BREEDING BIRD COMMUNITIES AND HABITAT SELECTION IN THE APPALACHIAN MOUNTAINS OF SOUTHWEST VIRGINIA

by

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INTRODUCTION

The active pursuit of nonconsumptive uses of wildlife has increased greatly in recent years. On national forest lands, in 1971, Schneegas (1975) reported approximately 18 million visitor-days of use by nature observers and wildlife photographers, in comparison to 13 million by big and small game hunters in 1972. A 1972 survey of southeastern U.S. households placed nonconsumptive values of fish and wildlife at $12.3 billion, as compared to $11.8 billion for hunting and fishing values (Zagata 1978).

Activity centered around nongame birds comprises one of the major components of nonconsumptive use of wildlife. Birds are found in nearly all habitats, providing an opportunity to observe wildlife in cities and suburbs as well as on farms, along beaches and in deep forests. In addition, they are one of the most observable forms of wildlife, especially during the breeding season, when males of songbird species loudly proclaim their presence. Payne and DeGraaf (1975) estimated that total direct expenditures in 1974 related to the nonconsumptive use of nongame birds in the United States was approximately $500 million. Photographic equipment and services, birdseed and binoculars comprised 95 percent of this total. Birds, then, contribute much to the nonconsumptive enjoyment of wildlife.

Increased public use of, and concern for, all wildlife species have created pressure for wildlife managers to include nongame as well as game species in management programs (Zagata 1978, Talbot 1975). This public pressure has encouraged implementation of multiple-use management strategies. Schneegas (1975:314) stated that "The key to planning the management for all species of wildlife is to know the species habitat requirements and provide a variety of habitat components in a desirable combination that will meet the needs of as many species as possible." At present, however, the data necessary to make sound management decisions for most wildlife species do not exist (Zagata 1978).

Nongame bird species are included in the wildlife group for which adequate management information is lacking. Much of the basic information needed for developing sound management programs and incorporating avian habitat assessments into forest inventories involves quantification of the relationship between avian species and communities and their habitat (see Lennartz and Bjugstad 1975, Curtis 1978). This information need can be approached on 2 levels of avifauna/habitat association.

Knowledge of the bird species associated with major seral and climax stages of vegetation is necessary before basic assessments of the impacts of particular management systems and changing land-use patterns on the avian resource can be made (Lennartz and Bjugstad 1975, Curtis 1978, Zeedyk and Evans 1975). A number of studies providing this type of information have been conducted. Among them are Stewart and Aldrich's (1952) study of breeding birds in a number of community types and seral stages in Maine, Kendeigh's (1946, 1948) studies of breeding birds in the Northeast and Michigan and Odum's (1950) study of breeding birds in several seral stages of the hemlock and oak-chestnut communities in the North Carolina Highlands. Beals (1960) studied breeding birds in 6 forest types on the Apostle Islands of Wisconsin. Johnston and Odum (1956) studied breeding birds associated with seral and climax stages in the Georgia Piedmont. Kricher (1973) in the New Jersey Piedmont and Shugart and James (1973) in Arkansas also studied breeding birds in relation to forest succession. In addition, Bond (1957) associated breeding bird species with stages of forest development in his study of populations in relation to a vegetative continuum in Wisconsin.

Beyond these basic avifauna/habitat type associations, a need in the development of a sound nongame bird management system is to gain greater insight into, and quantification of, specific components influencing habitat selection of avian species and resource division among them (Lennartz and Bjugstad 1975, Shugart et al. 1978, Verner 1975, Curtis 1978, Balda 1975). Through a more complete knowledge of the specific habitat components involved, we will be better equipped to predict and actively control impacts of habitat manipulations on nongame birds. One methodology which shows promise for quantifying these relationships, and which has been used in a number of recent studies, involves multivariate statistical analyses.

Sturman (1968) used multiple regression analysis to identify combinations of habitat components important in determining the abundance of 2 breeding species of chickadees in Washington. The same technique was used by Thomas et al. (1977) in Massachusetts for predicting abundance of breeding birds in residential areas. Shugart and Patten (1972) dealing with wintering birds in Georgia and Anderson and Shugart (1974) with breeding birds in Tennessee, used multiple discriminant function analysis to identify habitat components important in distinguishing plots where a species was absent, present, or abundant. Conner and Adkisson (1976) distinguished between nesting and non-nesting sites of 4 woodpecker species in Virginia, using this statistical technique. Klebenow (1969) also used multiple discriminant function analysis in an attempt to identify combinations of habitat components which would distinguish nesting versus non-nesting and brood use versus non-brood use sites of sage grouse in Idaho. The same type of analysis was used to identify combinations of variables which distinguished suitable and unsuitable territory sites for blue grouse in Montana (Martinka 1972) and nesting versus non-nesting sites of Canada geese in Michigan (Kaminski 1977).

In addition to the above studies, which dealt with habitat associations of individual species, a number of studies have employed multiple discriminant function and principle components analyses on a multi-species level. Such studies identify habitat gradients which maximize the distance, or explain the most variation, between the mean habitat vectors of the species included. James (1971) studied the habitat relationships among breeding birds in Arkansas. Whitmore (1975, 1977) did the same in the Virgin River Valley (Utah, Arizona, Nevada). Cody (1968) included analysis of interspecific differences in habitat in his study of resource division among grassland birds. Habitat relationships of territorial flycatchers were studied by Hespenheide (1971) in the Eastern Deciduous Forest, of nesting woodpeckers by Conner and Adkisson (1977) in Virginia and of 2 territorial thrush species by Bertin (1977) in Connecticut.

The present study was directed toward obtaining information necessary for the management of nongame birds, specifically in the southern Appalachians. This mountain region generally supports the greatest richness of nongame bird species in the South, due to altitude and the extension southward of the ranges of several species with northern affinities (Shugart et al. 1978). In addition, the mountain forests of the southern Appalachians (and the Ozarks) are less economically important than other Southern forests and are used heavily for outdoor recreation. Thus, incentives and political pressures for management of nongame birds may be greater in this region than surrounding areas (Shugart et al. 1978) and data necessary for sound management are needed.

This study was the first in a long-term project which will evaluate the effects of whole-tree harvesting by cable logging methods on breeding bird populations in the Appalachian mountains of southwestern Virginia. Both the indirect effects, as exhibited by the bird population of the adjacent uncut forest, and the direct effects of the logging operation will be studied. In light of the research needs discussed above, the objectives of this preliminary study were: 1) To provide baseline information on the breeding population of the area in relation to natural yearly fluctuations and use of the major habitat types present, prior to logging and 2) to identify combinations of habitat components which can be used to predict potential presence or absence and relative density of singing males of the more frequently observed species, through the use of multivariate statistical techniques.

METHODS AND MATERIALS

General Study Area

This study was conducted in the Appalachian Mountain region of southwestern Virginia, which is characterized by mountain ridges running in parallel series in a northeast-southwesterly direction (Epperson et al. 1958). These ridges are made up of sandstone, or sandstone and shale, and most of the soils belong to the Muskingum or Montevallo series and are of low fertility (Epperson et al. 1958). The study area was found within the Appalachian oak forest of Kuchler (1964) and the Ridge and Valley section of the Oak-Chestnut Forest region of Braun (1950).

Field data were collected from a portion of the southeast slope of Potts Mountain, in the New Castle Ranger District of the Jefferson National Forest, Craig County, Virginia (Fig. 1). The study area was located approximately 11 kilometers northwest of the town of New Castle, near Route 311. It was bounded on the lower edge by Forest Service road 604.1 and on the upper edge by a 5.3 kilometer temporary logging road which extended the length of the study area. Elevation of the area, which stretched across the midslope of Potts Mountain, ranged from 640 to 792 meters.

The area was composed of a second growth, even-aged forest, approximately 65 years old. Four distinct types of forest vegetation (hereafter referred to as habitat types) typical of this region of the Appalachian Mountains, have been recognized within the study area (Smith and Sharik 1977). From mesic to the most xeric sites, these include: 1) Cove hardwoods with little or no ericaceous understory,

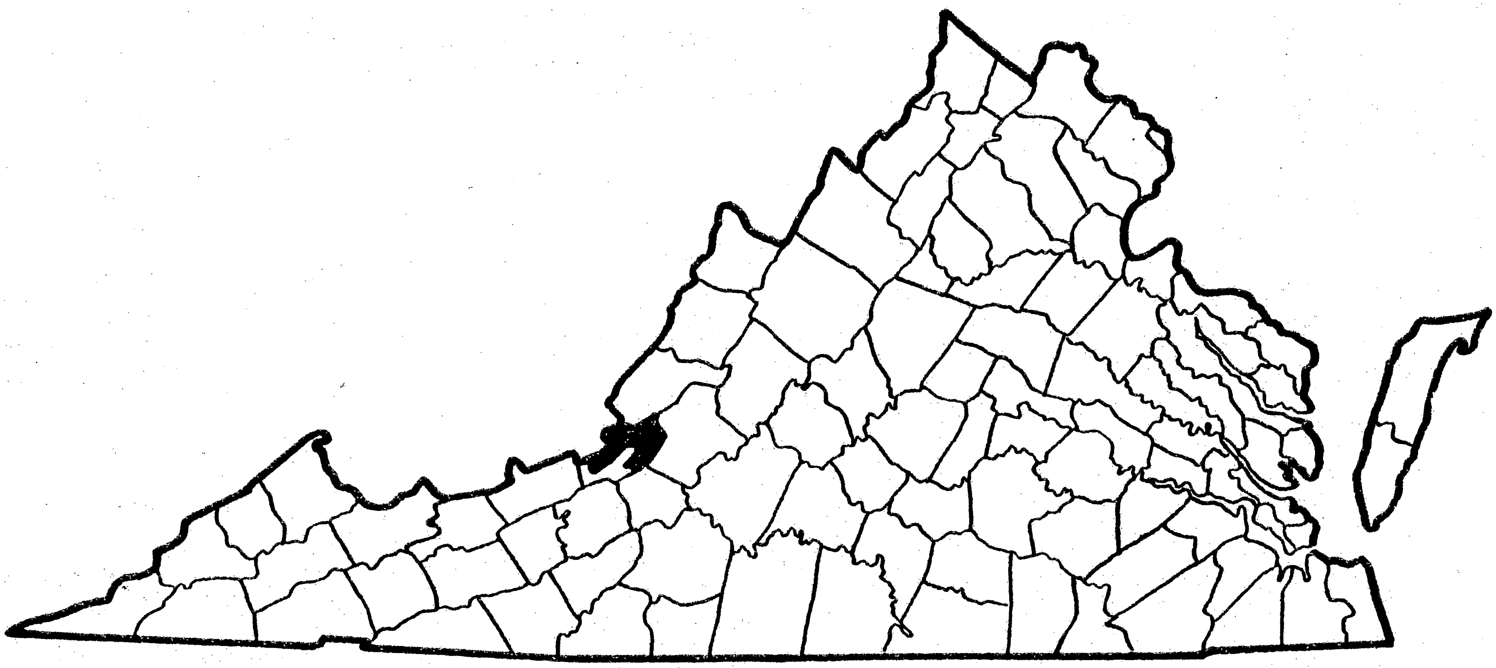

Fig. 1. Location of the New Castle Ranger District, Jefferson National Forest, within Craig County, Virginia.

2) mixed oak with light to moderate ericaceous understory, 3) mixed oak-pine with moderate to heavy ericaceous understory and 4) mixed pine with heavy ericaceous understory. The mixed pine type was the least common on the study area, located only in small patches on upper slopes.

Located within the study area were 4 noncontiguous compartments, ranging in size from 7.5 to 17.3 hectares (Fig. 2). Timber harvesting (clearcutting) of these compartments, using the cable logging method with whole-tree removal, began in the summer of 1978, after this study was completed. Prior to logging, these compartments were comprised mainly of the mixed oak and mixed oak-pine habitat types. The most extensive of the habitat types adjacent to these compartments was mixed oak-pine. Coves and their associated cove hardwood habitat type were narrow (approximately 40 to 125 meters) but were found frequently along the mountainside.

The mixed oak-pine and cove hardwood habitat types were selected for study. The dry mixed oak-pine type was chosen due to its extensive acreage. The cove hardwood type was selected because of its mesic properties, which results in a "disproportionately high amount of tree biomass and productivity" (Smith and Sharik 1977:6). These cove sites probably comprise an important habitat type for the wildlife of the area.

Description of Vegetation

The following descriptions of the vegetative composition of these 2 habitat types was taken from Lochmiller (1977). The data were obtained from the study area transects (see section Transects).

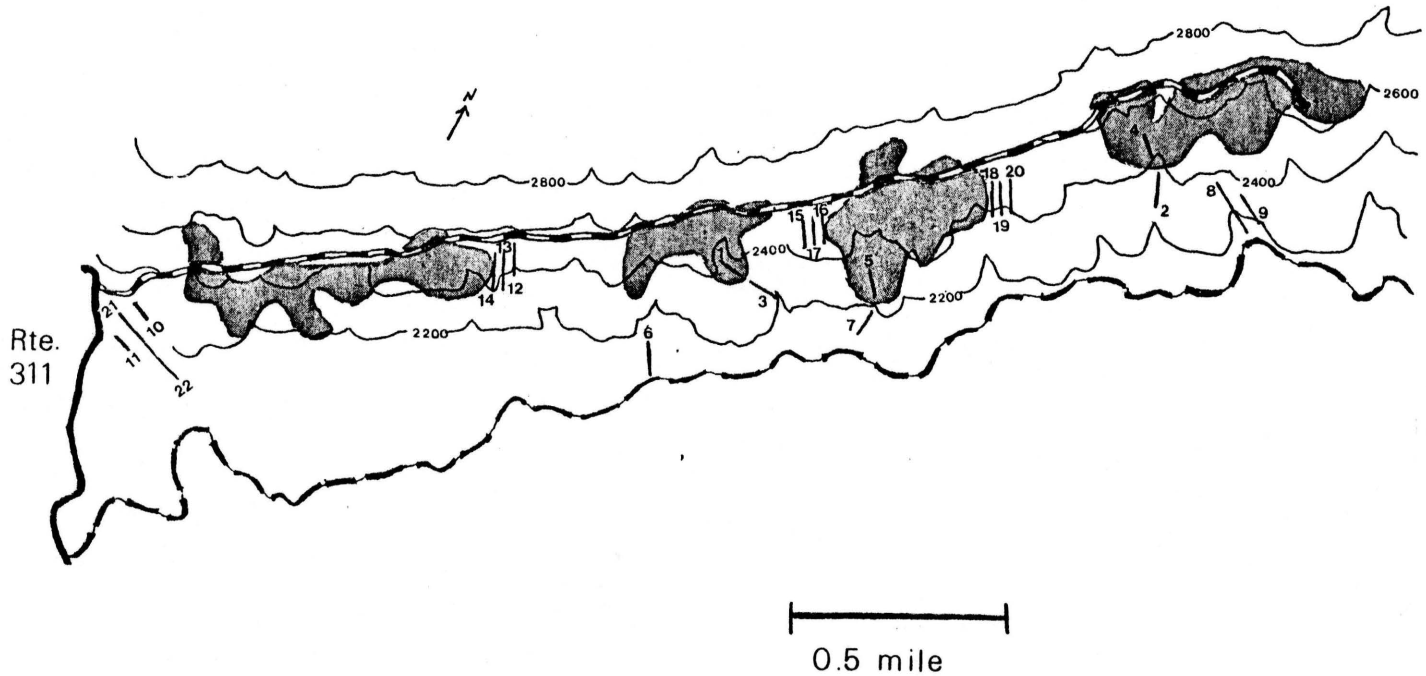

Fig. 2. General location of transect lines in relation to timber harvest compartments.

Mixed Oak-Pine

This vegetative community, found on dry slopes, was characterized by moderate canopy closure ($\bar{x}$ = 70 percent) and dense ericaceous understory. The important tree overstory species were chestnut oak, *Quercus prinus* (47 percent of the total basal area), scarlet oak, *Quercus coccinea* (22 percent) and pitch pine, *Pinus rigida* (22 percent). The total overstory basal area was 19.9 meters^2/hectare.

The understory was dominated by blackgum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*) and mountain laurel (*Kalmia latifolia*), which accounted for 30.6, 19.3, and 14.0 percent of the total understory basal area, respectively. Average understory cover was 25 percent. The herb layer (vegetation $<$ 1 meter in height) was moderate to heavy with blueberry (*Vaccinium vacillans*) and huckleberry (*Gaylussacia baccata*) being dominant. Sassafras, mountain laurel and pinxter-flower (*Rhododendron nudiflorum*) comprised much of this ground vegetation. Average cover for the herb layer was estimated at 43 percent.

Cove Hardwood

This habitat type was found on the most mesic sites in the study area and often had an intermittent stream running through it. It was characterized by a dense canopy cover ($\bar{x}$ = 85 percent) with little understory or herb cover. The most important overstory tree species were chestnut oak, red maple (*Acer rubrum*), black oak (*Quercus velutina*), sourwood (*Oxydendrum arboreum*) and mockernut hickory (*Carya tomentosa*), respectively. The oaks in general constituted 56 percent of the total basal area and dominated the overstory with chestnut oak being the most important, followed by black, northern red (*Quercus rubra*), scarlet and white (*Quercus alba*). Red maple accounted for 10 percent and the hickories, 7 percent, of the total basal area, which was 24.6 meters^2/hectare. The hickories, mockernut and pignut (*Carya glabra*), occured as important codominants along with sourwood, red maple and blackgum.

The understory was dominated by flowering dogwood (*Cornus florida*), constituting 16 percent of the understory basal area. Following dogwood in importance were blackgum, witch hazel (*Hamamelis virginiana*), summer grape (*Vitis aestivalis*) and red maple. Average understory cover was 11 percent. The herb layer, also dominated by dogwood, was relatively sparse. Sassafras, blueberry, greenbrier (*Smilax spp*.) and ferns also comprised much of this ground vegetation. Average cover for the herb layer was estimated at 14 percent.

Transects

In early May of 1977, 22 transects were established on the study area. Thirteen were located in the mixed oak-pine habitat type and 9 in the cove hardwood type. Eighteen of these transects were 50 meters wide and 100 meters long. The remaining 4 varied in length. The general position of these transects on the study area is shown in Figure 2. Transects 1 through 9 were located in cove hardwood habitat and 10 through 22 were in mixed oak-pine habitat.

Each transect was measured with a 100-foot tape and bearings were determined with a hand-held Silva compass. The center line of the transect area was marked with a labelled wooden stake every 25 meters and orange flagging was applied liberally along the entire length of the line. Twenty-five meters to either side of this center line, parallel lines of equal length (representing the boundaries of the transect area) were established, designated by abundant yellow flagging. This transect width would ensure the observer's hearing even the most soft-voiced singing species present within the 0.5 hectare area. Similar widths have been used by bird censusers in Finland (see Jarvinen and Vaisanen 1975). Hooper (1967) found the effective transect width in a nearby area of Virginia to be about 61 meters (200 feet).

The transects used in this study were established to meet the long-term objective of quantifying the effects of whole-tree removal by cable logging on the breeding bird populations of the cut and adjacent forested areas. Initially, it was considered desirable to locate the transects in the same number and manner (with relation to slope and clearcut boundaries) for both habitat types chosen for study. Due to the restricted size of the coves and the general location of the habitat types in relation to the compartment boundaries, modification of this plan was necessary. Therefore, the mixed oak-pine and cove hardwood transects are described separately.

Mixed Oak-Pine

Due to the lack of large homogeneous stands of this type within the compartments, transects were established adjacent to the boundaries only. It is desirable to moniter the area for at least 100 meters perpendicular to the boundary; therefore, 3 plots of 3 contiguous transects each were established. The area encompassed by each transect was 0.5 hectare, totalling 1.5 hectares for an entire plot. A control plot of equal area also was established (Fig. 2). However, individual transects in the control plot were of different lengths, due to the configuration of the habitat type. For the purposes of this study data were collected and analyzed on a transect basis. Census results can be validly compared only between areas of equal size, as size affects relative density estimates and the number of species encountered (Odum 1950). Therefore, transects 10 and 11 were excluded from the analyses. All plots were of similar relative distance to the logging road (i.e., typical edge or brush species encountered in one plot were found in all other plots).

Cove Hardwood

The coves on the study area were narrow in the upper and middle sections, with a few widening towards the lower boundary of the study area. Three of the coves located on the area were wide enough in the vicinity of the associated compartment to support the width of one transect. Therefore, 3 noncontiguous 0.5 hectare transect areas were established adjacent to the clearcut boundaries, with their length running perpendicularly away from it. Also, due to the extension of the coves through the compartments, 3 transects of equal area were established within the boundaries, enabling monitoring of the direct effects of the harvest on the avifauna of this habitat type. Three control transects, totalling 1.5 hectares, were established along Forest Service road 604.1 (Fig. 2). Transects 8 and 9 were 125 meters and 75 meters long, respectively. Therefore, for the purposes of this study, information obtained from transect 9 and the upper 25 meters of transect 8 was excluded from the analyses. No edge or brush species were recorded on the cove hardwood transects.

Avifaunal Surveys

Breeding season bird surveys, based primarily on encounters with singing males, were conducted along the transect lines from June 1 to July 7 of 1977 and May 27 to July 7 of 1978. Birds were surveyed by walking the center line of the transect. Twenty minutes were spent on each 100 meter line, with 5-minute stops at each of 4 stations located at equal distances along the length of the line. All birds seen or heard within the boundaries of the transect area were plotted on a transect map by species codes, sex (when possible) and activity (i.e., singing, calling, etc.). Care was taken to follow the movements of individual birds to avoid counting one bird twice. Observed nest locations were also plotted. In addition, general weather conditions and starting and stopping time of the transect survey were recorded.

The transects were divided into 4 groups and 1 group was sampled per survey day. The groups were picked on the basis of proximity of the transects, thereby minimizing travel time between areas to be surveyed each day. For each complete replication of all transects, the groups were randomized as to order of surveying. In addition, the survey order of transects within each group, as well as the starting end for each transect, was randomized wherever possible, within limitations of time and without causing unnecessary disturbance to the birds. Such randomization tended to eliminate biases in the survey results of individual transects due to variations in singing intensity of male songbirds with time of day.

Surveys were conducted between sunrise and 9:00 a.m. eastern daylight time. Initially, evening surveys were conducted also; however, these were discontinued due to low singing activity and no data obtained were included in the analyses. To stabilize survey conditions as much as possible, and thereby reduce variations in bird activity or survey efficiency due to uncontrollable weather factors, surveys were postponed if precipitation occurred during or shortly before survey hours, or if strong winds prevailed.

Relative Density of Avifauna

Relative density of singing (territorial) males for both individual species and total populations was based on an adaptation of Linsdale's (1928) frequency of occurrence. The relative density of a species for a given transect and year was simply the total number of observations of singing males of that species, divided by the number of times the transect was surveyed. The relative population density for that transect and year was the sum of the individual species relative densities. Hooper (1967:41) has expressed the logic of applying this approach to surveys conducted along narrow transects during the breeding season, where the territorial mapping method is not applicable. He stated that the method is "based on the premise that a given bird had a greater chance of being recorded the greater the proportion of its utilized territory the transect included." Therefore, relative density of a transect is an index of the number of territories contained within its boundaries.

Quantification of the Environment

Techniques

Intensive sampling and quantitative measurement of both vegetative and non-botanical components of the environment was conducted within each transect area during June and July of 1977. The intent was to describe, as completely as possible, the structure of each transect area as a whole. The following description of the vegetative sampling methods used was taken from Lochmiller (1977).

Sample points were established systematically within each transect area--12 points per 0.5 hectare (Fig. 3). Each of these points served as the center-point for sampling of the tree stratum. The point-center-quarter method (Cottam and Curtis 1956) was employed and the compass bearings used were those of the transect's boundaries. Included in the tree stratum were individuals of the overstory which were $\geq$ 10 centimeters dbh. In addition, canopy heights were recorded for 3 dominant trees at each sample point.

Around each sample point, within each of the quadrats created by the point-center-quarter technique, a nested circular plot was established. The larger of the two plots was 16 meters^2 and was used to sample the understory stratum, which consisted of individuals 1-5 meters in height. The smaller 1 meter^2 plot was used to sample the herb-ground stratum, which included individuals < 1 meter in height. This nested plot design enabled sampling of 15 and 1 percent of the understory and herb-ground strata on the transects, respectively.

Vegetative and non-botanical components measured and the instrumentation used for each are described in Table 1.

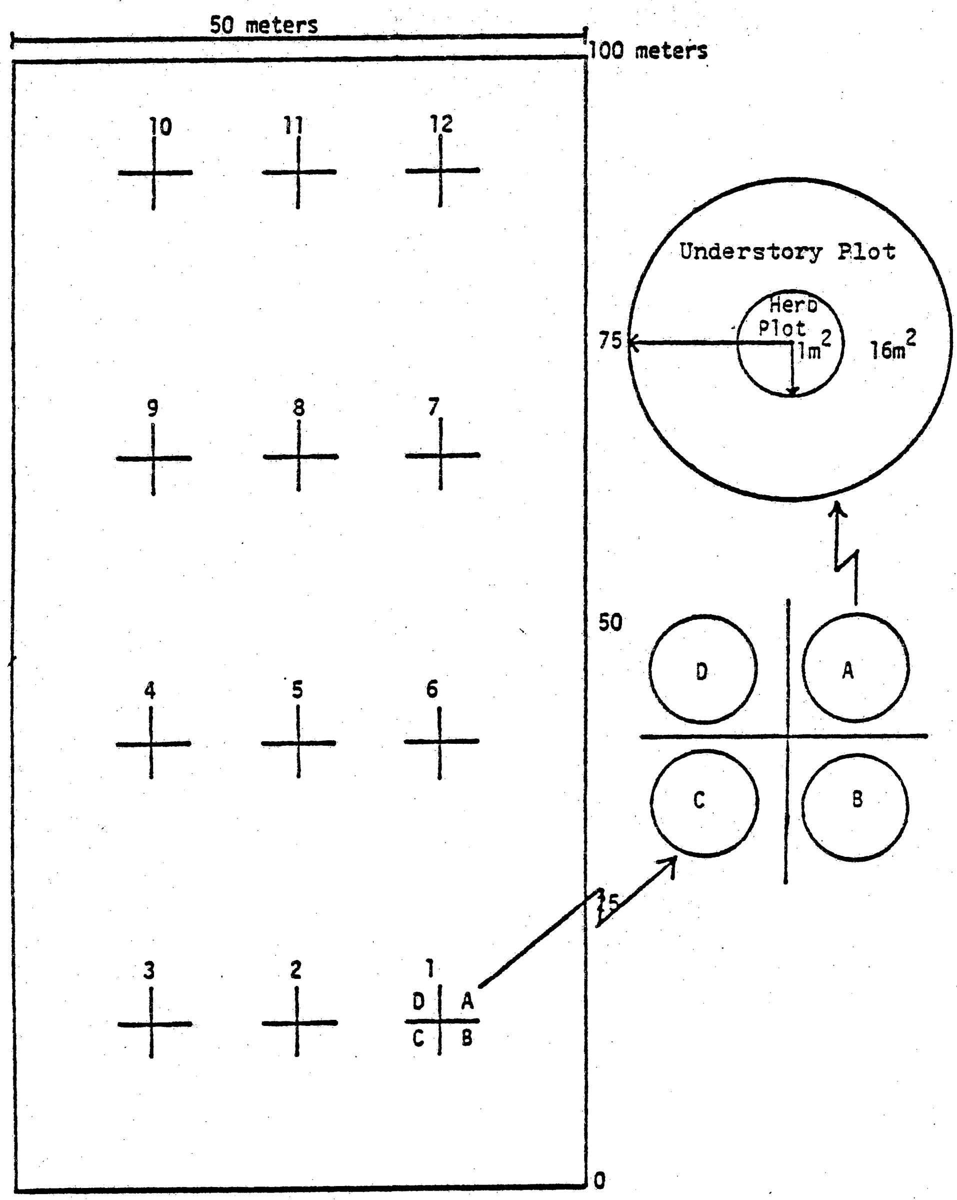

Fig. 3. Systematic sampling design used on each transect for collection of habitat data (adapted from Lochmiller 1977).

Table 1. Habitat components measured, and the instrumentation used, along 19 transects located in two habitat types on Potts Mountain, Craig County, Virginia.

Component	Stratum: Tree (T)	Stratum: Understory (U)	Stratum: Herb-ground (HG)	Instrumentation
Percent cover	x	x	x	Ocular
Canopy height	x	--	--	Altimeter
Height of individuals	x	x	--	Altimeter (T), ocular (U)
Point-to-plant distance	x	--	--	Range finder
Height of dominant	--	--	x	Meter stick
Diameter of individuals	--	x	--	Ocular: < 1 cm, 1-2 cm, 2-3 cm, 4-5 cm
DBH	x	--	--	Diameter tape
Number of downed logs	--	x	--	Ocular (16 m^2 plots)
Percent downed wood	--	--	x	Ocular
Percent rock	--	--	x	Ocular
Height of rock	--	--	x	Meter stick
Percent bare soil	--	--	x	Ocular
Depth of duff	--	--	x	Meter stick
Percent litter cover	--	--	x	Ocular
Slope	--	--	x	Abney level
Aspect	--	--	x	Compass

Habitat Variables

Habitat variables were calculated on a transect basis. The 80 variables considered in the analyses, their descriptions and abbreviations are presented in Table 2. Included in this set of habitat variables are a number of measures of heterogeneity (patchiness).

An index of horizontal heterogeneity (Wiens 1974) was calculated to express variablilty in distribution of vegetation in the tree stratum. The index was identical to that used by Roth (1976) for data collected using the point-center-quarter method. The formula, IH = 100SD/X, is that of a coefficient of variation, where X = the mean of the point-to-plant distances (for all trees sampled on a transect) and SD = the standard deviation.

The use of the coefficient of variation as an index of horizontal heterogeneity was extended to the understory stratum. Here, the index was the coefficient of variation of the number of individuals recorded in each of the 48 sample plots. Indices of heterogeneity were used in association with a number of other habitat variables also and express patchiness on both horizontal and vertical axes. Such expressions of patchiness can add a tremendous amount of information about the structure of an area to that included in means alone and are very important in the total description of an area.

Statistical Analysis

Three types of statistical techniques were used in the analysis of the data. Chi-square analysis was used to test for significant year or habitat effects on number of species and relative densities. Multiple linear discriminant function analysis was used to derive

Table 2. Descriptions of 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia.

Sampling method	Stratum	Variable code name	Description
Point-quarter	Tree	TNSPEC	Number of tree species sampled
		DIST	Mean point-to-plant distance in meters
		DISTCV	Coefficient of variation of DIST
		THT	Mean tree height in meters
		THTCV	Coefficient of variation of THT
		TDIA	Mean tree diameter in centimeters
		TDIACV	Coefficient of variation of TDIA
		TBA	Basal area in meters^2/hectare
		TPC	Mean percent cover
		TPCCV	Coefficient of variation of TPC
		CANHT	Mean canopy height of dominant trees in meters
		CANHTCV	Coefficient of variation of CANHT
		PCLT8	Percent of sampled trees 5-8 meters in height
		PC11	Percent of sampled trees 8-11 meters in height
		PC14	Percent of sampled trees 11-14 meters in height
		PC17	Percent of sampled trees 14-17 meters in height
		PC20	Percent of sampled trees 17-20 meters in height
		PC23	Percent of sampled trees 20-23 meters in height
		PC26	Percent of sampled trees 23-26 meters in height
		PCGT26	Percent of sampled trees greater than 26 meters in height

Table 2. Descriptions of 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Sampling method	Stratum	Variable code name	Description
Point-quarter	Tree	TEVRD	Percent (relative density) of sampled trees which were evergreens
		TEVDEN	Tree evergreen density/hectare
		TEVBA	Tree evergreen basal area in $meters^2$/hectare
		TEVHT	Mean height of evergreen trees in meters
		TEVDIA	Mean diameter of evergreen trees in centimeters
		TDTRD	Percent (relative density) of sampled trees which were dead
		TDTDEN	Dead tree density/hectare
		TDTBA	Dead tree basal area in $meters^2$/hectare
		TDTHT	Mean height of dead trees in meters
		TDTDIA	Mean diameter of dead trees in centimeters
16 $meter^2$ plots	Understory	NSPEC	Number of understory species sampled
		NSTEM	Mean number of stems (individuals)
		NSTEMCV	Coefficient of variation of NSTEM
		HT	Mean height of understory stems in meters
		HTCV	Coefficient of variation of HT
		DIA	Mean diameter of understory stems in centimeters
		DIACV	Coefficient of variation of DIA
		BA	Understory basal area in ($meters^2$/hectare) x 10
		PC	Mean percent cover

Table 2. Descriptions of 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Sampling method	Stratum	Variable code name	Description
16 meter^2 plots	Under-story	PCCV	Coefficient of variation of PC
		VOL	Mean volume in (meters^3/16 meter^2 plot) x 10
		VOLCV	Coefficient of variation of VOL
		LT2NO	Number of stems 1-2 meters in height
		LT2PC	Percent of stems 1-2 meters in height
		S3NO	Number of stems 2-3 meters in height
		S3PC	Percent of stems 2-3 meters in height
		S4NO	Number of stems 3-4 meters in height
		S4PC	Percent of stems 3-4 meters in height
		GR4NO	Number of stems 4-5 meters in height
		GR4PC	Percent of stems 4-5 meters in height
		EVRD	Percent (relative density) of stems sampled which were evergreens (*Kalmia latifolia* and *Pinus rigida*)
		EVDEN	Understory evergreen density/hectare
		EVBA	Understory evergreen basal area in (meters^2/hectare) x 100
		EVHT	Mean height of evergreens in meters
		EVDIA	Mean diameter of evergreens in centimeters

Table 2. Descriptions of 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Sampling method	Stratum	Variable code name	Description
16 $meter^2$ plots	Understory	EVVOL	Mean evergreen volume in ($meters^3$/ 16 $meter^2$ plot) x 10
		DTRD	Percent (relative density) of stems sampled which were dead timber
		DTDEN	Understory dead timber density/ hectare
		DTBA	Understory dead timber basal area in ($meters^2$/hectare) x 100
		DTHT	Mean height of dead timber in meters
		DTHTCV	Coefficient of variation of DTHT
		DTDIA	Mean diameter of dead timber in centimeters
		DTDIACV	Coefficient of variation of DTDIA
		LOG	Mean number of downed logs
		VITIS	Mean number of *Vitis aestivalis*
1 $meter^2$ plots	Herb-ground	HNSPEC	Number of herb stratum species sampled
		HPC	Mean percent cover
		HPCCV	Coefficient of variation of HPC
		HTDOM	Mean height of dominants in centimeters
		HTDOMCV	Coefficient of variation of HTDOM
		LITTER	Mean percent of ground covered by litter
		WOOD	Mean percent of ground covered by downed wood
		ROCK	Mean percent of ground covered by rock
		HTROCK	Mean height of rock in centimeters
		VOLROCK	Mean volume of rock in ($meters^3$/ $meter^2$ plot) x 1000

Table 2. Descriptions of 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Sampling method	Stratum	Variable code name	Description
1 meter^2 plots	Herb-ground	SOIL	Mean percent bare soil
		DUFF	Mean depth of duff in centimeters
		ASPECT	Mean aspect (north = 0)
		SLOPE	Mean percent slope
		WATER	Mean water value, where 1 = water present and 2 = water absent

models for predicting presence or absence of singing males. Multiple linear regression analysis was used to derive models to predict relative density of singing males.

Chi-Square Analysis

The C-TAB II (Haberman 1973) log linear model program was used for all chi-square tests on 2 x 2 contingency tables. In all tests of species number or relative density differences due to a year or habitat effect, the raw number of observations in each cell was weighted to account for imbalances in the number of censuses between the two years and the number of transects between habitat types. Results were considered significant at the 0.05 level.

Multiple Linear Discriminant Function Analysis

Linear discriminant function analysis was used to identify combinations of habitat variables which "best" distinguished between transects where the species was PRESENT (observed one or more times) and ABSENT (never observed). The maximum allowable variables in a discriminant run is limited to one less than the number of observations (here, transects) in the smallest group. Because of the small number of transects (19) sampled in this study, an iterative approach involving different combinations of variables had to be applied. It was, therefore, necessary to create, for each bird species, a subset of the 80 habitat variables which was of manageable size in terms of investigator- and computer-time expended. It was decided that 16 variables was the maximum that could be dealt with in any one species' analysis.

The number of variables was reduced by 35 to 50 percent using scatter diagrams produced by the SAS 76 (Barr et al. 1976) SCATTER procedure. A species' mean relative density (mean of 1977 and 1978/ transect) was plotted against each habitat variable. Those variables which showed little or no separation of the PRESENT and ABSENT transects into distinct groups were removed from that species analysis.

The SAS 76 DISCRIM procedure was then run on each of the remaining variables. Selection of the 16 to be included in the final subset was based on 2 criteria: 1) The results of the classification option and 2) the results of the test on homogeneity of group variance-covariance matrices.

The classification option uses the discriminant function, derived from *a priori* knowledge of group memberships, to reclassify the original set of observations when entered with no *a priori* knowledge. The percent of observations classified into their correct groups indicated the discriminating power of the variable(s). The best 16 discriminating variables were selected for a species analysis, provided they met the second criterion.

One of the assumptions of linear discriminant function analysis is the homogeneity of variance-covariance matrices of the groups. Generally, only variables which met this assumption were selected to be in a subset. Occasionally, however, a variable which did not meet this assumption was a much better discriminator than any of the other variables. Due to small sample sizes and the effect of increased degrees of freedom, such a variable is sometimes included in a homogeneous multiple linear discriminant function and was, therefore, selected for inclusion in the species' subset.

Once the 16 variables were selected, the DISCRIM procedure and the previously described criteria were used to select the best of all possible 2-variable models (about 15 or less). Each of these 2-variable models was then used to create 3-variable models by adding each of the remaining variables in the subset to it. The DISCRIM procedure was then run on the 3-variables models. This process was repeated until either the maximum number of variables allowed in the discriminant function or 100 percent correct classification was reached.

Frequently, the above procedure would not yield one unique solution. The criteria, then, for selecting the "best" species' model was: 1) The model should contain as few variables as possible, 2) have a P value (significance level for chi-square test) which improved over the lower-variable model and, if possible, have 3) a Wilks' lambda of 0.30 or less and 4) 100 percent correct classification. As SAS 76 does not provide the P or Wilks' lambda values, they were obtained from the SPSS (Nie et al. 1975) DISCRIMINANT program.

Both SAS 76 and SPSS provide the classification coefficients of the discriminant function. These classification coefficients correspond to the coefficients of a multiple regression equation and can be used to predict the potential presence or absence of a species in an area given the values of the habitat variables included in the function. These values are incorporated into both the PRESENT and ABSENT equations and the predicted group membership is the one whose equation yields the greatest value.

Multiple Linear Regression Analysis

Multiple linear regression analysis was used to identify combinations of habitat variables which best accounted for the variation between transects in a species' mean (1977 and 1978) relative density. Only transects where the species was observed one or more times were included in this analysis.

The number of variables included in a regression run is limited to n-1, where n = the number of observations (transects where the species occurred). Reduction of variable numbers was accomplished through use of the SAS 76 RSQUARE procedure. All 80 habitat variables were entered and the best 30 (highest r^2) of each of the 1-, 2- and 3-variable models were obtained. Computing all combinations of 3 variables from an 80-variable set took the maximum allowable computer time.

Next, the 1-, 2- and 3-variable models were compared, and n-1 variables were selected to be in the species' subset. Selection of these variables was based on recurrence in the best of the models. The 3-variable models were considered most important and the single-variable models least important during the selection process.

The subset of n-1 variables was then run on the RSQUARE procedure and the best of the 1- through n-1-variable models was obtained. From these, the "best" species' model was chosen. This model had the least number of variables with an r^2 of 0.95 or better. This model was then run on the SPSS REGRESSION program to obtain coefficients for the prediction equation, the F value and the standard error of estimate. The SAS 76 GLM (General Linear Model) procedure was used to obtain the P value.

RESULTS

Avifaunal Community Analysis

Seven complete surveys of all transects were conducted in 1977 and 9 in 1978. Twenty-three species of resident breeding season birds were recorded on the transects. A list of the common and code names of these species, in order of total number of observations over the 2 seasons, is presented in Table 3. Scientific names of these species, vagrants and additional resident species observed within the general study area are presented in Appendix Table I.

Singing males were surveyed for 18 of the 23 species encountered on the transects. Relative densities of these singing males, by species, are presented in Tables 4 (1977) and 5 (1978). The brown-headed cowbird is a nest parasite and, therefore, does not have the Type A territory (Nice 1943) common to the other songbirds of the area. However, the males do sing and they were included in the analysis of the songbird population. The remaining 5 species must be considered as a separate group.

While the male blue-gray gnatcatcher does sing, only calls were heard during the course of this study. The male ruby-throated hummingbird does not sing, nor does he take part in nesting activities or the care of the young (Pitelka 1942). Therefore, the territorial song method of survey is not appropriate for this species. In addition, due to early morning light conditions and dense foliage, it was often impossible to determine the sex of this hummingbird. In all 3 woodpecker species recorded (pileated, downy and hairy) no exclusively male vocalization is given and both sexes drum (Brackbill

Table 3. Common and code names of resident breeding bird species recorded on transects, listed in decreasing order of total number of observations for two seasons (1977 and 1978).

Common name	Code name
Scarlet tanager	ST
Ovenbird	OB
Red-eyed vireo	REV
Eastern wood pewee	EWP
Pine warbler	PW
Solitary vireo	SOLV
Black-and-white warbler	BWW
Rufous-sided towhee	RST
Worm-eating warbler	WEW
Brown-headed cowbird	BHC
Great crested flycatcher	GCF
Wood thrush	WT
Blue-gray gnatcatcher	BGG
Pileated woodpecker	PILW
Acadian flycatcher	ACF
Yellow-billed cuckoo	YBC
Downy woodpecker	DWP
Hairy woodpecker	HWP
Ruby-throated hummingbird	RTHUM
Tufted titmouse	TT
Carolina chickadee	CC
Rose-breasted grosbeak	RBGR
Carolina wren	CW

Table 4. Relative densities of singing males, by species and transect, for the 1977 breeding season on Potts Mountain, Craig County, Virginia.

Habitat	Transect	ST	OB	REV	EWP	PW	SOLV	BWW	RST	WEW	BHC	GCF	WT	ACF	YBC	TT	CC	RBGR	CW	Transect relative density
		Species																		
Cove hardwood	1	0	0	0	0	0	0	0.29	0	0.43	0	0	0.43	0	0	0.29	0	0	0	1.44
	2	0.14	0	0.57	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0	0	0.85
	3	0	0.14	0.14	0	0	0	0.29	0	0.57	0	0	0	0	0	0.14	0	0	0	1.28
	4	0.29	0	0.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00
	5	0.29	0.14	0	0	0	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0.57
	6	0	0	0.29	0.14	0	0	0	0	0.29	0	0.29	0	0	0	0	0	0	0	1.01
	7	0.71	0	1.00	0.14	0	0.14	0.14	0	0.14	0	0.14	0	0	0.14	0	0	0	0	2.55
	8	0.14	0	0.14	0	0	0	0	0	0.14	0	0	0	0	0	0	0.14	0	0	0.56
	Mean	0.20	0.04	0.36	0.04	0	0.02	0.09	0	0.21	0	0.07	0.05	0	0.02	0.05	0.02	0	0	1.16
Mixed oak-pine	12	0.14	0	0	0.71	0	0	0.14	0.29	0.14	0	0	0	0	0	0	0	0	0.14	1.56
	13	0.29	0.14	0	0	0	0	0.14	0.29	0	0	0.29	0.14	0	0	0	0	0	0	1.29
	14	0.43	0.29	0	0	0	0	0	0.14	0	0	0.29	0	0	0	0	0	0	0	1.15
	15	0.14	0.29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.43
	16	0.57	0	0.14	0	0.29	0.29	0	0	0	0	0	0	0	0	0	0	0	0	1.29
	17	0.14	0	0	0	0.29	0.57	0	0.14	0	0	0.14	0	0	0	0	0	0	0	1.28
	18	0.14	0.57	0	0	0	0.14	0	0	0	0.14	0.14	0	0	0	0	0.14	0	0	1.27
	19	0	0.43	0	0	0	0.14	0	0	0	0	0.14	0	0	0.29	0.14	0.14	0	0	1.28

Table 4. Relative densities of singing males, by species and transect, for the 1977 breeding season on Potts Mountain, Craig County, Virginia (continued).

Habitat	Transect	Species																		Transect relative density
		ST	OB	REV	EWP	PW	SOLV	BWW	RST	WEW	BHC	CCF	WT	ACF	YBC	TT	CC	RBGR	CW	
Mixed oak-pine	20	0.14	0.14	0	0	0.14	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0.56
	21	0	0.14	0	0	0.29	0	0	0	0	0	0.14	0	0	0	0	0	0	0	0.57
	22	0.43	0.14	0.14	0	0	0	0	0.14	0	0	0	0	0	0.14	0	0	0	0	0.99
	Mean	0.22	0.19	0.03	0.06	0.09	0.10	0.03	0.09	0.01	0.01	0.12	0.01	0	0.04	0.01	0.03	0	0.01	1.06
Total species' relative density		3.99	2.42	3.13	0.99	1.01	1.28	1.00	1.00	1.85	0.14	1.85	0.57	0	0.57	0.57	0.42	0	0.14	20.93

Table 5. Relative densities of singing males, by species and transect, for the 1978 breeding season on Potts Mountain, Craig County, Virginia.

Habitat	Transect	Species: ST	OB	REV	EWP	PW	SOLV	BWW	RST	WEW	BHC	GCF	WT	ACF	YBC	TT	CC	RBGR	CW	Transect relative density
Cove hardwood	1	0.11	0	0.11	0.78	0	0.56	0.11	0	0.44	0.11	0	0.33	0	0	0	0	0.11	0	2.66
	2	0.11	0	0.33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.44
	3	0.44	0	0.22	0.44	0	0.11	0.22	0	0	0.22	0	0	0.11	0	0	0	0	0	1.76
	4	0	0	0.33	0.22	0	0	0	0	0	0	0	0.11	0	0	0	0	0	0	0.66
	5	0.22	0	0.22	0.44	0	0.11	0	0	0	0.11	0.11	0.56	0	0	0	0	0	0	1.77
	6	0.22	0	0.22	0.11	0	0	0	0	0	0.11	0	0.11	0.67	0.11	0.11	0	0	0	1.66
	7	0.33	0	0.78	0	0	0	0	0	0	0	0	0.22	0	0	0	0	0	0	1.33
	8	0.11	0	0	0	0	0	0.33	0	0.22	0	0	0.11	0	0	0	0	0	0	0.77
	Mean	0.19	0	0.28	0.25	0	0.10	0.08	0	0.08	0.07	0.01	0.18	0.10	0.01	0.01	0	0.01	0	1.38
Mixed oak-pine	12	0.33	0.22	0	0.44	0	0.22	0.44	0.33	0	0.56	0.22	0.33	0	0	0	0	0.11	0	3.20
	13	0.22	0.22	0	0.22	0	0.11	0.33	0.33	0	0.33	0.11	0	0	0	0	0	0	0	1.87
	14	0.56	0.22	0	0	0	0.33	0.56	0.22	0	0.11	0.22	0	0	0	0	0	0.11	0	2.33
	15	0.11	0.22	0	0	0.33	0.11	0.33	0.44	0.33	0.44	0	0	0	0	0	0	0	0	2.31
	16	0.11	0.67	0	0.11	0.33	0	0	0.11	0	0	0.11	0.11	0	0	0	0	0	0	1.55
	17	0	0.56	0	0	0.67	0.44	0	0.56	0	0.11	0	0	0	0	0	0	0	0	2.34
	18	0.11	0.33	0	0.11	0	0.22	0	0	0.22	0.22	0.11	0	0	0	0	0	0	0	1.32
	19	0.79	0	0	0	0.33	0	0.11	0	0.11	0.11	0.11	0	0	0.11	0	0	0	0	1.67

Table 5. Relative densities of singing males, by species and transect, for the 1978 breeding season on Potts Mountain, Craig County, Virginia (continued).

		Species																		
Habitat	Transect	ST	OB	REV	EWP	PW	SOLV	BWW	RST	WEW	BHC	GCF	WT	ACF	YBC	TT	CC	RBGR	CW	Transect relative density
Mixed oak-pine	20	0.44	0.22	0	0	0.22	0	0	0.11	0.11	0.11	0.11	0.11	0	0.11	0	0	0	0	1.54
	21	0	0.22	0	0	0.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0.89
	22	0	0.22	0	0.11	0.33	0.22	0	0	0	0.11	0.11	0	0	0	0	0	0	0	1.10
	Mean	0.24	0.28	0	0.09	0.26	0.15	0.16	0.19	0.07	0.19	0.10	0.05	0	0.02	0	0	0.02	0	1.83
Total species' relative density		4.21	3.10	2.21	2.98	2.88	2.43	2.43	2.10	1.43	2.65	1.21	1.99	0.78	0.33	0.11	0	0.33	0	31.17

1953, Hailman 1959, Hoyt 1957, Lawrence 1967), preventing sexual recognition on an audio basis. In addition, due to light and foliage conditions, sex was often undeterminable on a visual basis.

For these 5 species (unsexed) the segment of the populations sampled was different than that for the majority of species, where most observations were of singing males. Although calculated in the same manner, the relative densities of these species were not comparable to the relative densities of singing males and are presented separately in Tables 6 (1977) and 7 (1978).

Habitat and Year Effects on Total Number of Species Encountered

Chi-square tests on a 2 x 2 contingency table were used to determine if any significant difference existed in the total number of species observed along the transects, due to habitat or year effects. Results are presented in Table 8. No significant habitat-year interaction or habitat or year effects were found.

Habitat and Year Effects on Relative Density of the Singing Male Population

A 2 x 2 chi-square contingency table was used to test for any significant difference in total relative density of singing males due to habitat or year effects. Results are presented in Table 9. No significant habitat-year interaction existed. No significant difference in relative density was found between the cove hardwood and mixed oak-pine habitat types. However, relative density was significantly higher ($P = 0.002$) in 1978 than in 1977.

Table 6. Relative densities of the unsexed population, by species and transect, for the 1977 breeding season on Potts Mountain, Craig County, Virginia.

Habitat	Transect	Species: BGG	PILW	DWP	HWP	RTHUM	Transect relative density
Cove hardwood	1	0	0	0	0	0	0
	2	0.29	0	0	0	0.14	0.43
	3	0.14	0	0.14	0	0	0.28
	4	0	0	0	0	0	0
	5	0.43	0	0.14	0.14	0	0.71
	6	0	0	0	0	0.14	0.14
	7	0.14	0.29	0	0	0	0.43
	8	0	0	0.14	0	0	0.14
	Mean	0.12	0.04	0.05	0.02	0.04	0.27
Mixed oak-pine	12	0	0	0	0	0	0
	13	0	0	0.14	0	0	0.14
	14	0	0	0	0	0	0
	15	0	0	0	0	0	0
	16	0	0.14	0	0	0.14	0.28
	17	0	0	0.14	0	0.29	0.43
	18	0	0.14	0	0	0	0.14
	19	0.14	0	0	0	0	0.14
	20	0	0.29	0	0	0.14	0.43
	21	0	0	0	0	0	0
	22	0	0	0	0	0	0
	Mean	0.01	0.05	0.03	0	0.05	0.14
Total species' relative density		1.14	0.86	0.70	0.14	0.85	3.69

Table 7. Relative densities of the unsexed population, by species and transect, for the 1978 breeding season on Potts Mountain, Craig County, Virginia.

Habitat	Transect	Species: BGG	PILW	DWP	HWP	RTHUM	Transect Relative density
Cove hardwood	1	0	0	0	0.11	0	0.11
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
	4	0	0.11	0	0	0	0.11
	5	0	0.11	0.11	0.22	0	0.44
	6	0.22	0	0	0	0	0.22
	7	0	0	0	0	0	0
	8	0.11	0	0	0	0	0.11
	Mean	0.04	0.03	0.01	0.04	0	0.12
Mixed oak-pine	12	0	0	0.11	0	0	0.11
	13	0.11	0	0	0	0	0.11
	14	0	0	0	0	0	0
	15	0	0	0	0.11	0	0.11
	16	0	0	0	0	0	0
	17	0	0	0	0	0	0
	18	0	0	0	0.11	0	0.11
	19	0	0	0	0	0	0
	20	0	0.11	0	0	0	0.11
	21	0	0	0	0	0	0
	22	0	0	0	0.11	0	0.11
	Mean	0.01	0.01	0.01	0.03	0	0.06
Total species' relative density		0.44	0.33	0.22	0.66	0	1.65

Table 8. Results of chi-square tests for significance of habitat and year effects on the total number of resident breeding season bird species recorded along the transect lines.

Null hypothesis	Degrees of freedom	X^2	P
No habitat-year interaction	1	0.12	0.7327
No habitat effect	2	0.24	0.8855
No year effect	2	0.24	0.8855

Table 9. Results of chi-square tests for significance of habitat and year effects on the relative density of singing male birds.

Null hypothesis	Degrees of freedom	X^2	P
No habitat-year interaction	1	2.46	0.1166
No habitat effect	2	3.74	0.1544
No year effect	2	12.68	0.0017

Habitat and Year Effects on Relative Densities of Singing Males, by Species

Chi-square tests for habitat and year effects were made on 12 of the 18 species. Results are presented in Table 10.

A significant (P = 0.03) habitat-year interaction was found for the worm-eating warbler. Frequency of observations of this species in the cove hardwood habitat declined significantly from 1977 to 1978. In the mixed oak-pine habitat, observations increased slightly from 1977 to 1978. However, frequency of observation was higher both years in the cove hardwood habitat than in the mixed oak-pine.

In addition to the worm-eating warbler, 2 species showed significant habitat preferences. The ovenbird was observed significantly more times (P = 0.0001) in the mixed oak-pine habitat. The red-eyed vireo showed a significant (P = 0.0001) preference for the cove hardwood habitat.

Two species showed significant differences in the frequency of observations between the 2 breeding seasons. Relative densities of the eastern wood pewee (P = 0.01) and the brown-headed cowbird (P = 0.002) were both higher in 1978 than in 1977.

Six species could not be included in the statistical analysis because 2 or 3 cells in the 4-celled contingency table contained 0's. Although the pine warbler and rufous-sided towhee were included in the 8 most frequently observed species in the study area, they were both exclusively mixed oak-pine species. Though not statistically analyzed, it should be noted that the relative density of the pine warbler increased nearly as much as that of the eastern wood pewee

Table 10. Results of chi-square tests for significance of habitat and year effects on the relative densities of singing male birds, by species.

	Hypotheses					
	No habitat-year interaction (df = 1)		No habitat effect (df = 2)		No year effect (df = 2)	
Species	X^2	P	X^2	P	X^2	P
Scarlet tanager	0.03	0.8583	0.37	0.8291	0.06	0.9718
Ovenbird	2.64	0.1044	21.99	0.0001	2.91	0.2336
Red-eyed vireo	1.10	0.2948	31.60	0.0001	2.01	0.3664
Eastern wood pewee	2.73	0.0985	4.63	0.0986	9.24	0.0098
Solitary vireo	1.27	0.2589	4.07	0.1308	3.56	0.1685
Black-and-white warbler	3.32	0.0685	3.35	0.1875	5.50	0.0638
Worm-eating warbler	4.85	0.0277				
Brown-headed cowbird	0.26	0.6110	3.94	0.1394	12.64	0.0018
Great crested flycatcher	1.32	0.2506	4.31	0.1157	2.24	0.3267
Wood thrush	0.01	0.9224	5.48	0.0644	5.10	0.0781
Yellow-billed cuckoo	0.05	0.8310	0.50	0.7771	0.36	0.8348
Tufted titmouse	0.18	0.6705	2.16	0.3389	2.03	0.3617

from 1977 to 1978. The Carolina chickadee, rose-breasted grosbeak and Carolina wren, though resident, were rare (observed $\leq$ 3 times). Six of the 7 Acadian flycatcher observations were on one individual's territory.

Habitat and Year Effects on Relative Density of the Unsexed Population

Results of chi-square tests for significant differences in the relative density of the total unsexed population due to habitat or year effects are presented in Table 11. No significant habitat-year interaction was found. Tests for habitat and year effects were both nonsignificant.

Habitat and Year Effects on Relative Densities of Unsexed Species

Four of the 5 unsexed species were tested for habitat and year effects, using chi-square analysis. Results are presented in Table 12. No habitat-year interactions and no year effects were found for any species. A significant (P = 0.05) habitat effect was found for the blue-gray gnatcatcher. This species was most frequently observed in the cove hardwood habitat type.

The ruby-throated hummingbird was observed only in 1977 and could not be included in the statistical analysis.

Habitat Variable Values

The mean, minimum and maximum values of all 80 habitat variables are presented in Appendix Table II.

Multivariate Analyses of Habitat Selection

Linear multiple discriminant function and regression analyses were performed on the 12 most frequently observed bird species. The resultant "best" species' models are presented in Appendix Tables III

Table 11. Results of chi-square tests for significance of habitat and year effects on the relative density of the unsexed bird population.

Null hypothesis	Degrees of freedom	X^2	P
No habitat-year interaction	1	0.01	0.9043
No habitat effect	2	3.38	0.1844
No year effect	2	4.77	0.0920

Table 12. Results of chi-square tests for significance of habitat and year effects on the relative densities of the unsexed birds, by species.

	Hypotheses					
	No habitat-year interaction (df = 1)		No habitat effect (df = 2)		No year effect (df = 2)	
Species	X^2	P	X^2	P	X^2	P
Blue-gray gnatcatcher	0.20	0.6537	6.17	0.0457	2.35	0.3083
Pileated woodpecker	0.63	0.4276	0.63	0.7297	1.64	0.4413
Downy woodpecker	0.04	0.8402	0.57	0.7521	1.70	0.4278
Hairy woodpecker	0.64	0.4254	1.10	0.5768	2.23	0.3279

through XIV and are discussed in the following pages. Variables are listed in the order of their inclusion in an SPSS (Nie et al. 1975) stepwise procedure. These models are based on 0.5 hectare sample areas (see METHODS).

Appendix Table XV contains means of the PRESENT, ABSENT and total transects for each habitat variable in the "best" discriminant function for each species. Also included is the Wilks' lambda for each of these variables. Appendix Table XVI contains the r^2 and sign (+ or -) of the standardized coefficient for each habitat variable included in the "best" regression function for each species. These tables are provided for inspection of the singular relationship between those variables included in a model and the species' relative density or presence and absence and will be referred to frequently. They are not necessarily the best singular variables of the original 80.

Scarlet Tanager

Discriminant function analysis could not be conducted for this ubiquitous species, as it was observed on all but one transect.

The results of the multiple regression analysis are shown in Appendix Table III. The r^2 for the function was 0.96. The F value was 31.31 with a P value of 0.0001. Over half of the 8 variables included in the model were concerned with the amount and distribution of vegetation in various height classes. Variables included were S3NO, LITTER, S4NO, TDTHT, S3PC, PC20, PC14 and BA. As seen in Appendix Table XVI, none of the variables were good predictors, when considered separately, although S3NO and S4NO had significant ($0.01 \leq P \leq 0.05$) r^2 values. There was a significant increase in scarlet tanager relative density with an increase in the amount of vegetation present 2 to 4 meters above ground.

Ovenbird

Results of the multivariate analyses for this species are presented in Appendix Table IV.

The discriminant function included only 1 variable, PC23. Discrimination between the PRESENT and ABSENT transects was very high, with a Wilks' lambda of 0.21 (X^2 = 25.68, df = 1, P = 0.000) and 100 percent correct classification. As seen in Appendix Table XV, the PRESENT habitat for the ovenbird had a much lower mean PC23 (percent of trees that were between 20 and 23 meters in height) than the ABSENT habitat. In fact, the ovenbird occurred in 11 out of 13 cases at a PC23 value of 0 percent.

The r^2 for the regression model was 0.97. The F value was 44.05 and was significant at the 0.0001 level. The variables included were HPC, PC20, GR4PC, TDTRD and THTCV. HPC (percent cover of vegetation < 1 meter in height) had an r^2 of 0.60 (Appendix Table XVI). Three of the 4 remaining variables in the model were concerned with the tree stratum. The relative density of ovenbirds increased significantly as the percent cover of vegetation in the herb-ground stratum increased.

Red-Eyed Vireo

Results of the analyses for this species are presented in Appendix Table V.

The separating power of the discriminant function, which included CANHT and EVDEN, was high. Percent correct classification was 100, with a Wilks' lambda of 0.30 (X^2 = 19.31, df = 2, P = 0.000). Red-eyed vireo PRESENT transects had a significantly greater mean canopy height (CANHT) and a significantly lower mean density of evergreens in the understory stratum (EVDEN) than ABSENT transects (Appendix Table XV).

The regression model r^2 was 0.99, with an F value of 315.63 and a P value of 0.0001. THT, VOL and DTBA were included in the model (Appendix Table XVI) and none were good predictors of red-eyed vireo relative density.

Eastern Wood Pewee

Results of the analyses are presented in Appendix Table VI.

Five variables were included in the discriminant function. They were DIST, TEVRD, EVDEN, LT2NO and LOG. Wilks' lambda was 0.26 (X^2 = 19.33, df = 4, P = 0.002) and classification was 100 percent correct. The PRESENT transects for the eastern wood pewee had a significantly lower mean TEVRD and a higher mean DIST and LOG than ABSENT transects (Appendix Table XV).

The r^2 for the regression function was 0.96 and the F value was 59.46 (P = 0.0001). The model included the variables DUFF, TEVDEN and EVRD. DUFF (depth of the duff), with a univariate r^2 of 0.77, was the only significant variable in the model (Appendix Table XVI). As the depth of the duff layer increased, the relative density of eastern wood pewees increased significantly.

Pine Warbler

Appendix Table VII contains the results of the multivariate analyses for this species.

Wilks' lambda for the discriminant function was 0.28 (X^2 = 19.78, df = 3, P = 0.000). Classification was 100 percent correct. The 3 variables in the model were EVDEN, DTDIACV and EVRD. All were concerned with the understory stratum. The pine warbler PRESENT transects were associated with a significantly higher mean value for all 3 variables than the ABSENT transects (Appendix Table XV).

The regression function r^2 was 0.97. The F value was 58.90 and the significance level was 0.0011. The 2 variables included in the model, DTRD and DTDIA, were concerned with dead timber in the understory stratum. DTRD (relative density of dead timber in the understory) had a univariate r^2 of 0.76 (Appendix Table XVI). The relative density of pine warblers increased significantly with an increase in the relative density of dead timber in the understory.

Solitary Vireo

Results of the multivariate analyses are shown in Appendix Table VIII.

The discriminant function had a Wilks' lambda of 0.32 (X^2 = 16.90, df = 4, P = 0.002) and 100 percent of the observations were classified correctly. The 4 variables included in the model were PC14, TPCCV, EVVOL and PC. Mean values for PRESENT transects were significantly higher for PC14 and TPCCV than mean values for ABSENT transects (Appendix Table XV).

The model r^2 for the regression was 0.99. The F value was 95.17 with a significance level of 0.0001. LOG, HNSPEC, EVBA, TEVBA and EVVOL were included in the model. None of the 5 variables, considered separately, were good predictors of solitary vireo relative density.

Black-and-White Warbler

As shown in Appendix Table IX, Wilks' lambda for this discriminant function was 0.30 (X^2 = 18.16, df = 4, P = 0.001) and percent correct classification was 100. Variables included in this model were TDTDIA, DTBA, HTROCK and VOLROCK. PRESENT habitat was characterized by significantly higher values for TDTDIA and HTROCK than ABSENT habitat (Appendix Table XV).

The regression model had an r^2 of 0.99 and an F value of 332.94 (P = 0.0001). The model included NSTEMCV, PCCV and NSPEC. None of these variables, considered separately, were good predictors of black-and-white warbler relative density.

Rufous-Sided Towhee

Results of this species' analyses are presented in Appendix Table X.

Wilks' lambda for the discriminant function was 0.20 (X^2 = 24.59, df = 3, P = 0.000). One hundred percent of the observations were classified correctly. Variables included in the model were EVVOL, PC17 and TPCCV. Rufous-sided towhee PRESENT habitat was characterized by significantly higher values than ABSENT habitat for all 3 variables (Appendix Table XV).

The r^2 for the regression model was 0.99. The F value was 192.20 (P = 0.0001). The model included PC14, S3PC and TBA, none of which were significant, by themselves, for predicting the relative density of rufous-sided towhees.

Worm-Eating Warbler

Wilks' lambda for the discriminant function (Appendix Table XI) was

0.24 (X^2 = 19.82, df = 6, P = 0.003). Classification was 94.74 percent correct, meaning that one observation was misclassified. Six variables were included in the model. They were EVRD, HPC, PC20, EVDEN, TNSPEC and SLOPE. Mean values for PRESENT transects were significantly lower than ABSENT transects for EVRD and EVDEN and significantly higher for PC20 and SLOPE (Appendix Table XV).

The regression model had an r^2 of 0.96 and an F value of 41.19 (P = 0.0002). Variables included in the model were EVDIA, GR4PC, PC26 and CANHT, none of which had significant univariate r^2 values for predicting relative density of worm-eating warblers.

<u>Brown-Headed Cowbird</u>

Results of the multivariate analyses of this species are presented in Appendix Table XII. The "best" discriminant function for this species had a Wilks' lambda of 0.44 (X^2 = 12.41, df = 4, P = 0.015). Classification of the observations was 94.74 percent correct. LT2PC, S4PC, PC14 and HT were included in the model. Cowbird PRESENT habitat was characterized by significantly higher values for LT2PC and PC14 and lower values for HT than ABSENT habitat.

The model r^2 for the regression was 0.97 with an F value of 12.01 (P = 0.0325). Variables included in the model were NSPEC, DUFF, GR4PC, PC11, S4NO, TEVBA, TEVHT, HT and VOLROCK. These variables included all 3 strata. NSPEC (number of species recorded in the understory stratum) had a univariate r^2 of 0.40 and was the only significant variable in the model (Appendix Table XVI). The relative density of brown-headed cowbirds increased significantly as the number of species in the understory stratum increased.

Great Crested Flycatcher

Results of the multivariate analyses are shown in Appendix Table XIII.

Wilks' lambda for the discriminant function was 0.22 (X^2 = 23.17, df = 3, P = 0.000). One hundred percent of the observations were classified correctly. Variables included in the model were DIA, S3NO and PC. All were concerned with the vegetation 1-5 meters in height. Great crested flycatcher PRESENT habitat was characterized by significantly lower mean DIA and significantly higher mean S3NO than ABSENT habitat (Appendix Table XV).

The regression r^2 was 0.96 (F = 30.31, P = 0.0001). The 5 variables included in the model were TEVRD, LT2PC, DIA, TPC and VOLCV, none of which were significant, by themselves, for predicting relative density of great crested flycatchers.

Wood Thrush

Results of analyses for this species are presented in Appendix Table XIV.

Wilks' lambda for the discriminant function was 0.20 (X^2 = 22.96, df = 5, P = 0.000). Percent correct classification was 100. The variables included in the model were PCLT8, DISTCV, BA, TNSPEC and HTROCK. PRESENT habitat values for PCLT8 and BA were significantly lower than ABSENT habitat values (Appendix Table XV).

The model r^2 for the regression was 0.97. The F value was 71.83 with a significance level of 0.0001. Included in the model were THTCV, SLOPE and TDTBA. THTCV (coefficient of variation of tree height) had a univariate r^2 of 0.69 and SLOPE (mean percent slope) had a univariate r^2 of 0.51 (Appendix Table XVI). The relative density of wood thrushes increased with an increase in percent slope and a greater variation in tree height.

DISCUSSION

Avifaunal Community Analysis

The number of species encountered did not differ significantly between the mixed oak-pine and cove hardwood habitats. Odum (1950) recorded a greater number of species in the intermediate hemlock-hardwood cove forest than in the intermediate oak-chestnut forest. However, in addition to the coniferous overstory component, his hemlock-hardwood forest had a well developed understory of Rhododendron, witch hazel and Azalea, in contrast to the less developed shrub layer of the oak-chestnut forest. Hooper (1967) in southwestern Virginia, compared breeding bird populations of middle slopes (mixed oak-pine) and bottom slopes (oak, hickory, poplar and white pine). The bottom slope sites held similar positions on the moisture gradient to the coves of the present study. He found no significant difference in the total number of species recorded. In contrast to the present study, his mesic bottom slope sites had a denser understory and more open canopy than the middle slope sites. Differences in the vegetative communities studied on Potts Mountain and by Hooper (1967) were not as drastic as those of Odum's (1950) intermediate stands. In general, according to Fawver (1950) Southern Appalachian cove forests do not support greater numbers of breeding bird species than surrounding forest types.

No significant difference was found in the relative population densities (both singing males and unsexed) between the mixed oak-pine and cove hardwood habitat type. Odum (1950) found slightly greater densities of breeding birds in the intermediate hemlock-hardwood forest than in the oak-chestnut forest; however, the difference was far greater in the mature stands. Hooper (1967) found significantly greater densities on his bottom slope than on his middle slope sites. In summarizing the literature, Hooper (1978) stated that cove forests generally support greater densities of breeding birds than other forest types in the South and Southeast. However, the studies conducted have concentrated on coves of the hemlock type or those of climax successional stage.

Differences in results, both between and within these studies were due to variation in the structure, composition and position of the vegetative communities studied. On Potts Mountain, there appeared to be a trade-off in benefits between the 2 habitat types. The mesic, mostly deciduous, cove hardwood was characterized by a dense canopy cover and a sparse herb and understory cover. The drier mixed oak-pine type, with its mixture of deciduous and coniferous species, had a more open canopy and dense herb and understory layers.

Although there were no differences in the total number of species or relative population densities, there were significant habitat preferences exhibited by 6 out of the 23 species recorded. The blue-gray gnatcatcher, red-eyed vireo and worm-eating warbler preferred the cove hardwood type. The ovenbird preferred the mixed oak-pine areas, and the pine warbler and rufous-sided towhee were observed exclusively in the mixed oak-pine areas. Excluding the blue-gray gnatcatcher, these species were included in the 9 most frequently observed within the study area.

Table 13 presents the relative dominance structure of the singing male population for the 2 communities. This is expressed as the

Table 13. Relative dominance structure of singing male bird species in two forest habitats (mean of 1977 and 1978 breeding seasons).

Cove hardwood		Mixed oak-pine	
Species	Percent of mean total relative density	Species	Percent of mean total relative density
Red-eyed vireo	24.9	Ovenbird	16.5
Scarlet tanager	15.3	Scarlet tanager	16.0
Worm-eating warbler	11.7	Pine warbler	12.2
Eastern wood pewee	11.2	Rufous-sided towhee	9.8
Wood thrush	9.2	Solitary vireo	8.8
Black-and-white warbler	6.8	Great crested flycatcher	7.5
Solitary vireo	4.5	Brown-headed cowbird	7.1
Acadian flycatcher	3.8	Black-and-white warbler	6.8
Great crested flycatcher	3.3	Eastern wood pewee	5.0
Brown-headed cowbird	2.7	Worm-eating warbler	2.9
Tufted titmouse	2.6	Wood thrush	2.2
Ovenbird	1.4	Yellow-billed cuckoo	2.0
Yellow-billed cuckoo	1.2	Red-eyed vireo	0.9
Carolina chickadee	0.7	Carolina chickadee	0.9
Rose-breasted grosbeak	0.6	Rose-breasted grosbeak	0.7
Pine warbler	0	Tufted titmouse	0.4
Rufous-sided towhee	0	Carolina wren	0.4
Carolina wren	0	Acadian flycatcher	0

percentage of the mean relative singing male density of a habitat type attributed to a given species. The relative dominance of a species in the 2 types was compared since it is assumed that conspicuousness was equal due to the narrowness of transects and dependency upon audio cues (see Robbins 1978). With the data from the 2 years averaged, some interesting trends are apparent, although there were yearly variations in relative dominance due to fluctuations in species relative densities.

The scarlet tanager was equally dominant in both communities, representing 15-16 percent of the mean relative density and being the second most frequently observed species. Approximately 53 percent of the mean relative density in both communities was composed of the scarlet tanager and those species showing a significant preference for that habitat type. Therefore, although total relative density was essentially equal between the 2 types, the structure of the avifaunal communities differed,with an average for the 2 years of 37-38 percent of the relative density attributable to species showing a definite preference for that type. In addition, although the bird species composition of the 2 communities was similar, an important segment of the mixed oak-pine community (22 percent), composed of the pine warbler and rufous-sided towhee, was not represented in the cove hardwood habitat.

In summarizing the literature on avian ecology, Shugart et al. (1978) stated that while the composition of dominant species in a forest stand remains constant from year to year, the presence or absence of "rare" species can very considerably. The Carolina chickadee, Carolina wren and ruby-throated hummingbird were recorded only in 1977, while the Acadian flycatcher and rose-breasted grosbeak were recorded only in 1978. However, the Acadian flycatcher, at least, was known to be present in the general study area during 1977. A territorial male was consistently heard outside of one of the transect areas. Oftentimes, the rare species may be missed due to the small size of sampling areas.

The population of singing males increased significantly from 1977 to 1978. There was a trend of increased relative densities in 9 of the 12 dominant species of the area. However, only 3 species showed significant differences in relative density between the 2 years.

Relative density of the eastern wood pewee was significantly higher in 1978. The brown-headed cowbird relative density increased dramatically in 1978. Although not tested statistically, the pine warbler increased nearly as much as the eastern wood pewee. The only species to show a significant decrease in 1978 was the worm-eating warbler. However, this decrease was observed only in its preferred habitat, the cove hardwood. Overall, its numbers were not statistically different between 1977 and 1978.

Shugart et al. (1978) pointed out that a given species' population in a particular forest stand can exhibit considerable variation from year to year, but that the causes are largely unknown. Migratory species present a special problem as population changes could occur due to factors in other parts of their range. In addition, they stated that apparent changes in the density of a species may be due to changes in distributional patterns and not in absolute numbers.

Finally, fluctuations in absolute numbers could be due to variations in territory size resulting from variations in available food supply. Stenger (1958) found a highly significant negative correlation between territory size in ovenbirds and available food within the territory. This relationship held over 4 different habitat types. (See Schoener 1968, for review on possible causes of intraspecific variation in territory size.) Changes in the density of one species could also be the result of changes in the density of another.

While such arguments provide possible explanations for variation on a species basis, the significant increase (49 percent) in total singing male relative density in 1978 warrants further consideration. The additive increases in some species were not countered by an equal decrease among the others. One possible explanation is that there was no real increase in the population of the study area in 1978 and that the increase recorded was due to distributional patterns alone. This would be possible if an area was poorly sampled. However, 19 transects, representing 9.5 hectares, seems an adequate sample size. In addition, if variation was due entirely to distributional patterns, it would be unlikely that a general trend of increase would be observed on the majority of the transects. Therefore, it appears that the area did, in fact, support more birds in 1978 than in 1977. In addition, the increase in relative density was significant (P = 0.02) even when the cowbird was removed from the analysis. Thus, there was increased use of the area by birds having type A territories (Nice 1943). This may have been related to natural yearly variations in the abundance of food.

Multivariate Analyses of Habitat Selection

In using multivariate statistical analyses, the attempt was to describe the association between a number of breeding bird species, represented by observations of singing males, and the surrounding forest habitat. These types of analyses provide an objective method of identifying configurations of specific components of a complex environment which appear important to a species--from the human point of view. It was an attempt to quantify and describe a species' habitat selection pattern and further, to explain or predict variation in relative density once the basic requirements determining presence have been met.

While birds certainly select territories on the basis of environmental stimuli, whether emitted from proximate or ultimate factors (Baker 1938), it cannot be assumed that a species' associated habitat configuration is a constant over time or space. Learning from experience and site tenacity in a changing habitat have been shown in certain species of birds (see Hilden 1965). In addition, even in relatively stable environments, the variable or combination of variables which best describe the acceptable or preferred habitat of a wide-ranging, tolerant species will most assuredly vary in different geographical regions due to different complexity and structure of the vegetative communities, which influences the relationships among various habitat components. Whitmore (1975), in comparing the variables important in separating the habitats of passerine species in Utah with those in Arkansas (James 1971), has demonstrated the effect of differing structural environments on the results of these types of studies.

Noon and Able (1978) have shown that a species occurring in forests which are structurally similar, but which sustain different avifaunal communities and, therefore, competitive environments, have different patterns of habitat utilization. Thus, the applicability of the results of this study outside of the general forest type and avifaunal community in which it was conducted will depend upon the variation in the structure of the vegetative communities in which the species is found and the degree of plasticity shown in habitat selection patterns under differing competitive situations.

All of the prediction models derived in this study were statistically significant at the 0.05 level. In addition, all species' associations with the surrounding forest were best characterized by different combinations of habitat variables, suggesting that resource division was adequately described through vegetative community structure.

The scarlet tanager was the most frequently observed species during both years of the study. It was obviously not highly selective and may potentially occur anywhere within the general forest type and avifaunal community. However, relative density within the study area did vary with a combination of 8 components, dealing mainly with the distribution and abundance of vegetation in the understory and lower tree strata. Broad habitat tolerances have been reported for this species (Beals 1960, Bond 1957). Beals (1960) and Forbush and May (1939) found the scarlet tanager associated with dense foliage and Anderson and Shugart (1974) with a dense canopy.

The ovenbird exhibited quite a different response to the habitat than the scarlet tanager. This species showed a significant preference for the dry mixed oak-pine areas. Only 1 variable, PC23, was necessary to distinguish ovenbird habitat from "non-habitat". The mixed oak-pine areas were characterized by a lower canopy than the cove hardwood areas and no trees 20 meters or taller were recorded on these transects. Relative density of this ground nesting species was most strongly associated (positively) with percent cover of herbaceous vegetation less than one meter in height. Reports in the literature on the habitat of this species conflict greatly. Anderson and Shugart (1974) found the ovenbird associated with an open canopy and dense understory and Beals (1960) found a significant positive regression of ovenbird density with understory density (1-7 feet high). Bond (1957) found greater abundance with decreasing density of undergrowth and Webb et al. (1977) found a progressive decrease in abundance with increased logging intensity. Smith (1977) and Anderson and Shugart (1974) found the ovenbird only in mesic forests. Hann (1937) found most nests in the open, although some were well surrounded by herbaceous plants. In reviewing the literature, he also discovered conflicting reports about this species. It appears that, in general, the ovenbird has a broad habitat tolerance, but that in local situations it is often restricted, possibly by competitive factors. On Potts Mountain, 2 other ground nesting warblers were present. The worm-eating warbler, which also feeds on the ground, preferred the cove hardwood areas. The black-and-white warbler showed no habitat preference. These were all dominant species in the overall avifaunal community.

The red-eyed vireo exhibited a significant preference for the cove hardwood habitat. A highly significant discrimination was accomplished by a combination of 2 habitat variables, CANHT and EVDEN. Great canopy height and low density of evergreens in the understory layer were characteristic of the cove hardwood areas. Where present, relative density of red-eyed vireos varied with a combination of THT, VOL and DTBA, dealing with both the tree and shrub strata. Although Anderson and Shugart (1974), using discriminant function analysis, found red-eyed vireo habitat characterized by a multiple set of variables, canopy biomass was among the strongest. Present plots had dense vegetation between 20 and 25 meters in height. Smith (1977), using principle components analysis, found a high positive correlation for red-eyed vireos with canopy cover and average tree height. James (1976) found 9 out of 10 nests to be in forests with abundant understory. Beals (1960), Bond (1957) and Smith (1977) reported a broad habitat tolerance for this species with a preference for mesic forests. Shugart and James (1973) also reported a preference for mesic forest by the red-eyed vireo. This species, as opposed to the ovenbird, appears to be fairly constant in its choice of habitat over wide geographical areas.

The eastern wood pewee showed a slight tendency ($P = 0.099$) to occur more often in the cove hardwood areas. Present habitat was described by the combination of a number of variables dealing with the understory and tree strata. Basically, singing male eastern wood pewees were associated with a combination of increasing deciduousness and distance between trees. Relative density was most strongly associated with the depth of the duff. This was probably an indicator of a number of environmental components, such as deciduousness, leaf volume and moisture. Anderson and Shugart (1974), using discriminant function analysis, found eastern wood pewee distribution correlated with a number of variables, none of which were dominant in identifying typical habitat. Bond (1957) and Beals (1960) found this species to be widely distributed. Beals (1960), whose study included stands of coniferous, deciduous and mixed forest did report a preference for areas with larger trees. Karr (1968) found eastern wood pewees associated with areas having little or no understory. Shugart and James (1973) also found this species in habitat with a sparse understory.

The pine warbler occurred only in the mixed oak-pine areas. The habitat within which this species was found was characterized by greater evergreeness in the understory layer than the habitat where this species was absent. Anderson and Shugart (1974) found this species associated with a dense canopy and sparse understory. In the present study, a more open canopy and denser understory were characteristic of the mixed oak-pine areas where the pine warbler was found. It is well known that during the breeding season, this species is restricted to areas where pine trees occur (Bailey 1913, Hausman 1947, Chapman 1966 and others). Both the present study and Anderson and Shugart's (1974) included deciduous forest habitats. Therefore, the vegetative characteristics of known "non-habitat" included in the multivariate analyses may have masked the true components important to the species. Perhaps where pines occur the pine warbler has a broad tolerance for the structure of the forest, or perhaps a study including only areas where pines are present would reveal characteristics important for breeding habitat. Nonetheless, in the present study, where they occurred, the pine warbler's relative density was positively influenced by characteristics of dead timber in the understory layer, most strongly by the dead timber relative density.

The solitary vireo exhibited no significant preference for cove hardwood or mixed oak-pine habitats. Present habitat was characterized by the combination of a number of variables, dealing with both the understory and tree strata. Relative density varied with a set of habitat components encompassing all 3 strata. Three of the 5 variables included in this regression equation, however, were measures of the abundance of evergreens in the tree and understory strata. Beals (1960) found the solitary vireo to be widely distributed, although he stated that they prefer forests with larger trees. Kendeigh (1945) reported that this species nests in both coniferous and deciduous forests, Baird et al. (1874) stated that they prefer deciduous oaks and Hausman (1947) reported preference for a mixture of deciduous and coniferous trees. The solitary vireo, then, appears to be a species of broad habitat tolerance, similar to the scarlet tanager.

The black-and-white warbler showed no statistical preference for the cove hardwood or mixed oak-pine habitat. Its habitat was best described by the combination of a number of habitat components dealing with the amount and configuration of rock and the amount and size of dead timber. On a singular basis, the habitat within which this warbler was found was characterized by significantly greater height of rocks and diameter of dead timber in the tree stratum than "non-habitat". This ground nesting species often nests in rocky places (Baird et al. 1874). Kendeigh (1945) reported that the black-and-white warbler sings from dead branches near the tops of exposed trees. Relative density varied most strongly, and negatively, with the patchiness of the vegetation in the understory stratum. In Beals' (1960) study, black-and-white warbler density increased with increasing density of woody understory and in particular, deciduous understory. This was associated with a preference for the mesic climax forests. Shugart and James (1973) also found that this species preferred mesic climax forests; however, their mesic forest had a sparse understory layer. In the present study it was found that understory density was not so important as the uniform distribution of that vegetation.

The rufous-sided towhee was observed exclusively in the mixed oak-pine habitat. Present habitat was described by a combination of 3 variables, dealing with the percentage of trees between 14 and 17 meters tall, patchiness of the cover in the tree stratum, and volume of evergreens in the understory stratum. On a singular basis, values for all 3 variables were significantly greater in the habitat where towhees were found than in the habitat where they were absent. Where present, relative density varied with a combination of habitat components dealing with the understory and tree strata. This species was found in the xeric, pioneer habitats of Beals (1960) and Bond (1957), characterized by a dense understory. Shugart and James (1973) found the rufous-sided towhee abundant in early successional stages, through the early tree stage and in forest edge habitats. In the present study, the mixed oak-pine transects had a denser understory layer than the cove hardwood transects. In addition, all mixed oak-pine areas were located near the logging road, providing edge areas with more open overstory and denser understory layers. In contrast, the 3 cove hardwood transects which were located near the lower road had a sparse understory and an open, parklike appearance.

The worm-eating warbler exhibited a significant preference for the cove hardwood habitat. Its habitat was best characterized by a combination of 6 variables which include all 3 strata. On a singular basis, evergreeness of the understory was significantly less, and slope and percent of trees 17 to 20 meters tall greater in habitat where this species was found than in habitat where it was absent. Relative density varied with the combination of a number of variables representing increased "coveness"--greater tree canopy height and greater percentage of the understory vegetation occurring in the upper layers, as well as decreased diameter of understory evergreens, where present. Shugart and James (1973) found this species only in the mesic forest. Forbush and May (1939) stated that it feeds mostly in low, damp, bushy places and usually nests near a stream or swamp. Hamilton and Noble (1975) and Evans (1978) noted that the worm-eating warbler requires a steep slope or hillside.

Though the brown-headed cowbird is parasitic and does not have a nesting territory, it was desirable to determine whether significant patterns of habitat usage exist for this species. No significant preference was found for the cove hardwood or mixed oak-pine habitats. The Wilks' lambda of 0.44 obtained for the discriminant function was significant. Habitat of this species was characterized by a combination of variables dealing with the distribution of vegetation in various height classes. More precisely, its habitat had a combination of greater percentages of trees 11 to 14 meters tall and lower mean shrub height with most vegetation distributed closer to the ground than that habitat where it did not occur. Relative density varied with a set of 9 variables, including tree, understory and ground components. This was because over 50 percent of the transects where the brown-headed cowbird occurred consisted of only 1 observation. The brown-headed cowbird was not restricted, like most songbirds, to a specific nest site and the area surrounding it. Beals (1960) noted very little pattern in distribution for this species. Bond (1957) noted a slight tendency for increased density in the mesic half of his continuum. James (1971) and Whitmore (1977) noted the remarkable latitude of habitat tolerance exhibited by the brown-headed cowbird.

The great crested flycatcher did not exhibit a preference for either of the 2 habitat types. All 3 variables which, together, characterized the habitat within which it occurred, were concerned with the size and abundance of vegetation in the understory stratum. On a singular basis, understory mean diameter was significantly lower and number of shrubs 2 to 3 meters tall was higher in the habitat where these flycatchers were found than in habitat where they were absent. Relative density varied with a set of components dealing with the understory and tree strata. Relative density did not vary greatly. Bond (1957) found the great crested flycatcher to be widely distributed. Beals (1960) found this also, especially where trees were close together. Shugart and James (1973) found this species in both the xeric and mesic forest. The limiting factor for this species today is the availability of tree cavities, where nesting occurs (Hardin and Evans 1977).

The wood thrush showed a tendency ($P = 0.064$) towards a preference for the cove hardwood habitat. Habitat of this species was distinguished by a combination of variables dealing predominantly with the understory and tree strata. On a singular basis, the percent of trees 5 to 8 meters tall and basal area of the understory were significantly lower in the habitat where these thrushes were found than in habitat where they were absent. Relative density was influenced most strongly by positive relationships with increased heterogeneity of tree height and increased slope. Shugart and James (1973) found this species only in the mesic forest, with its associated sparse understory. Bailey (1913) stated that the wood thrush is found on swampy ground or near a stream. Though more common in the mesic half of the continuum, Bond (1957) found that this species occurred most abundantly in intermediate forest stands because of the abundance of saplings with good nest crotches and sapling-like shrubs. Karr (1968) found the wood thrush associated with a dense shrub layer. Of 3 wood thrush nests found on Potts Mountain, 1 was located in a shrub (*Kalmia latifolia*) and 2 were found in saplings (*Cornus florida*).

The approach that was used in the collection of the habitat data for this study was to assume absolutely no knowledge of species/habitat associations and to describe the structure of the transects as completely and intensively as possible. The intent was that this approach would allow identification of the habitat components and variability within the components to which the species showed the most sensitivity. As pointed out by Anderson and Shugart (1974), who used 0.08 hectare sample plots, large study areas may mask the responses which exist on a small scale. However, the 0.5 hectare sample transects used in this study provided a means for determining the importance of horizontal heterogeneity of habitat components. The coefficient of variation of percent cover in the tree stratum was included in the discriminant functions of the solitary vireo and rufous-sided towhee. The coefficients of variation of the number of stems and percent cover in the understory stratum were very important in the prediction of relative density of the black-and-white warbler. The coefficient of variation of volume in the understory stratum was included in the regression model for the great crested flycatcher. Of the 80 habitat variables considered, 30 appeared in the "best" discriminant models, 43 in the regression models and 59 in the overall study of the 12 most frequently observed species.

The purpose of such an intensive study was to identify, for each species, habitat components or combinations of components which should be strongly considered for further testing and possible application in nongame bird management strategies. While the equations presented here are specific to the size of the sample areas (0.5 hectare) and the sampling intensity under which they were derived, it is hoped that these combinations of variables, with altered coefficients, will apply in other sampling situations as well. In addition, while the coefficients for the "best" models are the only ones presented, variables are listed in order of their inclusion in a stepwise procedure (Appendix Tables III - XIV). This will allow elimination of the least important variable(s) in the model if collection of all data is impossible.

Conner and Adkisson (1976) and Shugart et al. (1978), among others, pointed out the potential usefulness of this type of information. As discussed by Shugart et al. (1978), models have been and are being developed which simulate vegetative changes on both regional and forest stand bases. Such models could provide predictions of the effects of forest succession, habitat manipulations and land-use changes on species populations or communities, thus providing an invaluable aid to the decision making process. Likewise, they could provide an aid in determining actions to be taken to improve habitat for a threatened species, while predicting the impact of these actions on other species inhabiting the area. Computer simulation, then, could be a great management aid, particularly in tracts of land to be managed for multiple-resources; and, as stated by Hamilton and Noble (1975) most avian management will be in conjunction with other management objectives. However, much work needs to be done before implementation of this type of management aid can be realized for nongame birds.

Deriving models from multivariate statistical techniques is a new approach in ecological and management oriented studies. Much work on repeatability, accuracy and range of applicability of models derived by these methods needs to be done before they can be incorporated into management programs and used as aids to decision making. There is a great need for the development of standards, both in sample methods used to collect data and in the habitat components measured. Only then can results of different studies be compared. Only then will we be able to identify sensitive species which are closely associated with a specific habitat component. Noncomparability has been a fact in many aspects of bird study thus far. However, if we wish to develop a scientifically sound management system and incorporate bird habitat requirements into computer simulation, we must conduct our research in ways allowing tests of replication and comparison between studies conducted in different geographic areas or avifaunal communities. Thus, much of the future information needed for nongame bird management involves methodology as well as ecology.

SUMMARY AND CONCLUSIONS

The 2 avifaunal communities studied, defined by association with the cove hardwood and mixed oak-pine habitat types, were essentially the same in terms of relative density and species diversity. Species composition was also quite similar. However, a number of species exhibited definite habitat preferences. The blue-gray gnatcatcher, red-eyed vireo and worm-eating warbler preferred the cove hardwood habitat. The ovenbird preferred the mixed oak-pine habitat, and the pine warbler and rufous-sided towhee were observed exclusively in the mixed oak-pine areas. Over the 2 breeding seasons, all but the blue-gray gnatcatcher were common species of the study area and abundant members of their preferred habitat. Thus, the results of this study indicated the existence of 2 distinct avifaunal communities with differing species relative dominance structures. In addition, an important segment of the mixed oak-pine bird community, composed of the pine warbler and rufous-sided towhee, was not represented in the cove hardwood community.

The general relationships between the bird communities of the 2 habitat types, described above, remained stable during the 1977 and 1978 breeding seasons. However, fluctuations in the relative densities of a number of species occurred. Results indicated that although the species composition of the dominant segment of a community remained stable, yearly variation existed in the relative dominance structure. In addition, relative density of the singing males was greater in 1978 than in 1977. This was true even when the parasitic cowbird was removed from the anlaysis, and indicates the existence of yearly variation in the number of territorial birds the environment is able to support. This may be related to natural fluctuations in the abundance of food resources.

An attempt was made to proceed beyond general descriptions of variations and relationships, and to identify components influencing habitat selection of the 12 most frequently observed species. The results of the multivariate analyses indicated that all species' associations with the surrounding forest were best characterized by different combinations of habitat components. This suggests that resource division in this forest environment was adequately described through vegetative community structure, and that this type of data may have powers for predicting the occurrence and relative densities of species of breeding birds.

The "best" multiple discriminant and regression models for each species were presented to allow further testing. There is a great potential value for this type of data in nongame bird management. However, much work on repeatability, accuracy and range of applicability of these types of models needs to be done before they can be incorporated into management programs and used as aids to decision making.

REFERENCES CITED

American Ornithologists' Union, Committee on Classification and Nomenclature. 1957. Check-list of North American birds. 5th ed. AOU, Baltimore, Md. 691pp.

American Ornithologists' Union, Committee on Classification and Nomenclature. 1973. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. Auk 90(2):411-419.

American Ornithologists' Union, Committee on Classification and Nomenclature. 1976. Thirty-third supplement to the American Ornithologists' Union check-list of North American birds. Auk 93(4):875-879.

Anderson, S. H.,and H. H. Shugart, Jr. 1974. Habitat selection of breeding birds in an east Tennessee deciduous forest. Ecol. 55(4):828-837.

Bailey, H. H. 1913. The birds of Virginia. J. P. Bell Co., Inc., Lynchburg, Va. 362pp.

Baird, S. F., T. M. Brewer, and R. Ridgway. 1874. A history of North American birds: Land birds. Volume I. Little, Brown, and Co., Boston, Mass. 596+pp.

Baker, J. R. 1938. The evolution of breeding seasons.-- G. R. DeBeer: Evolution. Essays on aspects of evolutionary biology presented to E. S. Goodrich, 161-177. Oxford. (Cited by Hilden 1965; not seen).

Balda, R. P. 1975. Vegetation structure and breeding bird diversity. Pages 59-80 in Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Barr, A. J., J. H. Goodnight, J. P. Sall, and J. T. Helwig. 1976. A user's guide to SAS 76. SAS Institute, Inc., Raleigh, N.C. 329 pp.

Beals, E. 1960. Forest bird communities in the Apostle Islands of Wisconsin. Wilson Bull. 72(2):156-181.

Bertin, R. I. 1977. Breeding habitats of the wood thrush and veery. Condor 79(3):303-311.

Bond, R. R. 1957. Ecological distribution of breeding birds in the upland forests of southern Wisconsin. Ecol. Monogr. 27(4):351-384.

Brackbill, H. 1953. Notes on the drumming of some woodpeckers. Bird-banding 24(1):18.

Braun, E. L. 1950. Deciduous forests of eastern North America. Hafner Press, a Division of MacMillan Publishing Co., Inc., New York, N.Y. 596pp.

Chapman, F. M. 1966. Handbook of birds of eastern North America. Dover Publications, Inc., New York, N.Y. 581pp.

Cody, M. L. 1968. On the methods of resource division in grassland bird communities. Am. Nat. 102:107-147.

Conner, R. N., and C. S. Adkisson. 1976. Discriminant function analysis: A possible aid in determining the impact of forest management on woodpecker nesting habitat. For. Sci. 22(2): 122-127.

Conner, R. N., and C. S. Adkisson. 1977. Principle component analysis of woodpecker nesting habitat. Wilson Bull. 89(1): 122-129.

Cottam, G., and J. T. Curtis. 1956. The use of distance measures in phytosociological sampling. Ecol. 37(3):451-460.

Curtis, R. L., Jr. 1978. A representative sample of ongoing and planned nongame bird research in the Southeastern Region United States. Pages 166-176 in Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Epperson, G. R., S. S. Obenshain, H. C. Porter, and R. E. Devereaux. 1958. (Revised). Soils of Virginia. Agric. Ext. Serv. Bull. 203. Va. Poly. Inst. and State Univ., Blacksburg, 17pp.

Evans, K. E. 1978. Oak-pine and oak-hickory forest bird communities and management options. Pages 76-89 in Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Fawver, B. J. 1950. An analysis of the ecological distribution of breeding bird populations in eastern North America. Ph.D. Thesis. Univ. Ill., Urbana. 199pp. (Cited by Hooper 1978; not seen).

Forbush, E. H., and J. B. May. 1939. Natural history of the birds of eastern and central North America. Houghton Mifflin Co., Boston, Mass. 553+pp.

Haberman, S. J. 1973. C-TAB II: User's guide: Analysis of multidimensional contingency tables by log-linear models. A fortran IV program. National Educational Resources Inc., Ann Arbor, Mi. 18pp.

Hailman, J. P. 1959. Drumming by female hairy woodpeckers. Bird-banding 30(1):47.

Hamilton, R. B., and R. E. Noble. 1975. Plant succession and interactions with fauna. Pages 96-114 in Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Hann, H. W. 1937. Life history of the oven-bird in southern Michigan. Wilson Bull. 49(3):145-237.

Hardin, K. I., and K. E. Evans. 1977. Cavity nesting bird habitat in the oak-hickory forest . . . a review. USDA For. Serv. Gen. Tech. Rep. NC-30. North Cent. For. Exp. Stn., St. Paul, Minn. 23pp.

Hausman, L. A. 1947. The illustrated encyclopedia of American birds. Garden City Publishing Co., Inc., Garden City, N.Y. 541pp.

Hespenheide, H. A. 1971. Flycatcher habitat selection in the Eastern Deciduous Forest. Auk 88(1):61-74.

Hilden, O. 1965. Habitat selection in birds--a review. Ann. Zool. Fenn. 2:53-75.

Hooper, R. G., III. 1967. The influence of habitat disturbances on bird populations. M.S. Thesis. Va. Poly. Inst. and State Univ., Blacksburg. 134pp.

Hooper R. G. 1978. Cove forests: Bird communities and management options. Pages 90-97 in Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Hoyt, S. F. 1957. The ecology of the pileated woodpecker. Ecol. 38(2):246-256.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bull. 83(3):215-236.

James, R. D. 1976. Foraging behavior and habitat selection of three species of vireos in southern Ontario. Wilson Bull. 88(1):62-75.

Jarvinen, O., and R. A. Vaisanen. 1975. Estimating relative densities of breeding birds by the line transect method. Oikos 26(3):316-322.

Johnston, D. W., and E. P. Odum. 1956. Breeding bird populations in relation to plant succession on the Piedmont of Georgia. Ecol. 37(1):50-62.

Kaminski, R. M., and H. H. Prince. 1977. Nesting habitat of Canada geese in southeastern Michigan. Wilson Bull. 89(4): 523-531.

Karr, J. R. 1968. Habitat and avian diversity on strip-mined land in east-central Illinois. Condor 70(4):348-357.

Kendeigh, S. C. 1945. Community selection by birds on the Helderberg Plateau of New York. Auk 62(3):418-436.

Kendeigh, S. C. 1946. Breeding birds of the beech-maple-hemlock community. Ecol. 27(3):226-245.

Kendeigh, S. C. 1948. Bird populations and biotic communities in northern lower Michigan. Ecol. 29(1):101-114.

Klebenow, D. A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33(3):649-662.

Kricher, J. C. 1973. Summer bird species diversity in relation to secondary succession on the New Jersey Piedmont. Am. Midl. Nat. 89(1):121-137.

Kuchler, A. W. 1964. Potential natural vegetation of the conterminous United States. Am. Geogr. Soc., Special Publication No. 36. 116 pp.

Lawrence, L. 1967. A comparative life-history study of four species of woodpeckers. Ornith. Monogr. No. 5. 156pp.

Lennartz, M. R., and A. J. Bjugstad. 1975. Information needs to manage forest and range habitats for nongame birds. Pages 328-333 in Proc. Symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Linsdale, J. M. 1928. A method of showing relative frequency of occurrence of birds. Condor 30(3):180-184.

Lochmiller, R. L. 1977. Composition and structure of two vegetation types on a southeast aspect Appalachian slope. Independent study report, Va. Poly. Inst. and State Univ., Blacksburg. 13pp. +47 tables. (Unpublished).

Martinka, R. R. 1972. Structural characteristics of blue grouse territories in southwestern Montana. J. Wildl. Manage. 36(2):498-510.

Nice, M. M. 1943. Studies in the life history of the song sparrow. Volume II. The behavior of the song sparrow and other passerines. Trans. Linn. Soc. New York 6. 328pp.

Nie, N. H., C. H. Hull, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. Statistical package for the social sciences. 2nd ed. McGraw-Hill Book Co., Inc., New York, N.Y. 675pp.

Noon, B. R. and K. P. Able. 1978. A comparison of avian community structure in the Northern and Southern Appalachian Mountains. Pages 98-117 _in_ Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Odum, E. P. 1950. Bird populations of the Highlands (N.C.) Plateau in relation to plant succession and avian invasion. Ecol. 31(4):587-605.

Payne, B. R., and R. M. DeGraaf. 1975. Economic values and recreational trends associated with human enjoyment of nongame birds. Pages 6-10 _in_ Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Pitelka, F. A. 1942. Territoriality and related problems in North American hummingbirds. Condor 44(5):189-204.

Robbins, C. S. 1978. Census techniques for forest birds. Pages 142-163 _in_ Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Roth, R. R. 1976. Spatial heterogeneity and bird species diversity. Ecol. 57(4):773-782.

Schneegas, E. R. 1975. National Forest nongame bird management. Pages 314-318 _in_ Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Schoener, T. W. 1968. Sizes of feeding territories among birds. Ecol. 49(1):123-141.

Shugart, H. H., Jr., and D. James. 1973. Ecological succession of breeding bird populations in northwestern Arkansas. Auk 90(1):62-77.

Shugart, H. H., Jr., and B. C. Patten. 1972. Niche quantification and the concept of niche pattern. Pages 283-327 in B. C. Patten, ed. Systems analysis and simulation in ecology. Volume II. Academic Press, New York, N.Y. 592pp.

Shugart, H. H., T. M. Smith, J. T. Kitchings, and R. L. Kroodsma. 1978. The relationship of nongame birds to southern forest types and successional stages. Pages 5-16 in Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Smith, D. W., and T. L. Sharik. 1977. Progress report: The effects of commercial whole-tree harvesting on soil nutrients and natural regeneration. Submitted to Va. Agric. Found., Dept. of Agric. and Commerce, Richmond. 17pp. (Unpublished).

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecol. 58(4):810-819.

Stenger, J. 1958. Food habits and available food of ovenbirds in relation to territory size. Auk 75(3):335-346.

Stewart, R. E., and J. W. Aldrich. 1952. Ecological studies of breeding bird populations in northern Maine. Ecol. 33(2): 226-238.

Sturman, W. A. 1968. Description and analysis of breeding habitats of the chickadees, Parus atricapillus and P. rufescens. Ecol. 49(3):418-431.

Talbot, L. M. 1975. Concluding Address: The challenges of management of nongame birds. Pages 335-337 in Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Thomas, J. W., R. M. DeGraaf, and J. C. Mawson. 1977. Determination of habitat requirements for birds in suburban areas. USDA For. Serv. Res. Pap. NE-357. Northeast. For. Exp. Stn., Upper Darby, Pa. 15pp.

Verner, J. 1975. Avian behavior and habitat management. Pages 39-58 in Proc. Symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

Webb, W. L., D. F. Behrend, and B. Saisorn. 1977. Effect of logging on songbird populations in a northern hardwood forest. Wildl. Monogr. No. 55. 35pp.

Whitmore, R. C. 1975. Habitat ordination of passerine birds of the Virgin River Valley, southwestern Utah. Wilson Bull. 87(1): 65-74.

Whitmore, R. C. 1977. Habitat partitioning in a community of passerine birds. Wilson Bull. 89(2):253-265.

Wiens, J. A. 1974. Habitat heterogeneity and avian community structure in North American grasslands. Am. Midl. Nat. 91(1):195-213.

Zagata, M. D. 1978. Keynote Address: Management of nongame wildlife--a need whose time has come. Pages 2-4 in Proc. of the workshop management of southern forests for nongame birds. USDA For. Serv. Gen. Tech. Rep. SE-14. Southeast. For. Exp. Stn., Asheville, N.C. 176pp.

Zeedyk, W. D., and K. E. Evans. 1975. Silvicultural options and habitat values in deciduous forests. Pages 115-127 in Proc. symp. on management of forest and range habitats for nongame birds. USDA For. Serv. Gen. Tech. Rep. WO-1. Wash., D.C. 343pp.

APPENDIX

Appendix Table I. Common and scientific names of all bird species observed during the 1977 and 1978 breeding seasons in the general study area, Potts Mountain, Craig County, Virginia.

Common name*	Scientific name*	Category**
Red-tailed hawk	*Buteo jamaicensis*	RA
Broad-winged hawk	*Buteo platypterus*	V
Ruffed grouse	*Bonasa umbellus*	RA
Turkey	*Meleagris gallopavo*	RA
Mourning dove	*Zenaidura macroura*	RA
Yellow-billed cuckoo	*Coccyzus americanus*	RT
Barred owl	*Strix varia*	RA
Ruby-throated hummingbird	*Archilochus colubris*	RT
Pileated woodpecker	*Dryocopus pileatus*	RT
Red-bellied woodpecker	*Centurus carolinus*	V
Hairy woodpecker	*Picoides villosus*	RT
Downy woodpecker	*Picoides pubescens*	RT
Great crested flycatcher	*Myiarchus crinitus*	RT
Acadian flycatcher	*Empidonax virescens*	RT
Eastern wood pewee	*Contopus virens*	RT
Blue jay	*Cyanocitta cristata*	V
Common raven	*Corvus corax*	RA
Common crow	*Corvus brachyrhynchos*	V
Carolina chickadee	*Parus carolinensis*	RT
Tufted titmouse	*Parus bicolor*	RT
White-breasted nuthatch	*Sitta carolinensis*	RA
Carolina wren	*Thryothorus ludovicianus*	RT
Wood thrush	*Hylocichla mustelina*	RT
Blue-gray gnatcatcher	*Polioptila caerulea*	RT
Solitary vireo	*Vireo solitarius*	RT
Red-eyed vireo	*Vireo olivaceus*	RT
Black-and-white warbler	*Mniotilta varia*	RT

Appendix Table I. Common and scientific names of all bird species observed during the 1977 and 1978 breeding seasons in the general study area, Potts Mountain, Craig County, Virginia (continued).

Common name*	Scientific name*	Category**
Worm-eating warbler	*Helmitheros vermivorus*	RT
Chestnut-sided warbler	*Dendroica pensylvanica*	RA
Pine warbler	*Dendroica pinus*	RT
Ovenbird	*Seiurus aurocapillus*	RT
Louisiana waterthrush	*Seiurus motacilla*	V
Brown-headed cowbird	*Molothrus ater*	RT
Scarlet tanager	*Piranga olivacea*	RT
Rose-breasted grosbeak	*Pheucticus ludovicianus*	RT
Indigo bunting	*Passerina cyanea*	RA
American goldfinch	*Carduelis tristis*	V
Rufous-sided towhee	*Pipilo erythrophthalmus*	RT

*According to the American Ornithologists' Union, Committee on Classification and Nomenclature (1957, 1973, 1976).

**RT = Resident species observed on transects.
RA = Species resident in the general study area, but never observed on transects.
V = vagrant.

Appendix Table II. Mean, minimum and maximum transect values for 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia.

Variable	Mean	Minimum value	Maximum value
TNSPEC	7.05	3.00	12.00
DIST	3.64	3.03	4.53
DISTCV	54.16	46.21	64.50
THT	14.62	9.43	21.85
THTCV	28.12	19.94	38.34
TDIA	21.23	16.92	28.87
TDIACV	48.26	29.52	68.28
TBA	33.73	19.45	52.75
TPC	76.27	58.75	88.58
TPCCV	11.76	4.44	23.55
CANHT	9.36	6.43	13.00
CANHTCV	27.77	17.80	43.62
PCLT8	11.18	0.00	27.08
PC11	20.83	0.00	58.33
PC14	23.14	2.08	50.00
PC17	15.57	2.08	33.33
PC20	10.75	0.00	31.25
PC23	7.02	0.00	25.00
PC26	6.80	0.00	27.08
PCGT26	4.71	0.00	27.08
TEVRD	9.54	0.00	35.42
TEVDEN	81.26	0.00	330.00
TEVBA	4.31	0.00	24.01
TEVHT	6.85	0.00	14.53
TEVDIA	13.17	0.00	33.44
TDTRD	9.32	0.00	20.83
TDTDEN	73.37	0.00	181.66

Appendix Table II. Mean, minimum and maximum transect values for 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Variable	Mean	Minimum value	Maximum value
TDTBA	1.82	0.00	4.75
TDTHT	8.11	0.00	12.25
TDTDIA	15.83	0.00	28.96
NSPEC	10.74	5.00	15.00
NSTEM	5.28	0.98	12.23
NSTEMCV	90.33	47.38	158.83
HT	1.79	1.48	2.20
HTCV	47.21	32.57	58.13
DIA	1.22	0.90	1.77
DIACV	86.29	65.76	95.97
BA	53.23	9.17	108.29
PC	18.95	4.10	33.71
PCCV	96.64	45.63	204.49
VOL	55.54	13.23	96.98
VOLCV	121.96	45.84	278.99
LT2NO	197.79	30.00	459.00
LT2PC	74.73	53.05	88.84
S3NO	31.53	3.00	71.00
S3PC	12.44	6.38	22.14
S4NO	18.47	4.00	47.00
S4PC	9.19	1.99	17.94
GR4NO	5.89	1.00	18.00
GR4PC	3.64	0.20	11.29
EVRD	22.29	0.00	54.23
EVDEN	1011.51	0.00	3359.38
EVBA	11.43	0.00	32.12
EVHT	1.24	0.00	1.84
EVDIA	0.87	0.00	2.19

Appendix Table II. Mean, minimum and maximum transect values for 80 habitat variables considered in habitat selection analyses of common breeding bird species on Potts Mountain, Craig County, Virginia (continued).

Variable	Mean	Minimum value	Maximum value
EVVOL	12.53	0.00	28.74
DTRD	13.86	7.54	22.94
DTDEN	425.58	91.15	833.33
DTBA	12.66	3.04	21.06
DTHT	1.76	1.43	2.37
DTHTCV	44.67	28.47	59.50
DTDIA	1.66	0.97	2.79
DTDIACV	81.32	49.54	103.77
LOG	0.17	0.04	0.44
VITIS	0.05	0.00	0.25
HNSPEC	31.84	22.00	45.00
HPC	31.40	6.85	51.33
HPCCV	64.50	31.18	153.02
HTDOM	48.94	20.00	71.17
HTDOMCV	45.29	21.70	89.01
LITTER	87.96	62.08	99.87
WOOD	6.06	2.85	10.18
ROCK	7.29	0.02	25.04
HTROCK	7.09	0.05	17.64
VOLROCK	18.97	0.01	67.65
SOIL	2.77	0.10	8.23
DUFF	7.28	5.04	10.07
ASPECT	142.90	77.08	199.91
SLOPE	18.19	5.33	28.92
WATER	1.91	1.58	2.00

Appendix Table III. Multiple regression model for predicting relative density of scarlet tanagers, during the breeding season.

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
S3NO	-0.017	0.263	31.31	0.0001	0.035	18
LITTER	0.007	0.466	--	--	--	--
S4NO	0.009	0.502	--	--	--	--
TDTHT	-0.063	0.527	--	--	--	--
S3PC	0.045	0.567	--	--	--	--
PC20	-0.018	0.594	--	--	--	--
PC14	-0.014	0.693	--	--	--	--
BA	0.007	0.965	--	--	--	--
(Constant)	0.104	--	--	--	--	--

Appendix Table IV. Multiple discriminant and regression models for predicting occurrence and relative density of ovenbirds, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
PC23	0.084	0.988	0.211	100	25.68	0.000
(Constant)	-0.068	-9.262	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
HPC	0.009	0.604	44.05	0.0001	0.024	13
PC20	0.006	0.702	--	--	--	--
GR4PC	-0.024	0.784	--	--	--	--
TDTRD	-0.616	0.852	--	--	--	--
THTCV	0.623	0.969	--	--	--	--
(Constant)	-0.326	--	--	--	--	--

Appendix Table V. Multiple discriminant and regression models for predicting occurrence and relative density of red-eyed vireos, during the breeding season.

Discriminant model						
Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
CANHT	20.849	17.180	0.363	100	19.31	0.000
EVDEN	0.021	0.019	0.299	--	--	--
(Constant)	-118.708	-82.148	--	--	--	--

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
THT	0.074	0.344	315.63	0.0001	0.027	10
VOL	0.015	0.875	--	--	--	--
DTBA	-0.047	0.994	--	--	--	--
(Constant)	-1.308	--	--	--	--	--

Appendix Table VI. Multiple discriminant and regression models for predicting occurrence and relative density of eastern wood pewees, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
DIST	81.600	69.245	0.560	100	19.33	0.002
TEVRD	-2.169	-1.638	0.493	--	--	--
EVDEN	0.053	0.043	0.338	--	--	--
LT2NO	-0.181	-0.150	0.267	--	--	--
LOG	-44.547	-49.861	0.264	--	--	--
(Constant)	-153.921	-110.734	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
DUFF	0.140	0.774	59.46	0.0001	0.038	11

Appendix Table VI. Multiple discriminant and regression models for predicting occurrence and relative density of eastern wood pewees, during the breeding season (continued).

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
TEVDEN	0.002	0.862	--	--	--	--
EVRD	-0.005	0.962	--	--	--	--
(Constant)	-0.873	--	--	--	--	--

Appendix Table VII. Multiple discriminant and regression models for predicting occurrence and relative density of pine warblers, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
EVDEN	0.014	0.006	0.345	100	19.78	0.000
DTDIACV	0.628	0.507	0.317	--	--	--
EVRD	-0.510	-0.295	0.279	--	--	--
(Constant)	-33.231	-18.598	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
DTRD	0.064	0.760	58.90	0.0011	0.078	7
DTDIA	0.270	0.967	--	--	--	--
(Constant)	-0.831	--	--	--	--	--

Appendix Table VIII. Multiple discriminant and regression models for predicting occurrence and relative density of solitary vireos, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
PC14	0.508	0.207	0.683	100	16.90	0.002
TPCCV	-1.087	-0.514	0.593	--	--	--
EVVOL	1.097	0.611	0.472	--	--	--
PC	0.674	0.297	0.324	--	--	--
(Constant)	-16.342	-5.296	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
LOG	-0.369	0.227	95.17	0.0001	0.020	13
HNSPEC	-0.015	0.282	--	--	--	--

Appendix Table VIII. Multiple discriminant and regression models for predicting occurrence and relative density of solitary vireos, during the breeding season (continued).

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
EVBA	-0.027	0.695	--	--	--	--
TEVBA	0.019	0.944	--	--	--	--
EVVOL	0.010	0.986	--	--	--	--
(Constant)	0.826	--	--	--	--	--

Appendix Table IX. Multiple discriminant and regression models for predicting occurrence and relative density of black-and-white warblers, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
TDTDIA	1.123	0.833	0.720	100	18.16	0.001
DTBA	1.480	0.939	0.574	--	--	--
HTROCK	3.955	2.072	0.453	--	--	--
VOLROCK	-0.886	-0.475	0.298	--	--	--
(Constant)	-29.516	-12.309	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
NSTEMCV	-0.008	0.156	332.94	0.0001	0.008	9
PCCV	0.007	0.937	--	--	--	--

Appendix Table IX. Multiple discriminant and regression models for predicting occurrence and relative density of black-and-white warblers, during the breeding season (continued).

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
NSPEC	-0.011	0.995	--	--	--	--
(Constant)	0.370	--	--	--	--	--

Appendix Table X. Multiple discriminant and regression models for predicting occurrence and relative density of rufous-sided towhees, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
EVVOL	0.755	0.301	0.481	100	24.59	0.000
PC17	1.143	0.582	0.256	--	--	--
TPCCV	0.773	0.423	0.205	--	--	--
(Constant)	-25.928	-6.257	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
PC14	0.009	0.499	192.20	0.0001	0.013	8
S3PC	-0.029	0.741	--	--	--	--
TBA	0.012	0.993	--	--	--	--
(Constant)	-0.089	--	--	--	--	--

Appendix Table XI. Multiple discriminant and regression models for predicting occurrence and relative density of worm-eating warblers, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
EVRD	-0.062	0.955	0.651	94.74	19.82	0.003
HPC	0.596	0.296	0.573	--	--	--
PC20	0.019	-0.648	0.514	--	--	--
EVDEN	0.006	-0.005	0.383	--	--	--
TNSPEC	4.340	6.379	0.306	--	--	--
SLOPE	0.604	0.193	0.243	--	--	--
(Constant)	-33.991	-36.855	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
EVDIA	-0.057	0.345	41.19	0.0002	0.029	11

Appendix Table XI. Multiple discriminant and regression models for predicting occurrence and relative density of worm-eating warblers, during the breeding season (continued).

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
GR4PC	0.035	0.424	--	--	--	--
PC26	-0.023	0.728	--	--	--	--
CANHT	0.089	0.965	--	--	--	--
(Constant)	-0.617	--	--	--	--	--

Appendix Table XII. Multiple discriminant and regression models for predicting occurrence and relative density of brown-headed cowbirds, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
LT2PC	40.638	39.668	0.705	94.74	12.41	0.015
S4PC	6.956	6.173	0.545	--	--	--
PC14	4.560	4.417	0.477	--	--	--
HT	1616.105	1596.253	0.437	--	--	--
(Constant)	-3068.492	-2950.879	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
NSPEC	-0.060	0.403	12.01	0.0325	0.026	13
DUFF	-0.099	0.588	--	--	--	--

Appendix Table XII. Multiple discriminant and regression models for predicting occurrence and relative density of brown-headed cowbirds, during the breeding season (continued).

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
GR4PC	0.063	0.620	--	--	--	--
PC11	-0.002	0.648	--	--	--	--
S4NO	0.024	0.655	--	--	--	--
TEVBA	-0.042	0.784	--	--	--	--
TEVHT	0.043	0.825	--	--	--	--
HT	-0.621	0.877	--	--	--	--
VOLROCK	0.007	0.973	--	--	--	--
(Constant)	1.698	--	--	--	--	--

Appendix Table XIII. Multiple discriminant and regression models for predicting occurrence and relative density of great crested flycatchers, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
DIA	88.325	117.744	0.381	100	23.17	0.000
S3NO	-1.301	-1.808	0.355	--	--	--
PC	3.578	4.704	0.224	--	--	--
(Constant)	-61.627	-105.591	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
TEVRD	-0.002	0.193	30.31	0.0001	0.016	13
LT2PC	0.015	0.316	--	--	--	--
DIA	0.764	0.861	--	--	--	--

Appendix Table XIII. Multiple discriminant and regression models for predicting occurrence and relative density of great crested flycatchers, during the breeding season (continued).

		Regression model				
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
TPC	0.005	0.904	--	--	--	--
VOLCV	-0.0004	0.956	--	--	--	--
(Constant)	-2.220	--	--	--	--	--

Appendix Table XIV. Multiple discriminant and regression models for predicting occurrence and relative density of wood thrushes, during the breeding season.

Discriminant model

Variables	Classification coefficients PRESENT	Classification coefficients ABSENT	Cumulative Wilks' lambda	Model percent correct classification	Model X^2 value	Model P value
PCLT8	-0.880	-0.036	0.666	100	22.96	0.000
DISTCV	2.457	1.757	0.442	--	--	--
BA	0.047	0.210	0.391	--	--	--
TNSPEC	-0.455	1.802	0.297	--	--	--
HTROCK	-0.434	-1.066	0.205	--	--	--
(Constant)	-63.244	-55.299	--	--	--	--

Regression model

Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
THTCV	0.015	0.692	71.83	0.0001	0.023	10

Appendix Table XIV. Multiple discriminant and regression models for predicting occurrence and relative density of wood thrushes, during the breeding season (continued).

Regression model						
Variables	Prediction coefficients	Cumulative r^2	Model F value	Model P value	Standard error of estimate	Number of observations
SLOPE	0.012	0.893	--	--	--	--
TDTBA	-0.028	0.973	--	--	--	--
(Constant)	-0.477	--	--	--	--	--

Appendix Table XV. PRESENT, ABSENT and total means, and Wilks' lambda for each habitat variable included in the "best" discriminant models.

Species	Variable	PRESENT $\bar{x}$	ABSENT $\bar{x}$	Total $\bar{x}$	Wilks' lambda
Ovenbird	PC23	1.60	18.75	7.02	0.211**
Red-eyed vireo	CANHT	10.76	7.80	9.36	0.363**(x)
	EVDEN	549.48	1524.88	1011.51	0.764*
Eastern wood pewee	DIST	3.88	3.31	3.64	0.560**
	TEVRD	4.73	16.15	9.54	0.764*
	EVDEN	736.27	1389.97	1011.51	0.896
	LT2NO	159.18	250.88	197.79	0.887
	LOG	0.21	0.11	0.17	0.711*
Pine warbler	EVDEN	2074.03	391.71	1011.51	0.345**
	DTDIACV	90.18	76.16	81.32	0.770*
	EVRD	38.62	12.76	22.29	0.498**

Appendix Table XV. PRESENT, ABSENT and total means, and Wilks' lambda for each habitat variable included in the "best" discriminant models (continued).

Species	Variable	PRESENT $\bar{x}$	ABSENT $\bar{x}$	Total $\bar{x}$	Wilks' lambda
Solitary vireo	PC14	28.05	12.50	23.14	0.683*
	TPCCV	14.17	6.54	11.76	0.698*(x)
	EVVOL	13.53	10.36	12.53	0.981
	PC	20.84	14.86	18.95	0.893
Black-and-white warbler	TDTDIA	18.76	13.20	15.83	0.720*
	DTBA	14.46	11.04	12.66	0.915
	HTROCK	10.42	4.09	7.09	0.732*
	VOLROCK	27.82	11.00	18.97	0.847
Rufous-sided towhee	EVVOL	21.62	5.92	12.53	0.482**
	PC17	20.31	12.12	15.57	0.695*
	TPCCV	15.94	8.72	11.76	0.695*

Appendix Table XV. PRESENT, ABSENT and total means, and Wilks' lambda for each habitat variable included in the "best" discriminant models (continued).

Species	Variable	PRESENT $\bar{x}$	ABSENT $\bar{x}$	Total $\bar{x}$	Wilks' lambda
Worm-eating warbler	EVRD	13.41	34.50	22.29	0.650**
	HPC	26.79	37.76	31.40	0.870
	PC20	14.96	4.95	10.75	0.764*
	EVDEN	603.69	1572.27	1011.51	0.772*
	TNSPEC	8.09	5.62	7.05	0.829
	SLOPE	20.75	14.68	18.19	0.762*
Brown-headed cowbird	LT2PC	78.14	67.33	74.73	0.705*
	S4PC	8.11	11.53	9.19	0.884
	PC14	27.24	14.24	23.14	0.778*
	HT	1.72	1.94	1.79	0.776*
Great crested flycatcher	DIA	1.09	1.52	1.22	0.381**
	S3NO	38.15	17.17	31.53	0.756*
	PC	21.33	13.78	18.95	0.829

Appendix Table XV. PRESENT, ABSENT and total means, and Wilks' lambda for each habitat variable included in the "best" discriminant models (continued).

Species	Variable	PRESENT $\bar{x}$	ABSENT $\bar{x}$	Total $\bar{x}$	Wilks' lambda
Wood thrush	PCLT8	7.29	15.51	11.18	0.666**
	DISTCV	56.57	51.49	54.16	0.812
	BA	39.03	69.01	53.23	0.703*
	TNSPEC	8.10	5.89	7.05	0.860
	HTROCK	9.71	4.18	7.09	0.795

*Significant at 0.05 level.
**Significant at 0.01 level.
(x)Approximate due to significance of non-homogeneity test.

Appendix Table XVI. Simple r^2 and sign of beta coefficient for each habitat variable included in the "best" regression models.

Species	Variable	Simple r^2	Sign of beta coefficient
Scarlet tanager	S3NO	0.263*	+
	LITTER	0.049	-
	S4NO	0.237*	+
	TDTHT	0.211	-
	S3PC	0.199	+
	PC20	0.081	-
	PC14	0.001	+
	BA	0.139	+
Ovenbird	HPC	0.604**	+
	PC20	0.001	+
	GR4PC	0.220	-
	TDTRD	0.109	-
	THTCV	0.038	-
Red-eyed vireo	THT	0.344	+
	VOL	0.252	+
	DTBA	0.177	+
Eastern wood pewee	DUFF	0.774**	+
	TEVDEN	0.058	-
	EVRD	0.112	-
Pine warbler	DTRD	0.760*	+
	DTDIA	0.046	-

Appendix Table XVI. Simple r^2 and sign of beta coefficient for each habitat variable included in the "best" regression models (continued).

Species	Variable	Simple r^2	Sign of beta coefficient
Solitary vireo	LOG	0.227	-
	HNSPEC	0.145	-
	EVBA	0.008	-
	TEVBA	0.117	+
	EVVOL	0.040	+
Black-and-white warbler	NSTEMCV	0.156	-
	PCCV	0.012	-
	NSPEC	0.014	+
Rufous-sided towhee	PC14	0.499	+
	S3PC	0.066	-
	TBA	0.429	+
Worm-eating warbler	EVDIA	0.345	-
	GR4PC	0.104	+
	PC26	0.0003	+
	CANHT	0.139	+
Brown-headed cowbird	NSPEC	0.403*	+
	DUFF	0.178	+
	GR4PC	0.052	-
	PC11	0.010	-
	S4NO	0.129	+
	TEVBA	0.015	-
	TEVHT	0.133	+
	HT	0.001	+
	VOLROCK	0.173	+

Appendix Table XVI. Simple r^2 and sign of beta coefficient for each habitat variable included in the "best" regression models (continued).

Species	Variable	Simple r^2	Sign of beta coefficient
Great crested flycatcher	TEVRD	0.193	-
	LT2PC	0.003	+
	DIA	0.154	+
	TPC	0.00003	-
	VOLCV	0.005	+
Wood thrush	THTCV	0.692**	+
	SLOPE	0.509*	+
	TDTBA	0.077	+

*Significant at 0.05 level.
**Significant at 0.01 level.

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BREEDING BIRD COMMUNITIES AND HABITAT SELECTION
IN THE APPALACHIAN MOUNTAINS OF SOUTHWEST VIRGINIA

by

Patricia Ann Healy

(ABSTRACT)

Relationships between the breeding bird populations of the southern Appalachian cove hardwood and mixed oak-pine habitat types were studied during the 1977 and 1978 breeding seasons, in Craig County, Virginia. Relationships between habitat structure and bird utilization for each of the 12 most common breeding species were also investigated.

Bird and habitat data were collected within 100 meter x 50 meter transect areas. Eleven transects were located in the mixed oak-pine habitat and 8 in cove hardwood habitat.

Relative density and species diversity of the 2 bird communities were essentially the same. Species composition was similar; however, relative dominance structures of the 2 communities were different. The blue-gray gnatcatcher (*Polioptila caerulea*), red-eyed vireo (*Vireo olivaceus*) and worm-eating warbler (*Helmitheros vermivorus*) exhibited a significant preference for the cove hardwood habitat. The ovenbird (*Seiurus aurocapillus*) exhibited a significant preference for the mixed oak-pine habitat, and the pine warbler (*Dendroica pinus*) and rufous-sided towhee (*Pipilo erythrophthalmus*) were observed exclusively in the mixed oak-pine areas.

The relative density of the singing males was significantly

greater in 1978 than in 1977.

Multiple discriminant and regression analyses were used to analyze species/habitat associations. Eighty habitat components were considered for inclusion in these analyses. The "best" models derived for each species were presented and all were significant at the 0.05 level. Each species' association with the surrounding forest was best characterized by different combinations of habitat components, suggesting that resource division was adequately described through vegetative community structure. Research needs and potential uses for this type of data in nongame bird management were discussed.