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HABITAT CHARACTERISTICS RELATED TO PILEATED WOODPECKER DENSITIES IN MISSOURI

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ABSTRACT.—We examined relationships among Pileated Woodpecker (*Dryocopus pileatus*) densities and forest habitat characteristics on 16 study areas in Missouri during 1985–1986. Pileated Woodpecker abundance ranged from 0.5 to 4.1 territories/100 ha. Regression analysis indicated a positive, linear relationship between Pileated Woodpecker abundance and percent of an area covered with bottomland forest, density of trees ≥30 cm dbh, and density of snags ≥54 cm dbh. Percent of area covered with pole timber (>15 cm and <25 cm dbh) was negatively related to Pileated Woodpecker abundance. Study areas with greater amounts of bottomland forest (≥4.5%, N = 7) had a higher density of snags ≥54 cm dbh ($P = 0.005$) and smaller amounts of pole timber cover ($P = 0.04$) than study areas with <4.5% bottomland forest cover (N = 9). Our findings indicated that large trees and huge snags are important features in Pileated Woodpecker habitat, and these features were most often associated with bottomland forest. *Received 31 Mar. 1992, accepted 18 Aug. 1992.*

Pileated Woodpeckers (*Dryocopus pileatus*) are residents of mature, dense forests of the eastern and northwestern United States (e.g., Bock and Lepthien 1975, McClelland 1979, Bull 1987, Mellen et al. 1992). They have specific habitat requirements that often are not present in intensively managed forests (Bull and Meslow 1977). Pileated Woodpeckers occupy large home ranges (53–160 ha, Renken and Wiggers 1989) and use large trees and snags (average diameter at breast height [dbh] = 56 cm, Brawn et al. 1984) as nest sites. These specific requirements have served as justification for designating the Pileated Woodpecker as an indicator species in forest management plans for many state and federal natural resource agencies. It is assumed that if Pileated Woodpecker habitat requirements are met by the landscape and structure of a forest, then that forest should provide habitat for other primary cavity nesting birds (Thomas et al. 1979), as well as representing a mature tree stage in forest succession.

Our study examined which habitat characteristics are related to Pileated Woodpecker densities in oak-hickory (*Quercus* spp.–*Carya* spp.) forests of Missouri and examined the relationship between these forest characteristics and Pileated Woodpecker densities.

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STUDY AREAS AND METHODS

We selected 16 study areas in eastern, central, and southern Missouri. The study areas ranged in size from 287 to 599 ha and were selected to represent a range of forest stand types and age classes. Pileated Woodpecker densities on the study areas were unknown at the time the sites were selected. Central and eastern study areas had forest stands primarily composed of white oak (*Q. alba*), red oak (*Q. rubra*), black oak (*Q. velutina*), black walnut (*Juglans nigra*), and hickories (*Carya* spp.). Southern study sites had similar forest cover, except scarlet oak (*Q. coccinea*) generally replaced red oak.

Pileated Woodpecker populations were estimated on the study areas using the plot mapping technique (Christman 1984). Woodpeckers were surveyed on seven study areas in March 1985 and on the remaining nine study areas in March 1986. Each of the four bird counters followed two 1.25-km transects on each study area. Recorded Pileated Woodpecker calls and drums were broadcast from a cassette tape player two or more times at 50 m intervals along the transect to facilitate the location of birds. The location and direction of flight of each responding Pileated Woodpecker was recorded on maps to avoid counting a woodpecker more than once. Transects were walked from sunrise until 10:00 h CST and from 15:00 h CST until sunset. Each transect was followed for three morning and three afternoon counts.

Mapped bird locations within 300 m of either side of a transect were used to calculate density estimates. Plot mapping was not intended for counting birds that have a territory size greater than the transect width (Christman 1984). Therefore, our density estimates were inflated because Pileated Woodpecker territories never fit entirely within transect boundaries. Thus, reported densities should not be viewed as absolute density estimates but rather as relative estimates.

Forest vegetative structure was measured in random samples stratified by forest stand type and tree size. We categorized forest stand types into six general strata: oak-hickory—stands >50% oak and hickory; oak-pine—stands >50% oak and pine; bottomland hardwoods—stands >50% ash (*Fraxinus* spp.), birch (*Betula* spp.) and sycamore (*Platanus occidentalis*); cedar—stands >50% red cedar (*Juniperus virginiana*); or old field. Stand tree size categories were saw timber (average dbh ≥25 cm), pole timber (average dbh >15 and <25 cm), sapling (average dbh ≤15 cm), and regeneration (≤3 year-old clearcuts). A sample was measured for every 8 ha of forest within each stratum. Forest vegetative features were measured within 0.04-ha circular plots. Dbh was measured on all trees and snags (standing dead trees ≥1.4 m in height) with a dbh ≥10 cm. Overstory canopy cover was estimated with a densitometer at plot center. Tree or snag basal area was calculated from dbh and density data. Percentages of the study sites covered by saw timber, pole timber, and open/regeneration stands were calculated from forest inventory data and maps.

Some forest inventory data did not have any portion of the study areas classified as bottomland hardwoods, even though we knew that this habitat was present. To have a correct measure of this habitat, we derived a new measure from topographic maps and forest inventory data. Our criteria and procedures for measuring the amount of bottomland hardwoods were as follows. The lowest elevation point, which was always associated with an intermittent or permanent stream on topographic maps, was the starting point for measuring the amount of bottomland. The area of lowest elevation had to have vegetation characteristic of bottomland timber, such as sycamore or Ohio buckeye (*Aesculus glabra*), and a slope of <2%. The total amount of available bottomland was measured with a planimeter by following the topographic contour lines outlining the bottomland from the lowest elevation point up to and including the area enclosed by the contour line that was 18.5 m higher in elevation than the lowest point. The total amount of bottomland was summed for the study area, and the amount of bottomland covered by food plots, pasture, and sapling timber was subtracted from the total to calculate the amount of bottomland forest.

Vegetative samples were used to calculate study area means for habitat variables used in statistical analyses. Tests indicated that values for some variables were not normally distributed. Therefore, nonparametric tests were used. We observed that the smallest nest tree/snag used by Pileated Woodpeckers was 30 cm dbh (Renken 1988). To account for the use of these large trees/snags by Pileated Woodpeckers, we calculated values for the density of trees $\geq$30 cm dbh/ha and density of snags $\geq$30 cm dbh/ha. We also observed that the average nest tree/snag dbh for Pileated Woodpeckers was 52 cm (Renken 1988). Brawn et al. (1984) reported an average dbh of 56 cm for Pileated Woodpecker nest trees in central Missouri. To account for the use of huge snags by Pileated Woodpeckers, we used the midpoint between 52 and 56 as a value for density of huge snags ($\geq$54 cm dbh/ha).

We used Spearman's rank correlation, maximum R^2 regression (MAXR), and multiple regression analyses (SAS 1985) to determine which habitat characteristics were related to Pileated Woodpecker densities. In MAXR regression analysis, model variables that resulted in the largest R^2 value were assumed to influence Pileated Woodpecker densities. We examined the fit of the regression models with large R^2 values in individual multiple regression equations. We used the criteria of little or no correlation ($P > 0.05$) among independent model variables, and a random, even distribution in the plot of model residuals versus model predicted values as guidelines for determining the best combination of habitat variables for a regression equation. We realized the indiscriminate use of multivariate statistical analyses on habitat data sets could lead to misleading spurious results and interpretations of patterns in data (Rexstad et al. 1988). To avoid such problems we examined habitat variables we believed might be related to Pileated Woodpecker densities and applied three different analysis approaches to the data.

Study areas were also categorized as supporting high or low Pileated Woodpecker abundance, using the median density of our study areas as the threshold value in categorizing. We then determined if mean values for habitat variables differed between high and low Pileated Woodpecker density areas using Mann-Whitney U-tests.

RESULTS

The average density of Pileated Woodpeckers over the 16 study areas was 1.86 territories/100 ha (Table 1). Five habitat characteristics were related to Pileated Woodpecker densities in Spearman rank correlation. Pileated Woodpecker density was positively correlated with percent bottomland forest ($r = 0.72$, $P = 0.002$), density of snags $\geq$54 cm dbh ($r = 0.50$, $P = 0.050$), sycamore density ($r = 0.49$, $P = 0.054$), and sycamore basal area ($r = 0.53$, $P = 0.035$). Percent pole timber cover was negatively correlated with Pileated Woodpecker density ($r = -0.74$, $P = 0.001$). We examined scatter diagrams of Pileated Woodpecker density against the various habitat variables and did not see patterns that suggested curvilinear relationships.

MAXR regression analysis provided results similar to Spearman rank correlation. In a 1-variable model, a regression with percent bottomland forest produced the greatest R^2 value ($R^2 = 0.45$, $F = 11.57$, $P = 0.0043$). In a two-variable model, a regression with percent bottomland forest and

TABLE 1

PILEATED WOODPECKER (PW) DENSITIES AND MEAN VALUES FOR STUDY AREA HABITAT CHARACTERISTICS

Study Area	PW density terr/100 ha	Bottomland forest %	Pole timber %	Sycamore density trees/ha	Sycamore basal area m^2/ha	Snags ≥54 cm DBH snags/ha	Trees ≥30 cm DBH trees/ha	Snags ≥30 cm DBH snags/ha
A	4.1 (1.18)[a]	6.9	14.5	3.8 (3.3)	0.40 (0.30)	1.1 (0.8)	112.5 (12.1)	8.2 (2.5)
B	3.5 (0.86)	3.7	11.6	3.0 (1.8)	0.60 (0.30)	0.6 (0.6)	103.7 (9.2)	8.5 (2.7)
C	2.9 (0.90)	7.4	0.0	1.1 (1.2)	0.10 (0.10)	0.0 (0.0)	94.3 (7.2)	1.1 (0.8)
D	2.4 (0.57)	5.9	25.7	1.6 (1.6)	0.02 (0.02)	1.1 (0.7)	62.8 (6.4)	10.1 (2.6)
E	2.4 (0.57)	6.1	0.0	4.1 (2.8)	0.80 (0.60)	1.4 (1.3)	85.1 (11.1)	8.1 (2.4)
F	2.2 (0.73)	6.2	18.3	0.0 (0.0)	0.00 (0.00)	0.9 (0.6)	39.7 (5.5)	5.8 (2.0)
G	2.0 (0.65)	3.1	20.7	0.5 (0.5)	0.02 (0.10)	0.0 (0.0)	66.2 (6.2)	7.8 (2.1)
H	1.6 (0.45)	3.8	27.0	0.5 (0.5)	0.01 (0.01)	0.5 (0.5)	61.7 (7.6)	6.1 (2.0)
I	1.5 (0.49)	3.1	38.9	0.0 (0.0)	0.00 (0.00)	0.0 (0.0)	56.2 (6.0)	3.6 (1.1)
J	1.4 (0.53)	0.0	8.2	0.0 (0.0)	0.00 (0.00)	0.0 (0.0)	87.5 (8.0)	9.4 (2.1)
K	1.4 (0.78)	4.5	30.0	0.0 (0.0)	0.00 (0.00)	0.9 (0.6)	93.0 (8.2)	5.7 (1.4)
L	1.3 (0.53)	3.6	34.4	0.0 (0.0)	0.00 (0.00)	0.8 (0.8)	75.0 (10.3)	12.5 (3.4)
M	1.0 (0.41)	5.1	15.5	1.1 (1.1)	0.10 (0.10)	0.6 (0.6)	71.7 (6.9)	2.8 (1.2)
N	0.9 (0.37)	2.0	40.7	4.5 (3.2)	0.50 (0.30)	0.0 (0.0)	94.3 (6.2)	9.0 (2.1)
O	0.7 (0.33)	1.6	43.4	0.0 (0.0)	0.00 (0.00)	0.0 (0.0)	64.2 (5.7)	5.2 (1.2)
P	0.5 (0.24)	1.3	44.3	0.0 (0.0)	0.00 (0.00)	0.0 (0.0)	85.5 (8.4)	3.9 (1.4)

[a] Standard errors in parentheses.

density of trees ≥30 cm dbh produced the greatest R^2 value ($R^2 = 0.59$, $F = 9.37$, $P = 0.003$). Percent bottomland forest, density of trees ≥30 cm dbh, and percent pole timber were variables producing the largest R^2 value ($R^2 = 0.65$, $F = 7.52$, $P = 0.0043$) in a three-variable model. In all equations, percent bottomland forest and density of trees ≥30 cm dbh had positive coefficients, while percent pole timber had a negative coefficient.

After examining the diagnostics of several multi-variable regression equations in individual tests, we determined the best fitting regression equation had four variables: percent bottomland forest, percent pole timber, density of snags ≥30 cm dbh, and density of trees ≥30 cm dbh ($R^2 = 0.70$, $F = 6.4$, $P = 0.0065$; parameter estimates (B_x) = 0.25, −0.02, 0.07, and 0.01, respectively).

The variables percent bottomland forest and pole timber, density of trees ≥30 cm dbh, and density of snags ≥54 cm dbh appeared to best describe habitat suitability for the Pileated Woodpecker. The variables percent bottomland forest and pole timber were related to woodpecker density in both correlation and regression analyses. The density of trees

≥30 cm dbh and density of snags ≥54 cm dbh were related to Pileated Woodpecker density in either correlation or regression analyses. Although the variables sycamore density and sycamore basal area were also related to Pileated Woodpecker density in correlation analysis, we did not include them in our list because they were correlated with the density of trees ≥30 cm dbh ($r = 0.46$, $P = 0.072$ and $r = 0.50$, $P = 0.051$, respectively). The variable density of snags ≥30 cm dbh was not included in the list because it was closely related to density of snags ≥54 cm dbh ($r = 0.38$, $P = 0.15$).

Bottomland forest differed from upland saw and pole timber stands in several respects. Sycamore density was greater in bottomland forest habitat (Mann-Whitney *U*-test, one-tailed test, $T = 33$, $P < 0.05$) and overstory canopy cover was greater in bottomland forest habitat (Mann-Whitney *U*-test, two-tailed test, $T = 95$, $P < 0.05$). Also, study areas with greater amounts of bottomland forest (≥4.5%, N = 7) had a higher density of snags ≥54 cm dbh (Mann-Whitney *U*-test, $T = 83.5$, $P = 0.009$) and smaller amounts of pole timber cover (Mann-Whitney *U*-test, $T = 41.0$, $P = 0.057$) than study areas with <4.5% bottomland forest cover (N = 9).

DISCUSSION

Our results suggest Pileated Woodpecker abundance may be related to several structural features associated with mature, deciduous forest (abundant large trees and huge snags, and a reduced amount of pole timber), as well as to the presence and amount of bottomland forest. Our results concur with and support previous descriptions of Pileated Woodpecker habitat features. Graber et al. (1977) reported that Pileated Woodpecker densities were highest in bottomland, mature forests. Conner et al. (1975) noted that Pileated Woodpecker nests were never >150 m from streams in Virginia and that most nests were <50 m from water. Deciduous riparian forest was a preferred habitat in Pileated Woodpecker home ranges in northwestern Oregon (Mellen et al. 1992). Pileated Woodpeckers may concentrate in bottomland forest because mesic conditions promote growth of large trees (Conner et al. 1975). Study areas in Missouri with greater amounts of bottomland forest typically had higher densities of huge snags (≥54 cm dbh) which are a critical habitat component for nesting Pileated Woodpeckers (Renken 1988). Bottomland forests also had structural characteristics that are representative of mature forests. A greater amount of overstory canopy cover and small amounts of pole timber were bottomland forest structural features characteristic of mature deciduous forests.

Two Pileated Woodpecker habitat parameters, the density of trees ≥30 cm dbh and the density of snags ≥54 cm dbh, also were characteristics of older, mature forest. Pileated Woodpecker nest trees can be 100–180 years old (Conner 1978). In Missouri, oaks may not grow to dbhs of ≥30 cm until they are 80 years old (site index 55, Sander 1977). Even more time is required before trees grow to a dbh ≥54 cm and then die to become suitable snags.

Other workers have discussed the relationship between snag density and Pileated Woodpecker populations. Evans and Conner (1979) reported that a density of 40, 45–65 cm dbh snags/70 ha would result in the greatest possible densities of Pileated Woodpeckers in eastern forests. This recommendation translates into a huge snag (≥54 cm dbh) density of approximately 0.6 snags/ha. We agree with this recommendation because, in our study, 71% of the high Pileated Woodpecker density study areas (≥2 territories/100 ha) had mean huge snag densities meeting this standard. We also agree with the conclusion of Evans and Conner (1979) that an even distribution of huge snags should be encouraged. A forest with clustered pockets of huge snags may not hold as many Pileated Woodpecker pairs as would a forest with a dense, uniform distribution of huge snags.

Forests already having bottomland habitat should be protected because this habitat is critical to Pileated Woodpeckers. Forests without bottomland habitat can still be allowed to develop large trees and huge snags, but Pileated Woodpecker abundance in these areas may not reach maximum levels possible if bottomland forest is lacking. Those interested in Pileated Woodpecker conservation should consider acquiring land that has bottomland forest and managing that forest for high densities of large trees and huge snags.

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LITERATURE CITED

BOCK, C. AND L. LEPTHIEN. 1975. A Christmas count analysis of woodpecker abundance in the United States. Wilson Bull. 87:355–366.

BRAWN, J. D., B. TANNENBAUM, AND K. E. EVANS. 1984. Next site characteristics of cavity nesting birds in central Missouri. U.S. For. Serv. Res. Note NC-314.

BULL, E. L. 1987. Ecology of the pileated woodpecker in northeastern Oregon. J. Wildl. Manage. 51:472–481.

——— AND E. C. MESLOW. 1977. Habitat requirements of the pileated woodpecker in northeastern Oregon. J. For. 75:335–337.

CHRISTMAN, S. P. 1984. Plot mapping: estimating densities of breeding bird territories by combining spot mapping and transect techniques. Condor 86:237–241.

CONNER, R. N. 1978. Snag management for cavity nesting birds. Pp. 120–128 *in* Proc. workshop management of southern forests for nongame birds (R. M. DeGraff, tech. coord.). U.S. For. Serv. Gen. Tech. Rep. SE-14.

———, R. G. HOOPER, H. S. CRAWFORD, AND H. S. MOSBY. 1975. Woodpecker nesting habitat in cut and uncut woodlands in Virginia. J. Wildl. Manage. 39:144–150.

EVANS, E. F. AND R. N. CONNER. 1979. Snag management. Pages 214–225 *in* Proc. workshop management of north central and northeastern forests for nongame birds (R. M. DeGraaf, tech. coord.). U.S. For. Serv. Gen. Tech. Rep. NC-51.

GRABER, J. W., R. R. GRABER, AND E. L. KIRK. 1977. Illinois birds: Picidae. Ill. Nat. Hist. Surv., Biol. Note No. 102.

MCCLELLAND, B. R. 1979. The pileated woodpecker in forests of the northern Rocky Mountains. Pp. 283–299 *in* The role of insectivorous birds in forest ecosystems (J. G. Dickson, R. N. Conner, R. R. Fleet, J. A. Jackson, and J. C. Kroll, eds.). Academic Press, New York, New York.

MELLEN, T. K., E. C. MESLOW, AND R. W. MANNAN. 1992. Summertime home range and habitat use of pileated woodpeckers in western Oregon. J. Wildl. Manage. 56:96–103.

RENKEN, R. B. 1988. Habitat characteristics related to pileated woodpecker densities and territory size in Missouri. Ph.D. diss., Univ. Missouri, Columbia, Missouri.

——— AND E. P. WIGGERS. 1989. Forest characteristics related to Pileated Woodpecker territory size in Missouri. Condor 91:642–652.

REXSTAD, E. A., D. D. MILLER, C. H. FLATHER, E. M. ANDERSON, J. W. HUPP, AND D. R. ANDERSON. 1988. Questionable multivariate statistical inference in wildlife habitat and community studies. J. Wildl. Manage. 52:794–798.

SAS INSTITUTE. 1985. SAS user's guide: statistics, version 5 edition. SAS Institute, Cary, North Carolina.

SANDER, I. L. 1977. Manager's handbook for oaks in the north central states. U.S. For. Serv., Gen. Tech. Rep. NC-37.

THOMAS, J. W., R. G. ANDERSON, C. MASER, AND E. L. BULL. 1979. Snags. Pp. 60–77 *in* Wildlife habitats in managed forests; the Blue Mountains of Oregon and Washington (J. W. Thomas, ed.). Ag. Handbook No. 553, U.S. Dept. Ag., U.S. Forest Service, Portland, Oregon.

CORRECTION

The caption for the frontispiece of Vol. 104, No. 4, December 1992, was accidentally omitted. It should read:

Perched White-tailed Kite (above) and Black-shouldered Kite (below). Note that the White-tailed Kite has a relatively smaller head, a longer tail that exceeds tip of primaries, and holds wings above tail. Photos by W. S. Clark & B. K. Wheeler.