Habitat Associations of Birds and Mammals in an Appalachian Forest

William C. McComb, *Department of Forestry, University of Kentucky, Lexington, KY 40546*

Abstract: Relative abundance of small birds and mammals was determined on 18 0.4-ha plots in a mature, second-growth central Appalachian forest. Habitat heterogeneity had been increased by clearcutting and herbicide application on ridge-top, and south- and north-facing slopes 4 years prior to sampling. Areas with low basal area and high midstory cover provided the best habitat for white-footed mice (*Peromyscus leucopus*) and golden mice (*Ochrotomys nuttalli*). Areas with high basal area and low understory density provided the best habitat for ovenbirds (*Seiurus aurocapillus*) and red-eyed vireos (*Vireo olivaceus*). Areas with intermediate basal area and understory cover representative of stands following timber stand improvement (TSI) favored tufted titmice (*Parus bicolor*), hairy woodpeckers (*Picoides villosus*), and pine voles (*Microtus pinetorum*). Intermediate treatment and patch clearcutting should be restricted to upper slopes whenever possible to provide habitat for small mammals. Sites near water should be maintained as mature forests to provide habitat for ovenbirds and red-eyed vireos.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 39:420–429

Forest managers should consider habitat for nongame wildlife because insectivorous birds may contribute to control of some forest pests, and they may reduce the frequency of irruptions of insect pest populations (Dickson et al. 1979). Small mammals are prey for predatory reptiles, mammals, and birds, some are important seed eaters and seed dispersers, and some have been implicated in mycorrhizae dispersal (Rothwell and Holt 1978). Finally, 49% of adult citizens participate in some type of non-consumptive wildlife use, usually involving songbirds (U.S. Dep. Int., Fish and Wildl. Serv. 1982). Public relations would be enhanced if nongame were considered more seriously during forest management on private and public lands.

Many recent studies have quantified structural habitat characteristics important to common nongame birds and small mammals (James 1971, Anderson and Shugart 1974, Smith 1977, Dueser and Shugart 1978, Crawford et al. 1981, and others), but results have not been consistent among studies. For instance, James (1971), Crawford et al. (1981), and Conner et al. (1983) reported black-and-white warblers (*Mniotilta varia*) characteristic of closed-canopy, mature forest but Webb et al. (1977) found this species increased with increased logging activity.

Methodologies also differ. Smith (1977) found moisture to be an important variable in the distribution of birds in forested habitats, but James (1971), Dueser and Shugart (1978), and Crawford et al. (1981) did not include this variable in their studies of birds or small mammals. Anderson and Shugart (1974) reported small sampling plots (0.08 ha) are desirable when determining habitat associations of birds, yet plot sizes vary among studies from 0.04 ha (Noon 1981) to 2 ha (Crawford et al. 1981).

Following an investigation of the effects of herbicide application and clearcutting on wildlife habitat in the central Appalachians (McComb and Rumsey 1981), multivariate statistical analyses were applied to data on habitat and wildlife abundance collected from a range of habitat conditions. The objective was to identify habitat components important to common small birds and mammals on this site and then to provide recommendations to silviculturists for simultaneous management of timber and these nongame wildlife resources.

The author thanks J. B. Davis, G. M. Gigante, and the Robinson Forest staff for assistance in field work, Dow Chemical Co. for providing herbicides, and J. D. Gill, G. E. Jacoby, and P. J. Kalisz for reviewing an early draft of this manuscript. The information reported in this manuscript (85-8-70) is in connection with Kentucky Agricultural Experiment Station Projects No. 620 and 624 and is published with the approval of the director.

Methods

Snag Ridge Fork watershed, in the University of Kentucky's Robinson Forest, Knott and Breathitt counties, Kentucky, contains an approximately 60-year-old mixed-mesophytic forest typical of much of the central Appalachians (see McComb and Rumsey 1981).

Eighteen 0.4-ha square plots were established in the watershed. Four plots on each of a north-facing slope, south-facing slope, and ridge-top were randomly assigned 1 of the following hand-broadcast herbicide treatments applied in May 1976: 23 kg/ha TORDON 10K; 45 kg/ha TORDON 10K; 68 kg/ha TORDON 10K; or 90 kg/ha M-3864. TORDON 10K is a pelletized picloram-based (10% 4-amino-3,5,6-trichloropicolinic acid) herbicide and M-3864 is a 5% picloram pellet. (Mention of trade names is for identification and does not imply endorsement by the Kentucky Agricultural Experiment Station, Lexington.) A fifth plot on each aspect was clearcut with all stems cut but fallen trees not removed. A sixth plot on each aspect was established as an untreated control and located at least 75 m from any treated plot. Plots were located along the contour, and treated plots were 15 m to 50 m apart.

Habitat Sampling

Fifteen stations were established 4.2 m apart on a transect perpendicular to the contour through the center of each plot. Thirty environmental characteristics that have been identified as potentially important to songbirds or small mammals (Anderson and Shugart 1974, Dueser and Shugart 1978, Geier and Best 1980, Stauffer

Table 1. Habitat variables used in principal components analysis of bird and small mammal habitat associations, following univariate screening,[a] January to June 1980 and 1981, Knott County, Kentucky.

Characteristic	Use[b]
Diameter of nearest tree (cm).	WB, BB
Distance to nearest tree (m).	WB*, BB, SM*
Basal area of living stems (m^2/ha), wedge prism.	WB*, BB*, SM*
Diameter of nearest snag (cm).	WB, BB*
Distance to the nearest snag (m).	WB*, BB
Distance to the nearest log (m).	SM*
Percent of ground covered by logs within 2 m of a station.	SM*
Percent of ground covered by rocks within 2 m of a station.	SM
Percent crown cover above 6.1 m at a station (overstory).	WB, BB
Percent vegetation cover between 2 m and 6.1 m at a station (midstory).	WB, BB
Percent of the ground covered by fallen leaves within 2 m of a station.	BB, SM
Percent vegetation cover <2 m tall (understory) per 4-m^2 in January and in April.	WB, SM*
Number of understory stems per 4-m^2 in January and in April.	BB*, SM
Distance to water (m).	WB, BB*, SM*
Slope (%).	WB, SM*
Foliage height diversity.	WB, BB

[a]See McComb and Rumsey (1982), (1983*a*) for complete list used in univariate screening.
[b]WB = winter birds; BB = breeding birds; SM = small mammals.
*Used in discriminant function analysis.

and Best 1980, Crawford et al. 1981) were measured at each station in January and April 1980 (see McComb and Rumsey 1981). Following univariate analyses (McComb and Rumsey 1981, 1982, 1983*a*), 16 habitat variables were selected for multivariate analyses (Table 1). Mean habitat characteristics were calculated for each 0.4-ha plot and used to characterize each plot.

Bird Sampling

Birds were counted 15 times on each plot from 15 January to 5 March in 1980 and 1981 (winter birds), and 13 times on each plot from 20 March to 15 June in 1980 and 1981 (breeding birds). Approximately 10 minutes were spent at the center of each plot during each visit counting birds seen or heard on the plot. Only winter birds observed foraging on the plot and plot edge were assumed using a plot, while breeding birds that were either vocalizing, drumming, or foraging were tallied. Birds were counted within 3 hours of sunrise or sunset. Eight morning and 7 evening visits were made to each plot during winter, and 7 morning and 6 evening visits were made to each plot during the breeding season. Data for 1980 and 1981 were pooled for analysis.

Small Mammal Sampling

Two Museum Special snap-traps, baited with peanut butter, were set within 2 m of each of the 15 stations per plot for 1 night each month on each plot, January to

June 1980. Plots on each aspect were sampled simultaneously, and aspects were sampled on consecutive nights for a total of 180 trap-nights per plot.

Statistical Analysis

Of an initial 30 habitat characteristics measured, univariate analysis and multiple regression were used to screen for potentially important variables. Variables that were normally distributed and showed significant ($P < 0.05$) associations with animal densities were retained for multivariate analyses. Eleven variables were used for multivariate analysis of winter bird habitat associations, 11 for breeding bird habitat associations, and 10 for small mammal habitat associations.

Principal components analysis (PCA) was used to classify plots with similar characteristics potentially important to winter birds, breeding birds, and small mammals. Average numbers of birds observed per plot and average small mammal captures per plot were compared among PCA delineated groups. Linear correlation was used to detect association between bird or small mammal abundance and PCA scores. Analysis of variance was used to compare habitat characteristics and average total individuals observed or captured per plot among PCA groups.

Discriminant function analysis (DFA) was used to identify habitat associations of species groups. Because confidence ellipses on canonical class means are dependent on sample size (Van Horne and Ford 1982), class means were used to identify relative species positions on DFA habitat axes rather than to discriminate among species. A subsample of 3 winter bird habitat variables, 4 breeding bird habitat variables and 7 small mammal habitat variables were used in DFA based on the results of PCA. Variables potentially important to these 3 species groups and having a high degree of heterogeneity were used in DFA. Mean plot habitat values were weighted by the number of observations or captures of individuals on a plot. Linear correlation was used to identify the association between DFA scores and bird or small mammal abundance over plots. Statistical analyses were performed using the SAS82 statistical package (SAS Institute 1982).

Although previous investigators have used PCA and DFA with sample sizes as small as 5 to 9 observations (James 1971, Anderson and Shugart 1974, Smith 1977, Dueser and Shugart 1978), a minimum sample size of 14 occurrences on the 18 plots was chosen for this study. Though less than the 20 recommended by Johnson (1981), this author found habitat associations consistent with previous studies while using sample sizes as low as 18. DFA results were not validated by testing on an independent data set.

Results and Discussion

Winter Birds

Eleven habitat variables potentially important to winter birds were used to classify the 18 study plots into 3 groups along 3 PCA axes that accounted for 73.7% of the variability in the data set. The 3 groups were identifiable as: 1) plots with high

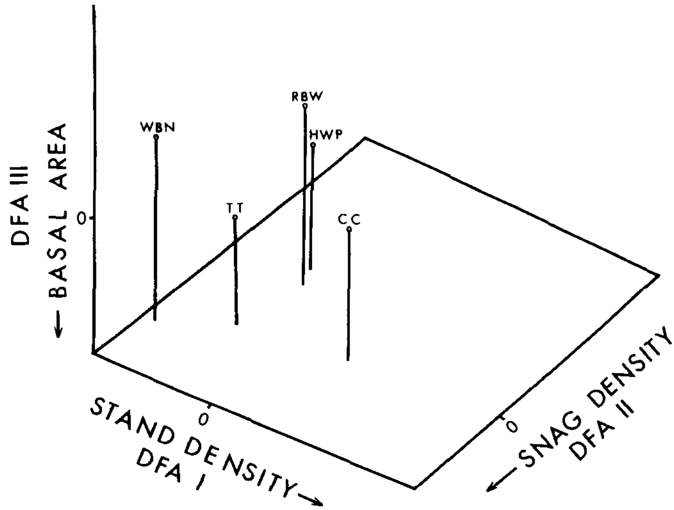

Figure 1. Discriminant function analysis of winter birds, Knott County, Kentucky, 1980. WBN = white-breasted nuthatch, RBW = red-bellied woodpecker, CC = Carolina chickadee, HWP = hairy woodpecker, TT = tufted titmouse.

basal area ($\bar{x}$ = 23.9 m^2/ha), high midstory cover ($\bar{x}$ = 39.8%) and few snags ($\bar{x}$ = 32.7 m to a snag) (mature forest); 2) plots with low basal area ($\bar{x}$ = 9.3 m^2/ha), high midstory cover ($\bar{x}$ = 40.9%) and few snags ($\bar{x}$ = 94.8 m to a snag) (clearcut); and 3) plots with intermediate basal area ($\bar{x}$ = 18.9 m^2/ha), low midstory cover ($\bar{x}$ = 20.2%), and many snags ($\bar{x}$ = 16.5 m to a snag) (partial disturbance).

No differences ($P > 0.05$) were found among the 3 groups in number of winter birds observed. A 5-group DFA was used to identify habitat variables that, in combination, were important to these species. Discriminant function analysis axes were correlated with distance to a tree (R = +0.93; DFA I), distance to a snag (R = +0.65; DFA II) and basal area (R = +0.72; DFA III) (Fig. 1). Since distance among objects is inversely related to density, axes I and II were interpreted as tree density and snag density, respectively. Correlation of DFA scores with the habitat values for each species provided insight into identification of the habitat variables important to each species (Conner et al. 1983). Winter habitat of red-bellied (*Melanerpes carolinus*) and hairy woodpeckers was similar within the range of habitat characteristics measured in this study. Discriminant function analysis scores for both species were associated with high midstory cover and low overstory density stands (R >0.74). Red-bellied woodpeckers used plots with slightly lower basal area than hairy woodpeckers. White-breasted nuthatches (*Sitta carolinensis*), another bark forager, selected stands with high snag abundance (R = 0.98). Sites selected by Carolina chickadees (*Parus carolinensis*) and tufted titmice had higher basal area than those used by woodpeckers and higher stand density than those selected by white-breasted nuthatches. Basal area or stand density was important to all 5 species ($R > 0.72$). Abundance of all species was skewed toward mid-basal area, mid-stand density, and high snag density. Silvicultural practices such as TSI that would entail killing some trees and creating snags and that would reduce basal area and stand density would probably favor these 5 bird species during the winter in central Appalachian hardwood stands similar to those at Robinson Forest.

Breeding Birds

Eleven habitat variables potentially important to breeding birds were used to classify the 18 study plots into 3 groups similar to those classified for winter birds. Mean group characteristics were similar to those described for winter bird habitat ordination. No differences ($P > 0.05$) in breeding bird observations were found among the 3 groups. Hairy woodpecker abundance was correlated ($R = +0.45$) with PCA II and PCA III indicating an association with plots having high understory density on dry sites with large diameter snags. Ovenbird abundance was correlated ($R = -0.50$) with PCA I scores indicating the importance of mature forest to ovenbirds.

An 8-group DFA separated breeding species along axes associated with basal area ($R = +0.70$; DFA I), snag dbh ($R = +0.70$; DFA II) and distance to water ($R = -0.40$; DFA III) (Fig. 2). Ovenbirds were separated from other species on the basis of high basal area and nearness to water. Red-eyed vireos were also associated

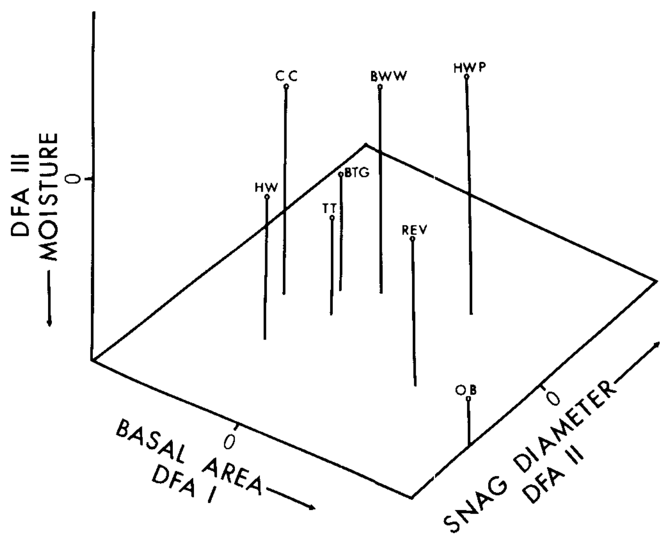

Figure 2. Discriminant function analysis of breeding birds, Knott County, Kentucky, 1980. CC = Carolina chickadee, HWP = hairy woodpecker, TT = tufted titmouse, BWW = black-and-white warbler, HW = hooded warbler, BTG = black-throated-green warbler, REV = red-eyed vireo, OB = ovenbird.

with mature stands, but they were not as exacting in proximity to water as ovenbirds. Hairy woodpeckers were associated with plots having high understory density and large diameter snags on dry sites, similar to the habitat that they used during the winter. Black-and-white warblers were associated with high snag abundance, large snag dbh, and high understory and leaf cover.

Black-throated-green warblers (*Dendroica virens*), tufted titmice and ovenbirds were associated with sites near water (Fig. 2), but ovenbirds selected stands with higher basal area than the former 2 species. Tufted titmouse and Carolina chickadee DFA scores were associated with snag dbh and/or density. Hooded warbler (*Wilsonia citrina*) DFA scores were associated with nearness to water and high basal area, but the position of hooded warblers on the DFA I axis relative to the other species is low. Hooded warblers are a species associated with canopy gaps and are usually found in openings in mature forests (James 1971). Hooded warblers may benefit from 0.4-ha patches of young forest in a mature forest, whereas ovenbirds and red-eyed vireos may not benefit from such a practice.

Small Mammals

Ten habitat variables potentially important to small mammals classified sample plots into 3 groups similar to the 3 identified for winter birds. The first PCA axis represented change in overstory structure similar to that accomplished by silvicultural treatments. Small mammal habitat in mature forest was characterized by having low log abundance, high leaf cover, and high basal area. Partially disturbed sites had high basal area and intermediate log and leaf cover, while clearcuts had high log cover, low leaf cover, and low basal area. More white-footed mice and golden mice were captured on clearcuts than on partially disturbed forest or mature forest ($P < 0.05$). White-footed mouse, golden mouse, and smoky shrew (*Sorex*

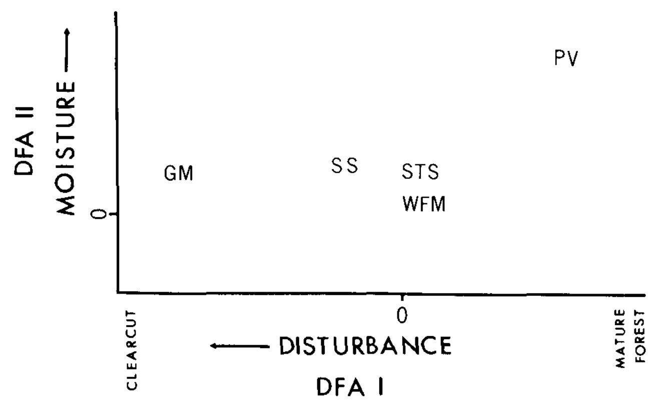

Figure 3. Discriminant function analysis of small mammals, Knott County, Kentucky, 1980. GM = golden mouse, WFM = white-footed mouse, STS = short-tailed shrew, SS = smoky shrew, PV = pine vole.

fumeus) captures were associated ($R > 0.49$) with PCA I, indicating a skew toward disturbance.

A 5-group DFA separated the species along overstory disturbance and moisture gradients. Since there were no significant correlations of habitat variables with DFA III scores, only 2 axes are presented (Fig. 3). Golden mice were skewed toward clearcut situations while pine voles were skewed toward partially disturbed to mature forest sites near water. Smoky shrews, short-tailed shrews (*Blarina brevicauda*), and white-footed mice were intermediate along both axes. Discriminant function analysis scores for short-tailed shrews and white-footed mice were correlated with log cover ($R = +0.97$), basal area ($R > +0.77$), and distance to a tree ($R = -0.92$). Discriminant function analysis scores for smoky shrews were also associated with basal area ($R = +0.80$), distance to a tree ($R = -0.93$), and distance to water ($R = -0.73$).

Management Implications

The degree of forest disturbance as measured by basal area or tree dispersion was an overriding factor determining the relative abundance of nongame species in this central Appalachian forested watershed. Silvicultural activities such as timber stand improvement (TSI), thinning, patch clear-cutting, or single-tree selection cutting can be expected to alter the bird and small mammal communities occupying a stand. For instance, light TSI, thinning, or single-tree selection cutting to a basal area below 24 m^2/ha may adversely effect ovenbirds. Disturbance to mid-basal area levels (about 19 m^2/ha) may adversely affect pine voles and red-eyed vireos in addition to ovenbirds, but most species would probably be unaffected (Table 2). At low basal area (<9 m^2/ha), or following patch clearcutting, most bird species studied would be adversely affected for up to 4 years. A clear cut on a dry site would have less adverse impact on ovenbirds and black-throated-green warblers than would one near water, but clearcutting on south-facing slopes and ridge-tops would adversely affect habitat for cavity-using species in the central Appalachians (McComb and Muller 1983), especially during the winter. Gill et al. (1974) indicated that management for nongame birds should be concentrated on moist sites. The results of this study and those of Smith (1977) indicate that some bird species may be adversely affected by forest disturbance on moist sites; forest disturbance should not occur on sites near water.

The following are recommendations for simultaneous management of central Appalachian forests similar to those at Robinson Forest for timber and the nongame species observed in this study:

1. Cuts or intermediate treatments of 0.4-ha on dry sites (ridge-tops and upper slopes) would be more desirable to the species studied than disturbance on sites near water.

2. Retain snags and den trees for cavity-nesting wildlife and for bark-foraging species, and create additional snags by girdling or injection during TSI (McComb

Table 2. Expected occurrence and relative abundance of some nongame species following forest disturbance in central Appalachian hardwoods similar to Robinson Forest, Knott County, Kentucky.

	Disturbance					
	Mature (~ 24 m^2/ha BA)[a]		TSI (~ 19 m^2/ha BA)		Patch clearcut (0.4 ha) (~ 9 m^2/ha BA)	
Species	Moist	Dry	Moist	Dry	Moist	Dry
Hairy woodpecker	*	**	*	**		
Red-bellied woodpecker	*	**	*	**		
White-breasted nuthatch	**	**	**	**		
Carolina chickadee	**	**	**	**	*	*
Tufted titmouse	**	*	**	*		
Hooded warbler	*	*	**	**		
Black-throated-green warbler	**	*	**	*		
Black-and-white warbler	**	**	**	**		
Red-eyed vireo	**	**	*	*		
Ovenbird	**	*	*			
Golden mouse					*	*
White-footed mouse	*	*	**	**	**	**
Pine vole	*		**		*	
Short-tailed shrew	*	*	**	**	**	**
Smoky shrew	*	*	**	*	**	*

[a]BA = basal area at breast height.
*Species will likely occur.
**Species will likely be common.

and Rumsey 1983*b*). As snags age and fall, they become logs and provide cover for small mammals.

3. Retain slash for small mammal cover following cutting; do not burn or remove slash.

Literature Cited

Anderson, S. H. and H. H. Shugart, Jr. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecology 55:828–837.

Conner, R. N., J. G. Dickson, B. A. Locke, and C. A. Segelquist. 1983. Vegetation characteristics important to common songbirds in East Texas. Wilson Bul. 95:349–361.

Crawford, H. S., R. G. Hooper, and R. W. Titterington. 1981. Songbird response to silvicultural practices in central Appalachian hardwoods. J. Wildl. Manage. 45:680–692.

Dickson, J. G., R. N. Conner, R. R. Fleet, J. A. Jackson, and J. C. Kroll, eds. 1979. The role of insectivorous birds in forest ecosystems. Academic Press, New York. 381pp.

Dueser, R. D. and H. H. Shugart, Jr. 1978. Microhabitats in a forest-floor small mammal fauna. Ecology 59:89–98.

Geier, A. R. and L. B. Best. 1980. Habitat selection by small mammals of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 4:16–24.

Gill, J. D., R. M. DeGraaf, and J. W. Thomas. 1974. Forest habitat management for nongame birds in central Appalachia. U.S. Dep. Agric., For. Serv. Res. Note NE-192. 6pp.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bul. 83:215–236.

Johnson, D. H. 1981. How to measure habitat—a statistical perspective. Pages 53–58 *in* D. E. Capen, ed. The use of multivariate statistics in studies of wildlife habitat. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-87.

McComb, W. C. and R. N. Muller. 1983. Snag densities in old-growth and second-growth Appalachian forests. J. Wildl. Manage. 47:376–382.

——— and R. L. Rumsey. 1981. Habitat characteristics of forest clearings created by picloram herbicides and clearcutting. Proc. Ann. Conf. Southeast. Assoc. Fish and Wildl. Agencies 35:174–184.

——— and ———. 1982. Response of small mammals to forest clearings created by herbicides in the central Appalachians. Brimleyana 8:121–134.

——— and ———. 1983*a*. Bird density and habitat use in forest openings created by herbicides and clearcutting in the central Appalachians. Brimleyana 9:83–95.

——— and ———. 1983*b*. Characteristics and cavity-nesting bird use of picloram-created snags in the central Appalachians. South. J. Appl. For. 7:34–37.

Noon, B. R. 1981. Techniques for sampling avian habitats. Pages 42–52 *in* D. E. Capen, ed. The use of multivariate statistics in studies of wildlife habitat. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-87.

Rothwell, F. M. and C. Holt. 1978. Vesicular-arbuscular mycorrhizae established with *Glomus fasciculatus* spores isolated from the feces of cricetine mice. U.S. Dep. Agric., For. Serv. Res. Note NE-259. 4pp.

SAS Institute Inc. 1982. SAS User's Guide: Statistics, 1982 edition. SAS Institute Inc., Cary, N.C. 584pp.

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecology 58:810–819.

Stauffer, D. F., and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. J. Wildl. Manage. 44:1–15.

U.S. Department of the Interior, Fish and Wildlife Service. 1982. 1980 National Survey of Fishing, Hunting, and Wildlife-associated Recreation. U.S. Dep. Int., Washington, D.C. 156pp.

Van Horne, B. and R. G. Ford. 1982. Niche breadth calculation based on discriminant analysis. Ecology 63:1172–1174.

Webb, W. L., D. F. Behrend, and B. Saisorn. 1977. Effect of logging on songbird populations in a northern hardwood forest. Wildl. Monogr. 55. 34pp.