



## Original Article

# Black-Backed Woodpecker Nest-Tree Preference in Burned Forests of the Sierra Nevada, California

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**ABSTRACT** Black-backed woodpeckers (*Picoides arcticus*) are well-known to occur at higher densities in recently burned forests than they do in nearby green forests. In the forests of the Sierra Nevada, California, USA, there is relatively little information on the types of nest trees that these birds use in recently burned forests. From 2009 to 2011, we studied nest-tree preference by black-backed woodpeckers in 2 burned forests in the northern Sierra Nevada. For each of 31 nest trees and 389 randomly selected trees, we recorded decay class, diameter at breast height, top condition, and species. We also recorded the number of snags with >23 cm diameter at breast height within an 11.3-m radius of each nest tree and randomly selected tree. We evaluated nest-tree preference by comparing the characteristics of nest trees to randomly selected trees. Black-backed woodpeckers preferred dead but not heavily decayed trees and moderate (29–61 cm dbh) diameter trees. There was no evidence that black-backed woodpeckers had strong preferences for trees with broken tops or trees of particular species. Snag density around nest trees was higher than around randomly selected trees. Our results suggest that in conifer forests of the Sierra Nevada, the distribution of black-backed woodpeckers in post-fire environments is influenced more by surrounding snag densities than by particular characteristics of potential nest trees. © 2012 The Wildlife Society.

**KEY WORDS** black-backed woodpecker, California, cavity nest, conifer forest, fire ecology, forest management, *Picoides arcticus*, Sierra Nevada.

The highest densities of black-backed woodpecker (*Picoides arcticus*) have long been recognized to occur in areas of recently burned forest (Blackford 1955, Murphy and Lehnhausen 1998). Because of this affinity for a cover type that is relatively rare, highly dynamic, and subject to degradation by fire-suppression and post-fire salvage programs, there is increasing concern about the management and conservation of the species (Hutto 2008, Nappi and Drapeau 2009). This concern has been illustrated recently by the species' selection by the U.S. Forest service as an indicator that a sufficient number of snags have been retained in burned forest of the Sierra Nevada (USFS 2008), and by the fact that the species is currently being considered for listing as threatened or endangered in California, USA, by the California Department of Fish and Game (JMP and CBD 2010, CDFG 2012).

Like all members of the *Picidae* family, black-backed woodpeckers nest in cavities. For some cavity-nesting birds, the availability of suitable nest trees can limit the density of

breeding pairs (Walters et al. 1992, Cockle et al. 2010). Thus, studies that provide information about the types of trees preferred by nesting woodpeckers can provide managers with the information they need to make decisions about management and restoration of forest environments to support woodpecker populations. In western North America, published accounts on the size, species, and decay condition of black-backed woodpecker nest trees are primarily from Oregon (Bull et al. 1986, Forristal 2009), Idaho (Saab et al. 2009), and Montana (Caton 1996), USA. Despite the prevalence of, and conservation concern for, this species in the Sierra Nevada, we know of only a single study on the nesting habitat of black-backed woodpeckers, and this study had a sample size of only 7 nests (Raphael and White 1984).

Here, we describe nest-tree preference of black-backed woodpeckers in 2 large (6,000–26,000 ha) burns in the northern Sierra Nevada, California. We used habitat selection ratios to compare the size, decay class, top condition, and species of trees used for nesting to those of trees randomly selected. We also quantified the density of snags in the immediate area around nests trees and randomly selected trees to evaluate whether black-backed woodpeckers preferred areas with relatively high snag densities. Our objectives were to generate information that can be used to ensure

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the retention of suitable nest trees and to evaluate the degree to which the creation of suitable nest trees versus the overall density of snags may explain the high densities of black-backed woodpeckers that occur in recently burned forests of the Sierra Nevada, California.

## STUDY AREA

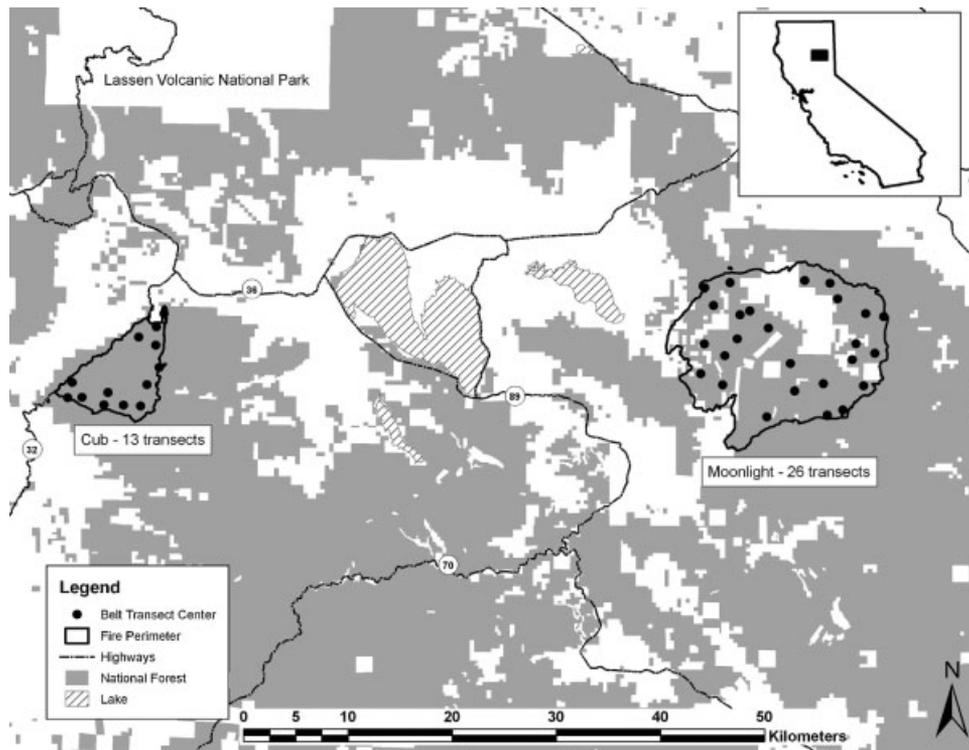
We studied nest-site selection by black-backed woodpeckers in 2 recently burned areas (hereafter, burns) in the Lassen and Plumas National Forests at the intersection of the Sierra Nevada and Cascade mountain ranges in northeastern California (Fig. 1). The 2 burns were 40 km apart. The Moonlight Fire (40°14'N, 120°45'W) burned in September 2007 over an area of 26,290 ha. Within this burn, our survey transects ranged in elevation from 1,199 m to 2,190 m ( $\bar{x}$  = 1,779 m). The Cub Fire (40°11'N, 121°28'W) burned in June and July of 2008 over an area of 5,960 ha. Our survey transects in this burn ranged in elevation from 1,126 m to 1,998 m ( $\bar{x}$  = 1,658 m). Using the composite burn index (Miller and Thode 2007), 56% of the Moonlight Fire was high-severity burn, 27% was moderate, and 17% was low. Thirteen percent of the Cub Fire was classified as high severity, 21% as moderate, and 66% as low. Both burns were dominated by mixed-conifer forest types with some true fir and montane chaparral present prior to burning. The most common trees in these areas were yellow pine (*Pinus ponderosa* and *P. jeffreyi*), true firs (*Abies* spp.), lodgepole pine (*Pinus contorta*), and Douglas-fir (*Pseudotsuga menziesii*).

## METHODS

### Sampling Design and Data Collection

For nest-searching, we established 26 belt-transects in the Moonlight Fire site and 13 in the Cub Fire site (Fig. 1). We generated belt-transect locations by selecting a random starting point with a minimum spacing of 1,500 m to minimize the chance transects would overlap. To allow timely access and safe navigation on foot, starting locations were limited to U.S. Forest Service land and sites with a slope of <40%. From each starting point, we established a 20-ha belt-transect (200 × 1,000-m rectangle) with the orientation of the transect based on a random compass bearing. All site selection was carried out in ArcMAP 9.2 (ESRI 2004).

Nest searching was conducted during May–early July in 2009, 2010, and 2011. This time period covered the regular nesting cycle of black-backed woodpeckers in our study area. In each year, we visited all belt-transects twice, with  $\geq 7$  days and up to 21 days between visits. We conducted nest searches following protocols established by Dudley and Saab (2003). Nest surveys along belt-transects began 1–2 hours after sunrise, and continued for 2–4 hours, depending on woodpecker activity and ease of navigation, such that all nest surveys were completed by noon. The primary cue we used to find nests was bird behavior (Martin and Geupel 1993). We searched for nests by meandering through the belt-transects looking for woodpeckers, but did not use playback of recorded black-backed woodpecker vocalizations. After we detected a black-backed woodpecker, we attempted to follow it to its nest cavity; we usually followed the bird for up to 1 hour. When we encountered birds that we suspected to be nesting but



**Figure 1.** Study area with fire perimeters and belt-transect locations at 2 burns in the Plumas and Lassen National Forests of the Sierra Nevada, California, USA.

could not be followed directly to a cavity, we conducted a systematic search of snags in the vicinity. We considered nests to be active if we observed adults entering and remaining in the cavity, if we observed adults leaving a cavity we had not seen them enter, if we heard young begging within a cavity with adults observed nearby, or if we observed adults carrying food into a cavity. When we found excavated cavities that adults entered briefly, but for which there was no evidence of incubation or nestling attendance, we did not recorded them as active.

Once a nest was confirmed active, we recorded nest-tree characteristics that included diameter at breast height (dbh), tree decay class, and condition of the tree top. We recorded dbh to the nearest cm; and for the analysis, we binned the measurements into 3 categories: 15–28 cm, 29–61 cm, and >61 cm. We chose these categories to correspond to the California Wildlife Habitat Relationship dbh categories that are used to describe poles (6–11 in. [approx. 15–28 cm]), small trees (11–24 in. [approx. 29–61 cm]) and large-medium trees (>24 in. [>61 cm]) in snag retention guidelines (Airola 1988). For decay class, we used a scale ranging from 1 to 8; 1 being an intact live tree and 8 a severely decayed stump (Hunter 1990). For the analysis, we lumped categories 1 and 2 (live and dying trees), categories 3 and 4 (completely dead, but with branches and bark remaining—low to moderate decay), and categories 5, 6, 7, and 8 (dead trees that had lost all bark and branches—high decay). Finally, we recorded the condition of the tree top as intact, broken before the fire, or broken after the fire. When possible, we recorded the species of the nest tree, but in some cases severely decayed snags could not be identified to species. For our final analysis, we lumped the tree species into 3 groups: true fir (*Abies concolor* and *A. magnifica*), yellow pine, and other species (including trees unidentified to species or species group). We chose the true fir and yellow pine groupings because they were both abundant in the study area and the snags of closely related species in these groups could not be readily distinguished to the species level. The trees in the “other” category either could not be identified, or were so uncommon that it was not meaningful to include them in the analysis.

We randomly selected trees in each belt-transect using the random point generator in Hawth's Tools extension for ArcMap 9.2 (ESRI 2004); we then recorded the same information at nest trees and randomly selected trees. We navigated to the coordinates of randomly selected points using a handheld global positioning system unit. Once we were within 10 m of the random point, we stopped and selected the nearest tree (live or dead) >12 cm dbh. On the rare occasion that random points fell close to known nest trees, we selected a random tree that was  $\geq 25$  m from the nest tree. Each year we measured a new set of randomly selected trees. We chose a cut-off of 12 cm because this was the smallest size tree in which we had found nesting woodpeckers of any species during the first year of the study. Over the 3 years of the study, we sampled 145 random trees in the Cub Fire site and 244 random trees in the Moonlight Fire site.

We used the nest trees and randomly selected trees as the center point of an 11.3-m-radius plot, in which we counted

all snags >23 cm dbh. We chose this plot size based on the widespread use of a 0.1-acre (0.04-ha) plot to quantify habitat characteristics in earlier studies (e.g., Raphael and White 1984, Saab et al. 2009). We performed these snag counts at all randomly selected trees and at all nest trees. For these plots, we binned snag densities into 3 categories: low (<5 snags/plot), medium (5–8 snags/plot), and high (>8 snags/plot). We chose these categories based on the distribution of snag densities at the random plots. For continuous variables (tree dbh and snag density) we also present the mean, standard deviation, and range for the nest trees and randomly selected trees.

### Statistical Analysis

We evaluated nest-tree preference of black-backed woodpeckers by comparing the characteristics of nest trees to those of the randomly selected trees. This corresponds to the Sampling Protocol A and Design I described by Manly et al. (2002). We considered all randomly selected trees to be available to nesting black-backed woodpeckers, such that we were comparing a sample of available nest trees to a sample of the used nest trees. For all analyses, we pooled data across the 3 years of the study. Because we searched the same plots in all years, it was likely that the same pairs were recorded in multiple years. This corresponds to Design 1 and is appropriate for making inferences about the population in our study area (Manly et al. 2002).

We evaluated nest-tree preference for each burn separately, as well as for both burns combined. For each of these groups, we calculated the proportion of used and available (randomly selected) trees in each category of a nest-tree characteristic. We treated both the used and available trees as a sample of the larger population and calculated the standard error of the proportion in each category following Manly et al. (2002). After preliminary analyses revealed relatively minor differences between the 2 burns, we limited our subsequent analyses of selection ratios to the pooled data set.

We calculated selection ratios by dividing the proportion of a used resource by the proportion of the corresponding available resource. If nest trees were used in proportion to their availability they would have a selection ratio of 1.0. A selection ratio >1 implied preference, whereas a value <1 implied avoidance. We first used a Pearson's chi-square goodness-of-fit test ( $\chi^2$ ) to evaluate whether the pattern of nest-tree use differed from the pattern of available trees (Manly et al. 2002). If we found evidence of preference ( $P < 0.05$ ), we further interpreted the selection ratios for each category using simultaneous 95% Bonferroni confidence interval calculated over all categories. If these confidence intervals did not include 1, we rejected the null hypothesis of use proportional to availability (Manly et al. 2002). For most nest tree characteristics, the proportion of available trees was sufficient to meet the assumption that the expected number of observations would be >5 for most categories. For categories where the proportion of available nest trees for more than one category was small (e.g., tree top condition) the significance tests should be interpreted cautiously. When there were no observed nests in a category

(e.g., large diameter snags), we did not use the selection ratios to make inferences about preference. All statistical analyses were conducted in Program R (R Version 2.10.1, <http://cran.r-project.org/>, accessed 16 Feb 2011) using the package *adehabitat* (Calenge 2006).

## RESULTS

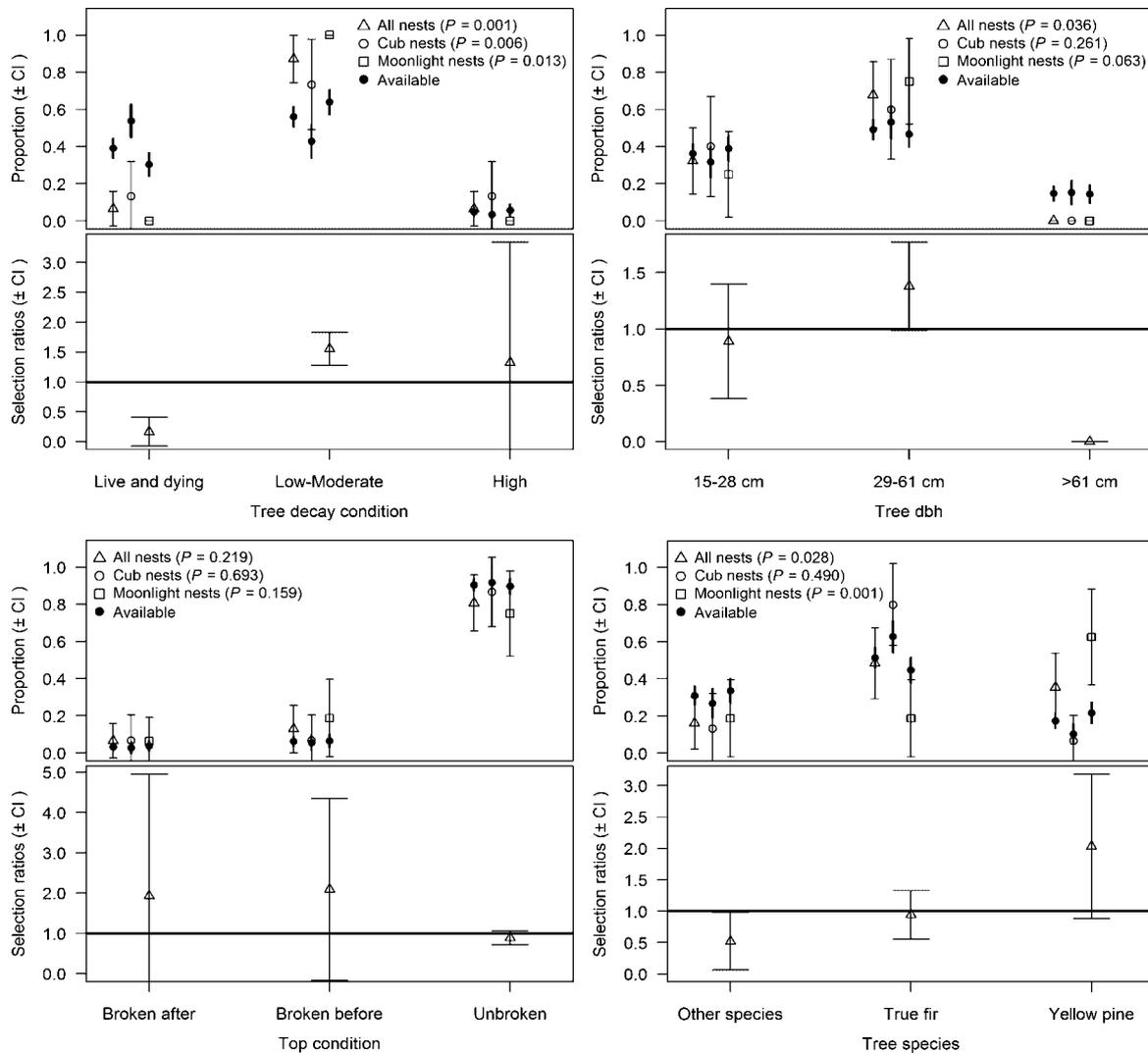
Over the course of the study, we found 31 black-backed woodpecker nests, 15 in the Cub Fire site and 16 in the Moonlight Fire site. None of the cavities were re-used between years and each appeared to have been freshly excavated in the year of its use.

### Preference of Nest-Tree Characteristics

Of the 31 nests, relatively few ( $n = 2$ , 6.5%) occurred in live or dying trees, most ( $n = 27$ , 87.0%) occurred in the low to

moderately decayed snags, and relatively few ( $n = 2$ , 6.5%) occurred in highly decayed snags. The differences in the proportion of decay classes of used and available trees were similar between the 2 fires (Fig. 2). When the nests from the Cub and Moonlight fire sites were combined there was evidence of preference ( $\chi^2_2 = 13.2$ ,  $P < 0.05$ ); the selection ratio for live and dying trees was significantly  $< 1$ , the selection ratio for the moderately decayed snags was significantly  $> 1$ , and highly decayed snags were used in proportion to their availability (Fig. 2).

For the 31 nest trees we measured, the mean dbh was 33 cm (SD = 7, range = 18–50), whereas the mean dbh of randomly selected trees was 40 cm (SD = 24, range = 15–142). For nest-tree size class, there was evidence of preference from the pooled sample ( $\chi^2_2 = 6.65$ ,  $P < 0.05$ ); black-backed woodpeckers used the smallest



**Figure 2.** Black-backed woodpecker preference for 4 nest-tree characteristics in 2 burns (15 in the Cub Fire site and 16 in the Moonlight Fire site) compared with characteristics of available (randomly selected) trees (145 in the Cub Fire site and 244 in the Moonlight Fire site). Data were collected in 2009, 2010, and 2011 in the Plumas and Lassen National Forests of the Sierra Nevada, California, USA. The upper panel presents the proportion of all nest trees and randomly selected trees with 95% confidence intervals. The  $P$ -values are from Pearson's chi-squared goodness-of-fit tests for the null hypothesis that the proportion of nest trees did not differ from the randomly selected (available) proportions. Bottom panel presents selection ratios for each category with 95% Bonferroni confidence intervals. If nest trees were used in proportion to their availability, they would have a selection ratio of 1; a selection ratio  $> 1$  implies preference, whereas a value  $< 1$  implies avoidance.

size class (15–28 cm dbh) in proportion to their availability, showed the strongest preference for the moderate size class (29–61 cm dbh), and were never found in trees >61 cm dbh. When the Cub and Moonlight fire sites were considered separately the patterns were similar, but not significant (Fig. 2).

We found nests in trees with unbroken tops ( $n = 25$ , 80.5%), tops broken before the fire ( $n = 4$ , 13.0%), and tops broken after the fire ( $n = 2$ , 6.5%). There was no evidence of preference for trees with broken or unbroken tops either for all nests combined ( $\chi^2_2 = 3.4$ ,  $P > 0.05$ ) or when the 2 fires were considered independently (Fig. 2).

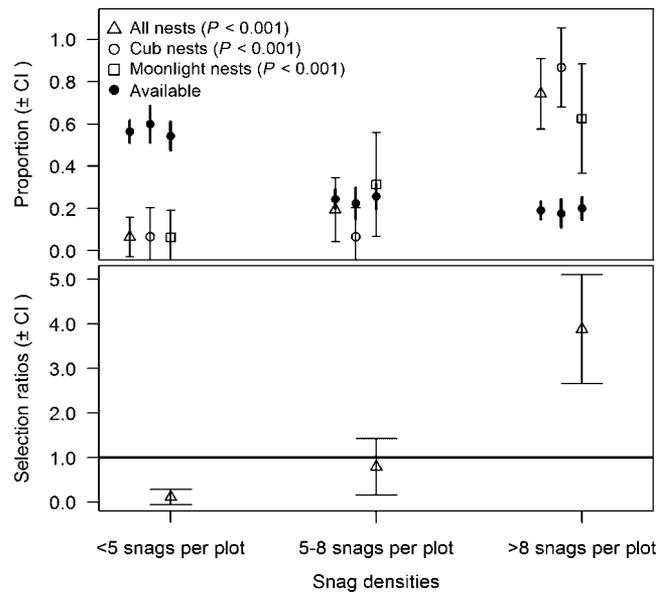
We found black-backed woodpecker nests in white fir (*Abies concolor*,  $n = 14$ ), red fir (*Abies magnifica*,  $n = 1$ ), lodgepole pine (*Pinus contorta*,  $n = 1$ ), yellow pine ( $n = 11$ ), Douglas-fir ( $n = 1$ ), incense cedar (*Calocedrus decurrens*,  $n = 1$ ), and trees that we could not confidently identify ( $n = 2$ ). For tree species groups, there was evidence of preference ( $\chi^2_2 = 7.2$ ,  $P < 0.05$ ) for the pooled sample, in which the selection ratio for species other than yellow pine and true fir was significantly  $<1$ , whereas the selection ratio was  $>1$  for yellow pine, and true fir was used in proportion to its availability (Fig. 2). However, when the Cub Fire or Moonlight Fire sites were considered independently, the pattern of preference was only significant for the Moonlight Fire site ( $\chi^2_2 = 13.5$ ,  $P < 0.05$ ), where true fir was used less frequently than its availability and yellow pine was used more frequently than its availability. In the Cub Fire site, although the pattern was not significant, there was a trend toward a preference for true fir, whereas yellow pine was used proportionately to its availability (Fig. 2).

### Preference of Surrounding Snag Density

For the 31 nests, the mean number of snags/plot was 13.3 (SD = 7.6, range = 1–29 snags/plot), whereas the mean number of snags on plots at randomly selected trees was 5.0 (SD = 5.2, range = 0–35 snags/plot). In both the Cub Fire and Moonlight Fire sites, black-backed woodpeckers preferred nest trees located in areas with high snag densities (Fig. 3). When the nests from the Cub and Moonlight Fire sites were combined, the selection ratio for the lowest snag density (<5 snags/plot) was significantly  $<1$ , the selection ratios for the moderate snag density was close to 1, and selection ratios for areas of high snag density was substantially  $>1$  (Fig. 3).

## DISCUSSION

Previous studies in western North America suggest that black-backed woodpeckers generally nest in harder, recently dead trees or in the dead portion of live trees (Raphael and White 1984, Bull et al. 1986, Saab and Dudley 1998); they do not re-use their own cavities or those of other species in subsequent years (Saab et al. 2004); they typically nest in trees of <50 cm dbh (Bull et al. 1986, Caton 1996, Saab et al. 2002), often in ponderosa pine, red fir, lodgepole pine, and western larch (*Larix occidentalis*; Raphael and White 1984, Bull et al. 1986, Caton 1996). Our results modify or reinforce these generalizations in several ways. First, while our results



**Figure 3.** Snag densities measured within an 11.3-m-radius plot centered on black-backed woodpecker nests in 2 burns (15 in the Cub Fire site and 16 in the Moonlight Fire site) compared with snag densities at available (randomly selected) sites (145 in the Cub Fire site and 244 in the Moonlight Fire site). Data were collected in 2009, 2010, and 2011 in the Plumas and Lassen National Forests of the Sierra Nevada, California. The upper panel presents the proportion of all nest trees and randomly selected trees with 95% confidence intervals. The  $P$ -values are from Pearson's chi-squared goodness-of-fit tests for the null hypothesis that the proportion of nest trees did not differ from the randomly selected (available) proportions. Bottom panel presents selection ratios for each category with 95% Bonferroni confidence intervals. If nest trees were used in proportion to their availability, they would have a selection ratio of 1; a selection ratio  $>1$  implies preference, whereas a value  $<1$  implies avoidance.

support the observation that black-backed woodpeckers prefer less decayed snags to more decayed (and presumably softer) snags, we found that black-backed woodpeckers nested in live trees and trees that were dying less than would be expected based on their availability. This result was surprising because almost all of the black-backed woodpecker nests we have located in unburned forest in the region have been located in live trees where bark had been removed and sap was exuding from around the cavity entrance. Our results support the observation that black-backed woodpeckers do not preferentially nest in the largest snags. Although we did not find evidence that they avoided smaller diameter snags (15–28 cm dbh), the fact that the smallest tree in which we found a nest was 18 cm dbh suggests that this may represent the lower limit of the size of trees used for nesting.

Overall, our results suggest black-backed woodpeckers are less specialized in their selection of nest trees compared with other woodpeckers. For example, several studies from post-fire environments have shown that other woodpecker species often use snags that had broken tops prior to the fire (Haggard and Gaines 2001, Lehmkuhl et al. 2003). We found no evidence of preference for trees with broken or intact tops, a result consistent with descriptions of black-backed woodpecker nests in Idaho (Saab and Dudley 1998). In contrast to black-backed woodpeckers, other woodpeckers that nest sympatrically show strong preferences for heavily

decayed snags (white-headed woodpeckers [*Picoides albolarvatus*]; Raphael and White 1984), or large-diameter snags (Lewis' woodpecker [*Melanerpes lewis*]; Raphael and White 1984, Saab et al. 2009). Thus, even though the black-backed woodpecker is considered more of a habitat specialist than is any other woodpecker in western forests (Hutto 2008), its preference for particular types of nest trees (at least in these 2 burns) does not seem strong.

We did, however, find strong evidence that black-backed woodpeckers preferred nest trees within areas of high snag densities and avoided nest sites with low snag densities. It seems likely that preference for nest sites with high densities of snags within an 11.3-m radius of the nests probably reflects a preference for larger areas of high snag density, but with our data it is not possible to say at what scale they are selecting for snag density. Converting our snag densities to a per-hectare measurement, as most previous studies have reported, suggests that black-backed woodpeckers select sites with >200 snags/ha and that the mean snag density at nests sites was 332 snags/ha. In post-fire environments in Idaho, Saab et al. (2009) reported that the mean snag density at black-backed woodpecker nest sites was 316 snags/ha. In both Idaho and our study sites in the Sierra Nevada this species is nesting in areas with extremely high snag densities in post-fire environments and far greater snag densities than most salvage operations leave behind (Hutto 2006). Certainly, developing a better understanding of the spatial scale at which black-backed woodpeckers respond to patches of high snag density is a priority for improving ecosystem management of post-fire environments in the Sierra Nevada.

### Scope and Limitations

The interpretation of nest-tree preference in our study might be complicated by possible correlations among some characteristics, such as top condition and decay class. As a result, evidence for selection for one characteristic may reflect preference for other correlated characteristics. We also caution that our sample was of a relatively small number of nests ( $n = 31$ ) collected from a small portion of the species' range in the Sierra Nevada. Thus, the degree to which our results can apply to the greater Sierra Nevada region remains untested. However, the consistency in nest preferences between the 2 burns, despite differences in fire severity, is suggestive of patterns that may hold across a range of possible conditions. The Cub Fire burned at generally moderate to low severity with small to medium-sized patches of high severity, whereas the Moonlight Fire burned primarily at higher severities with high-severity patch sizes generally being very large.

### MANAGEMENT IMPLICATIONS

Snag management guidelines have often been based on wildlife needs for nest trees. Our results suggest that for black-backed woodpecker in burned forest, snag retention should not be restricted to nest-tree characteristics, because this species does not demonstrate strong selection for particular types of nest trees. Instead, our results reinforce the findings of other studies that black-backed woodpeckers

prefer to nest in areas with high snag densities (Murphy and Lehnhausen 1998, Nappi et al. 2003, Saab et al. 2009).

Our results, in combination with studies that have shown that black-backed woodpeckers are extremely sensitive to salvage logging (Hutto 2008, Saab et al. 2009), suggest that currently the best strategy for protecting black-backed woodpecker habitat is to maintain large patches of high snag densities (Dudley and Saab 2007, Russell et al. 2007). Given the current levels of salvage logging on public and private land in the Sierra Nevada, there is an immediate need for more information about how snag densities at larger spatial scales, patch-size thresholds, and landscape composition (e.g., fire severity mosaics and distance to unburned forest) influence habitat suitability for black-backed woodpeckers.

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