NEST-SITE HABITAT USE BY WHITE-HEADED WOODPECKERS IN THE EASTERN CASCADE MOUNTAINS, WASHINGTON

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ABSTRACT—The white-headed woodpecker (*Picoides albolarvatus*) is strongly associated with old-growth ponderosa pine (*Pinus ponderosa*) forest, a degraded and increasingly uncommon habitat in the Pacific Northwest. We investigated the nest-site habitat use of this species by collecting vegetation data at 21 known nest sites in the eastern Cascades of Washington, 12 of which we found in 1999. Sixteen of 17 (94%) nests in the ponderosa pine vegetation zone were in the 72% of the zone that occurred below 1219 m, and 15 (88%) nests were on slopes of <20% (which comprised 48% of the zone); the total area characterized by both slopes <20% and elevation below 1219 m was 181,664 ha or 33.6% of the vegetation zone. Most (16 of 21) nests were in ponderosa pines and 81% (17 of 21) were in snags. The nest snags and trees were generally large, with a mean diameter at breast height of 51.5 cm ($s_{\bar{x}}$ = 5.13). The mean height of nest snags and trees was 12.6 m ($s_{\bar{x}}$ = 2.33), and the mean height of the nest cavity entrance was 5.8 m ($s_{\bar{x}}$ = 1.37). Compared to random sites located <1 km from each nest, nest sites were characterized by a greater abundance, size, and basal area of large trees and snags, primarily ponderosa pines. Management of habitat for this species should include retention of 6 to 8 large snags/0.8 ha and 8 to 10 large trees/0.8 ha in the immediate vicinity of nesting areas. Habitat requirements at the home range scale should be investigated.

Key words: white-headed woodpecker, *Picoides albolarvatus*, habitat, nest sites, Washington

The white-headed woodpecker (*Picoides albolarvatus*) is dependent on pine or mixed pine-fir forests throughout its range in western North America (Garrett and others 1996). On the east slopes of the Cascade Mountains in Washington, it is considered an uncommon resident in ponderosa pine (*Pinus ponderosa*) forests (Smith and others 1997). The white-headed woodpecker is both a candidate for listing and a priority species in Washington (WDFW 1999) and is a priority species for Partners in Flight (for example, Altman 2000). The ponderosa pine forest type, which is limited in extent compared to most other forest types in the region (Chappell and others 2001), has been greatly impacted by timber harvest practices (Noss and others 1995) and the effects of fire suppression and grazing (Sallabanks and others 2001). Species strongly associated with old-growth ponderosa pine are therefore at risk of population declines due to habitat degradation or loss.

Descriptions of habitat conditions used by the white-headed woodpecker are known from portions of the species' range (for example, Raphael and White 1984; Bull and others 1986; Milne and Hejl 1989; Dixon 1995), but have not been reported from eastern Washington. Two attributes of ponderosa pine forests are apparently very important to this species: the presence of adequate snags or cavity trees used for nesting and an abundance of ponderosa pine cones, typically associated with large trees, from which the woodpeckers derive seeds used as a food source during winter. We present the results of a study whose objectives were to describe habitat conditions associated with nest sites and determine whether the species selected specific habitat attributes at nest sites in the eastern Cascade Mountains of Washington.

METHODS

Study Area

Our study area included the ponderosa pine forest association (Franklin and Dyrness 1973) and vicinity on the eastern slope of Washington's Cascade Mountains from near the Oregon border north through western Okanogan County (Fig. 1). This area occurs between 457

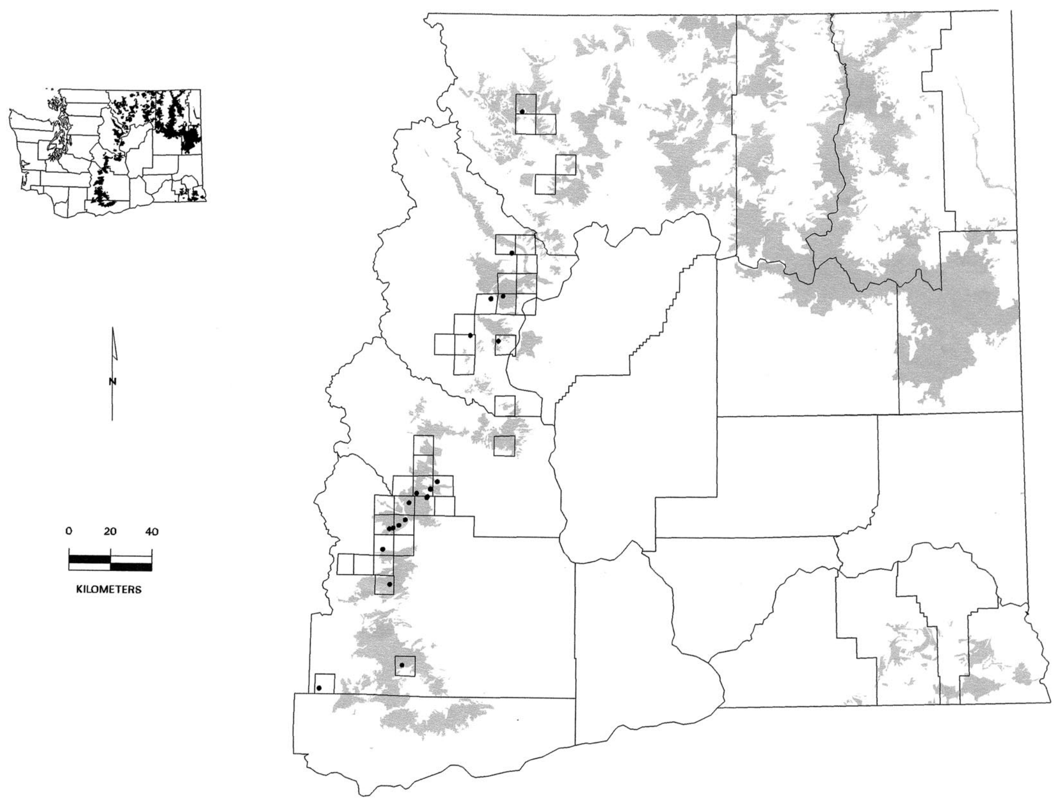

FIGURE 1. Range of the ponderosa pine vegetation zone (as defined by Cassidy 1997) in Washington. Nest site locations and townships within which we searched for white-headed woodpeckers are indicated.

m and 1829 m elevation (Cassidy 1997) and is generally characterized by dry, open forest with little understory vegetation. All of the nest records available to us were from this area. Some ponderosa pine forests in the study area, particularly those at higher elevations, on some north-facing slopes, and in areas closer to the Cascade Mountains crest, have been substantially influenced by fire suppression during much of the past century. This has resulted in greater densities of trees, particularly Douglas-fir (*Pseudotsuga menziesii*) and grand fir (*Abies grandis*) but also including ponderosa pine, and more developed understory vegetation (Agee 1993).

Locating Nest Sites

We were aware of several nest locations prior to beginning our survey effort, and we wished to locate others that were representative of the habitats used across the study area. We obtained information from the Washington Department of Fish and Wildlife database, some of it based on records submitted by bird-watchers, and from solicited observation records of bird-watchers and biologists with field experience in the region. From this information, we prioritized the observations to more efficiently locate nests as follows: (1) known nest locations, (2) known, but poorly documented nest locations, (3) suspected breeding locations (for example, sites where 2 birds were observed together during the breeding season), (4) locations with multiple breeding season records (involving an unspecified number of birds), (5) locations with single breeding season records, and (6) locations based on unspecified details other than the location itself. We visited all known nests (n = 9) and searched each site in categories 3 to 5 (n = 50) for up to several hours or until we found a nest. We searched some of the poorly documented locations (category 6) opportunistically as we encountered them.

In searching for nests, our effort in an area reflected the level of detail of the record for each site. When nest or pair locations were reported to within an area of 1 quarter section (¼ mi^2), we generally limited our search to that area. If the nest or pair location was generalized to a larger area, we searched an area of up to 1 legal section (1 mi^2) around the reported location. The nest searches were restricted to forest areas dominated by ponderosa pines, as white-headed woodpeckers are not generally known to nest in other forest types in the Pacific Northwest (Bull and others 1986; Dixon 1995). While visiting these forests we solicited vocalizations by playing amplified recordings of white-headed woodpecker calls for 2 to 3 min upon arriving at the stand and then every 20 to 25 min while walking through the area. Of the nest sites we found, woodpeckers were observed incubating or interacting with fledged young in our subsequent visits to all except 2 sites. At the latter 2 sites we were unable to verify nesting although woodpeckers entered the cavities early in the season.

Vegetation Sampling

We based our sampling protocol on other studies of this species (Milne and Hejl 1989; Dixon 1995). At each known nest tree or snag (hereafter referred to as the nest snag) we collected data to describe its condition and attributes. We identified the nest snag to species; determined the diameter at breast height (dbh) and the total height; and described the physical condition by determining whether the top was either intact or broken, by using guidelines developed by Cline and others (1980) to determine the decay class of nest snags, and by estimating the amount of bark present on the bole (percent coverage) and the number of cavities present. Additional features of the nest snag that we measured or estimated included percent lean, lean aspect, orientation of the nest cavity, diameter of the bole at the height of the cavity, and height of the cavity above ground.

Habitat attributes were measured in either of 2 plots. In a 0.10-ha plot centered at the nest snag, we recorded elevation, slope, aspect, topographic position (for example, upper ⅓, middle ⅓, or bottom ⅓ of a slope), macro-relief (butte, major ridge, minor ridge, plateau, terrace, floodplain, or valley; Dixon 1995), the percent ground cover of woody shrubs, the number of seedlings or saplings <10 cm dbh, and the number of trees between 10 and 29 cm dbh and between 30 and 49 cm dbh.

In a 0.81-ha plot centered at the nest snag we described a number of stand- and landscape-level attributes. We used a concave spherical densiometer (Lemmon 1956) to measure percent canopy closure at the nest snag (2 m to north), and at both 18 m and 50.75 m from the nest snag in each octant; readings were taken in each cardinal direction at each of the 9 points and the mean from all points was used to characterize the site. We also recorded the dbh and species of all trees ≥ 50 cm dbh, and the dbh, species, decay class, and height of all snags ≥ 20 cm dbh. The total height of the largest trees was measured by recording with a clinometer the total height of 5 dominant and/or co-dominant trees that were selected at random. We felt that presence of perch sites near the nest site might be important, so we recorded the distance to the nearest potential perch site both directly in front of the nest cavity (within 45° of cavity orientation) or in any direction from the cavity. We defined a perch site as any tree or snag ≥ 3 m in height. Finally, we described forest association and noted stand conditions that occurred naturally or as a result of human disturbance (for example, timber harvest and fire).

To evaluate whether white-headed woodpeckers were selectively using certain habitat features, we compared habitats at the nest vicinity with habitat attributes present on the landscape in the vicinity of the nest. For each of the nest sites visited we collected data, using the same procedures described above for nest sites, at an equal number of random sites. These sites were located by randomly selecting distance and direction coordinates to locate a sampling point <1 km from the nest; random plots were spatially independent of nest plots. Because white-headed woodpeckers are strongly associated with ponderosa pine forests in this region (Dixon 1995) and our goal was to determine whether the species selects specific attributes from within its primary habitat, we considered other habitat types, such as shrub steppe or closed-canopy Douglas-fir forest, to be unsuitable habitats; therefore, all random sites were located in forests of the ponderosa pine association. To be considered suitable for sampling, potential random locations required a tree density of ≤ 445/ha to eliminate closed canopy stands recently invaded by firs. Random plots were centered on trees or snags, using the tree or snag ≥20 cm dbh that was closest to the actual measured location.

Data Analysis

We conducted analyses to address aspects of habitat use at 2 spatial scales. Analyses at the 1st spatial scale involved habitat features used and available within the 0.8-ha vicinity of the nest snag or random plot center. In those analyses, we used paired sample *t*-tests to determine whether there were differences in the individual habitat attributes between nests and random locations. We used chi-square analysis for tests of proportions and Watson's goodness-of-fit test (Zar 1996) to determine whether slope aspect and nest cavity orientation were randomly distributed. Because we were able to collect random data at only 19 sites, some sample sizes differed in the analyses. We then identified the variables that differed at a P value ≤0.10 (Mickey and Greenland 1989) and these variables were evaluated for correlations. After removing strongly correlated ($r^2 \geq 0.7$) variables, and retaining those that we felt had the greatest explanatory capability, we used logistic regression (Hosmer and Lemeshow 1989; PROC LOGISTIC, SAS Institute 2001) to identify the combination of variables that most effectively discriminated the nest and random sites. We used a forward stepwise procedure that retained only those variables that significantly improved the model. We evaluated models by assessing corrected Akaike information criterion values (AICc), as suggested by Burnham and Anderson (1998) when sample size is small relative to the number of estimated parameters, and by examining correct classification rates.

In the 2nd scale of analysis we compared certain geographical attributes of the nest sites with those of the entire study area. We 1st used a Geographic Information System (GIS) to identify the boundaries and total areas of the 3 vegetation zones, as defined by Cassidy (1997), that comprised our study area: ponderosa pine (553,848 ha; 37.8% of the study area), Douglas-fir (623,300 ha; 42.5%), and grand fir (289,934 ha; 19.8%)(Fig. 1). Next, we used the GIS to determine the elevation, percent slope, and site aspect at 2000 points that were randomly located across the study area. We then compared proportional values of these variables with those recorded at nest sites; sample size constraints in various distributional ranges prevented formal analyses. We restricted the comparisons to regional points and nest sites within the ponderosa pine zone, because this zone contained most of our nests. Finally, even though our sample resulted largely from records from bird-watchers and was therefore not derived systematically, we wished to determine whether our sample was unbiased with respect to geographical attributes representative of the ponderosa pine forest zone (Cassidy 1997). Consequently, we used the GIS to randomly select 25 points in each of the 100 legal sections that we searched for nests. The distribution of data for elevation, slope, and aspect were compared to similar data from the regional level.

Results

We collected vegetation data in 1999 at 21 white-headed woodpecker nests distributed along the east slope of the Cascade Mountains in Washington (Fig. 1). We found 12 nests in 1999. The remaining 9 nests had been located in prior years by bird-watchers or biologists. Seventeen of the nests were in the ponderosa pine vegetation zone defined by Cassidy (1997), and others were found in Interior Douglas-fir (3) or Grand Fir (1) zones (Fig. 1).

Topographical

The nest sites were situated in a variety of settings. Sites ranged in elevation from 599 to 1310 m ($\bar{x} = 928.9$, $s_{\bar{x}} = 48.5$) and occurred in areas of gently sloping terrain ($\bar{x} = 10.4\%$, $s_{\bar{x}} = 1.8$, range $= 0$ to 29%). Most of the paired nest and random sites were on major or minor ridges ($n = 12$), followed by floodplains or valleys (4), terraces (3), and buttes or plateaus (2). Within these major landform categories, there were differences between nest and random locations in slope position with comparatively more nests on lower slopes (11 nest sites vs. 6 random sites) and fewer on mid-slopes (1 vs. 3) or upper slopes (8 vs. 10; Fisher's exact test, $P = 0.03$). The prevailing nest site slopes were oriented strongly southward (mean angle = 169°, $r = 0.52$; Watson's goodness of fit test, $U^2 = 2.25$, $P < 0.001$).

TABLE 1. Comparison of habitat attributes at white-headed woodpecker nest sties (n = 20) and associated random locations (n = 19) in the foothills of the eastern Cascade Mountains, Washington. Anayses were based on 2-tailed, paired-sample t-tests. Values are expressed on the basis of the 0.81 ha plots used for sampling. PIPO = ponderosa pine.

Attribute	Nest site $\bar{x} \pm s_{\bar{x}}$ (range)	Random site $\bar{x} \pm s_{\bar{x}}$ (range)	t	P
No. of large trees	10.2 ± 2.0 (1–34)	5.3 ± 1.2 (0–17)	2.35	0.03
Basal area (m^2) of large trees	9.6 ± 2.1 (0.8–33.2)	4.2 ± 0.1 (0.0–14.2)	2.65	0.016
Mean dbh (cm) of large trees	66.1 ± 2.0 (53.5–82.4)	61.0 ± 1.5 (52.0–69.0)	2.62	0.020
No. 10 to 29 cm trees	7.8 ± 1.8 (0–30)	10.3 ± 2.3 (0–25)	−1.04	0.312
No. 30 to 50 cm trees	3.9 ± 0.7 (0–10)	3.4 ± 0.7 (0–10)	0.74	0.467
No. 10 to 50 cm trees	11.8 ± 2.0 (0–32)	13.7 ± 2.7 (0–32)	−0.74	0.471
No. of saplings	25.1 ± 9.5 (0–260)	23.7 ± 7.0 (0–103)	0.12	0.903
Height (m) of live trees	22.5 ± 2.0 (7.6–37.3)	19.6 ± 1.8 (0.0–31.4)	1.21	0.244
No. of large PIPO trees	8.4 ± 1.6 (1–24)	4.2 ± 1.1 (0–17)	2.78	0.013
Basal area of large PIPO trees	8.3 ± 2.0 (0.8–33.2)	3.5 ± 0.9 (0–13.4)	2.56	0.02
No. of snags	7.1 ± 1.3 (1–18)	4.2 ± 1.4 (0–27)	1.67	0.111
Basal area (m^2) of snags	2.8 ± 0.4 (0.1–6.1)	1.0 ± 0.3 (0–4.6)	3.90	0.001
Mean dbh (cm) of snags	46.8 ± 4.6 (23.8–87.3)	35.8 ± 3.0 (23.3–64.0)	1.92	0.076
No. of PIPO snags	4.8 ± 1.1 (1–17)	3.8 ± 1.5 (0–27)	0.64	0.529
Basal area (m^2) of PIPO snags	2.1 ± 0.4 (0.1–6.1)	0.9 ± 0.3 (0–4.2)	2.88	0.01
Mean dbh of PIPO snags	47.5 ± 4.7 (25.0–87.3)	35.9 ± 3.5 (18.0–64.0)	1.88	0.081
% cover woody shrubs	28.1 ± 7.4 (0–98)	17.7 ± 4.2 (0–70)	1.82	0.085
% canopy closure	7.2 ± 0.9 (0.1–15.0)	7.5 ± 1.0 (0.0–16.3)	−0.32	0.754
Distance (m) to perch	5.8 ± 1.3 (1.5–25.7)	5.9 ± 1.8 (1.5–35.0)	−0.03	0.973

Nest Snags

Sixteen of 21 (76%) white-headed woodpecker nests were in ponderosa pine snags. Nests were also found in grand fir (2), quaking aspen (*Populus tremuloides*; 2), and Douglas-fir (1). Seventeen of the nests were in snags and 4 were in living trees.

The condition of nest snags was variable. The snags were generally large, with a mean dbh of 51.5 cm ($s_{\bar{x}}$ = 5.13, range 20 to 112.5 cm). The mean height of nest snags was 12.6 m ($s_{\bar{x}}$ = 2.33) and ranged from 1.9 to 36.1 m. The mean height of the nest cavity entrance was 5.8 m ($s_{\bar{x}}$ = 1.37, range = 0.4 to 17.9), and the mean diameter at the nest cavity was 43.4 cm ($s_{\bar{x}}$ = 4.88, range = 16 to 112.5). Twelve of the trees and snags were fully intact and 9 had broken tops; 2 showed no signs of decay, 12 showed little decay (decay classes 1, 2), and 7 showed moderate decay (decay classes 3, 4). The amount of bark present on the snags was 77.2% ($s_{\bar{x}}$ = 7.27, range = 0 to 100). The median number of cavities present in nest snags was 1, but 1 snag had 19 cavities and another had 12. The mean angle of nest cavity openings was 80° and differed from a random distribution (r = 0.34; Watson's goodness of fit test, U^2 = 0.18, P = 0.053).

Nest Sites

Most of the differences in structural attributes between nest and random sites were related to large trees and large snags. In general, nest sites had more and/or larger trees and snags compared to random sites (Table 1). Also, when all snags at nest sites were assessed relative to decay class, there was a significant difference between expected and observed proportions of snags (χ^2 = 8.77, P = 0.067), with fewer snags than expected in decay class 2 (49.7% vs. 68.7%) and more snags than expected in decay classes 3 to 5 combined (25.5% vs. 12.0%).

Two comparable models were produced using logistic regression (Table 2). Model A included the parameters PIPOSNAGBA (basal area of ponderosa pine snags) and PIPOTREEBA (basal area of ponderosa pine trees), whereas Model B included the parameters TREEBA (basal area of all trees) and SNAGBA (basal area of all snags). In both models, the Wald chi-square statistic indicated that snag variables were more influential predictors of correct classification of nest sites (Table 2). Both equations fit the data well, as indicated by Hosmer-Lemeshow lack-of-fit analyses (χ^2 = 5.28, P = 0.73 and χ^2 = 8.98, P = 0.34, respectively). Al-

TABLE 2. Summary of logistic regression analyses to classify nest and paired random white-headed woodpecker locations in the eastern Cascade Mountains, Washington. AICc = Akaike information criterion.

Parameter	Logit model Estimate	$s_{\bar{x}}$	Wald χ^2	P	AICc	Correct classification rates Mean	Nest	Random
Model A								
Intercept	−1.1504	0.5704						
PIPOSNAGBA	0.4624	0.2457	3.54	0.06	52.36	69.2	94.7	45
PIPOTREEBA	0.1143	0.0706	2.62	0.105				
Model B								
Intercept	−1.6893	0.6977						
TREEBA	0.1108	0.0722	2.36	0.124	48.08	74.4	89.5	60
SNAGBA	0.5564	0.2246	6.14	0.013				

though Model A had an overall correct classification rate that was slightly lower than that of Model B, Model A correctly classified 18 of 19 nest sites, compared to 17 of 19 correct classifications in Model B (Table 2). On the other hand, the AICc value for Model B was lower than for Model A (Table 2), suggesting that it was a better model. The rather small sample size in our study, however, precludes definitive conclusions regarding the comparative optimality of the 2 models.

Geophysical Attributes

White-headed woodpecker nest locations were not distributed randomly across the range of geophysical conditions characteristic of the study area. Of the 17 nests in the ponderosa pine vegetation zone, 16 (94%) were below 1219 m, an elevation band encompassing 72% of the zone, and 13 (76%) occurred between 772 and 1219 m, an elevation band encompassing 54% of the zone. Similarly, 15 of 17 (88%) nests in this vegetation zone were on slopes of <20%, although these slopes characterized only 48% of the zone. The total area of the vegetation zone characterized by both slopes <20% and elevation below 1219 m was 181,664 ha or 33.6% of the vegetation zone (Fig. 2).

Search Effort

A spatial summary of our search effort indicates that 2 of the 3 geophysical attributes we evaluated differed when the landscape scale was compared to the scale of the legal sections we searched. We noted a difference in site aspect (2 × 4 contingency test; $\chi^2 = 9.5$, $P < 0.025$) in that we searched slightly more areas on north-facing slopes (28% vs. 23% of random locations) and slightly fewer sites on east-facing slopes (26% vs. 31% of random locations). Also, a lower proportion (46%) of the sections we searched were >20% slope compared to the random locations (52%) in the ponderosa pine zone ($Z = 2.87$, $P < 0.005$). Mean elevation was nearly identical between random landscape locations and the points associated with the sections we searched.

Site Disturbance

Only 4 of 21 (19%) nest locations exhibited any signs of past timber harvest and this proportion did not differ from the paired random locations (Fisher's exact test, $P = 0.34$).

DISCUSSION

On average white-headed woodpeckers nested in open ponderosa pine forest areas containing substantially more large-diameter trees and snags than found in random locations within 1 km of the nest. This woodpecker's use of snags for nesting (Garrett and others 1996; this study) and large trees for foraging (Ligon 1973; Garrett and others 1996) obviously influences this pattern of habitat use.

In use-versus-availability studies it is generally not possible to determine that a species does not occur in an area or does not use a particular habitat (for example, the random comparison plot) without radio telemetry data (North and Reynolds 1996). This makes interpretation of some habitat-use models potentially tenuous. Although our 2 LR models had only moderate mean rates of correct classification (69.2% and 74.4%), the rates for actual nest sites were ≥89.5%. Lower classification rates for random sites appeared to result from the presence of large snags and/or large trees at

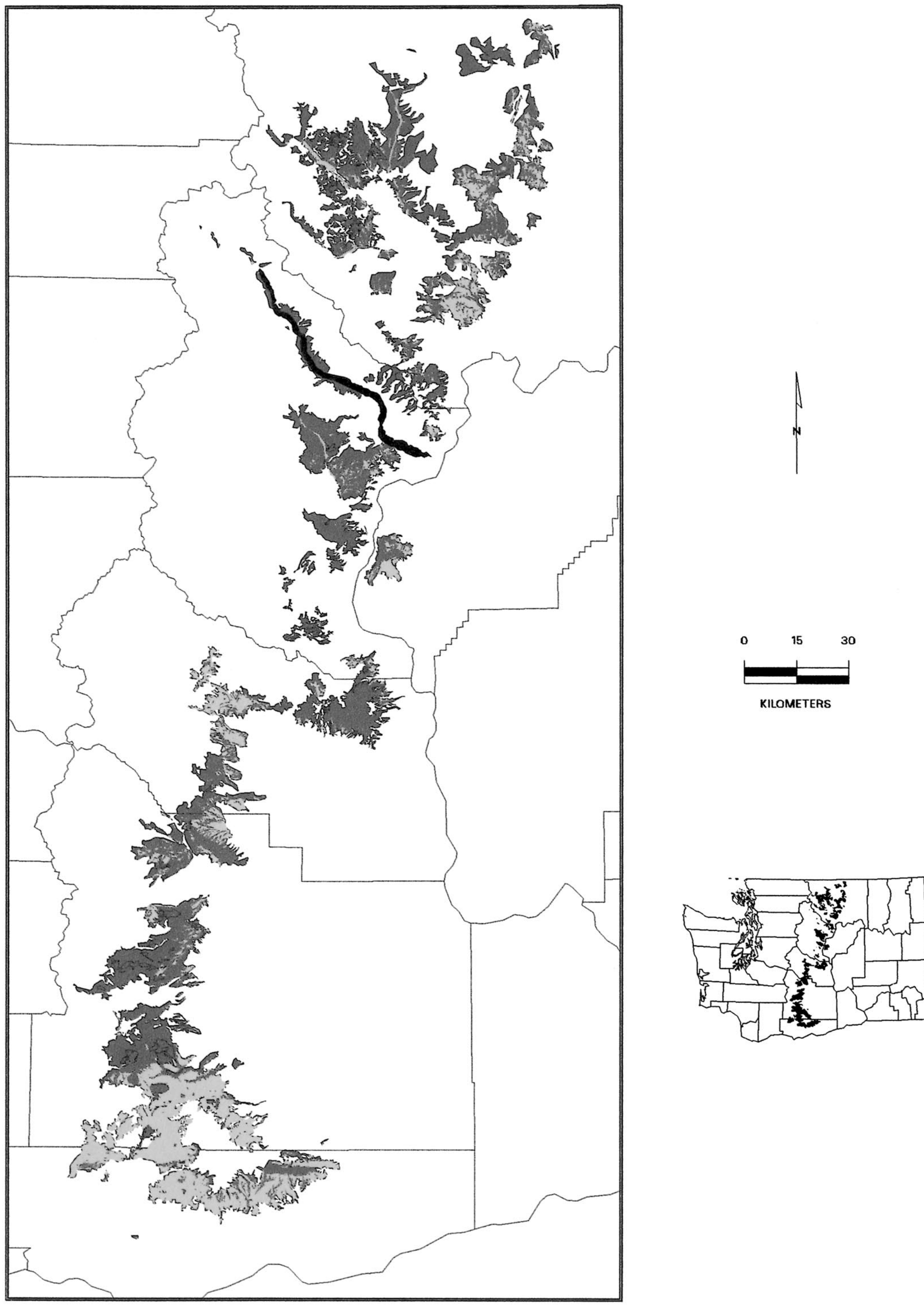

FIGURE 2. Map of the ponderosa pine vegetation zone (shaded area; from Cassidy 1997) in the eastern Cascade Mountains, Washington, indicating the areas of <20% slope and <1219 m elevation (lighter shade).

some of those locations (see range of random site values in Table 1). The high classification rates for nest site habitat in our models indicate that they have substantial value for identifying potentially suitable habitat for conservation purposes. On the other hand, use of the models to identify areas likely not used for nesting would result in erroneous designation of habitats not suitable for nesting by including ''false negative'' locations that are actually suitable.

Our analyses suggest that white-headed woodpecker territories (as indicated by the location of nests) were not uniformly distributed across the full range of geophysical conditions present in the ponderosa pine vegetation zone in Washington. We found only 1 nest >1219 m in elevation and few nests on slopes >20%, suggesting that this woodpecker prefers lower- and mid-elevation ponderosa pine forests on flat or gently sloping terrain. Information from Idaho indicates that ponderosa pine seeds produced in higher elevation stands are of lower quality compared to those from lower- and mid-elevation forests (Curtis and Lynch 1965). In addition, ponderosa pine seed crops vary substantially through time, with years of better production occurring every 4 or 5 y in the Pacific Northwest (Barrett 1979). These results suggest that the distribution and/or density of white-headed woodpeckers may be influenced by food quality or availability, particularly at higher elevations, and that this influence may vary somewhat in years of peak seed production.

Other factors may also explain the apparent geophysical relationships that we found. Our search for nests was not a systematic survey of all potentially suitable habitats, but rather was based on known nests or previous observations of breeding season locations. This approach may have introduced bias to our sampling. For example, the geophysical pattern we observed would be expected if bird watchers were more likely to visit areas in gentle terrain in the ponderosa pine vegetation zone. We attempted to evaluate this possible source of bias by comparing the geophysical attributes of the areas we searched with the attributes characteristic of the ponderosa pine vegetation zone in general. The analysis indicated slight but statistically significant differences in 2 of 3 geophysical attributes between the areas we searched and the greater landscape, suggesting the presence of a bias. The importance of this potential source of bias could be evaluated by conducting additional nest searches, particularly in steeper terrain and on east-facing slopes in the upper elevations of the ponderosa pine vegetation zone.

Despite this unknown potential for bias, we believe that the observed geophysical relationship was influenced in part by the effects of fire suppression. The well-documented influence of fire suppression on forest structure and tree species composition in the Intermountain West (Agee 1993) makes it likely that some forests in the ponderosa pine vegetation zone have become unsuitable nesting habitat for white-headed woodpeckers entirely for this reason. Some higher elevation ponderosa pine stands, particularly those on steeper, north-facing slopes; those in the western part of the vegetation zone; or those in the Douglas-fir or grand fir zones, have been invaded by Douglas-fir and grand fir during the last century (Camp 1995). Changes to the structure and composition of dry forests in these areas would explain the low number of nests in upper elevations and on steep slopes. The fire suppression effects scenario could be evaluated by determining whether white-headed woodpeckers colonize stands containing remnant ponderosa pines after the removal of invading Douglas-firs and grand firs.

Although we lack demographic information on the white-headed woodpecker population in Washington, this species is of management concern due to its strong association with ponderosa pine forests. Forests of mature and old-growth ponderosa pine, important to this woodpecker because of a substantial seed crop apparently associated with larger trees, have become increasingly uncommon within the rather limited area of the ponderosa pine forest association (Cassidy 1997). Remaining stands of trees have been degraded by fire suppression and lost to timber harvest in the last century (Sallabanks and others 2001). Management of habitat for this species should focus on providing snags suitable for nesting and retention of large live trees for foraging at the home-range scale (Garrett and others 1996), although additional information is needed to characterize home range requirements. Future research should determine whether the species' distribution within the ponderosa pine vegetation zone is restricted. The possibility that conversion of dense forest stands to an open pine condition dominated by large trees may increase both the distribution and population size of this species should be experimentally evaluated.

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