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NEST-SITE HABITAT SELECTED BY MERLINS IN SOUTHEASTERN MONTANA[1]

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Abstract. Nest-site selection of Merlins (*Falco columbarius*) was studied for 3 years in southeastern Montana where Merlins utilized Black-billed Magpie (*Pica pica*) nests in ponderosa pine (*Pinus ponderosa*) trees. Twenty-seven habitat variables were sampled at utilized and adjacent nonutilized nest sites. Logistic regression identified five variables useful in distinguishing utilized nest sites from nonutilized sites: maximum height of trees at the nest site, total basal area of the nest site, diameter at breast height of the nest tree, and slope and elevation at the nest site. The resulting equation correctly classified 95% of the utilized nests and 90% of the nonutilized nest sites. Merlins tended to select sites that combined easy access with maximum concealment of the nest contents.

Key words: Falco columbarius; *Merlin; logistic regression; raptors; breeding biology; Montana; nest site.*

INTRODUCTION

The Merlin (*Falco columbarius*) breeds in a large portion of the Northern Great Plains. It ranges eastward from the eastern slopes of the northern Rocky Mountains to the western Dakotas and Nebraska and from the southern edge of the Aspen Parkland in the Canadian prairies to eastern Wyoming and northwestern Nebraska (Temple 1972). Within this area Merlins nest in several different habitats.

Merlins in the prairies of Alberta and Saskatchewan have been associated with deciduous stands near rivers and streams and with natural or planted shelterbelts (Bent 1938, Fox 1964, Hodson 1976, Houston and Schmidt 1981). Recently, an increasing number of breeding pairs has been documented in conifers within several urban areas in Saskatchewan and Alberta (Oliphant 1974, Houston and Schmidt 1981, James 1988, Warkentin and James 1988).

Information on breeding habitat of Merlins in the United States is limited. In the United States, Merlins most often nest in coniferous stands near open prairie/grassland habitat (Lock and Craig 1975; Ellis 1976; Postovit 1979; Becker 1984; J. Squires, pers. comm.). Due to limited information on habitat requirements and the uncertain status of Merlins in the Northern Great Plains, a study of nest-site selection by Merlins was undertaken from 1979 through 1981. Our objectives were to: (1) describe and compare habitat characteristics of utilized and nonutilized nest sites; and (2) identify variables most useful in discriminating utilized and nonutilized nest sites.

STUDY AREA

The study area in southeastern Montana (10,650 ha) was characterized by stands of ponderosa pine (*Pinus ponderosa*) on the side slopes of sandstone buttes that rose approximately 300 m above adjacent grasslands. Small pockets of aspen (*Populus tremuloides*), box elder (*Acer negundo*), and green ash (*Fraxinus pennsylvanica*) occurred in narrow drainages. Adjacent grasslands were dominated by western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), prairie junegrass (*Koeleria cristata*), and needle-and-thread grass (*Stipa comata*). Climate was characterized by frequent winds, hot summers, cold winters, and a semi-arid moisture regime. Annual precipitation averaged 39 cm, of which 70% occurred from May through September. Temperatures ranged from −34°C to 41°C.

METHODS

A systematic ground search of potential Merlin breeding habitat (i.e., stands of coniferous forest

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adjacent to open shrub/grassland) was conducted on the study area during the summers of 1979 through 1981. Forty-four active Merlin nests were located, and the location of each was plotted on U.S. Geological Survey quadrangle maps (scale: 67.4 mm = 1.61 km). Following completion of nesting activities each year, habitat variables at each nest site were measured using techniques similar to those of James and Shugart (1970). Twenty-six physical and vegetative features were measured or calculated at nest sites. Physiographic variables measured at each nest site included aspect (degree), slope (%), elevation (m) above sea level, and distance (m) to open habitat, nearest road, and nearest occupied dwelling. Aspect data were recorded to a four-digit dummy variable for analyses, using 0 as no and 1 as yes for the four cardinal directions.

Vegetation was sampled in 0.04-ha circular plots (radii = 11.3 m) centered at each nest tree and at four additional 0.04-ha circular plots centered on lines radiating from the nest tree in four azimuths (90°, 180°, 270°, and 360°) at distances of 35 m from the nest trees. Measurements in each of the five plots on each nest site were averaged. Vegetation at the nest sites was characterized by measuring percentage ground cover and overstory cover at 100 points in each plot with an occular tube (Noon 1980), height (m) of the tallest tree in each plot, and density (number/ha) of trees by six dbh size classes (<12 cm; 12–22.5 cm; 22.5–37.5 cm; 37.5–58.8 cm; 58.8–67.5 cm; >67.5 cm). Total density was the total number of trees in all size classes; total basal area (m^2/ha) was calculated from tree density data.

Nest-tree variables included height (m) and dbh (cm) of the tree, and distance (m) above and below the nest to live tree branches. The presence or absence of mud cups and stick canopies at the nest was also recorded, as well as the number of alternate Black-billed Magpie (*Pica pica*) nests within 400 m of the nest.

To compare features at Merlin nest sites with those of available, but unused nest sites, variables at paired nonutilized sites were quantified in an identical manner as utilized nest sites. Because Merlins nested almost exclusively in Black-billed Magpie nests on the study area, one nonutilized nest was randomly selected from existing magpie nests located within a 400-m radius of each active Merlin nest. At the end of the fieldwork, nests whose status (utilized or nonutilized) was unchanged during the 2 years were included in the analyses, resulting in a total of 42 pairs of utilized and nonutilized nests.

STATISTICAL ANALYSES

Assumption of homogeneous variances was tested (Bartlett-Box F-test) before paired t-tests were used to analyze differences in noncategorical variables between utilized and nonutilized nest sites (Nie et al. 1975). Variables with heterogeneous variances were log-transformed. Categorical variables were analyzed with chi-square contingency tables. We included P values when ≤ 0.1 since the tradition of setting $\alpha = 0.05$ developed in relatively controlled experimental circumstances compared to ecological field studies (Hinds 1984), and religious adherence (Salsburg 1985) to setting $\alpha = 0.05$ ignores information provided by test statistics when $P > 0.05$ (Toft and Shea 1983) and fails to recognize the inverse relationship between α and the test's power level.

Logistic regression (Dixon 1983) was used to identify variables that were most useful in distinguishing utilized nest sites from nonutilized nest sites. Logistic regression was chosen over discriminant analysis because it allows the inclusion of categorical variables and normality is not assumed (Press and Wilson 1978). Pearson's product-moment correlation coefficients (Nie et al. 1975) were calculated for pairs of all combinations of 26 variables. Correlation analyses were conducted separately for utilized and nonutilized nests. Only one of a pair of highly correlated variables ($r^2 > \pm 0.7$) was included in the logistic regression analysis. The variable chosen for further analyses was that which was most readily interpretable in a biological sense. Variables highly correlated with other variables and those with a large number of zero data points were not included in the logistic regression analysis. Variables included in the final equation were those that significantly ($P \leq 0.1$) improved prediction, fit the logistic regression model, and increased the correct classification of nests. Estimates of correct classification were based on resubstitution of developmental data into the logistic regression model.

RESULTS

PHYSIOGRAPHY

Aspects of utilized nest sites differed ($\chi^2 = 7.9$, $P = 0.005$) from aspects of nonutilized nest sites. A greater number of utilized nests were located

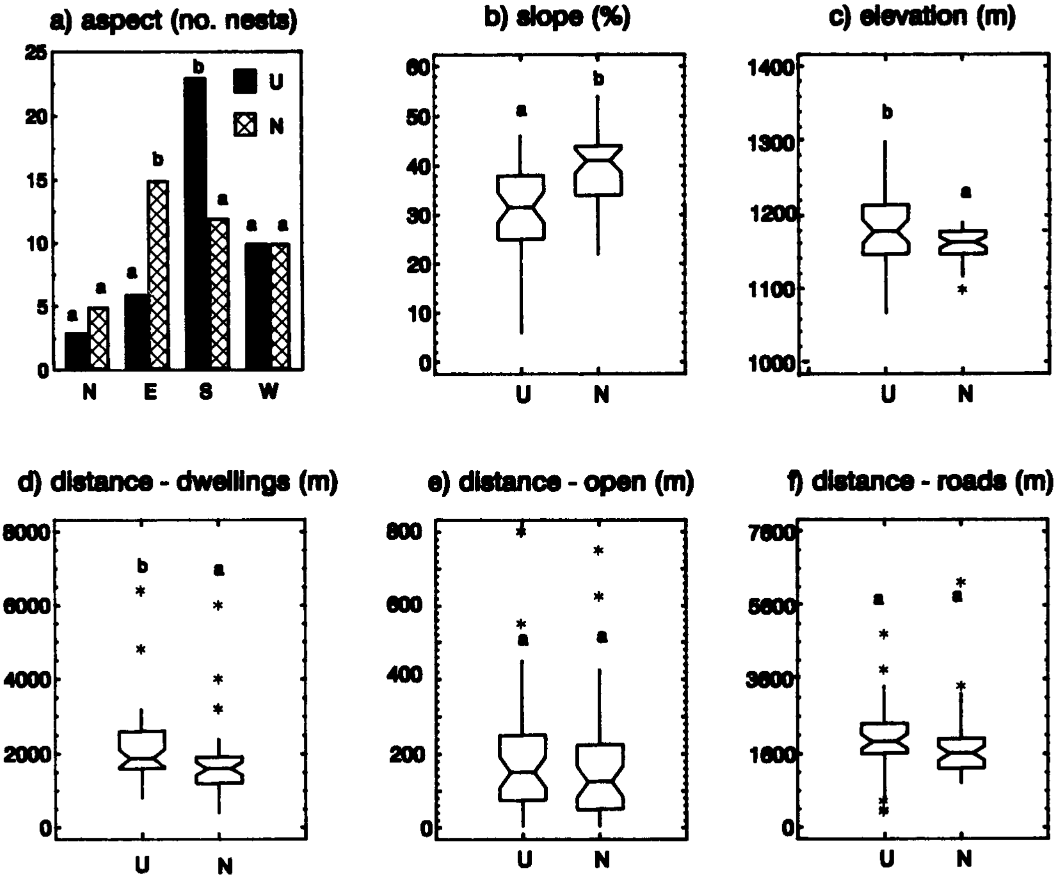

FIGURE 1. Physiographic measurements at utilized (U) and nonutilized (N) Merlin nests in southeastern Montana: (a) aspect (N = north, E = east, S = south, W = west), (b) slope, (c) elevation, (d) distance to dwellings, (e) distance to open grasslands, and (f) distance to roads. Similar means ($P > 0.1$) are indicated by the same letter. The central, horizontal line of the notched box-and-whisker plots (McGill et al. 1978) is the median; the range of values within 1.5 times the interquartile range is indicated by the vertical line, and the boxed area covers the middle 50% of the data values. Asterisks indicate extreme values (>1.5 times the interquartile range). The notch corresponds to the width of the confidence interval for the median.

on south-facing slopes; fewer utilized nests were located on east-facing slopes when compared to nonutilized nest sites. Nests used by Merlins were on less steep slopes ($t = 4.36$, $P < 0.01$), but at higher elevations ($t = 2.24$, $P = 0.03$), and in areas farther from dwellings ($t = 2.01$, $P = 0.05$) than were nonutilized nest trees. Distance to roads and to open habitat did not differ ($P \geq 0.1$) between utilized and nonutilized nest sites.

VEGETATION

Maximum heights of trees adjacent to nest trees were greater ($t = 5.91$, $P < 0.01$) and total basal area was lower ($P = 0.01$) on utilized nest sites than on sites where nonutilized nests were located (Fig. 2). There was a tendency toward higher ground cover ($t = -1.94$, $P = 0.06$) and lower overstory cover ($t = -1.77$, $P = 0.08$) at utilized sites when compared to nonutilized ones. Total tree density ($t = 2.38$, $P = 0.02$), densities of small trees (<12 cm dbh) ($t = -3.13$, $P < 0.01$), and densities of trees in one of the larger size classes (58.8–67.5 cm dbh) were lower ($t = 2.84$, $P < 0.01$) on sites selected by Merlins when compared to nearby nonutilized areas. Utilized sites also showed a tendency towards lower density of trees with 12.0–22.5 cm dbh ($t = -1.79$, $P = 0.08$), but higher density of trees with 22.5–33.5

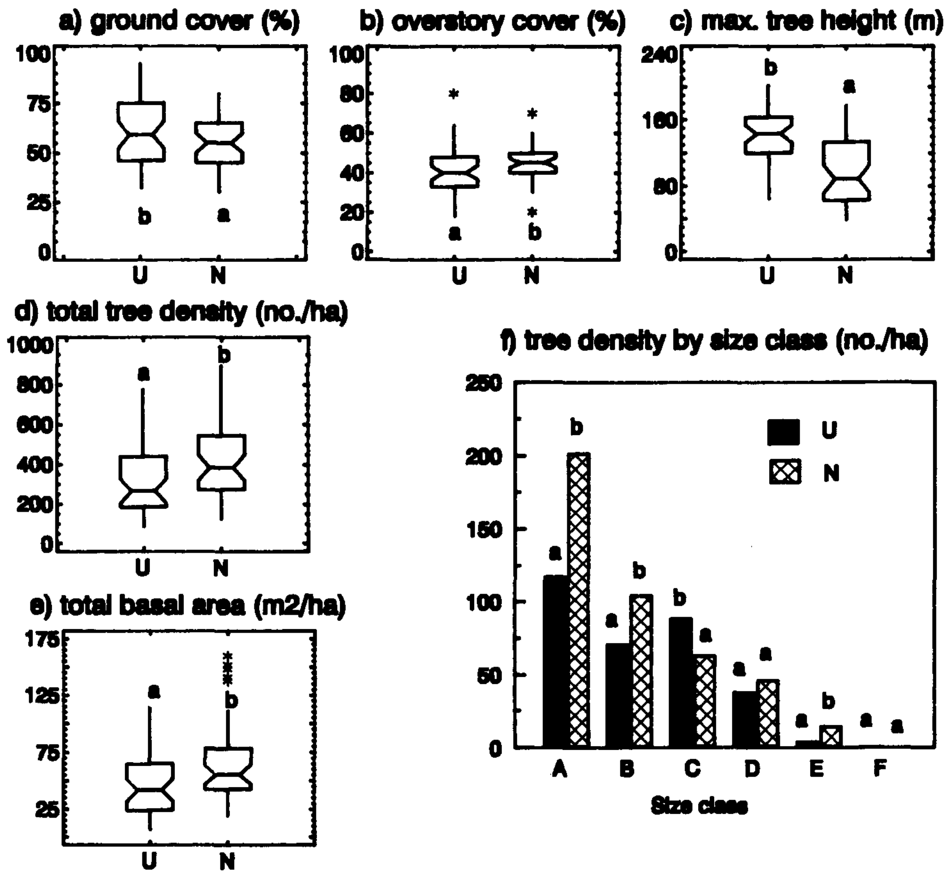

FIGURE 2. Vegetative characteristics at utilized (U) and nonutilized (N) Merlin nest sites in southeastern Montana: (a) ground cover, (b) overstory cover, (c) maximum tree height, (d) total tree density, and (e) tree density by diameter size classes (A = <12 cm, B = 12–22.5 cm, C = 22.5–33.5 cm, D = 37.5–58.8 cm, E = 58.8–67.5 cm, F = >67.5 cm). Similar means ($P > 0.1$) are indicated by the same letter. (See Figure 1 for explanation of notched box-and-whisker plots.)

cm dbh ($t = 1.71$, $P = 0.1$). Densities of trees in other size classes did not differ ($P > 0.1$) between utilized and nonutilized sites.

NEST TREE

Nest trees selected by Merlins were smaller ($t = -3.05$, $P < 0.01$) in diameter, when compared to nonutilized nest trees (Fig. 3). However, utilized and nonutilized nest trees did not differ ($P > 0.1$) in height, number of live branches above and below, number of alternate nests available, and height of nest in the tree. Sixty percent of the utilized nests had a mud cup in the base of the nest; only 26% of nonutilized nests had this feature ($\chi^2 = 9.5$, $P < 0.001$). All magpie nests used by breeding Merlins were covered with a stick canopy; 91% of nonutilized nests had stick canopies ($\chi^2 = 4.2$, $P < 0.05$).

LOGISTIC REGRESSION

Based on the results of the logistic regression, two variables, maximum tree heights adjacent to the nest and total basal area, were most useful in discriminating between utilized and nonutilized nest sites ($P = 0.001$) (Table 1). Diameter of the nest tree, slope, and elevation improved the prediction at $P = 0.05$; % ground cover improved the prediction at $P = 0.1$. The first three variables provided an equation that correctly classified 90% of utilized nest sites and 86% of nonutilized nest sites. However, when slope and elevation were added to the equation, the per-

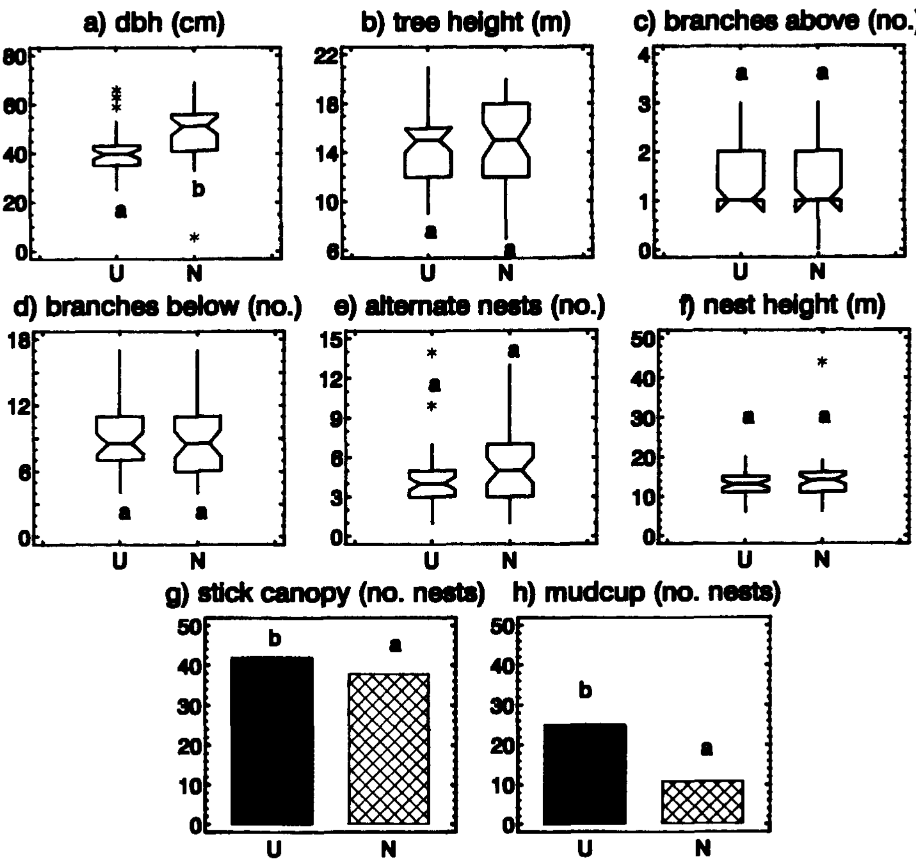

FIGURE 3. Characteristics of the nest and nest tree at utilized (U) and nonutilized (N) Merlin nest sites in southeastern Montana: (a) diameter breast height (dbh), (b) tree height, (c) number of live branches above the nest, (d) number of live branches below the nest, (e) number of alternate nests available, (f) nest height, (g) number of nests with stick canopies, (h) number of nests with mud cups. Similar ($P > 0.1$) means are indicated by the same letter. (See Figure 1 for description of notched box-and-whisker plots.)

centage correct classification of utilized sites increased to 95%; correct classification of nonutilized sites increased to 90%. The addition of % ground cover did not improve the correct classification of either utilized or nonutilized sites, and therefore was not included in the final equation:

probability of use =

$$\frac{e^{-0.89+0.82\mathrm{MAXHT}-0.88\mathrm{TBA}-0.12\mathrm{DBH}-0.21\mathrm{SLOPE}+0.31\mathrm{ELEV}}}{1+e^{-0.89+0.82\mathrm{MAXHT}-0.88\mathrm{TBA}-0.12\mathrm{DBH}-0.21\mathrm{SLOPE}+0.31\mathrm{ELEV}}}$$

Variables not included in the logistic regression analysis were those that were highly correlated with other variables: total density and nest height; variables with large numbers of zero data points in both categories: density of large-diameter trees (>67.5 cm); and densities of trees in individual size classes that were used to calculate total basal area.

DISCUSSION

Univariate analyses indicated a tendency for Merlins to select nest sites that combined the attributes of easy access with maximum concealment of the nest. The predominance of nests on south-facing slopes, in areas of lower tree density, was an indication of the Merlins' selection for nesting in relatively open forest stands. Utilized nest sites had, or showed a tendency of, lower tree densities in most diameter classes; density of trees in only one diameter class (22.5–33.5 cm) tended to be higher on utilized sites compared to nonutilized sites. Lower tree densities likely provided both easy access and greater

TABLE 1. Results of logistic regression analysis of utilized Merlin nesting habitat and potential nest habitat in southeastern Montana.

Step number	Variable[a] entered	Log likelihood	Improvement chi-square	Chi-square[b] P	Goodness-of-fit[c] Chi-square	Goodness-of-fit[c] P
1	MAXHT	−42.58	31.3	0.001	1.1	0.6
2	TBA	−29.58	26.0	0.001	0.3	0.9
3	DBH	−25.22	8.7	0.01	2.7	0.3
4	SLOPE	−21.68	7.1	0.01	0.2	0.9
5	ELEV	−19.29	4.8	0.03	0.2	0.9

[a] MAXHT = Maximum height of trees at nest site; TBA = total basal area, DBH = diameter breast height of nest tree; SLOPE = % slope; ELEV = elevation.
[b] The improvement chi-square tests the hypothesis that the variable entered at that step improves prediction (a small *P*-value, e.g., <0.1, indicates a significant improvement at that step).
[c] The "C. C. Brown" goodness-of-fit test compares the fit of data to the logistic or to some alternate member of the family of models (a small *P*-value, e.g., <0.1, indicates that the logistic model is not appropriate for the data).

visibility of surrounding areas. Merlins have been reported to use sites that offered a good view of surrounding terrain (Lawrence 1949, Newton et al. 1978). Sparse tree cover has been observed at breeding sites of Merlins in Saskatchewan (Fox 1964), Alberta (Hodson 1976), South Dakota (O'Brien, pers. comm.), and Nebraska (Lock, pers. comm.).

Concealment of the nest was apparently an important attribute of nest sites selected by Merlins. Heights of the nest trees were similar on utlized and nonutilized sites; however, heights of trees around the nest tree were greater on utilized sites. Tall trees adjacent to Merlin nests and the exclusive use of magpie nests with a stick canopy probably provided concealment and security for the nesting Merlins and the nest contents. The importance of concealment of the nest may be a major consideration where other avian predators, such as Great Horned Owls (*Bubo virginianus*) and American Crows (*Corvus brachyrhynchos*) are numerous (Warkentin and James 1988).

Throughout their breeding range, Merlins nest in a variety of habitats. Brown (1976, p. 213–225) and Newton et al. (1978) discussed the use of ground nests in heather moors in the United Kingdom. Use of deciduous shelterbelts has been reported in the Canadian provinces by Fox (1964) and Hodson (1976), and Merlins nest in planted conifers in some Canadian cities (Oliphant 1974, Warkentin and James 1988). In ecotones of the Northern Great Plains, Merlins nest in sparse stands of conifers (Ellis 1976, Becker 1984).

Merlins are able to adapt to a variety of habitats that provide good nest sites, food resources, and other requisites for survival. A key feature of Merlin habitat is the nest itself. It is probably safe to assume that the population of Merlins in our study area would not be present were it not for nests constructed by Black-billed Magpies. We never observed Merlins nesting on the ground and rarely in other corvid nests. Further, although Red-tailed Hawks (*Buteo jamaicensis*), American Kestrels (*F. sparverius*), Prairie Falcons (*F. mexicanus*), Golden Eagles (*Aquila chrysaetos*), and Great Horned Owls nested on the study area, we never observed Merlins using nests of these species. Although magpies on the study area constructed nests in a variety of habitats, Merlins selected nests with specific features such as mud cups and stick canopies. Nest trees were primarily in stands of greater tree heights than those of unused nest sites. All nest sites in our study provided a good view of surrounding areas, and most were located in sites of lower tree densities relative to nonutilized sites. All sites were within a short distance of open grassland habitats in which the adults hunted (Becker and Sieg 1987). We have observed Merlins nesting in similar ponderosa pine habitats in Montana, eastern Wyoming, the western Dakotas, and western Nebraska. Although local differences in nesting habitat may occur between these areas, the factors identified in this study appeared to be present at these areas as well.

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