agency biolo-
gists have proposed prescriptive burns within
northern spotted owl HCAs (J. Perkins, United
States Forest Service (USFS), Klamath National For-
nal, unpublished report). Because of uncertainty
over fire effects on owls, controlled burning is a
habitats management tool not conducted routine-
ly within areas reserved for spotted owls. For exam-
ple, researchers have examined occupancy of spot-
ted owl territories in years following a wildfire
(Dillon 1986, MacCracken et al. 1996, Gingles et
impacts on individuals could not be assessed
because owls were not color-marked.

We describe minimum survival, site fidelity, mate
fidelity, and reproductive success of color-marked
spotted owls after wildfires burned nest and roost
areas in northwestern California, southern Califor-
nia, Arizona, and New Mexico. After a fire occurred
within an owl territory, we posed 4 questions:

1. Did the owl(s) survive the fire (minimum sur-
vival)?

2. If an owl survived, was it found in the same

3. If both members of a pair survived a fire, did they
retain the same mate (mate fidelity)?

4. If both members of a pair survived a fire, did
they nest successfully the year after the fire
(reproductive success)?

Direct observations of fire effects on spotted owls are difficult to obtain because of the patchy
and infrequent (due to fire suppression) nature of
fire, and logistical or political limitations associated with conducting fire experiments on a meaningful
scale. Nevertheless, we provide insight on short-
term effects of fire on spotted owls by presenting
observations gathered during 15 years of study
throughout a large portion of the species range.

Study areas

We recorded spotted owl responses to fires >440
acres that occurred on 4 long-term demographic study
areas, representing all 3 subspecies of the owl.
Study areas were located in northwestern Califor-
nia (292 km², 1985–2000, northern spotted owl),

San Bernardino Mountains, southern California (1,800 km²; 1987–2000), California spotted owl (Strix occidentalis), Tulare Lake, central California (550 km²; 1991–2000), Mexican spotted owl, and Coconino Plateau, Arizona (585 km²; 1991–2000), Mexican spotted owl.

Forests in southwestern California were primarily mixed evergreen (Sweyer et al. 1988), dominated by white fir (Abies concolor) and pines (Pinus spp.). Forests in the San Bernardino Mountains consisted of mixed evergreens (Sweyer et al. 1988) below 1,500 m, and ponderosa pine (Pinus ponderosa) and white fir-sugar pine (P. lambertiana) forests (Thorne 1988) above 1,500 m. Forests consisted of various combinations of white fir, ponderosa pine, sugar pine, incense cedar (Calocedrus decurrens), and black oak (Q. kelloggii) at higher elevations, and canyon live oak and bigtooth Douglas-fir (Pseudotsuga macrocarpa) at lower elevations. Forests in the Tulare Mountains were primarily mixed-conifer forests. Douglas-fir and white fir were the dominant species in mixed-conifer forests. Pine-oak forests was dominantly dominated by ponderosa pine and Gambel oak (Quercus gambelii). Pinyon—juniper woodland, dominated by pinyon pine (P. edulis) and alligator juniper (Juniperus deppeana), was an extensive community within the mountain range. Forests on the Coconino Plateau were pine-oak dominated by ponderosa pine and Gambel oak (Peet 2000). Other communities on the plateau included mixed-conifer forest having Douglas-fir, ponderosa pine, and white fir in the overstory and quaking aspen (Populus tremuloides) and Gambel oak in the understory, and pinyon-juniper woodland dominated by pinyon pine and junipers (Juniperus spp.; Peet 2000).

Methods

Owl surveys

We surveyed each study area annually for spotted owls during the breeding season from 1985–2001 following methods described by Forsman (1983) and Franklin et al. (1996). We captured adult and juvenile owls using voice arousal, song putting, and mist nets. All captured birds were marked with a locking aluminum USFWS band on 1 leg and a plastic tube with a unique color combination on the other leg (Forsman et al. 1996). We determined the sex of owls by calls and behaviors (Franklin et al. 1996). Rate of band loss for spotted owls was negligible (Franklin et al. 1996). This project was approved by the University of Minnesota's Animal Care and Use Committee (Animal Subjects Code Number: 00033A/24261).

Impacts of fire

We used USFS records of severity, extent, and duration of all fires >50 ha occurring within territories of individually color-marked spotted owls. We limited our study to fires at least this large because burn-range sizes of spotted owls range from 422–591 ha in northwestern California (northern spotted owl, Zabel et al. 1995), 115–851 ha in the San Bernardino Mountains (California spotted owl; Zinzerle et al. 2001), and 648 ha in Arizona (Mexican spotted owl; Haney and Baldi 1989). In each case, nest and roost areas were located within the fire perimeter, and all were burned. Detailed information about conditions (e.g., weather conditions, fuel moisture, humidity, and fuel load) at nest and roost sites was unavailable. We used available USFS data to describe the extent of each fire at the landscape and territory scale. At the landscape scale, we assigned the name, season, and year of the fire, as well as total size and duration of each fire. We addressed fire at the territory scale by estimating percent of each individual owl territory that burned, and percent of the fire-affected area in the territory that burned at high, moderate, or low severity. We defined an owl territory as a circle, with a radius of one-half the average nearest neighbor distance for each study area (see Brigham and Noss 1998) around the nest or roost site during the breeding season, at the time of or prior to the fire (northern spotted owl: 710 m [Franklin et al. 2001]; California spotted owl, ZA = 1,178 m [May 2000]; and 348–1,006 m [Tetreau et al. 1999]). To estimate percent of each territory that burned and nest or roost area location within the fire, we overlaid owl territories onto digitalized fire maps obtained from the USFS using ArcView GIS 5.2 (Environmental Systems Research Institute 1996). Fire-severity classifications for each coverage were conducted by each USFS district within which the fire occurred. Coverages were classified as follows: 1987 autumn King Tulip fire (24,282 ha)
in northwestern California (3 owl territories) into low (<50% canopy kill), moderate (51-70% canopy kill), and high severity (>70% canopy kill). 1995 summer HB fire (>70% crown fire) destroyed 3 owl territories into low (<50% canopy kill) and high severity (>50% canopy kill) severity; 1987 autumn Cold fire (4,760 ha) in northwestern California (1 owl territory) into high (small and subcanopy trees killed) and moderate (most small trees killed, some subcanopy and subcanopy trees killed) and moderate (most small trees killed, some subcanopy trees killed or heavily damaged), and occasional mortality of overstory trees) severity; and 1990 spring Pol fire (2,853 ha) in Arizona (1 owl territory) into crown (standing dead black sticks with no live trees), high (>70% crown scorch of standing overstory trees), medium (30-70% crown scorch of standing overstory trees), and low (underburn (<30% scorch of standing overstory trees or generally on limbs or bed of fire area) severity on the King Titus and HB fires was estimated using aerial photography; satellite imagery was also used on the HB fire. The Cold fire severity was estimated from ground surveys. The Pol fire map was developed using satellite imagery followed by ground verification. Unfortunately, USFS GIS data for the remaining 3 summer fires in southern California (Verbenca, 1995 [2,308 ha], Mill, 1997 [541 ha], Willow, 1999 [25,991 ha]) portrayed only boundaries. We recognize that a boundary may be over-simplified, but several maps for these fires were unavailable. We did not include more detailed pre- and post-fire habitat information in our analysis because our study focused on short-term effects of fire on survival and movements of owls rather than long-term habitat changes. No salvage logging or other major anthropogenic changes to vegetation within owl territories occurred between the time of the fire and the time we surveyed owls the following year.

We qualitatively described impacts of fire on survival, site fidelity, mate fidelity, and reproductive success of individuals and pairs because these were opportunistic observations taken over a long period of time. We pooled data across subspecies because sample sizes for each subspecies were small (<5 territories) and we were describing observational responses rather than conducting comparative statistical analyses. We defined minimum survival rate as percent of individuals residented at least 1 year after the fire (n=21 owls). We defined site fidelity as percent of individuals resighted in the same territory the fire occurred in and 1 year after the fire occurred (n=18 owls). We defined state fidelity as percent of pairs that survived the fire (n=7 owl pairs) and both original pair members remained together (i.e., resighted in same territory as a social pair) 1 year after the fire occurred. Our evaluation of mate fidelity does not imply cause and effect if a pair bond was broken. Rather, we interpreted it to mean only that a fire did not mediate a pair dissolution if they remained together. Reproductive success was defined as average number of fledglings per pair of owls that survived (n=7 owl pairs) 1 year after the fire occurred.

We compared overall estimates of annual adult spotted owl survival and reproductive success for each study area from our previous research (W. S. Lahr, unpublished data; Senne, et al. 1999, Franklin et al. 2000) with qualitative findings from this study. Our previous survival estimates were based on mark-recapture estimators, whereas fire survival estimates were empirical estimates from a small sample site. Therefore, confidence limits for empirical estimates did not reflect uncertainty due to recapture probabilities. We compared short-term (1-year) reproductive success of owls surviving fires with general rates of owl reproduction. However, caution must be used when drawing conclusions about reproduction because spotted owl reproduction was more variable than survival and differences from overall averages could have been due to annual variation rather than effects of fire.

We also estimated overall annual site fidelity for each study area based on long-term data. We calculated annual site fidelity by dividing number of owls remaining on territories from year 1 to year (+1) by total number of owls surviving from year 1 to year (+1). Only banded, adult owls were used in site-fidelity calculations.

**Results**

Data were gathered from 4 study areas representing 38 observation years, >2,000 banded owl, >360 owl territories, and 7 wildlife areas. Owls occurred in all 4 northern, 3 California, and 4 Mexican spotted owl territories. All territories were >80% burned (85-100%). In all cases, nest and nest areas were burned. Four of 8 territories where fire severities were mapped were burned primarily at low to moderate severity. However, the remaining 4 territories experienced fires.
that burned 36-98% of the territory at high-sev-er-ty levels. Eighteen of 21 (86%) individual owls affected by fire were reared at least 1 year after the fire, and 16 of the 18 (89%) resighted owls were located in the same territories in the breeding season after the fire. Among 7 owl pairs in which both mem-bers were reared after a fire, all were sin-gle-oviparous. Among 5 individuals whose mates were never reared, 2 females were reared after the fire on different territories with different males, and 1 male exhibited one-oviparous behavior after the fire but was found paired with a different female. Four of 7 surviving owl pairs (57%) produced 7 fledglings the year following fire.

Minimum survival of spotted owls experiencing fires was similar to overall annual survival rates reported for the 3 subspecies (Table 1). Site fidelity among fire-exposed birds was also similar to overall estimates from the 4 demographic studies (Table 1). Reproductive success of spotted owls 1 year after fire occurred was higher than overall annual rates of reproduction (Table 1).

Discussion

Results from previous studies on impacts of wildfires on spotted owls have been equivocal. In some cases, large stand-replacing wildfires appeared to have a negative impact on owl occupancy (Elliot 1989, MacClellan et al. 1996, Gaines et al. 1997). Other reports have suggested that low- to moderate-severity wildfires did not adversely impact spotted owls (Yusuda 1997, Scott 1998, Johnson 2000). Although high-severity fires may dis-place some owls from ter-ritories (Elliot 1989, Gaines et al. 1997), it was unknown whether birds moved or died because owls in these studies were not marked. Since we monitored the presence of color-marked owls, we could draw modified estimates on the effects of fire on individual survival, site fidelity, mate fidelity, and reproductive success. In our study, sites of only 3 of 21 owls exposed to fire were unknown. Retractile, sharp-nosed owls (pennant nests and roost areas appeared to have little short-term effect on survival, site fidelity, mating success, and reproductive success of spotted owls, as seen were similar to estimates independent of fire. While post-fire reproductive rates were highest than background rates for those populations, they were well within the range of variation seen in these populations. Most (6 of 8) territories burned ≥50% at low to moderate severity. Therefore, we hypothesize that spotted owls may have the ability to withstand the immediate, short-term (1-year) effects of fire occurring at particular low to moderate severities within their territories.

Horton and Mauran (1988) noted that animals that occupied forests having frequent fire intervals that burned 36-98% of the territory at high-severity levels were not marked. Since we monitored the presence of color-marked owls, we could draw modified estimates on the effects of fire on individual survival, site fidelity, mate fidelity, and reproductive success. In our study, sites of only 3 of 21 owls exposed to fire were unknown. Retractile, sharp-nosed owls (pennant nests and roost areas appeared to have little short-term effect on survival, site fidelity, mating success, and reproductive success of spotted owls, as seen were similar to estimates independent of fire. While post-fire reproductive rates were highest than background rates for those populations, they were well within the range of variation seen in these populations. Most (6 of 8) territories burned ≥50% at low to moderate severity. Therefore, we hypothesize that spotted owls may have the ability to withstand the immediate, short-term (1-year) effects of fire occurring at particular low to moderate severities within their territories.

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should be adapted to recurring fires. While prescribed fire regimes of western forests consisted of frequent low-intensity burns, infrequent high-severity fires are important determinants of forest structure, composition, and distribution (Agee 1990, Stephenson et al. 1991). Given historical fire regimes within its range, the spotted owl may be adapted to survive wildfires of various sizes and severities. Therefore, prescribed burning could be an effective tool in reducing current fire risk and restoring forests to natural conditions with minimal short-term impact to owls. However, we believe that programmatic prescribed burning in spotted owl territories cannot be justified solely on the observations we report here. Experiments testing effects of fire on spotted owls are still needed to corroborate the effects we observed, establish cause-and-effect relationships, and determine long-term impacts on spotted owls.

Acknowledgments. We thank the following United States Forest Service Eastern Districts for information on wildlife: Mountain Top (San Bernardino National Forest), Hayfork (Coastal-Triune National Forest), and Happy Camp (Klamath National Forest), California; Reserve (Gila National Forest), New Mexico; and Long Valley (Coconino National Forest), Arizona. J. Anderson, R. Armstrong, C. Beyers-heim, J. Fox, B. Greco, R. Hall, M. Kolb, S. Redlar, and S. Vagele were particularly helpful in securing data on owl nesting. We also thank J. Hunter for valuable advice, as well as numerous research assistants for collecting field data. Funding for this study was provided by the USDA Forest Service (contract #FSBB-5188-00-EC14-2 to M.G.) and the University of Wisconsin.

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