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NEST-SITE CHARACTERISTICS OF THREE WOODPECKER SPECIES IN MANAGED PONDEROSA PINE FORESTS OF THE EASTERN CASCADE RANGE

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ABSTRACT—In order to conserve populations of woodpeckers in managed forests of the inland Northwest, managers require information about the nest substrates (for example, trees and snags) in which woodpeckers excavate cavities and the habitat characteristics surrounding those substrates. I describe and compare the nest-site characteristics of the White-headed Woodpecker (*Picoides albolarvatus*), Hairy Woodpecker (*Picodes villosus*), and Northern Flicker (*Colaptes auratus*) in burned and unburned logged Ponderosa Pine (*Pinus ponderosa*) stands of the eastern Cascade Range of Washington, 2003 to 2010. All 3 woodpecker species most frequently excavated cavities in well-decayed snags. In burned stands, Northern Flickers used nest substrates that had a larger mean diameter at breast height (dbh) than those used by Hairy Woodpeckers, and that were shorter in height than those used by Hairy and White-headed Woodpeckers. Northern Flickers also excavated cavities lower in height than Hairy Woodpecker cavities. In unburned stands, flickers used nest substrates with larger dbh than those used by Hairy and White-headed Woodpeckers. Despite these differences, overall similarity among the nest sites of the 3 species suggests that they make similar use of managed Ponderosa Pine stands for breeding in Washington.

Key words: *Colaptes auratus*, Hairy Woodpecker, nest-site characteristics, Northern Flicker, *Picoides albolarvatus*, *Picodes villosus*, *Pinus ponderosa*, Ponderosa Pine, snags, White-headed Woodpecker

Interior Ponderosa Pine (*Pinus ponderosa*) forests of the Pacific Northwest have changed dramatically since the time of European settlement. As a result of decades of fire suppression and timber management that focused on selective removal of large-diameter trees (Arno 1996; Hessburg and others 2005), Ponderosa Pine forests today have high densities of small-diameter trees and low densities of large-diameter trees and snags, as well as an encroachment of shade tolerant tree species (for example, Douglas-fir [*Pseudotsuga menziesii*] and Grand Fir [*Abies grandis*]) (Fulé and others 1997; Keeling and others 2006). These conditions can promote outbreaks of disease and insect pests (Hessburg and others 2005) which, in addition to high tree density, make these forests susceptible to stand replacement fires (Fulé and others 1997; Agee 1998; Keeling and others 2006). In response, some land management agencies and private industrial landowners use forest management practices (for example,

thinning harvests and controlled understory burns; Wightman and Germaine 2006; Harrod and others 2007) to reduce fire intensity and aid in restoring Ponderosa Pine forests to a condition that is open, park-like, and dominated by large-diameter trees (Converse and others 2006). However, it will take many years and multiple management actions to reach this goal. Therefore, it is important to understand how cavity-nesting birds use current forest conditions, particularly in regard to nest-site characteristics, because land managers can manipulate these habitat features.

Woodpeckers are considered keystone species in many forested ecosystems because they create nest cavities and foraging excavations that other species use (Blendinger 1999; Aitken and Martin 2007). The White-headed Woodpecker (*Picoides albolarvatus*) inhabits interior pine forests from British Columbia, Canada, to southern California, USA (Garrett and others 1996). In Washington it is confined to forests

dominated by Ponderosa Pine. Research on White-headed Woodpeckers has focused on foraging (Koch and others 1970; Ligon 1973; Morrison and With 1987; Kozma 2010), nest-site characteristics and reproductive success (Milne and Hejl 1989; Buchanan and others 2003; Wightman and others 2010; Kozma and Kroll 2012), and phylogeography (Alexander and Burns 2006). The results from many of these studies suggest that White-headed Woodpeckers are associated with old-growth forest structures (for example, basal area of live trees [>53 cm dbh] >12 m^2/ha and maximum canopy height >32 m; Dixon 1995). However, most studies that investigated White-headed Woodpecker nest-site characteristics were conducted in areas containing mature forest, such as National Forests and National Parks (Milne and Hejl 1989; Wightman and others 2010) or in areas that were not actively managed via timber harvest (Buchanan and others 2003). Although recent studies have documented White-headed Woodpeckers inhabiting early to mid-seral Ponderosa Pine forests (Lindstrand and Humes 2009; Kozma 2011), their breeding biology in these forests, particularly those influenced by timber management, remains poorly studied.

The Hairy Woodpecker (*Picodes villosus*) and Northern Flicker (*Colaptes auratus*) are primary cavity excavators that occur in a wide variety of forest types in North America (Ripper and others 2007; Wiebe and Moore 2008). Despite the large geographic distribution of the Hairy Woodpecker, quantitative data is lacking for many aspects of its breeding biology (Jackson and others 2002). In contrast, the breeding biology of the Northern Flicker is well-studied; although most information is from 1 study area in Quaking Aspen-dominated (*Populus tremuloides*) forests of British Columbia (Wiebe and Moore 2008). Both of these species co-occur with White-headed Woodpeckers in Ponderosa Pine forests of Washington. It is therefore important, especially in the context of managing lands for timber production and dry-site forest restoration, to determine the extent that nest-site characteristics differ between these 3 woodpecker species. If nest-site characteristics differ considerably, managers may have to manage a suite of features appropriate for each of the species, where as if nest-site characteristics are similar, managers could manage for 1 or 2

important habitat features required by all 3 species.

My goal was to evaluate how the White-headed Woodpecker, Hairy Woodpecker, and Northern Flicker use managed Ponderosa Pine forests for breeding in Washington. Earlier results from this work (Kozma 2009) involved smaller sample sizes and only compared nest-site characteristics between Hairy and White-headed Woodpeckers combined across burned and unburned treatments. In contrast, my objectives for this study were to: 1) describe the characteristics of nest trees or snags and other fine-scale habitat features associated with nest sites of the 3 woodpecker species in burned and unburned treatments; and 2) evaluate differences in nest-site characteristics among these species within each treatment.

METHODS

Study Area

I conducted this study in 5 study areas (Kozma and Kroll 2012) along the eastern slope of the Cascade Range in southern Kittitas, Yakima, and northern Klickitat counties, Washington, from 2003 to 2010. The topography of this region is complex with intermixed slopes (Everett and others 2000) and with elevation of study areas ranging from 560 to 1270 m. The climate is characterized by hot, dry summers, with over 80% of the annual precipitation occurring in winter as snow (Wright and Agee 2004).

My study areas included 33 White-headed Woodpecker territories in the lower elevations of the dry forest zone. I selected these territories opportunistically based on reviews of proposed timber harvests where White-headed Woodpeckers were encountered, by reviewing historical sightings of this species in a database maintained by the Washington Department of Fish and Wildlife (Buchanan and others 2003), and by finding breeding pairs opportunistically as I conducted field work. Territories were located on lands managed by the Okanogan-Wenatchee National Forest (n = 7), the Washington State Department of Natural Resources (n = 13), and 3 private landowners (n = 13). The overstory of the territories contained a mix of tree species dominated by Ponderosa Pine, with lower abundances of Douglas-fir, Western Larch (*Larix occidentalis*), Grand Fir, and Quaking Aspen, depending upon site history, elevation,

and aspect. The understory was dominated by Antelope Bitterbrush (*Purshia tridentata*), Wax Currant (*Ribes cereum*), Snowbrush Ceanothus (*Ceanothus velutinus*), Snowberry (*Symphoricarpos alba*), and Birch-leaved Spirea (*Spiraea betulifolia* var. *lucida*). Overall, the area is characterized as a mixture of the ''hot dry shrub-herb'' (Ponderosa Pine–bitterbrush–Bluebunch Wheatgrass [*Agropyron spicatum*]) and ''warm dry shrub-herb'' (Douglas-fir–bitterbrush–Bluebunch Wheatgrass) vegetation types (Harrod and others 1999). Twenty-three territories were in unburned stands that had experienced timber harvest within the past 25 y and 10 territories were in burned and salvaged stands 1 to 11 y post-fire. Thirteen unburned territories were managed by pre-commercial thinning, where small diameter understory trees were removed leaving more large-diameter trees ($\bar{x}$ = 157.8 trees/ha >10.16 and ≤40.6 cm dbh [95% confidence interval {CI} 128.9, 186.8], and $\bar{x}$ = 68.0 trees/ha >40.6 cm dbh [95% CI: 41.7, 94.4]; n = 7; Kozma [2011]). Ten were managed by removing dominant and co-dominant trees resulting in evenly spaced trees with a similar dbh and fewer large-diameter trees ($\bar{x}$ = 136.4 trees/ha >10.16 and ≤40.6 cm dbh [95% CI: 106.5, 166.2], and $\bar{x}$ = 27.2 trees/ha >40.6 cm dbh [95% CI: 14.4, 40.1]; n = 7; Kozma [2011]). Burned stands were salvage logged and the majority of merchantable dead trees were removed, leaving larger overstory trees that survived the fire mixed with smaller diameter fire-killed trees.

Nest Searching

I searched for nests beginning in early April and continuing until early July. I searched a subset of the 33 territories each year due to time constraints and because new territories were added each year as I discovered new pairs of White-headed Woodpeckers. I searched territories for nests of the 3 woodpecker species at least once every 7 to 10 d, often searching more than 1 territory/d, resulting in approximately equal search effort at each territory. I used playbacks of calls and drumming to locate White-headed and Hairy Woodpeckers, to make finding nests easier (Johnson and others 1981; Nappi and Drapeau 2009). I followed either sex during the nesting season to find cavities (because both males and females excavate cavities and incubate eggs), and I followed

adults carrying food, adult distress calls, or sounds of begging chicks to reveal the cavity location. I used the same procedure for locating Northern Flicker cavities, with the exception of call playbacks, and I also checked cavities used by flickers in previous years due to their propensity for reusing cavities (Gentry and Vierling 2008). To confirm that a nest was active (at least one egg was laid), I viewed contents of cavities up to 11 m above ground with a Tree Top Peeper IV nest-inspection system (Kozma and Kroll 2010). If nests were taller than 11 m, I used behaviors such as adults entering cavities for extended periods with no evidence of excavation, adults carrying food to the cavity or removing fecal material, or the sound of begging chicks to confirm nesting.

Vegetation Sampling and Statistical Analysis

I sampled vegetation surrounding each active nest after cavities were vacated. At each nest tree or snag (hereafter nest substrate) I recorded habitat variables that included the nest substrate species, decay class Types 1–4 (defined in Table 1; Kozma 2009), height (m), dbh (cm), cavity height (m), slope (%), canopy cover (%), shrub height (m), and presence of fungal fruiting bodies (hereafter conks) on the nest substrate. I measured shrub height with a meter tape, and cavity height and nest substrate height with the telescoping nest-inspection pole (gradated in cm) or a clinometer for cavities and nest substrates higher than 11 m. I calculated relative cavity height by dividing the cavity height by nest substrate height (Siegfried and others 2010). Using a spherical crown densiometer at the base of the nest tree or snag, I estimated canopy cover in the 4 cardinal directions and then averaged the 4 estimates (Farnsworth and Simons 1999).

I sampled habitat in 5- and 11.3-m radius circles centered on each nest substrate (modified from James and Shugart 1970 and Martin and others 1997). Within the 5-m radius circle, I visually estimated the percent cover of each shrub species. Within the 11.3-m radius circle (0.04 ha) I tallied trees and snags in 3 dbh categories (25.4 to <50.8 cm, 50.8 to <76.2 cm, and ≥76.2 cm). After vegetation sampling was completed, I marked each nest substrate with a numbered aluminum tag in order to determine reuse of nest substrates and cavities.

TABLE 1.   The proportion of trees and snags by decay class used for nesting by Hairy Woodpecker, Northern Flicker, and White-headed Woodpecker in managed Ponderosa Pine stands of the eastern Cascade Range, Washington, 2003 to 2010. Type 1 = live tree with a dead top or other defect; Type 2 = recently dead tree with brown foliage; Type 3 = snag with moderate decay, foliage and small branches missing, top intact; Type 4 = snag in advance decay with broken top and most branches gone (Kozma 2009).

	Type 1	Type 2	Type 3	Type 4	Total
	Hairy Woodpecker ($n = 91$)				
Douglas-fir	0.00	0.02	0.02	0.03	0.08
Ponderosa Pine	0.01	0.15	0.27	0.34	0.78
Quaking Aspen	0.04	0.01	0.00	0.09	0.14
Total	0.05	0.19	0.30	0.46	1.00
	Northern Flicker ($n = 114$)				
Douglas-fir	0.00	0.00	0.00	0.10	0.10
Grand Fir	0.00	0.00	0.01	0.05	0.06
Ponderosa Pine	0.10	0.04	0.06	0.59	0.79
Quaking Aspen	0.02	0.01	0.01	0.01	0.05
Total	0.12	0.05	0.08	0.75	1.00
	White-headed Woodpecker ($n = 77$)				
Blue Elderberry[a]	0.01	0.00	0.00	0.00	0.01
Douglas-fir	0.00	0.00	0.01	0.11	0.12
Grand Fir	0.00	0.00	0.00	0.01	0.01
Ponderosa Pine	0.04	0.08	0.22	0.48	0.82
Quaking Aspen	0.01	0.01	0.00	0.01	0.04
Total	0.06	0.09	0.23	0.61	1.00

[a] *Sambucus cerulea*

Due to small sample sizes in some years, I combined nests across years. If the same species reused a cavity in subsequent years, I randomly chose one attempt and used the vegetation sampled during that attempt in the analyses. I simplified dbh classes of trees and snags by creating 3 categories: 1) all trees ≥25.4 cm dbh; 2) all snags ≥25.4 cm dbh; and 3) all stems (trees and snags combined; Kozma and Kroll 2010). I used a Chi-square goodness-of-fit test to determine if the woodpecker species differed in their frequency of use of nest substrates based on decay class. I also used a Chi-square goodness-of-fit test to determine if decay class of nest substrate used by each species differed from a uniform distribution, because many woodpecker species tend to excavate cavities in snags with moderate to advanced decay more frequently (Mannan and others 1980; Ganey and Vojta 2004). Finally, I used 95% CI to compare nest-site vegetation variables among the 3 woodpecker species within burned and unburned stands.

RESULTS

I sampled vegetation at 77 White-headed Woodpecker, 89 Hairy Woodpecker, and 114 Northern Flicker nests (Table 1). Due to the fact that my study areas were not randomly selected,

the following results and their implications should only be applied to the areas I sampled. In burned stands, Northern flickers used nest substrates with larger dbh than those used by Hairy Woodpeckers and that were shorter in height than substrates used by Hairy and White-headed Woodpeckers (Fig. 1). Flickers also excavated cavities lower in height than Hairy Woodpecker cavities in burned stands (Fig. 1). In unburned stands, flickers used nest substrates with larger dbh than substrates used by Hairy and White-headed Woodpeckers (Fig 1). The other habitat variables I measured did not differ among the 3 species in either burned or unburned stands (Fig. 1). Mean relative cavity height in burned stands was 0.54 m (95% CI: 0.45, 0.62) for the Hairy Woodpecker, 0.63 m (95% CI: 0.57, 0.70) for the Northern Flicker, and 0.47 m (95% CI: 0.33, 0.61) for the White-headed Woodpecker. Similarly, mean relative cavity height in unburned stands was 0.56 m (95% CI: 0.46, 0.66) for the Hairy Woodpecker, 0.62 m (95% CI: 0.55, 0.68) for the Northern Flicker, and 0.57 m (95% CI: 0.49, 0.64) for the White-headed Woodpecker.

Ponderosa Pine, which has the highest importance value (the sum of relative density, relative cover, and relative frequency) in my study area (Kozma 2011), contained 79% of all
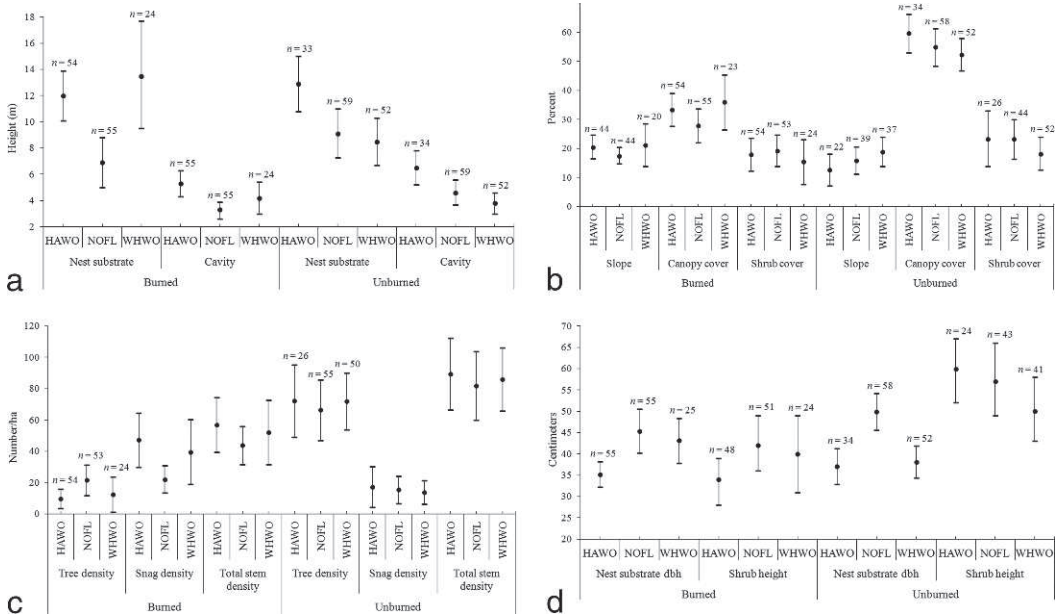
FIGURE 1. Mean (95% confidence interval with sample sizes) nest-site characteristics of Hairy Woodpeckers, Northern Flickers, and White-headed Woodpeckers, in burned and unburned managed Ponderosa Pine stands of the eastern Cascade Range, Washington, 2003 to 2010: A) nest substrate height and cavity height; B) percent slope, canopy cover, and shrub cover; C) tree density, snag density, and total stem density; and D) nest substrate dbh and shrub height.

cavities and was the most frequently used nest substrate by each species (Table 1). Douglas-fir , which has the 2nd highest importance value in my study area (Kozma 2011), was the 2nd-most frequently used nest substrate (11% of cavities) followed by Quaking Aspen (5% of cavities; Table 1). Decay class of nest substrate used by Hairy Woodpeckers, Northern Flickers, and White-headed Woodpeckers differed from a uniform distribution ($\chi^2 = 32.4$, $df = 3$, $P < 0.01$; $\chi^2 = 156.1$, $df = 3$, $P < 0.01$; $\chi^2 = 58.4$, $df = 3$, $P < 0.01$; respectively), with each species using Type 4 nest substrates (snags with broken tops) most frequently (Table 1). Compared to the other species, Northern Flickers used Type 1 substrates (Table 1) more frequently ($\chi^2 = 6.8$, $df = 2$, $P = 0.03$) and Hairy Woodpeckers excavated cavities more frequently in Type 2 ($\chi^2 = 8.6$, $df = 2$, $P = 0.01$) and Type 3 ($\chi^2 = 9.0$, $df = 2$, $P = 0.01$) substrates (Table 1). Conks were present on 29, 21, and 12% of nest substrates where new cavities (as opposed to reused cavities) were excavated by Hairy Woodpeckers, White-headed Woodpeckers, and Northern Flickers, respectively.

Rate of cavity reuse was highest for Northern Flickers; 42% of cavities used were excavated in a previous year. White-headed Woodpeckers rarely reused cavities; 1 cavity was reused in 3 different years, 2 other cavities were old but the original excavator was unknown, and 1 cavity was reused in the same year after the 1st nest attempt failed. Hairy Woodpeckers only reused a cavity once when a pair renested after the initial nest attempt was unsuccessful.

DISCUSSION

I found few differences in nest-site characteristics among the 3 woodpecker species, with all differences involving the nest substrate. Unburned stands in this study were managed through uneven-aged harvests, resulting in stands that visually appeared similar to each other, with trees of uniform spacing, although the size and density of leave trees may differ between harvest units (Kozma 2011). Likewise, the salvage-logging procedures were similar among burned stands, resulting in similarly structured stands. The structural similarity within each treatment type may explain why,

aside from features of the nest substrate, vegetation characteristics at nest sites in this study did not differ among the species. In other words, the range of variability in vegetation characteristics among stands was too low to detect ecologically meaningful differences.

Northern Flickers used substrates with larger dbh than those used by the other 2 species, except White-headed Woodpeckers in burned stands, because their larger body size and larger clutches (Wiebe and Swift 2001) necessitate a cavity with greater volume, which can only be effectively excavated in larger trees and snags. Although flickers tended to nest in substrates with large dbh, the mean dbh of substrates used by flickers in my study (45.3 cm in burned stands and 49.9 cm in unburned stands) is smaller than that reported in other studies describing flicker nest-site characteristics in conifer dominated forests. For example, Haggard and Gaines (2001) found that the mean dbh of snags used by flickers in Ponderosa Pine/Douglas-fir forests was 64 cm, and Raphael and White (1984) reported flickers nesting in trees-snags with a mean dbh of 60.9 cm in the Sierra Nevada, California. The high use of old cavities by flickers in my study area (42% of nest attempts occurred in old cavities) may indicate a limited supply of suitable substrates with large diameters in which to excavate new cavities (Wiebe and others 2007). Indeed, my previous work (Kozma 2011) found that large-diameter snags (>40.6 cm dbh) are in low abundance in many of these stands. This lack of large-diameter snags is also reflected in the fact that the mean dbh of nest substrates used by White-headed Woodpeckers in this study (43.1 cm in burned stands and 38.1 cm in unburned stands) is smaller than that reported by studies in California (Raphael and White 1984, 64.6 cm dbh; Milne and Hejl 1989, 80.0 cm dbh), Oregon (Dixon 1995, 65.0 cm dbh) and Washington (Buchanan and others 2003, 51.5 cm dbh).

Northern Flickers used nest substrates in burned stands that were shorter in height than those used by Hairy and White-headed Woodpeckers. All burned stands had some degree of salvage logging, where many of the largest fire-killed trees were removed. The act of salvage logging results in a more open stand structure that causes the remaining dead and dying trees

to be more susceptible to wind throw and breakage (Haggard and Gaines 2001). Large-diameter snags that remain after salvaging tend to break close to the ground as they continue to decay (Kozma, pers. obs.). Thus, substrates with advanced decay and with diameters large enough to support a flicker cavity tend to be short, resulting in flickers excavating cavities in shorter substrates than the other 2 species, and in flicker cavities being lower in height than Hairy Woodpecker cavities. Hairy Woodpeckers more frequently used intact snags with less decay (Type 2 and Type 3), allowing them to excavate cavities higher in these taller substrates. Flickers excavated cavities higher than those excavated by White-headed Woodpeckers because the latter have a propensity for nesting close to the ground (Raphael and White 1984; Milne and Hejl 1989; Dixon 1995).

All 3 woodpecker species most frequently excavated cavities in well-decayed snags with broken tops (Type 4). The high frequency use of well-decayed snags also accounts for the lack of decay fungi present on nest substrates; all conks on conifer snags were from the Pouch Fungus (*Cryptoporus volvatus*), which is found predominantly on dead trees up to 18 mo after death (Parks and others 1997). Therefore, woodpeckers in my study area may use broken tops to indicate suitability for cavity excavation rather than using conks of decay fungi as indicators of softened wood. The high use of broken topped snags suggests that the preference of woodpeckers to excavate cavities in the softest substrates with advanced decay, as observed in other regions (Raphael and White 1984; Bevis and Martin 2002; Ganey and Vojta 2004; Chambers and Mast 2005), also holds true in the managed Ponderosa Pine forests I studied.

The overall similarity among the nest sites of the 3 woodpecker species suggests that they make similar use of managed Ponderosa Pine stands for breeding in Washington. However, the limited range of variation in vegetation characteristics among stands may have limited my ability to detect differences in nest-site vegetation among the species. All inter-species differences involved characteristics of the nest substrate, and these differences were similar in both burned and unburned stands, suggesting that managers should focus on specific nest substrate characteristics when attempting to

manage for these 3 woodpeckers. Land managers should retain snags >35.0 cm dbh post harvest in order to provide nest substrates of adequate size for flickers (78% of all nest substrates used by flickers were >35.0 cm dbh). This will also benefit White-headed Woodpeckers and Hairy Woodpeckers, because 57 and 44% of nest substrates they used, respectively, were >35.0 cm dbh. However, all 3 species may have selected larger snags if they were available, as suggested by the larger dbh of nest trees reported by other studies (for example Raphael and White 1984; Milne and Hejl 1989, Dixon 1995; Buchanan and others 2003). Additional studies have also highlighted the benefits of retaining large-diameter snags for cavity-nesting species (for example Lundquist and Mariani 1991; Christman and Dhondt 1997; Everett and others 1999). It is also important for land managers to protect all snags with broken tops during harvest operations and retain defective live trees >35.0 cm dbh to recruit as future snags. Future research should focus on comparing the nest-site characteristics of these 3 woodpecker species with random sites in order to determine if these species are selecting nest sites based on availability.

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