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# BIRD USE OF BURNED AND UNBURNED CONIFEROUS FORESTS DURING WINTER

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ABSTRACT.—Cavity-nesting bird species have been shown to be associated with early post-fire habitat during the breeding season but little study has been done of birds in the non-breeding season. We compared bird composition and foraging behavior during the winter in burned and unburned forests. We conducted point counts during four consecutive winters immediately following a stand replacement fire. Burned and unburned forests had similar numbers of bird species, yet species composition was distinctly different. Trunk and branch foraging species were 2.5 times more abundant in burned forest than in unburned forest. Within burned forests, trunk and branch foraging species significantly decreased from the first winter post-fire to the fourth winter post-fire. We conducted foraging observations of four woodpecker species within burned forests only. Woodpeckers used western larch (*Larix occidentalis*), ponderosa pine (*Pinus ponderosa*) and Douglas-fir (*Pseudotsuga menziesii*) snags that were greater than 23 cm in diameter. Stand replacement fires may play an important role in maintaining populations of trunk and branch foraging species in mixed coniferous forests in northeastern Washington. *Received 24 August 1998, accepted 28 Dec. 1998.*

Wildfire plays a major role in determining landscape patterns by creating large mosaics of burned habitat intermixed with unburned habitat. Prior to fire suppression policies in the early 1900s, wildfires were more frequent and widespread in the western United States (Agee 1994, Hejl 1994). Mixed-conifer forests of the Pacific Northwest have a history of stand replacement fires, in which most trees are killed, occurring every 140–340 years (Agee 1994). Stand replacement fires create a unique habitat of large patches of standing dead trees that host great numbers of bark and wood-boring beetles (Furniss 1965, Amman and Ryan 1991) which serve as food for birds inhabiting recently burned forests (Spring 1965, Wickman 1965). This food resource is thought to decrease dramatically 2–5 years post-fire (Koplin 1972).

Cavity-nesting bird species are associated with early post-fire forests (1–9 years post-fire, Hutto 1995). Many researchers have compared bird abundance in burned and unburned forest during the breeding season and found increased numbers of cavity-nesting bird species in early post-fire forests (Bock and Lynch 1970, Raphael and White 1984, Raphael et al. 1987, Hutto 1995, Caton 1996, Hitchcox 1996). Some species, including the Black-backed Woodpecker (*Picoides arcticus*), Three-toed Woodpecker (*Picoides tridactylus*), and Mountain Bluebird (*Sialia mexicana*) have been shown to be more common in the first few years after a fire than later (Hutto 1995). How long this high abundance of cavity-nesting bird species persists in post-fire habitat is unclear.

There are few data on bird species composition of burned forests during the non-breeding season. In Montana, Blackford (1955) anecdotally noted numerous woodpecker species in burned forests during the winter. Blake (1982) compared stand replacement burned and unburned ponderosa pine (*Pinus ponderosa*) forests during the non-breeding season and found bark insectivores (including woodpeckers) to be more abundant in burned forests. Non-breeding season habitat may play a significant role in determining overall survival and numbers of individuals that breed (Conner 1979, Graber and Graber 1983, Klein 1988) and is probably as important as breeding season habitat for the persistence of avian populations. Many resident species present in burned forest during the non-breeding season may not remain in burned forest year-round but seasonally migrate short distances to different habitats, thereby maximizing their use of available resources.

Several studies have examined the characteristics of trees used for nesting by cavity-nesting birds in burned forests. In general, cavity-nesters seem to prefer broken top snags

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and snags greater than 23 cm in diameter for nesting (Raphael and White 1984, Hutto 1995, Caton 1996, Hitchcox 1996). Fewer researchers have examined the snag characteristics used for foraging by cavity-nesting birds in burned forests (Hutto 1995, Caton 1996), even though food availability may be as important to excavating cavity-nesting species as the availability of nest sites, especially in burned forests where nest snags may be abundant (Caton 1996). Because snags used for nesting and foraging by cavity-nesting birds may differ, information on the characteristics of snags used for nesting would be of particular interest to managers to maintain fire-dependent bird populations.

To investigate the use of burned forests during the winter, we examined bird community composition and foraging behaviors in burned and unburned forests during four consecutive winters in northeastern Washington.

## STUDY AREA AND METHODS

*Study area.*—The study sites were located in the Kettle River Range on the Colville National Forest in the northeastern corner of Washington, 26 km north of Republic (48° 65′ N, 118° 73′ W). This area is predominantly a mixed-conifer forest consisting of subalpine fir (*Abies lasiocarpa*), Douglas-fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), ponderosa pine, western larch (*Larix occidentalis*), and lodgepole pine (*Pinus contorta*), with a minor understory component of ninebark (*Physocarpus malvaceus*). Both the burned and unburned study sites had similar tree species composition and were located in unlogged areas.

In August 1994 the Copper Butte fire was ignited by lightning and burned 4000 ha, resulting in large mosaics of high intensity burned areas mixed with low intensity and unburned areas (U.S. Dept. of Agric. 1995). We chose two stand replacement burned sites of greater than 80 ha within the Copper Butte fire area, with elevations ranging from 1320–1650 m. The unburned site was located 20 km north of the burned sites, 0.6 km from the burn boundary. The 80 ha unburned site had similar slope and aspect to the burned sites but was only 1030–1320 m in elevation. Average yearly rainfall for this area is 384 cm and average yearly temperature is 6.1° C. During November–February, when all of the data were collected, the average monthly precipitation was 42 cm (predominantly snow) and the average temperature was −2.1° C.

*Avian sampling.*—We used the point count method to quantify birds in burned and unburned forests (Blondel et al. 1981, Hutto et al. 1986). Point count stations were systematically laid out at least 200 m apart, 100 m from a change in habitat, and 50 m from roads and creeks. We conducted ten-minute counts, recording all birds seen and heard within 100 m (Hutto 1995). Unfortunately, we could not always distinguish between Hairy (*P. villosus*), Three-toed (*P. tridactylus*), or Black-backed (*P. arcticus*) woodpeckers so we created a category of "unknown woodpecker" to account for these detections. Counts were conducted on fair weather days when winds were less than 25 kph, with little or no precipitation, and temperatures greater than −9° C. Winter counts were conducted between 08:00 PST (1 h after sunrise) and 16:00 from 8 November to 4 February 1994–1997.

Over the four years of the study, the number of point count stations surveyed was as follows: first winter to fourth winter post-fire, burned (8, 9, 13, 13) and unburned (0, 9, 9, 9). The number of stations on the burned site varied over the four years because of logging that occurred in 1996 at four of the stations. These four stations were no longer used, and eight new stations were added in a nearby similarly burned area. The difference in the number of count stations in burned and unburned forest affected bird diversity very little. The four point count stations in addition to nine on the burned study site added only one bird species that was not detected in the first nine stations. On both study sites there were two visits to each point count station during a winter and these were averaged. We used the mean number of birds per point in comparing burned and unburned forests and number of points as sample size.

Bird species were assigned to three foraging guilds based on Ehrlich and coworkers (1988) and Hutto (1995): (1) trunk and branch foragers (timber drillers and timber gleaners), (2) foliage foragers (including aerial foragers), and (3) ground foragers.

*Foraging sampling.*—We recorded foraging observations of four woodpecker species in the burned forest only, during and after point count surveys. A bird was considered foraging when it appeared to be actively searching for and/or obtaining food (i.e., digging or pecking). Only the first foraging observation was recorded for each individual (Hejl et al. 1990). The following foraging data were recorded: bird species, maneuver (pecking = tapping on the surface, flaking = removing bark, drilling = excavating into wood), zone of foraging (lower trunk, middle trunk, upper trunk, branches), tree species, tree dbh class (8–22, 23–37, 38–53, >53 cm), burn severity of trees (alive and green, possibly alive with some green present, dead with brown needles present, dead and severely burned), and top condition (broken, crooked, double, intact). We combined the foraging data for each species over four winters in order to increase sample size (Morrison 1984). Consequently, we do not have information on between year differences in foraging.

*Tree sampling.*—Several tree characteristics within the burned forest were recorded at count stations and between stations in 0.04-ha circular samples for a total of 24 samples (Martin 1994): tree species, tree dbh, burn severity, bark cover, branch condition, and top condition.

TABLE 1. Species detected in burned and unburned early post-fire mixed-conifer forests in northeast Washington during the winters, 1994–1997.

| Species | Forage guild[a] | Nest guild[b] | Burned[c] | | Unburned[c] | | $P$[d] |
|---|---|---|---|---|---|---|---|
| | | | Year | Mean/pt | Year | Mean/pt | |
| Blue Grouse, *Dendragapus obscurus* | G | O | 2 | 0.083 | — | 0 | >0.05 |
| Downy Woodpecker, *Picoides pubescens* | T | C | 1,2,4 | 0.175 | — | 0 | >0.05 |
| Hairy Woodpecker, *Picoides villosus* | T | C | 1,2,3,4 | 0.410 | 2,4 | 0.056 | 0.035 |
| Three-toed Woodpecker, *Picoides tridactylus* | T | C | 1,2 | 0.042 | — | 0 | 0.047 |
| Black-backed Woodpecker, *Picoides arcticus* | T | C | 1,2,3,4 | 0.406 | 2 | 0.019 | 0.001 |
| Pileated Woodpecker, *Drycocopus pileatus* | T | C | — | 0 | 3 | 0.019 | >0.05 |
| Unknown Woodpecker | T | C | 1,2 | 0.144 | 2 | 0.019 | 0.05 |
| Gray Jay, *Perisorius canadensis* | F | O | 1,2 | 0.075 | 2,3 | 0.093 | >0.05 |
| Steller's Jay, *Cyanocitta stelleri* | F | O | — | 0 | 4 | 0.019 | >0.05 |
| Clark's Nutcracker, *Nucifraga columbiana* | F | O | 1,2 | 0.016 | — | 0 | >0.05 |
| Black-billed Magpie, *Pica pica* | G | O | 2 | 0.014 | — | 0 | >0.05 |
| Common Raven, *Corvus corax* | G | O | 1 | 0.016 | 4 | 0.037 | >0.05 |
| Black-capped Chickadee, *Parus atricapillus* | F | C | 1,2 | 0.031 | 2 | 0.074 | >0.05 |
| Mountain Chickadee, *Parus gambeli* | F | C | 1,2,3,4 | 0.179 | 2,3,4 | 0.352 | >0.05 |
| White-breasted Nuthatch, *Sitta carolinensis* | T | C | 4 | 0.048 | — | 0 | >0.05 |
| Red-breasted Nuthatch, *Sitta canadensis* | T | C | — | 0 | 2,3,4 | 0.389 | 0.001 |
| Brown Creeper, *Certhis americana* | T | C | 3 | 0.019 | — | 0 | >0.05 |
| Winter Wren, *Troglodytes troglodytes* | G | O | — | 0 | 4 | 0.019 | >0.05 |
| Golden-crowned Kinglet, *Regulus satrapa* | F | O | — | 0 | 2,3,4 | 0.260 | 0.001 |
| Varied Thrush, *Ixoreus naevius* | G | O | — | 0 | 4 | 0.056 | >0.05 |
| Red Crossbill, *Loxia curvirostra* | F | O | 2,4 | 0.067 | 2 | 0.148 | >0.05 |

[a] Forage guild: T = trunk and branch, F = foliage, G = ground.
[b] Nest guild: O = open, C = cavity.
[c] Burned and Unburned: year: year post-fire that bird species were present during the winter, mean/pt: mean number of birds per point averaged over 4 years.
[d] $P$-value: 2-way ANOVA, treatment effect (burned-unburned).

*Statistical analyses.*—The mean numbers of birds per point in burned and unburned forests were compared with a 2-way Analysis of Variance (ANOVA). Bird abundance between years within a treatment was compared using a Kruskal-Wallis nonparametric 1-way ANOVA and pairwise comparisons were made using Tukey's HSD procedure. Bird abundances, grouped by foraging guilds, were compared between burned and unburned forests using a Mann-Whitney $U$-test. To determine trends in abundance over four years, a Spearman rank order correlation was performed (Zar 1996). Comparisons of foraging observations and available vegetation were made using the $\chi^2$ Goodness of Fit test for categorical data. For example, if the distribution of tree species used by Downy Woodpeckers was significantly different than the proportion of available tree species the Goodness of Fit test would have a $P < 0.05$. $P$ values of less than 0.05 were considered significant for all tests. Statistical analyses were performed using SPSS (SPSS 1993).

## RESULTS

*Winter bird assemblage in burned and unburned forests.*—During the winter, 20 bird species were detected in burned and unburned forests combined (Table 1). Bird species composition differed between the two forests. In burned forests 7 of the 14 species detected were restricted to burned forests and in unburned forests, 6 of the 14 species detected were restricted to unburned forests. Averaged over four years trunk and branch foraging species were 2.5 times more abundant in burned forest ($U = 2.0$, df = 1, $P > 0.05$), and foliage foraging species were 3 times more abundant in unburned forest ($U = 2.0$, df = 1, $P > 0.05$; Fig. 1). Woodpecker species combined were 10 times more abundant in burned forests than in unburned forest. The four most abundant species detected in burned forest in descending order were the Hairy Woodpecker, Black-backed Woodpecker, Mountain Chickadee (*Parus gambeli*), and Downy Woodpecker (*Picoides pubescens*), and in unburned forest the Red-breasted Nuthatch (*Sitta canadensis*), Mountain Chickadee, Golden-crowned Kinglet (*Regulus satrapa*), and Red Crossbill (*Loxia curvirostra*). Black-backed Woodpeckers (2-way ANOVA: $F = 11.26$, df = 1, $P = 0.001$) and Hairy Woodpeckers ($F = 4.62$, df = 1, $P = 0.035$) were significantly more abun-

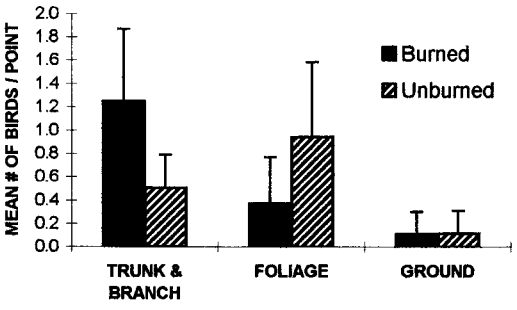


FIG. 1. Mean (±SD) number of birds per point over four years, by foraging guild in burned and unburned forests during winter (Mann-Whitney *U*-test: for each guild all $P > 0.05$).

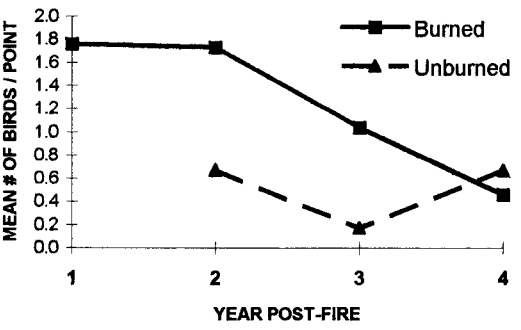


FIG. 2. Trunk and branch foraging species abundance over four years, in burned and unburned forest during winter (Spearman rank: Burned $s_r = -1.0$, df = 3, $P = 0.001$; Unburned $s_r = 0$, df = 2, $P > 0.05$).

dant in burned forest regardless of year (Table 1). The Three-toed Woodpecker was significantly more abundant ($F = 4.12$, df = 1, $P = 0.047$) in burned forest only during the second winter post-fire (Kruskal-Wallis: $\chi^2 = 11.9$, df = 3, $P = 0.008$; Tukey $P = 0.042$). The Red-breasted Nuthatch ($F = 13.10$, df = 1, $P = 0.001$) and Golden-crowned Kinglet ($F = 11.80$, df = 1, $P = 0.001$) were significantly more abundant in unburned forest.

*Change in bird abundance over four years.*—Bird species composition and abundance in burned forests during the winter changed from 1994–1997. Eleven species were present the first or second winter post-fire and were absent by the third winter post-fire (Table 1). The Brown Creeper (*Certhia americana*) was not present until the third winter post-fire and the White-breasted Nuthatch (*Sitta canadensis*) was not present until the fourth winter post-fire. The abundance of trunk and branch foraging species decreased 3.8 times from winter 1994–1997 and showed a significant negative trend (Spearman rank: $r_s = -1.0$, $P = 0.001$; Fig. 2). Although all four woodpecker species present in burned forest during the winter had declined by the fourth winter post-fire, none of the changes was significant (all $P > 0.05$). Within burned forest there was no significant trend in the abundance of foliage and ground foraging species from 1994–1997. Within unburned forest there was a significant decreasing trend of foliage foraging species ($r_s = -1.0$, $P = 0.001$) during the four years.

*Foraging.*—In burned forest Downy, Hairy, Three-toed, and Black-backed woodpeckers foraged upon standing dead trees 99% of the time and 1% of the time on logs ($n = 145$). Woodpeckers used burned trees with brown needles 51% of the time, significantly different than the proportion available (20%; Goodness of Fit: $\chi^2 = 14.98$, df = 2, $P = 0.001$). They foraged predominantly on Douglas-fir (61%), western larch (38%), and ponderosa pine (38%; Fig. 3). Western larch (13% available) and ponderosa pine (2% available) were used for foraging significantly more than expected ($\chi^2 = 60.58$, df = 4, $P = 0.001$). Trees greater than 23 cm in diameter were used (84%) significantly more than the proportion available (36%; Fig. 4; $\chi^2 = 85.86$, df = 3, $P = 0.001$). Broken top snags were used (14%) in similar proportions to their availability (12%; $\chi^2 = 0.28$, df = 1, $P > 0.05$). Available snags consisted mainly of severely burned (80%), intact top (83%), Douglas-fir (78%), western larch (13%), or sub-alpine fir (6%) with a mean diameter of 22 cm.

The four woodpecker species foraged differently. Downy Woodpeckers foraged predominantly by pecking while Hairy, Three-toed, and Black-backed woodpeckers foraged predominantly by flaking and drilling. Hairy and Three-toed woodpeckers foraged on similar tree species (Fig. 3) and on similar parts of trees (Fig. 5). Black-backed Woodpeckers foraged on western larch and Douglas-fir (Fig. 3) and foraged predominantly on the middle and lower trunks, of trees (Fig. 5). Downy Woodpeckers foraged most frequently on branches of ponderosa pine (Figs. 3, 5).

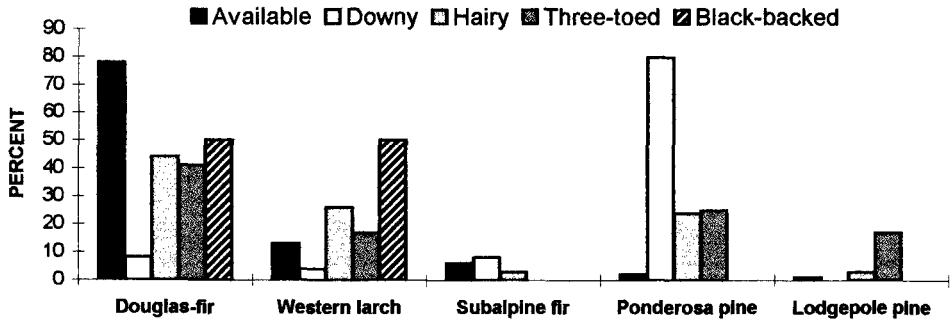


FIG. 3. Proportion of tree species available and used for foraging by four woodpecker species during winter in burned forests (Goodness of Fit, the tree species distribution used by all woodpeckers combined was significantly different than the available distribution, $\chi^2 = 60.58$, df = 4, $P = 0.001$; each bird species used a significantly different tree species distribution than what was available (all $P < 0.001$) and each bird species foraged on different tree species than each other (all $P < 0.003$) except Hairy and Three-toed woodpeckers which foraged similarly ($\chi^2 = 3.573$, df = 4, $P > 0.05$)).

## DISCUSSION

Trunk and branch foraging species were more abundant in recently burned forests than in unburned forests. Other studies of burned forests had similar results (Raphael and White 1984, Hutto 1995). This may be due to changes in forest structure and related food resources as a result of stand replacement fire. Stand replacement fire changes the structure of a forest from a dense canopy cover, with shrub undergrowth and few standing dead trees to little canopy cover, few shrubs, and numerous standing dead trees. Food in unburned forests include a variety of seeds and insects on foliage, bark, and shrubs. During the winter, food in burned forests may be limited to seeds from fire opened cones and bark and wood-boring beetle larvae in fire-killed trees (Hutto 1995). Bird species that forage on the ground and foliage probably have more food available in unburned forests, and species that forage on trunks and branches of trees probably have more food available in burned forests. Bark and wood-boring beetle larvae that are abundant in fire-killed trees are the major food source of woodpeckers, especially during winter (Brawn et al. 1982). Therefore, fire-killed trees may be crucial in supplying year round food for trunk and branch foraging species. Large diameter, thick barked snags are typical locations for bark and wood-boring beetle larvae (Otvos 1965). Woodpecker species in this

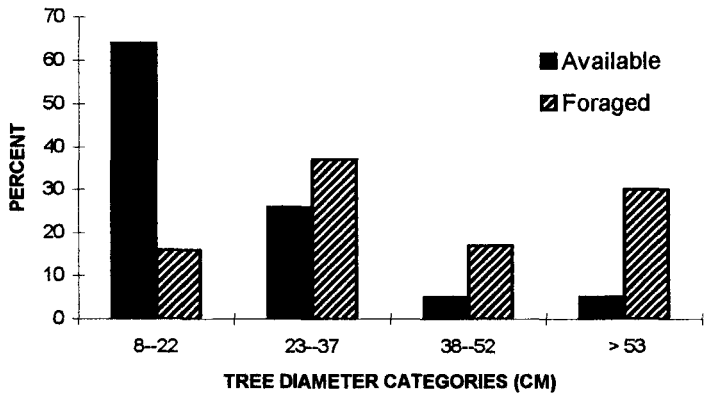


FIG. 4. Proportion of tree diameters available ($n = 173$) and used for foraging ($n = 145$) by woodpeckers in burned forests. Significantly different tree diameters were used than what was available (Goodness of Fit, $\chi^2 = 85.86$, df = 3, $P = 0.001$).

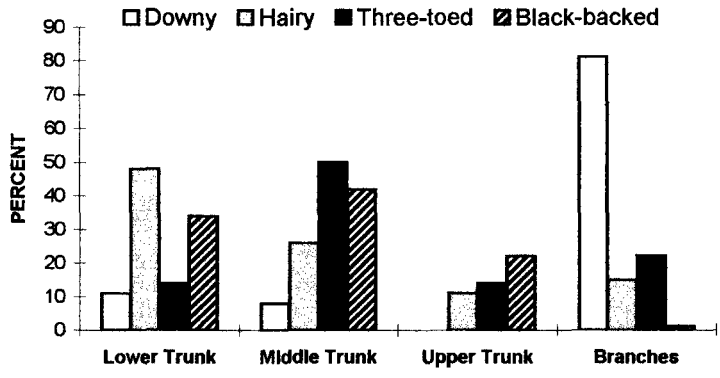


FIG. 5. Foraging zones used by four woodpecker species during winter in burned forests [Goodness of Fit: Downy ($n$ = 26, $\chi^2$ = 20.89, df = 3, $P$ = 0.001) and Black-backed ($n$ = 42, $\chi^2$ = 14.83, df = 3, $P$ = 0.002) woodpeckers used zones significantly different from an even distribution. Each woodpecker species foraged in significantly different zones from each other (all $P < 0.012$) except Hairy ($n$ = 55) and Three-toed ($n$ = 12) woodpeckers which foraged in similar zones ($\chi^2$ = 6.01, df = 3, $P > 0.05$)].

study used large snags between 23 and 37 cm dbh disproportionately more often for foraging in burned forest. In Montana, the average foraging snag diameter was 10–30 cm (Caton 1996). Snag species used most often for foraging in this study included thick barked western larch, ponderosa pine, and Douglas-fir. Hutto (1995) and Caton (1996) also found that woodpeckers foraged on these same snag species in burned forests in Montana.

Within burned forest there were several changes in the bird community from the first winter post-fire to the fourth. Some species were present only the first or second winter and were absent by the third winter. Woodpeckers, however, decreased in abundance from the first winter to levels equal to that found in unburned forests by the fourth winter. In the Sierra Nevada Mountains, Bock and Lynch (1970) found woodpeckers to be in low numbers by six years post-fire. Hutto (1995) found Three-toed and Black-backed woodpeckers to be most common 1–9 years post-fire. Post-fire forests appear to support a succession of bird species, with early post-fire conditions being conducive to specific woodpecker species. The decrease in abundance of the Downy, Hairy, Three-toed, and Black-backed woodpeckers may have occurred as a result of a decrease in food resources. Bark and wood-boring beetle larvae dramatically decrease 2–5 years post-fire (Koplin 1972). Food resources may be as important to the distribution of these species as nest-site availability. Caton (1996) suggested that the availability of suitable foraging snags played a large role in the distribution of woodpecker species in burned forests in Montana. Further studies on food resource availability in burned and unburned forests may better help explain their distribution.

Non-breeding season habitat quality is probably as important to the persistence of bird populations as breeding season habitat (Conner 1979) because most bird mortality occurs during the non-breeding season (Graber and Graber 1983). Favorable winter habitat can increase winter survival and result in more birds breeding the following season. Local movements to burned habitats by resident bird species may increase survival. The use of burned forests during the winter by woodpeckers may also increase their overwinter survivorship by increasing food and decreasing predation. Different foraging techniques observed by woodpeckers in burned forest may allow many species to coexist. All of these factors may contribute to the increased capability of recently burned forests to support bird species, including woodpeckers, during the non-breeding season.

The 100 m radius point counts seemed to be an adequate way to compare the relative abundance of birds in these two forests. Visual detections of birds in the burned and unburned forests were probably different, and audible detections, which most of ours were, were probably similar in the two forests. Differenc-

es in auditory detections were most likely minimal during the winter when it was extremely quiet. Dellasala and coworkers (1996) found little difference in detection rates of birds in 100 m radius point counts in young (20 yr) and old growth forests.

Fire suppression over the past 100 years (Agee 1994, Hejl 1994) has probably had a major effect on bird communities in mixed-conifer forests. Stand replacement fires may help to increase populations of cavity-nesting and trunk and branch foraging species. Populations of Hairy, Three-toed, and Black-backed woodpeckers might be maintained by periodic occurrences of stand replacement fires throughout the landscape. The spatial and temporal pattern of stand replacement fires needed to maintain bird populations needs further investigation.

*Management implications.*—Forest managers can increase cavity-nesting bird populations by relaxing fire suppression policies and/or by initiating prescribed burning programs. To manage for cavity-nesting birds in burned forests snags of western larch, ponderosa pine and Douglas-fir larger than 23 cm in diameter should be present. If managers can delay logging of burned forests three to four years, the habitat will be less suitable for trunk and branch foraging species and logging may have less impact on these species. Future studies investigating snag densities and patch sizes of burned forests required to maintain populations of cavity-nesting species during summer and winter are needed to help managers provide for these species.

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