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3 SURVEY METHOD BIAS THE DESCRIPTION OF NORTHERN HAWK NEST-SITE STRUCTURE?

SONYA K. DAW,¹ Oregon Cooperative Wildlife Research Unit, 104 Nash Hall, Oregon State University, Corvallis, OR 97331, USA
STEPHEN DESTEFANO,^{2,3} Oregon Cooperative Wildlife Research Unit, 104 Nash Hall, Oregon State University, Corvallis, OR 97331, USA
ROBERT J. STEIDL, School of Renewable Natural Resources, 325 Biological Sciences East, University of Arizona, Tucson, AZ 85721, USA

Abstract: Past studies on the nesting habitat of northern goshawks (*Accipiter gentilis*) often relied on nests found opportunistically, either during timber-sale operations, by searching apparently "good" goshawk habitat, or by other search methods where areas were preselected based on known forest conditions. Therefore, a bias in the characterization of habitat surrounding northern goshawk nest sites may exist toward late-forest structure (large trees, high canopy closure). This potential problem has confounded interpretation of data on nesting habitat of northern goshawks and added to uncertainty in the review process to consider the species for federal listing as threatened or endangered. Systematic survey methods, which strive for complete coverage of an area and often use broadcasts of conspecific calls, have been developed to overcome these potential biases, but no study has compared habitat characteristics around nests found opportunistically with those found systematically. We compared habitat characteristics in a 0.4-ha area around nests found systematically ($n = 27$) versus those found opportunistically ($n = 22$) on 3 national forests in eastern Oregon. We found that both density of large trees (systematic: $\bar{x} = 16.4 \pm 3.1$ trees/ha; $\bar{x} \pm SE$; opportunistic: $\bar{x} = 21.3 \pm 3.2$; $P = 0.56$) and canopy closure (systematic: $\bar{x} = 72 \pm 2\%$; opportunistic: $\bar{x} = 70 \pm 2\%$; $P = 0.61$) were similar around nests found with either search method. Our results diminish concern that past survey methods mischaracterized northern goshawk nest-site structure. However, because northern goshawks nest in a variety of forest cover types with a wide range of structural characteristics, these results do not decrease the value of systematic survey methods in determining the most representative habitat descriptions for northern goshawks. Rigorous survey protocols allow repeatability and comparability of monitoring efforts and results over time.

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Northern goshawks use a variety of forest structural stages for breeding and foraging, but mature or old-growth forest with large trees and high canopy closure may be especially important to northern goshawks in the western United States (Reynolds et al. 1982, Bright-Smith and Mannan 1994, Siders and Kennedy 1996, Squires and Ruggiero 1996, Beier and Drennan 1997, Daw 1997). Recent petitions to list the northern goshawk as threatened or endangered in the southwestern and western United States have been generated because of concern for the effects of timber harvest on their habitat (Kennedy 1997). Concern for northern goshawk

populations has also been voiced in northern Europe, where forest management has increased fragmentation and reduced the amount of older forest, resulting in an estimated decline of populations by 50-60% from the 1950s to the 1980s (Widén 1997).

There is some debate over the accuracy of nest-site descriptions, however, because many nest sites throughout the western United States have been discovered either opportunistically or by use of a priori knowledge of habitat structure (e.g., drainage bottoms with large trees, high canopy closure, and other old-growth characteristics) to direct decisions on where to search for nests (Siders and Kennedy 1996, Squires and Ruggiero 1996). Many nest sites have been located by U.S. Forest Service personnel and others while performing other duties in the field (e.g., timber surveys in areas with large merchantable trees) and were not located as part of a rigorous sampling protocol. This potential

¹ Present address: 251 Hillside Drive, Moab, UT 84532, USA.

² Present address: U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, 104 Biological Sciences East, University of Arizona, Tucson, AZ 85721, USA.

³ E-mail: destef@ag.arizona.edu

source of error, called "errors of nonobservation," is a main source of error in surveys and can lead to sample data that do not accurately mirror the population sampled, even if the sampling and measuring were done with extreme care and accuracy (Scheaffer et al. 1996:52-53).

In the midst of the debate over whether to list the northern goshawk under the federal Endangered Species Act, Squires and Reynolds (1997) reviewed the scientific literature on northern goshawk life history and identified the potential bias in the description of nesting habitat as a hindrance to understanding nest-habitat preference; they recommended clarification of the extent and importance of this potential bias as a priority topic for future research. Potential bias in nest-site description has also been expressed as a concern related to management and possible federal listing of the Queen Charlotte subspecies of northern goshawk (*A. g. laingi*; G. W. Pendleton, Alaska Department of Fish and Game, personal communication).

Our objective was to compare forest vegetation around northern goshawk nests found with a systematic survey method to nests found opportunistically. Our goals were to provide insight into the extent of potential nonobservation bias in the characterization of nest sites and to provide additional information on habitat use by nesting northern goshawks.

STUDY AREA

We surveyed for northern goshawk nests on 3 national forests in eastern Oregon: the Wal-

lowa-Whitman, Malheur, and Fremont (Fig. 1). The climate in eastern Oregon was dry, with snowfall providing the majority of precipitation during cold winters. Topography on all national forests was dominated by moderately sloped hills, ridges, and deeply cut drainages. Elevations ranged between 900 and 2,000 m. Natural forest openings included wet meadows, dry grass and sagebrush (*Artemisia* spp.) meadows, dry rocky flats, and burns.

METHODS

We selected 5 survey blocks of 90-130 km² that contained representative timber-harvest conditions in 3 forest types: ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), and mixed-conifer forest composed of Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western larch (*Larix occidentalis*), ponderosa pine, lodgepole pine, and other conifer species. There was 1 survey block on the Wallowa-Whitman National Forest and 2 each on the Malheur and Fremont national forests (DeStefano et al. 1994). Partial cutting was the method typically used for harvesting mixed conifer and ponderosa pine forest types; clear cutting was used to harvest lodgepole pine. Within our survey blocks, we intentionally included some areas defined by the U.S. Forest Service as "old-growth set-aside" units (U.S. Department of Agriculture 1990). These units ranged in size from about 60 to 160 ha and added to the variety of forest structural conditions we examined for northern goshawk use.

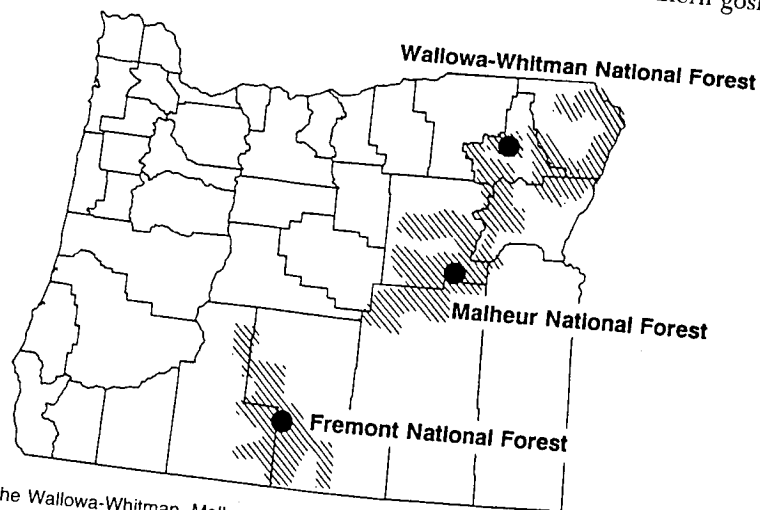


Fig. 1 Location of the Wallowa-Whitman, Malheur, and Fremont national forests (diagonal lines) in eastern Oregon. Surveys for northern goshawk nests took place on 5 90-130 km² surveys blocks (located within the circles) during May-August 1992-93: 1 block on the Wallowa-Whitman, 2 on the Malheur, and 2 on the Fremont.

We used the protocol developed by Kennedy and Stahlecker (1993), modified to handle steep terrain (B. Woodbridge. 1990. Survey protocol for nesting northern goshawks (*Accipiter gentilis*) on national forest lands in the Pacific Southwest region, unpublished. U.S. Forest Service, Macdoel, California, USA) to search for nests within survey blocks during May–August 1992 and 1993. This protocol incorporates the broadcast of taped northern goshawk calls along a grid of stations within a survey block. At stations spaced 300 m apart along a transect, we used a megaphone (modified Realistic model 32–2030) coupled to a cassette player (Sony Walkman model WMA53) to intermittently broadcast either the adult alarm, adult wail, or juvenile begging call, depending on stage of the breeding season. Sound output was 90 dB (SD = 3 dB) at 3 m, which was slightly greater than what Kennedy and Stahlecker (1993) used, but similar to what Fuller and Mosher (1987) recommended. We spent about 4 min at each station. Kennedy and Stahlecker (1993) spaced parallel transect lines 260 m apart, and Woodbridge departed from that pattern in steep terrain by first placing transects along existing roads and then in survey gaps with transect lines established along topographical contours. Our transects in steep terrain were never >450 m apart, which ensured audibility of broadcast calls in different forest conditions. When a northern goshawk was seen or heard, we immediately searched the vicinity for a nest. If a nest was not found, we returned to the area at a later date to conduct additional broadcast surveys and nest searches.

We grouped nests found by this protocol into the “systematic” search category. We grouped nests found by timber survey and marking crews, during wildlife inventories for different species, or during searches of historic northern goshawk nest sites into the “opportunistic” search category. The key distinction was that nests found opportunistically were a result of searching some preselcted type of forest structure throughout the national forests, whereas nests found systematically resulted from thoroughly searching a broad range of forest structural conditions within a contiguous block.

We used 2 variables to compare vegetation characteristics at nest sites between search methods: the number of large (>53 cm diameter at breast height [dbh]) live trees per hectare and total percent canopy closure. We ex-

pected that if a bias existed, nests found opportunistically would be characterized by a higher density of large trees and higher canopy closure than nests found systematically. Abundant large trees and high canopy closure are 2 important characteristics of old-growth forests in the Pacific Northwest and have been identified as key characteristics around northern goshawk nests throughout the western United States (Reynolds et al. 1982, Moore and Henny 1983, Hayward and Escano 1989, Squires and Ruggiero 1996, McGrath 1997). If a bias exists in the characterization of northern goshawk nest sites, it could be because observers seek these forest structural characteristics before looking for nests.

At each nest, we measured these 2 variables (density of large trees, % canopy closure) at 5 plots: a center nest-tree plot surrounded by 4 plots radiating in 4 cardinal directions 30 m from the center plot. Total area covered by the 5 plots was approximately 0.4 ha. We used a Lemmon spherical densiometer (Lemmon 1957, Nuttle 1997) to measure canopy closure 5 m from each plot center in the 4 cardinal directions and averaged the 4 measurements for a plot value; we then averaged the 5 plots. At each of the same 5 plot centers, we estimated stem density with a 20-factor basal area prism and variable-radius plots from which we calculated the number of large live trees per hectare for the entire 0.4-ha area (Bell and Dilworth 1988).

Our use of “nest site” refers to the 0.4 ha around a single active nest (i.e., a pair of northern goshawks used the nest) and is synonymous with Mosher et al.’s (1987) “activity site” (0.04–0.75 ha around some activity point). Our use of nest site is a subset of Postupalsky’s (1974) “breeding territory,” Steenhof’s (1987) “nesting territory,” and Reynolds et al.’s (1992) “nest area”; these areas can contain a number of alternative nests used in different years. We used the 1993 nest site if active, and the 1992 nest for sites active in 1992 only.

We used analysis of variance to determine the effect of search method on large trees per hectare and percent canopy closure, after blocking on national forest (Wallowa-Whitman, Malheur, Fremont) and forest type (ponderosa pine, lodgepole pine, mixed conifer) to remove the variability due to inherent differences in forest structure from these sources (Zar 1996); blocking increased our power to detect differences in

Table 1. Number of active northern goshawk nests found in 1992–93 by search method (systematic vs. opportunistic) in ponderosa pine (PP), mixed conifer (MC), and lodgepole pine (LP) forest types on 3 national forests in eastern Oregon.

Search method	National forest									Total
	Wallowa-Whitman			Malheur			Fremont			
	PP	MC	LP	PP	MC	LP	PP	MC	LP	
Systematic	0	4	0	6	6	0	1	4	6	27
Opportunistic	0	6	0	3	7	0	1	3	2	22
Total	0	10	0	9	13	0	2	7	8	49

forest structure attributable to search method (Steidl et al. 1997). To address the possibility of Type II errors, we calculated 90% confidence intervals (CI) for the estimated differences in measured variables between search methods (Steidl et al. 1997). We used the variance we observed and $\alpha = 0.1$ to estimate the power of our statistical tests to detect a 25% difference in variables between nests found with both search methods. We logit transformed percent canopy closure for analyses but report untransformed values.

RESULTS

We measured forest structure around 49 northern goshawk nest sites located in 1992–93 (Table 1), 27 of which were located during systematic searches and 22 opportunistically. Both density of large trees and canopy closure were similar in 0.4-ha areas around nests found with either search method (Table 2). The difference in density of large trees per hectare between nests found systematically and opportunistically was estimated to be 1.20 (90% CI = -2.3, 4.7); the difference in percent canopy closure between nests found systematically and opportunistically was estimated to be -0.93 (90% CI = -3.2, 1.4). Hence, differences in forest characteristics between search methods were minor and probably not important biologically.

DISCUSSION

In eastern Oregon, northern goshawks used nest sites (0.4 ha) with large trees and high can-

opy closure, and this trend was consistent regardless of the survey method used to find nests. Narrow confidence intervals around differences in characteristics of forest structure provide further evidence that true differences in structure between systematic and opportunistic nests were negligible, as they excluded differences we believe to represent biologically important effect sizes (Steidl et al. 1997). Thus, we found little evidence to suggest the method in which nests were located biased the description of nest-site habitat of northern goshawks toward older forest structure. Researchers in Southeast Alaska also found no apparent bias associated with how a nest was found (K. Titus, Alaska Department of Fish and Game, personal communication).

The pattern of northern goshawks selecting nest sites with abundant large trees and high canopy closure has been shown to occur throughout much of the western United States, including Oregon (Reynolds et al. 1982, McGrath 1997), Idaho (Hayward and Escano 1989), Wyoming (Squires and Ruggiero 1996), California (Hargis et al. 1994, Woodbridge and Detrich 1994), northern Arizona (Reynolds et al. 1992), and New Mexico (Kennedy 1988). This pattern also holds true for northern goshawks nesting in deciduous forests of the eastern United States (Speiser and Bosakowski 1987), coniferous forests of Southeast Alaska (Iverson et al. 1996), aspen (*Populus* spp.) stands in the Great Basin (Young and Bechard 1994), and pine (*Pinus* spp.) and oak (*Quercus*

Table 2. Mean number of large (>53 cm dbh) live trees per hectare and total percent canopy closure in a 0.4-ha area around northern goshawk nests in eastern Oregon by nest-search method.

Structural characteristic	Systematic (n = 27)			Opportunistic (n = 22)			P	Power ^b
	\bar{x}	LSM ^a	SE	\bar{x}	LSM ^a	SE		
Trees/ha	16.4	12.4	3.1	21.3	14.8	3.2	0.56	0.27
Canopy closure (%) ^c	72.4	70.3	2.1	69.8	68.4	2.4	0.61	>0.99

^a Least squares means are means after adjusting for other model parameters (here, national forest and forest type).

^b Estimated for a 25% difference between nests found with different search methods using the variance we observed and $\alpha = 0.10$.

^c Untransformed data.

forest on isolated mountain ranges in desert regions of southeastern Arizona (H. Snyder, Portal, Arizona, personal communication). Northern goshawks will indeed nest in a variety of forested conditions in eastern Oregon and elsewhere but will choose areas with large trees and high canopy closure when available (Daw 1997, Desimone 1997, McGrath 1997).

In eastern Oregon, northern goshawk nests occasionally did occur in patches of forest with high canopy closure but few to no large trees, and our systematic surveys in younger forests showed northern goshawks exhibited some flexibility in use of nesting cover. Thus, we caution that although searching dense, late-forest structure may be the most efficient method for locating northern goshawk nests, such selective searches may not fully represent the distribution of nests among all forest structural stages. In addition, there are likely other habitat variables we did not measure that could be important components of northern goshawk nesting habitat and that may differ between nests found systematically and opportunistically. We therefore suggest researchers continue to use, test, and evaluate rigorous, standardized protocols when searching for nest sites, particularly if the goal is to describe nesting habitat. Rigorous search methods for nests of forest raptors do not necessarily have to incorporate broadcast calls of the species; for example, extensive and intensive foot surveys conducted by experienced personnel can be very efficient (R. T. Reynolds, U.S. Forest Service, personal communication).

There are many good reasons for following rigorous survey protocols when searching for nests of any species, including repeatability of survey methods, estimation of survey effort, calculation of reliable estimates of density, and comparability among studies. Our finding of no biologically important differences between search methods in density of large trees or percent canopy closure at least partly addresses the question of survey bias in northern goshawk nest-site descriptions, but we do not believe these results diminish the value of complete coverage or systematic surveys when a goal is habitat description.

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