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NEST SITE CHARACTERISTICS OF CAVITY NESTING BIRDS IN CENTRAL MISSOURI

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ABSTRACT.—Two study sites in central Missouri oak-hickory forests were searched for nest sites of cavity nesting birds. Researchers located and measured 133 nests of 11 species. Cavity nesting bird habitat selection is affected by both snag characteristics and vegetation structure.

KEY WORDS: Snags, vegetation structure, woodpecker nesting habitat, habitat management.

Recently, concern has increased for bird species that depend on snags, i.e., dead and dying trees. Cavity nesting birds utilize holes in dead, dying, or hollow trees for nesting, as well as for foraging, perching, drumming, and roosting. Silvicultural techniques such as clearcutting and thinning and increasing public demand for firewood select against retention of dead and dying trees, and may have an adverse impact on cavity nesting birds.

There are two groups of cavity nesting birds: primary and secondary. Primary cavity nesters can excavate their own holes; secondary cavity nesters use previously excavated or natural cavities. In Missouri, cavity nesters are a major element of avian communities and comprise about 20 percent of the species encountered on breeding bird surveys (Evans and Dawson 1976). At least 20 of the 85 North American species of cavity nesting birds breed in the oak-hickory forest type of central Missouri (Hardin and Evans 1977).

We have collected data on nest sites of primary and secondary cavity nesting bird species found in oak-hickory forests of central Missouri. The data are analyzed and interpreted to suggest timber management guidelines that would benefit cavity nesting birds.

METHODS

Field work was conducted on two 16.5 ha study areas located in central Missouri near Columbia during the 1978 and 1979 breeding seasons. The areas typical of the oak-hickory timber type (Braun 1950) were dominated by oaks (*Quercus* spp.) on upland sites and by American sycamore (*Platanus occidentalis*) and green ash (*Fraxinus pennsylvanica*) on bottomland habitat. The areas, known as Rock Bridge and Cedar Creek, were generally similar in stand composition, except Rock Bridge supported more sugar maple (*Acer saccharum*), and eastern red cedar (*Juniperus virginiana*) was more common on Cedar Creek. The areas also differed in stand maturity. Analysis of aerial photographs indicated that sawtimber (d.b.h. >23 cm) covered >63 percent of the Rock Bridge and 28 percent of the Cedar Creek study plots. Pole timber (d.b.h. 10 to 23 cm) covered 27 percent of Rock Bridge and 59 percent of Cedar Creek. Both areas were contiguous with forest habitat, similar in stand composition and stand maturity, interspersed with open fields and pasture.

A search for active nests of cavity nesting species was conducted from March to July, 1978 and from February to May, 1979. The birds' drumming, tapping, and vocalizations were used to determine activity centers and to locate nests.

Measurements of nest site snags were based on Conner and Adkisson's (1977) methods. Degree of decay was determined by examining the hardness of sapwood and heartwood, and by examining branches, upper trunk, and bark. Nest site snags were then assigned a numerical ranking from 1 to 5, in which 1 is the least decayed and 5 the most decayed, using standards developed by Mannan (1977). Principal Component Analysis, a multivariate statistical technique, was used to identify combinations of habitat variables that the birds may be responding to when they select nest sites (Barr *et al.* 1976).

To compare use versus availability of various snag types we inventoried all snags on both areas. We define a snag as a dead or partially dead tree >10 cm d.b.h. and 1.5 m tall. Snags were mapped and marked with chalk to avoid measuring them again. Species (if identifiable), height, d.b.h., and decay class of each snag were recorded. Previously excavated holes were also counted on each snag.

RESULTS AND DISCUSSION

We found 133 nests of 11 species. The six primary cavity nesting species, all of which are woodpeckers, accounted for 72 percent of all nests. Nests of five secondary cavity nesting species were more difficult to locate; therefore, sample sizes for these species are small.

Nests were found within a wide range of sizes and decay classes (table 1). The smallest nest tree (12 cm d.b.h.) was that of a downy woodpecker; the largest was that of a pileated woodpecker (99 cm d.b.h.). In general woodpeckers used snag sizes in proportion to their body sizes. Average body weight and average size of snag at nest height were highly correlated among primary cavity nesting species ($r = 0.72$, $N = 96$, $P < 0.01$). Secondary cavity nesters did not exhibit the same relation between body size and snag diameter ($r = 0.21$, $N = 37$, $P = 0.27$).

Nests in bottomland hardwood habitat accounted for 61 percent of all nests located. Pileated woodpecker nests were found only in bottomland habitat. The eastern bluebird was the only species not found to nest in bottomland areas. Nine of the 11 species nested in bottomland, upland hardwoods, and open areas.

More than nine species of trees were used for nesting, of which oaks (30 percent) and American sycamores (26 percent) were selected most frequently. White oaks were the most common species of snag and were selected according to availability. Sycamores, however, were used much more often than availability alone would predict (X^2 test, $P < 0.05$, df = 1), and appear to be highly valuable as nest sites.

Snags selected for nests were of a wider variety of species than those selected as winter foraging substrates by cavity nesting birds (Brawn *et al.* 1982). In winter, cavity nesters rarely foraged on snags.

Nests were found in snags of all decay classes, but nearly half of the nests were in decay class 4 snags (fig. 1). The average decay class was lower for the secondary cavity nests ($x = 2.4$, $N = 37$) than for the primary cavity nesters ($x = 3.2$, $N = 96$). Secondary cavity nesters might be expected to use more decayed trees where old excavations would be more available. However, secondary cavity nesters in 23 of 37 cases selected natural cavities in otherwise sound trees.

Overall, the cavity nesters did not choose snags randomly with respect to decay class (X^2, $P < 0.01$, df = 4). Decay class 1 snags were selected much less and class 4 snags were selected much more than availability would predict.

Snags selected for nesting were more decayed than those typically chosen as winter foraging substrates by woodpeckers (Brawn *et al.* 1982). These data indicate that a wide variety of snag types is required by cavity nesters on a year-round basis.

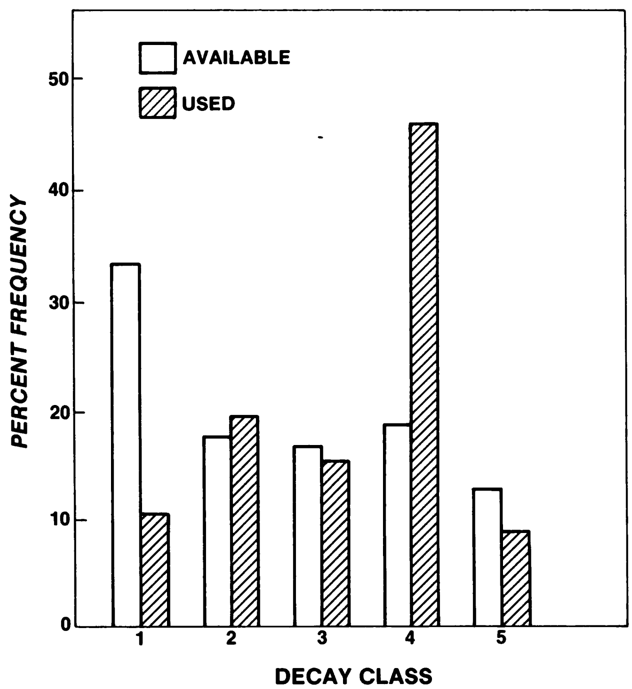

Figure 1.—*The relation of snag decay class and use for nesting by cavity nesting birds (N = 133).*

Table 1.—*Mean values of variables for nest sites of six species of primary cavity nesting birds and five species of secondary cavity nesting birds*

Species	Diameter at breast height	Diameter at nest height	Decay class of nest tree (Mannan 1977)	Height of nest hole	Height of nest tree	Canopy height	Basal area	Density of stems/ha	Distance to nearest opening in canopy
	cm	*cm*			*----m----*		*m²*	*ha*	*m*
PRIMARY									
Common flicker (12)[1]	61.3(22.4)[2]	32.7(10.5)	3.3(2.1)	10.0(2.9)	13.6(3.7)	14.3(4.8)	19.6(13.7)	256(14.1)	79.8(134.2)
Pileated woodpecker (14)	56.0(20.3)	39.6(13.1)	3.6(1.9)	10.3(2.6)	13.7(5.3)	19.9(3.9)	35.5(10.1)	296(10.1)	79.3(107.5)
Red-bellied woodpecker (31)	48.4(22.7)	25.3(11.5)	2.7(2.1)	10.6(4.9)	15.5(6.3)	17.1(5.8)	26.4(10.8)	307(11.9)	50.9(90.2)
Red-headed woodpecker (21)	44.2(18.6)	26.7(12.4)	3.8(1.2)	10.2(4.2)	10.7(6.3)	15.3(6.2)	23.0(7.1)	312(16.4)	12.2(15.0)
Hairy woodpecker (5)	37.2(21.2)	21.2(8.6)	3.1(2.2)	9.9(3.1)	14.5(5.0)	17.0(3.5)	22.4(3.8)	257(11.3)	7.4(93.7)
Downy woodpecker (13)	20.9(5.2)	14.2(2.9)	3.3(1.6)	6.6(2.2)	9.6(3.0)	14.3(2.5)	23.9(5.4)	296(10.3)	43.4(44.8)
SECONDARY									
Great-crested flycatcher (6)	36.3(11.7)	24.7(8.2)	3.0(1.9)	8.6(3.2)	12.5(4.4)	10.0(8.2)	13.8(12.0)	158(15.7)	10.8(15.6)
Black-capped chickadee (4)	17.9(5.4)	13.0(4.7)	4.2(0.8)	3.8(0.8)	5.0(2.7)	16.3(4.8)	26.0(10.0)	236(10.6)	25.8(49.5)
Tufted titmouse (5)	38.3(14.6)	24.8(12.5)	2.1(2.2)	5.1(1.7)	12.3(5.7)	12.8(8.2)	21.0(9.1)	274(17.1)	24.6(27.0)
White-breasted nuthatch (18)	53.7(18.6)	34.9(13.4)	1.7(2.0)	12.2(5.9)	17.0(6.5)	17.5(3.7)	28.6(6.7)	294(6.4)	58.3(107.7)
Eastern bluebird (4)	38.9(28.2)	18.3(5.4)	2.9(3.8)	4.7(2.9)	8.7(7.3)	0.0	6.3(2.9)	62(3.9)	0.0

[1]Numbers of nests located.
[2]Standard deviation.

Cavity nesters probably select nest habitat according to more than one factor. Much previous work suggests that a set of environmental factors may simultaneously influence habitat selection.

Principal component analysis of the primary cavity nesters' nest sites yielded three components, or groups of habitat variables that the birds appear to respond to (Brawn 1979). Micro-habitat variables associated with the size of the nest tree, including d.b.h., nest height, and tree height, accounted for the first component. The second component was comprised of macro-habitat variables associated with the maturity of the stand, including density of stems and basal area.

The nesting habitat of the primary cavity nesters in terms of these two components is depicted in figure 2. Pileated woodpeckers were highly correlated on both axes; their habitat can be characterized as large snags in relatively mature (i.e., sawtimber) stands. In contrast, downy woodpeckers nest in small snags in younger stands.

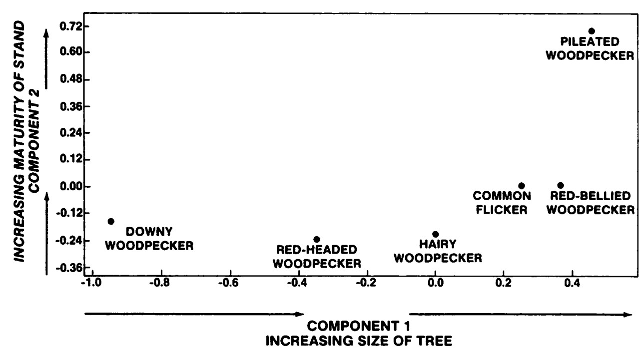

Figure 2.—*Two-dimensional ordination of nesting habitats for six primary cavity nesting birds along first and second principal components.*

Principal component analysis of the secondary cavity nesters, despite a small sample size, suggested that this group of birds used criteria similar to those of primary cavity nesters. Component 1, representing the nest tree micro-habitat, was associated with tree height, nest height, d.b.h., and decay class. White-breasted nuthatches were highly positively correlated with component 1 (fig. 3); nuthatch nests were in large relatively sound trees. In contrast, black-capped chickadees nested in small, well-decayed snags.

Component 2 for the secondary cavity nesters was highly correlated with basal area, density of stems and canopy height. Therefore, species negatively correlated with component 2 nested in either open habitat such as pasture edges or young poletimber stands.

The nest site data for all species indicate that size of nest tree and structure of surrounding habitat are important components of the breeding habitat of cavity nesting birds. Snags in bottomland habitat are apparently preferred, but snags should also be available in upland hardwood, field or pasture edges.

Snag and Cavity Availability

The Cedar Creek area contained 201 snags with 392 holes. The Rock Bridge area, which had generally older timber stands, contained 305 snags with 575 holes. The snag densities on Cedar Creek and Rock Bridge were, by extrapolation, 496 and 752 snags/40 ha, respectively. Snag densities on both areas were well in excess of snag densities recommended by Evans and Conner (1979).

Qualitative as well as quantitative differences were found between the two areas with regard to snag availability. For example, although snags <20 cm d.b.h. were equally abundant on the plots, there were proportionately more large snags (>30 cm d.b.h.) on the Rock Bridge plot (fig. 4). Therefore, a mature stand not only has more snags but larger snags.

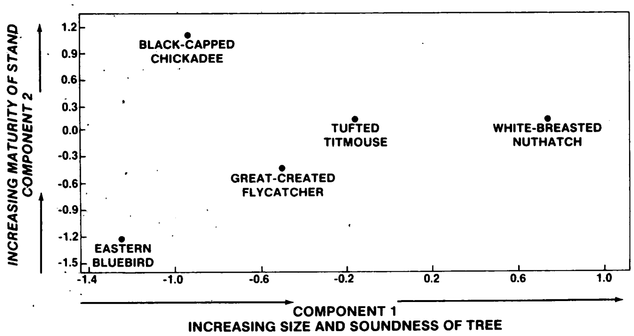

Figure 3.—*Two-dimensional ordination of nesting habitat for five secondary cavity nesting birds.*

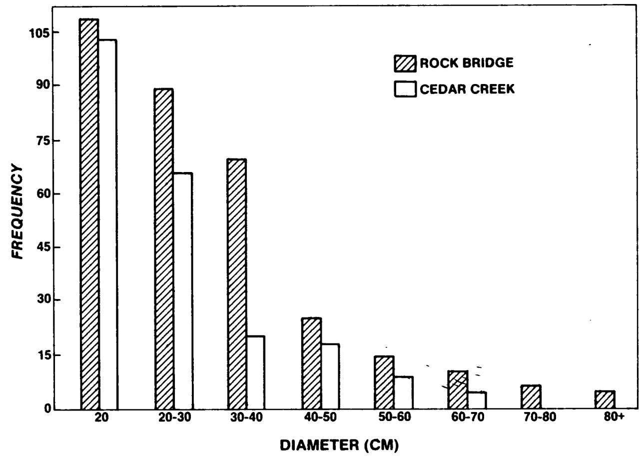

Figure 4.—*Distribution of snags by diameter class.*

We found an average of 1.62 cavities/snag on Cedar Creek and 1.9 cavities/snag on Rock Bridge. Twenty percent of the cavities on Cedar Creek and 15 percent of the cavities on Rock Bridge were judged to be natural, i.e., nonexcavated cavities.

Excavated cavities were distributed unevenly on the snags in terms of snag size (table 2). Few (7 percent) of the snags in the <20 cm d.b.h. size class were found to contain excavated cavities. In contrast, more than 50 percent of snags in the size classes >30 cm d.b.h. contained excavated cavities. These data are consistent with data from the active nests we located. Larger snags (>30 cm d.b.h.) appear to be utilized more frequently than smaller snags. Moreover, cavity nesters prefer larger snags as winter foraging substrates (Brawn *et al.* 1982).

The relation between snag size and number of excavated cavities is the result of these main factors: (1) larger snags have a greater surface area and will

Table 2.—*Distribution of excavated cavities in snags of various diameter classes*

	Diameter class (cm d.b.h.)					
	20	21-30	31-40	41-50	51-60	60+
Mean number of cavities/snag	0.4	1.4	3.4	5.1	2.7	2.1
Percent of total number excavated cavities in diameter class	10.0	14.0	36.0	27.0	8.0	5.0
Percent of snags available in size class with >1 cavity	7.0	2.0	52.0	63.0	59.0	70.0

probably remain standing longer, increasing the likelihood that primary cavity nesters will use them; and (2) snags must be large enough to accomodate a breeding bird and its brood.

Management Recommendations

Results of this study support concern voiced in previous studies (summarized by Evans and Conner 1979) that intensive silvicultural management of oak-hickory forests can be selective against cavity nesters. Overall, cavity nesters benefit most from large snags, and snag densities affect breeding densities of cavity nesters. Short rotation times, fuelwood removal, and salvage or sanitation cuts would probably result in insufficient densities of large snags. The following management recommendations are made with regard to oak-hickory forests.

(1) *Extend rotation length.* Rotation length is important because older timber stands have more and larger snags than younger stands. A single recommendation for rotation length is not feasible because growth rates of trees vary according to habitat quality or site index (Sander 1977). On poor sites (site index 54 and below) the rotation period should be at least 125 years. On better quality sites (site index 55 and greater) the rotation length should be at least 90 years. These rotation lengths should allow a timber stand to mature to the point where trees are large enough to be used as nest sites by all the cavity nesters. Sander (1977) reported that on site index 55 to 74 timber stands, the diameter of harvestable oak trees will be 50 to 60 cm d.b.h. after 90 years. These rotation lengths will further benefit cavity nesters that forage in the canopy of live vegetation. In addition, older stands of oaks have high mast production and would benefit red-headed woodpeckers in the fall and winter.

(2) *Restrict removal of snags when thinning timber stands.* Thinning techniques such as timber stand improvement and salvage and sanitation cuts select against cavity nesters because snags or otherwise defective trees are usually removed. Snags should be removed only when they pose an obvious safety or fire hazard. Large unmerchantable live trees should be girdled and left standing. If snags are to be removed selectively, the largest, relatively sound snags should be retained. These snags remain standing longer, are preferred for winter foraging (Brawn *et al.* 1982), and eventually become sufficiently decayed for woodpecker nesting. However, snags with old woodpecker holes should be retained for the secondary cavity nesters. As a stand matures the density of snags retained should increase because the number of cavity nesting species potentially using the area will increase. Snag removal should also be restricted on stands that are used for firewood collection. The "best" snags should be marked and the public should be instructed not to cut them.

(3) *Minimize the effects of clearcuts.* In general a clearcut area will be unusable for many of the cavity nesters. If sufficiently large snags were retained on a clearcut, it could be used as breeding habitat by common flickers, great crested flycatchers, and eastern bluebirds, especially if the snags were at least 35 cm d.b.h. and had old woodpecker holes in them. Live defective trees should be girdled and left standing. These trees will eventually decay and replace snags that have fallen. Snags should also be retained on the edges of clearcuts. This would be particularly beneficial to red-headed woodpeckers, which nest in mature stands near openings.

(4) *Retain uncut strips of bottomland timber along waterways.* Bottomland hardwoods are especially useful to cavity nesters in the oak-hickory forest. More than 60 percent of the nests located in this study were in bottomland habitat. Many of the tree species grow quickly and are available sooner for nesting by all cavity nesters than the slower growing upland hardwoods. Uncut strips of bottomland habitat at least 50 m wide should be retained on both sides of streams and rivers. Mean territory sizes of two small woodpecker species in the study areas ranged from 3.5 to 6 ha (Brawn 1979). If trees are cleared close to streambanks, a long strip of riparian forest would be needed to satisfy a nesting pair's requirement. Narrow bottomland strips would probably not be suitable for species that utilize large territories.

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