HABITAT USE BY NONGAME BIRDS IN CENTRAL APPALACHIAN RIPARIAN FORESTS
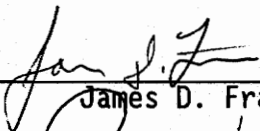
by

Norman L. Murray

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APPROVED:

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Dean F. Stauffer, Chairman

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James D. Fraser

_____

Roy K. Kirkpatrick

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(ABSTRACT)

I sampled bird densities and habitat characteristics along a gradient from a second-order stream to 454 m upland at 16 locations. Total bird density, species richness, and densities of 28 bird species were tested to determine whether riparian habitats influenced bird communities. Total bird density and species richness showed no riparian influence. Acadian flycatchers and Louisiana waterthrushes were closely linked to the streams. Carolina wrens, American robins, and red-eyed vireos showed weaker but positive associations with the streams. Eastern wood-pewees, black-and-white warblers, pine warblers, worm-eating warblers, and scarlet tanagers demonstrated a negative association with streams.

A cluster analysis was used to group the 28 bird species into 5 assemblages based on their distribution among the sampling stations. The species were classified as belonging to the following assemblages: riparian, upland forest, mesic hardwoods, xeric forest, and mature hardwoods generalist. Logistic models were developed to predict the number of species in each assemblage that were present and the presence of each species at each station based on the habitat characteristics at the site. Regression models were developed to predict the relative abundance of each assemblage and species at occupied stations.

clear our minds.

I owe special thanks to Sheila Joann (Hosier) Murray for her understanding, encouragement, and love during the past 3 years. Her long distance support during the first year and constant encouragement for the past 2 years were a great help. She was understanding when I was frustrated and encouraged me to keep trying. And she helped me forget about work and school at times so I could relax. She also helped me collect field data during the fall of both field seasons. I also want to thank our son, Dwight Murray, for arriving and brightening our lives during the past summer.

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Introduction

Riparian areas (habitats along the edge of a stream or river) have been considered as unique habitats for > 30 years. These sites usually support higher wildlife species diversity, densities, and productivity than do neighboring sites (Brown et. al. 1978). This occurs not only because riparian zones are ecotones between aquatic and upland habitats but also because they often have vegetation characteristics distinct from adjacent habitats. Riparian zones usually contain plant species that occur only in close proximity to water. More than 100 plant species are present in New Mexican riparian systems; approximately 40 % of the woody species in these areas are considered to be riparian obligates by Hubbard (1977). Even riparian habitats with the same plant species as upland habitats may be different in structure. Anderson (1980) showed that riparian aspen (<u>Populus tremuloides</u>) stands in Wyoming differed structurally from adjacent aspen stands on mountainsides and valleys. Bull (1978) attributed the unique vegetation structure and diversity of riparian zones to the influence of water. She stated that the mesic soils in riparian zones supported greater plant biomass, more diversity, and allowed faster growth than more xeric drier upland areas.

The unique vegetation structure and plant species diversity are important to many species, including man. Accelerated plant growth makes riparian areas valuable for production of row crops, livestock, timber production, and other agricultural products. In addition, the level terrain characteristic of these areas promotes development for houses and other buildings. Roads and railroads often follow stream courses because of the relatively level and gentle topography.

Riparian habitats provide food, water, and shelter for many wildlife species (Carothers et. al. 1974) and also affect wildlife productivity on adjacent upland sites (Carothers 1977). In some areas, this zone of influence may extend more than several hundred meters beyond the edge of the riparian habitat. Because of these characteristics, riparian habitat, although it accounts for a small proportion of total habitat in many areas, may be the most valuable of all wildlife habitats (Bull 1978).

Riparian habitats contain unique bird communities (Anderson 1980). Many studies have shown that both bird species richness and bird densities
are higher in riparian habitats than in adjacent habitats (Smith 1977, Dickson 1978, Stauffer and Best 1980, Szaro 1980, Tubbs 1980). However, few of these studies give detailed descriptions of the differences between bird assemblages in upland and riparian habitats. Dickson (1978) found breeding bird densities in riparian zones to be 2 to 4 times higher than those in the best upland habitats along the Louisiana-Texas border. Riparian zones may be the only explanation for

the presence of many "woodland" bird species in western Kansas, which may account for 58 % of the breeding species in the area (Tubbs 1980). Wauer (1977) attributed the presence of many eastern bird species in the Rio Grande area to the unique riparian habitats along the river. These habitats also served as refugia to several declining avian species. Riparian habitats also may be critical for migrating birds and winter residents (Stevens et. al. 1977, Szaro 1980).

Studies of forest bird communities have demonstrated that bird densities and species richness are highly correlated with the structure of the vegetation. In general, habitats with highly diverse or complex vegetation structure will have higher bird densities and species richness (MacArthur and MacArthur 1961, MacArthur et. al. 1962, Karr and Roth 1971, Willson 1974, Noon and Able 1978). Although MacArthur and MacArthur (1961) stated that bird species diversity increased with plant species diversity because of the corresponding increase in foliage height diversity, Carothers et. al. (1974) and Holmes et. al. (1979) showed that bird species richness within a site cannot be explained entirely by foliage height diversity. However, they did not state that vegetation structure is not important in determining the bird species present. Riparian habitats have been shown to contain more vegetation structure diversity than upland habitats (Bull 1978, Anderson 1980). This often is the explanation for the observed riparian effects on the bird communities.

In contrast to these studies, McGarigal and McComb (1992) found higher bird species diversity, richness, and densities along transects

400 m from streams than at transects along the stream edges in Oregon. They also found more species to be more abundant in the upland areas than were more abundant in the riparian habitats. More species were recorded exclusively on the upland transects (11 of 33 species) than species detected only along the stream edges (3 of 33 species).

In Maine, Hooper (1991) studied riparian effects in floodplain and "upland riparian" forests. She defined floodplain forests as being deciduous riparian forests that were flat, poorly-drained, and having standing water at some time during the year. "Upland riparian forests" were stream-side forests that were coniferous or deciduous on steeper, well-drained sites and were more similar to nonriparian forests than were the floodplain forests. She found that species richness and total bird abundance decreased with distance from the stream in the floodplain forests but not in the "upland riparian" forests. Therefore, a riparian effect was present in areas having distinct vegetation differences between the riparian and adjacent habitats but not in areas where the riparian effect on vegetation was less pronounced.

The riparian habitats in which bird communities were found to be unique or more dense were of high contrast to the adjacent habitats in vegetation structure. Croplands were adjacent to the forested riparian areas studied by Stauffer and Best (1980). In others, grasslands, shrub, or desert habitats were the adjacent upland habitat types (Tubbs 1980, Emmerich and Vohs 1982, Szaro and Jakle 1985). Therefore, the riparian areas were readily delineated and often contained the only large trees in the area. Under these circumstances, differences in

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bird communities between riparian and adjacent habitats is expected and easily explained. The areas studied by McGarigal and McComb (1992) and Hooper (1991) had forested habitats adjacent to the riparian area. The interfaces between the forested riparian sites and their adjacent habitats were less well defined and, therefore, difficult to identify.

Riparian habitat is important to humans, and much of it has been altered to produce other resources. A major problem for riparian areas is livestock grazing (Carothers 1977). The animals trample and eat the vegetation, possibly causing major habitat changes. Trampling and the resulting reduced vegetation cause increased erosion problems in addition to the decreased habitat value for riparian wildlife. Forested riparian habitats also are destroyed for other agricultural production, conservation of water, and increased transport of flood water. Timber production has altered many riparian habitats (Carothers 1977). As demand for food, water, and timber for human use increases, more pressure will be placed on riparian zones and further deforestation and alteration may occur.

Because of their high structural and species diversity, riparian habitats may be extremely sensitive to alterations (Bull 1978). Lacy et. al. (1975) suggested that riparian habitats are so sensitive that they might be considered a nonrenewable resource. Because vegetation structure and species richness may be so important to bird species richness and density, alterations to these sensitive habitats may have great impacts on the associated wildlife community (Noon and Able 1978).

Although many studies have been conducted on riparian habitats,

most have occurred in the western and central U. S. where water limitations or land use cause the habitats along streams to be more distinct than those in the eastern U. S. Few studies have addressed differences between upland and riparian habitats in detail and even fewer have been conducted in eastern deciduous forests. Information on the importance of these habitats for birds and other wildlife is critical for effective management and assessment of the impact of specific activities.

Because most studies of riparian areas have been conducted in areas with high contrast between riparian and upland habitats, the findings may not be valid in the central Appalachians where, on public lands, the riparian zone and adjacent areas are forested, resulting in a poorly defined edge. McGarigal and McComb (1992) and Hooper (1991) found few differences in bird communities in riparian and upland habitats in areas having forested land adjacent to riparian areas. However, no study has been conducted in the central Appalachian area to determine whether the riparian areas support unique bird communities or are only slightly different from adjacent habitats. This study addresses the differences in vegetation characteristics between riparian and upland forested habitats and describes their influence on the avifauna that is present in hemlock and deciduous habitats in southwestern Virginia.

USDA Forest Service policies concerning riparian zones

Because riparian zones are unique, special policies are employed by the U.S. Forest Service to protect and minimize impact on these areas. The policies discussed here are those set forth in the Jefferson National Forest Land and Resource Management Plan (USDA For. Serv. 1985) and its amendments (USDA For. Serv. 1987).

The Forest Service recognizes four types of riparian habitat:

1. all floodplains, wetlands, springs, lakes, and perennial streams;
2. a minimum of 100 horizontal ft (30.5 m) from a lake shore;
3. a minimum of 100 horizontal ft (30.5 m) from perennial stream banks;
4. a minimum of 50 ft (15.2 m) from each bank of the lower 1,000 ft (304.8 m) (or 50% of length) of intermittent streams flowing into a cold water trout fishery.

For consideration in timber sales and harvesting, streams have been classified as (1) perennial trout streams, (2) perennial non-trout streams, and (3) intermittent streams. Perennial trout streams consist of stocked and native trout streams. Springs and natural seeps also are recognized as having riparian zones.

Clearcutting is not permitted within 100 horizontal ft (30.5 m) of trout streams or within 50 horizontal ft (15.2 m) of all other perennial streams. All timber harvest within the riparian zone must be either single tree or group selection cuts. Because single tree selection is economically inefficient and does not provide sufficient regeneration and growth for the primary timber species, group selection cuts are used (USDA Forest Service 1985). These cuts may not exceed 2 acres (0.81 ha)

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in size with a cutting cycle of 5 to 20 years. A minimum of 12 snags >
20 in. (50.8 cm) dbh per 100 acres (40.5 ha) will be retained in the
cuts. If necessary, trees > 20 in. (50.8 cm) dbh will be killed to
obtain this density.

Filter strips, or buffer zones, are required along all roads and
watercourses. The policies set forth in the Forest Plan Amendments
(1987) require that no more than 5 percent of the ground litter will be
disturbed to exposed soil in these strips along streams. Filter strips
vary from 30 to 290 ft (9.1 to 88.4 m) in width, depending on the slope
and soil erodability of the site.

The width of the riparian habitats defined by the Forest Service
would be more appropriate if they were based on vegetation or bird
community characteristics that are associated with riparian zones. In
some cases, the specified width set forth by the Forest Management Plan
(USDA For. Serv. 1985) may be narrower or wider than the functioning
riparian system. If these zones were delineated based on some
characteristics of the riparian biota, these sensitive systems could be
better managed and protected. This study describes riparian habitats
based on the bird assemblages and vegetation characteristics inherent to
these areas. It will define riparian influence on bird assemblages in
mature forests and will enable management of these habitats to be based
on terrestrial as well as aquatic wildlife.

Objectives

The primary goal of this study was to determine and describe the existence of any riparian influence on avian assemblages in southern Appalachian hardwood and hemlock forests. Specific objectives were to:

1. Estimate species richness and abundance of bird assemblages in selected riparian habitats and their adjacent upland habitats.

2. Describe vegetation structure and species composition in riparian and adjacent upland habitats.

3. Describe bird species abundances and richness in relation to the vegetation present along the moisture gradient described by riparian and upland habitats.

4. Evaluate the Forest Service policies for riparian zones in the Jefferson National Forest as stated in the Jefferson National Forest Land and Resource Management Plan (USDA For. Serv. 1985) and its amendments (USDA For. Serv. 1987) and recommend monitoring techniques for bird species exhibiting a riparian influence.

Study area

The study area consisted of the Blacksburg, New Castle, and Glenwood ranger districts of the Jefferson National Forest in Montgomery, Giles, Craig, Botetourt, and Rockbridge counties in southwestern Virginia (Fig. 1). The forest is in the Ridge and Valley Province of the Blue Ridge mountains of the Appalachian mountain range (Bailey 1976) and is dominated by oak and oak-hickory forests. Elevation of the study sites ranged from 1426 m (1560 feet) at the lowest riparian site to 2560 m (2800 feet) at the highest upland site. The average monthly temperature at the weather station in Lynchburg, Virginia for 1971-1980 ranged from a low of 1.3 C in January to 24.1 C in August (U.S. Dept. of Commerce 1989). Precipitation averaged 117.2 cm per year.

Common overstory species were white oak (scientific names of overstory and understory trees and shrubs are in Appendices A-C), chestnut oak, scarlet oak, pignut hickory, and mockernut hickory. Virginia pine occurred on ridges and white pine was common along streams and moist slopes. Eastern hemlock occurred along streams and yellow poplar and cucumber magnolia occurred in moist areas.

Common understory trees included flowering dogwood, red maple,
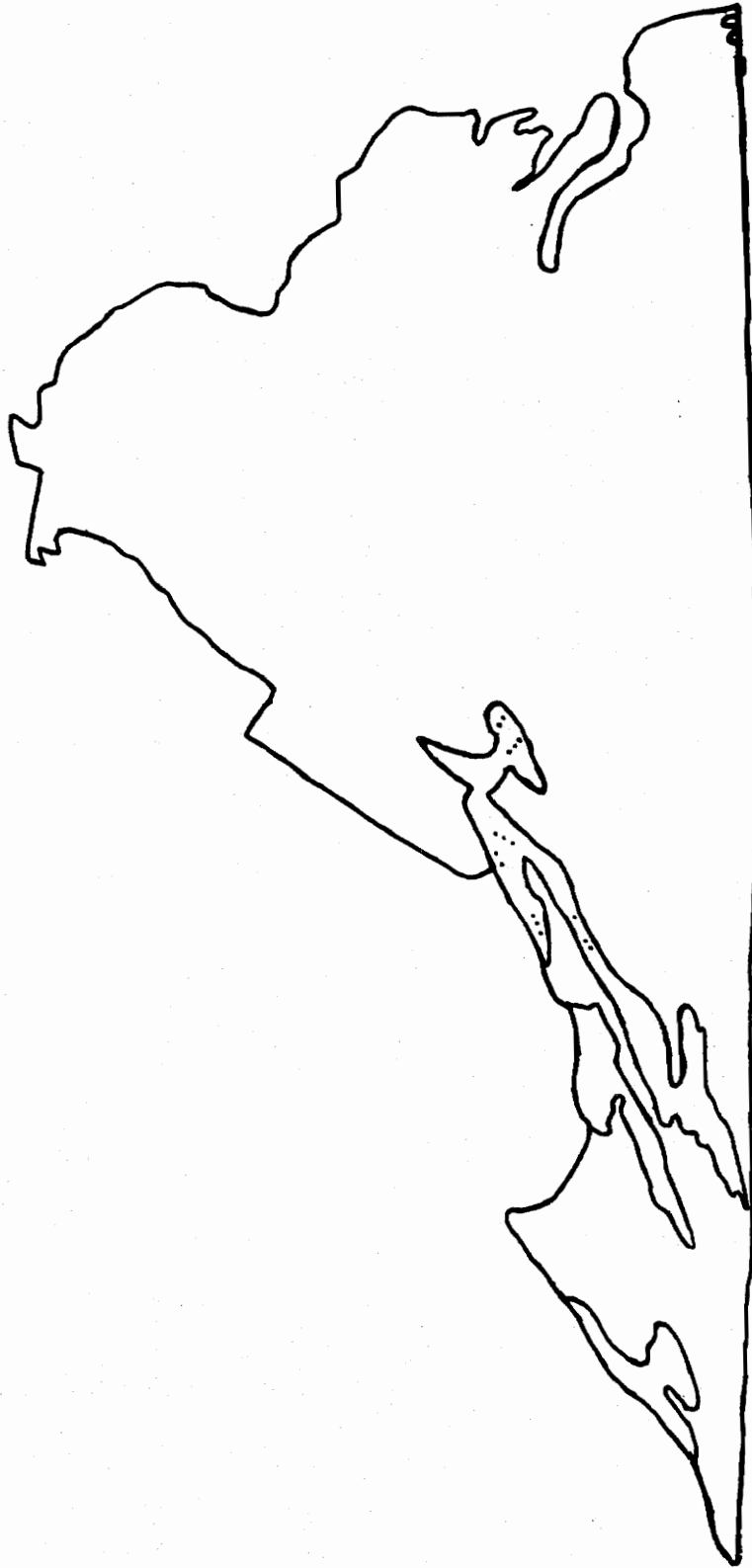
Fig. 1. Locations of 16 study sites along streams in the Jefferson National Forest in southwestern Virginia that were sampled during 1990-1991.

Study area

serviceberry, chestnut, black gum, and sourwood. Eastern hemlock and great rhododendron were common along streams. Common shrubs were mountain laurel, greenbriar, blueberry, and huckleberry.

Methods

Sampling design

I randomly selected 16 sites having riparian areas wide enough ($\geq$ 60 m total width) for bird censusing on the Jefferson National Forest for study. Only areas with mature (> 50 years) second growth forest were used. Study sites were located in areas dominated by hemlock ($\underline{n}$ = 7) or deciduous forests ($\underline{n}$ = 9) along streams; deciduous hardwood forest dominated upland sites. Sites were > 300 meters apart to ensure independence of the bird censuses; only 2 sites were close enough to warrant measurement. Eight second-order streams were sampled (Table 1).

Bird sampling

I sampled diurnal birds at each of the 16 study sites using the variable circular-plot method (Reynolds et. al. 1980). A series of 4 stations at 150 m intervals was located at each of the 16 study sites. The first station was placed 4 m from the stream edge to decrease the effect of stream noise. The remaining 3 stations were placed along a transect perpendicular to the stream edge (Fig. 2). A first-order stream was located near (< 300 m) the station located 454 m from the

Table 1. Distribution of study sites among U.S. Forest Service ranger districts on the Jefferson National Forest, and second-order streams on which birds and vegetation were sampled in 1990-1991.

Ranger district	Stream	Number of sites
Blacksburg	Craig Creek	1
	Poverty Creek	2
	Stony Creek	3
Glenwood	Apple orchard Creek	1
	Elk Creek	2
	North Creek	2
New Castle	Barbour's Creek	3
	Pott's Creek	2
Total		16

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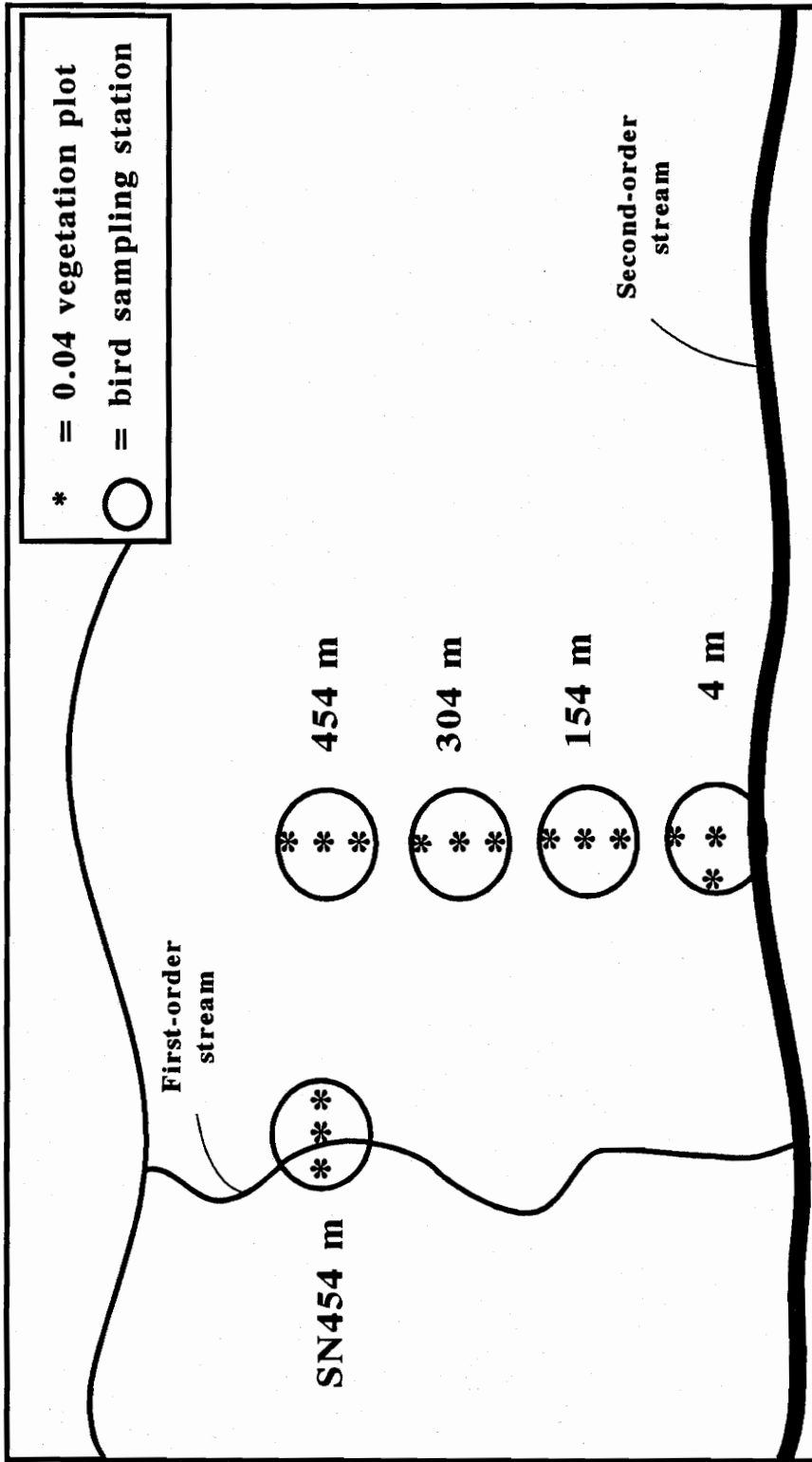
Fig. 2. Design of sampling stations along a riparian-upland gradient at which birds and vegetation characteristics were sampled in southwestern Virginia in 1990-1991.

primary stream at 5 sites; I placed a station on these streams near the 454 m station ("SN454 m" in Fig. 2) to assess whether riparian effects were evident on these streams. Diurnal birds were sampled at 69 stations.

I sampled birds at each station 6 times per year (excepting 2 sites that were sampled 5 times in 1991 because the mid-July deadline for census completion arrived before the site could be censused a sixth time) from mid-May through mid-July during 1990 and 1991. Censusing began within 30 minutes after sunrise and was usually completed by 0930 hours (see Robbins 1981a, Skirvin 1981). No censusing was conducted later than 1030 hours. Censuses were not conducted during periods of rain or winds > 13 km/hour (see Robbins 1981b, Skirvin 1981).

I conducted all the censuses during the 2 years. Following a 1-minute resting period after arriving at the station, all birds seen or heard during an 8-minute listening period were recorded by 10 m distance classes from the station center. Only birds estimated to be within 70 m of the station center were recorded to ensure independence among the sampling stations.

An index of bird abundance was calculated from the census data for each of the 69 stations for hypothesis testing and modelling. Observations of birds within 60 m of the station center were averaged over the 12 visits (11 visits for 2 sites) to produce an average number of birds observed per visit. This was done for each species and all species combined at each station. I used this index because sample

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sizes were too small to calculate a reliable density for each station (Burnham et. al. 1980).

Vegetation sampling

I measured habitat characteristics in 3 0.04 ha plots at each of the stations used for sampling birds. One plot was centered at the station center and the other 2 were placed either 36 m from the station center toward or away from the stream (Fig. 2). Values for habitat variables measured were averaged over the 3 samples taken at each station, which constitutes the basic sampling unit.

Because of the presence of the stream, placement of vegetation sampling plots was modified for the streamside station. The center vegetation sampling plot was placed 11.3 m from the stream edge to avoid sampling in the open stream. The upland 0.04 ha plot was located 36 m upland from the center of the center vegetation plot, i.e. 47.3 m from the stream edge. The plots normally located 36 m toward the stream from the station center were located randomly 36 m to the right or left of the station.

Vegetation sampling plots in the station on the first-order stream 450 m from the primary stream were placed along a line passing through the station center and the upland station 450 m from the stream. One 0.04 ha plot was centered at the station center and the other 2 were 36 m toward and away from the upland station 450 m from the primary stream.

Most of the vegetation variables were measured as described by

James and Shugart (1970) and Noon (1981). Snags and overstory and understory trees were tallied by species and placed into the following diameter categories: 3 - 8 cm, 8 - 15 cm, 15 - 23 cm, 23 - 38 cm, 38 - 53 cm, 53 - 69 cm, 69 - 84 cm, 84 - 102 cm, and > 102 cm dbh (Noon 1981). Dominant and codominant trees were defined as "overstory" (Sharpe et. al. 1986). Understory trees were identified by being completely overtopped by the upper canopy. Four 11.3 m transects at right angles were marked in each plot. Overstory and understory canopy cover, shrub cover < 1 m in height, and ground cover (including litter) were sampled with a sighting tube at 5 points along each transect. Density of small stems < 3 cm dbh and > 1 m tall were sampled along the transects as described in Noon (1981) except that a 2 m rod was held at breast height rather than using outstretched arms. This allowed more standardized measurements of small stem density. Overstory and understory height and average slope were measured with a clinometer. The number of foliage layers present (short ground layer, shrub layer, tall shrubs and short understory, tall understory or subcanopy, and overstory layer) was estimated ocularly. Distance from the primary stream to the center of the 0.04 ha plot was recorded.

Ground cover of various plant types was measured in 4 1 m^2 plots placed 5 m from the center of the vegetation plot on each of the transects in the vegetation sampling plots used for estimating small stem density. Coverage classes (0 - 1 %, 1 - 5 %, 5 - 25 %, 25 - 50 %, 50 - 75 %, 75 - 95 %, and 95 - 100 %) (Mueller-Dombois and Ellenberg 1974) were recorded for club mosses, ferns, legumes, teaberry

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(Gaultheria procumbens), other forbs, panic grasses (Panicum spp.),
rushes (Juncaceae), sedges (Carex spp.), and other grasslike plants.
The cover class midpoints of each vegetation type were averaged in the
0.04 ha plot and then averaged for the station.

Combining vegetation characteristics

Because of the high number of habitat variables recorded at each
station (n = 200), analyses to determine habitat response by bird
species would be difficult. Therefore, I combined vegetation variables
into 31 composite variables representing specific habitat
characteristics. To accomplish this, I first separated variables
describing the overstory and understory tree layers into 2 groups.
Basal areas were not included in the analyses because of the high
correlation of basal area with tree density. Principle components
analyses (Digby and Kempton 1987) were conducted on each variable group.
Species with low importance (factor loadings < absolute value 0.45 and
0.40 for overstory and understory variables respectively) in the first 4
components were removed from further analyses (Fig. 3).

Variables retained in the analyses in each group were submitted to
a second principle component analysis. Variables correlated with the
first 4 components with an absolute value < 0.5 were removed as in the
previous step.

Principle component analysis then was conducted on all of the
remaining habitat variables combined. Habitat variables for the

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200 vegetation variables
measured.

Variables describing
the understory
layer

Variables
describing the
overstory layer

Conducted principle
component
analyses to identify
variables not
important in
explaining variation
in the data set.

Conducted principle
component
analyses to identify
variables not
important in
explaining variation
in the data set.

If
factor
loading
<
|0.40|
then
remove
from
data
set.

Conducted
a second
principle
component
analysis
and
retained
variables
with factor
loadings >
|0.5|.

Conducted
a second
principle
component
analysis
and
retained
variables
with factor
loadings >
|0.5|.

If
factor
loading
<
|0.45|
then
remove
from
data
set.

Principle component analysis
conducted on all remaining
variables and variables with
similar loadings were
combined.

31 composite vegetation variables

Fig. 3. Process used in combining vegetation variables measured in
southwestern Virginia during 1990-1991 into composite variables
describing specific habitat characteristics for use in
describing habitat use by birds.

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overstory and understory were combined into composite variables based on similar factor loadings on the first 7 components. Variables with similar scores on a component were assumed to represent similar habitatsor habitat characteristics and were combined to form a new variable describing that structure type. The new variables were formed by summing the densities of the tree species having similar factor loadings (Table 2). Tree species not grouped by the principle component analyses but that were correlated and occurred together (pers. observ.) were combined.

Analyses

Location differences

The null hypothesis that abundance indices of each bird species, total bird abundance (i.e. sum of all species), bird species richness, and vegetation variables did not differ with distance from the stream was tested with Friedman's test (Hollander and Wolfe 1973) with A Nonparametric Statistical Package (NPSP) (Pirie 1988). The Friedman's test was used because it makes no assumptions concerning data distributions (i.e., it does not assume the data are from a normal distribution). Distance from the stream was used as the treatment and sites were used as blocks to account for as much variation in the data as possible. The 5 stations located on first-order streams were not included because of the unequal sample size generated. Differences were

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Table 2. Vegetation variables used in analyses to describe habitat differences between riparian and upland areas and to describe habitat use by birds in southwestern Virginia.

Variable	Definition
White oak overstory density	overstory density (#/ha) of white oak
Serviceberry understory density	understory density (#/ha) of serviceberry
Rhododendron density	understory density (#/ha) of greater rhododendron > 3 cm dbh
Small stem density	density (#/ha) of stems < 3 cm dbh
Total overstory density	density (#/ha) of overstory trees
Total overstory basal area	basal area (m^2/ha) of overstory trees
Total understory density	density (#/ha) of understory trees
Total understory basal area	basal area (m^2/ha) of understory trees
Mesic hardwood overstory density	overstory density (#/ha) of sweet birch, tulip poplar, cucumber magnolia, and sycamore
Mesic hardwood understory density	understory density (#/ha) of sweet birch, American beech, tulip poplar, and cucumber magnolia
Xeric overstory density	overstory density (#/ha) of Virginia pine, scarlet oak, chestnut oak, and black oak
Xeric understory density	understory density (#/ha) of American chestnut, Allegheny chinkapin, black gum, scarlet oak, chestnut oak, black oak, and sassafras
Snag density	density (#/ha) of all snags $\geq$ 10 cm dbh
Hemlock density	density (#/ha) of overstory and understory hemlock

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Table 2. (continued)

Group name	Definition
Mesic mixed understory density	understory density (#/ha) of red maple, sugar maple, flowering dogwood, roundleaf dogwood, sourwood, white pine, and white oak
Striped maple/hornbeam density	understory density (#/ha) of striped maple and hornbeam
Overstory canopy height	overstory height (m)
Understory canopy height	understory height (m)
# of foliage layers	number of foliage layers present
% slope	average % slope
% overstory canopy cover	percent overstory canopy cover
% understory canopy cover	percent understory canopy cover
% ground cover	percent ground cover: includes litter, small plants, slash, and logs
% shrub cover	percent cover of shrubs < 1 m in height
% fern cover	percent cover by ferns
% teaberry cover	percent cover of teaberry
% herbaceous cover	percent herbaceous cover-excluding ferns and teaberry
Stream distance	distance from a stream

considered to be significant at $\underline{P} \leq 0.10$. This alpha level was selected because management decisions often must be made with less certainty than researchers are willing to offer (Romesburg 1981). All pairwise comparisons for variables significant in the Friedman's test were conducted with multiple response permutation procedures (MRPP) (Biondini et. al. 1988) using an alpha = 0.05. A smaller alpha level was used in the multiple comparisons to be more conservative when stating which of the 10 pairwise comparisons among stations were significant.

The null hypothesis that abundance indices of each bird species, total bird abundance, bird species richness, and vegetation variables did not differ among the stations at the 5 sites with a station located on a first-order stream was tested with Friedman's test (NPSP) using an alpha = 0.10. Pairwise comparisons for significant variables were tested with MRPP using 0.05 as the alpha level.

The null hypothesis that abundance indices of each bird species, total bird abundance, bird species richness, and vegetation variables at sites with deciduous riparian habitat were not different from those with hemlock riparian habitats was tested with multiple response permutation procedures (MRPP). All sites were classified as having either deciduous or hemlock riparian habitats and a two-sample test was conducted for differences between the 2 classifications with all the distances from the stream combined. Because hemlock was most common near the stream, I also tested the null hypothesis that areas with deciduous and hemlock riparian habitats did not differ at the first two stations (at 4 m and 154 m) or at the remaining stations (at 304 m, 454 m, and the

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first-order stream station near 454 m) in 2 additional tests using MRPP. An alpha = 0.10 was used to determine significance in each of the tests.

Cluster analyses

A cluster analysis (Digby and Kempton 1987) was used to identify bird species exhibiting similar distributions among the 69 sampling stations. Species with similar distributions were assumed to be similar in their habitat use; these species were grouped to form a assemblage, defined here as being a group of species using similar habitats. This definition does not address the manner in which the species use the habitat. The centroid linkage method and the chi-square distance measure were used in the BMDP (Dixon 1983) program P2M, cluster analysis of cases.

Modelling habitat uses by species and assemblages

I developed a 2-step model (Fig. 4) for each species and assemblage to predict presence or absence of the species or assemblage and then to predict relative abundance of the species or assemblage if the model predicted that it would be present based on habitat characteristics. I constructed a data set of the presence or absence of each species at each station. A species was considered to be present at a station if it was recorded at least once during each census season. This definition was used to be more conservative when classifying a

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Predicting presence of a guild or species

Predicting abundance of a guild or species

Use habitat-species presence/absence data matrix to develop a logistic regression model to predict guild (species) presence or absence.

Use habitat-species data matrix to develop a regression model to predict guild (or species) relative abundance.

Predict the number of species in the guild present at the site based on habitat characteristics.
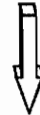
Use linear regression model to predict the relative abundance of the guild (or species) given at least 1 species is present.

If the number of species in the guild is predicted to be 0 then...

If the model predicts that at least 1 species in the guild is present (or a species is present), then estimate the relative abundance of the guild.
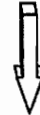
Predicted relative abundance of the guild (or species) at the site of concern based on the habitat characteristics.

End.
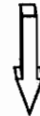
End.

Fig. 4. Conceptual development of the 2-step model for predicting the presence of a species or the number of species in a assemblage that are present, and subsequently, the relative abundance given an outcome of presence based on the habitat characteristics present.

species as being present so that transient or random occurrences would be less likely to be included in the analyses. Also, stations at which a species was present both years may be assumed to be more suitable habitat for the species than stations at which the species was present in only one year. Data for the assemblages were developed by summing the presence data for each species (where "0" denotes the species was absent and "1" denotes it was present). Therefore, the presence or absence models for the assemblages actually predict the number of species in that assemblage that will be present based on the habitat characteristics at the site in question.

Multiple logistic regression (Myers 1986) with presence of the species or assemblage as the dependent variable was used to develop a model to predict the presence of a species or the number of species in a assemblage that would be present. Forward stepwise selection in the LOGIST procedure (SAS Institute Inc. 1989) was used to select habitat variables that were significant ($P \leq 0.05$) in predicting the presence or absence status of the species or the number of species in the assemblage that were present. Percent concordance of the model was used for evaluating the "goodness" of the model.

Relative abundance data at each station for each bird species in a assemblage were summed to produce a relative abundance index of the number of individuals in each guild at the stations. Multiple linear regression (Myers 1986) was conducted on the relative abundance data at stations denoted as having the species or assemblage present in the presence or absence data used in the logistic regression model.

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Therefore, the models predicting relative abundance are conditional models to be used only if the logistic model predicts that the species or assemblage is present. Forward stepwise selection (SAS Institute Inc. 1989) was used to identify habitat variables significant ($P \leq 0.05$) in predicting the relative abundance of the species or assemblage given it was present. The "goodness" of each model was determined by the R^2 and R^2_{PRESS} of the model.

Results

Trends in vegetation characteristics

Relationships to stream distance 4 m to 454 m

White oak overstory density (X^2 = 25.49, 3 df, $\underline{P}$ = 1.2x10^{-5}),
overstory canopy height (X^2 = 11.64, 3 df, $\underline{P}$ = 0.009), understory canopy
height (X^2 = 13.68, 3 df, $\underline{P}$ = 0.003), total overstory basal area (X^2 =
15.08, 3 df, $\underline{P}$ = 0.002), overstory density of mesic hardwoods (X^2 =
25.65, 3 df, $\underline{P}$ = 1.1x10^{-5}) (see Table 2 for definitions of variables),
hemlock density (X^2 = 28.79, 3 df, $\underline{P}$ = 2.5x10^{-6}), and percent herbaceous
cover (X^2 = 9.12, 3 df, $\underline{P}$ = 0.028) were highest near the stream (Table
3). Overstory and understory canopy heights, overstory density of mesic
hardwoods, and percent herbaceous cover steadily declined with
increasing distance from the stream. White oak overstory density,
overstory basal area, and hemlock density declined steadily to 304 m
then increased slightly at 454 m, but the trend was not significant ($\underline{P}$ >
0.05) beyond 154 m. White oak overstory density at 4 m from the stream
differed ($\underline{P}$ > 0.05) from that at stations 304 and 454 m from the stream
(Table 3).

Percent ground cover (X^2 = 11.35, 3 df, $\underline{P}$ = 0.01), percent shrub

Table 3. Mean vegetation characteristics (standard error) at stations at 150 m intervals from 4 m from the stream to 450 m measured in southwestern Virginia during 1990-1991. Sample size was 16 for each distance.

Variable	Sig.[a]	Distance from the stream			
		4 m	154 m	304 m	454 m
White oak overstory density (#/ha)	<0.001	34.9(10.4)A[b]	33.3(10.6)AB	11.5(6.1)B	18.8(11.0)B
Serviceberry understory density (#/ha)	0.574	11.5(5.4)	82.8(46.2)	41.7(19.6)	24.0(9.3)
Rhododendron understory density (#/ha)	0.019	329.2(168.9)A	50.5(35.3)AB	4.2(3.2)B	28.7(24.6)AB
Percent overstory canopy cover	0.027	82(3)	77(4)	77(4)	84(3)
Percent understory canopy cover	0.425	64(4)	52(5)	52(5)	57(4)
Percent ground cover	0.010	92(2)A	95(2)AB	98(1)B	96(2)B
Percent shrub cover	0.043	17(3)A	24(4)AB	37(6)B	39(7)B
Percent fern cover	0.788	3(1)	2(1)	1(1)	1(0)
Percent teaberry cover	0.042	1(0)	3(1)	1(1)	2(1)
Percent herbaceous cover	0.028	10(3)A	4(1)AB	4(1)B	2(1)B
Percent slope	<0.001	11(2)A	38(4)B	33(4)B	28(5)B
Small stem density (#/ha)	0.960	3643(565)	3510(689)	3728(587)	4161(794)
Overstory canopy height (m)	0.009	23.5(1.1)A	21.8(1.6)AB	19.6(1.6)B	18.2(1.3)B
Understory canopy height (m)	0.003	6.7(0.4)A	5.7(0.5)AB	5.3(0.5)B	5.3(0.6)B
Number of foliage layers	0.056	2.4(0.1)A	2.8(0.1)B	2.7(0.1)AB	2.7(0.1)AB
Total overstory density (#/ha)	0.251	435.9(24.6)	441.2(44.2)	478.7(70.6)	556.8(63.6)
Total overstory basal area (m²/ha)	0.002	27.5(1.9)A	21.8(1.4)B	18.7(1.3)B	21.2(1.6)B
Total understory density (#/ha)	0.494	1148.4(192.7)	850.0(104.4)	901.0(108.7)	993.8(99.5)
Total understory basal area (m²/ha)	0.226	4.9(0.6)	3.7(0.4)	4.0(0.7)	4.0(0.4)

Results

Table 3. (continued)

Variable	Sig.	Distance from the stream			
		4 m	154 m	304 m	454 m
Mesic hardwood overstory density (#/ha)	<0.001	87.0(20.3)A	39.6(16.6)B	9.9(6.4)BC	6.8(3.9)C
Mesic hardwood understory density (#/ha)	0.003	51.6(14.5)A	19.3(7.7)AB	11.5(6.1)B	20.8(12.6)AB
Xeric overstory density (#/ha)	0.004	44.3(10.6)A	123.4(33.1)B	183.9(36.2)B	180.7(37.9)B
Xeric understory density (#/ha)	<0.001	54.2(14.7)A	149.5(41.1)B	354.2(76.5)C	415.6(91.9)C
Snag density (#/ha)	0.086	76.0(10.8)A	112.0(16.7)AB	133.3(17.4)B	127.6(13.5)B
Hemlock density (#/ha)	<0.001	249.5(52.0)A	30.2(12.0)B	6.3(2.7)B	8.3(5.3)B
Open understory tree density (#/ha)	0.347	266.2(49.6)	409.4(65.6)	338.5(108.1)	314.6(66.0)
Striped maple/hornbeam density (#/ha)	0.834	25.0(11.2)	24.0(11.4)	18.2(11.4)	47.9(40.9)

[a] Means within a row with different letters are significantly different ($p \leq 0.05$, MRPP).

[b] Significance is based on a Friedman's test.

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cover (X^2 = 8.15, 3 df, P = 0.043), xeric overstory density (X^2 = 13.26,3 df, P = 0.004), xeric understory density (X^2 = 18.50, 3 df, P = 3.5×10^{-4}), snag density (X^2 = 6.58, 3 df, P = 0.086), and percent slope (X^2 = 23.48, 3 df, P = 3.2×10^{-5}) were lowest at the stream edge (Table 3). Percent shrub cover, xeric understory density, and snag density increased with each distance category from the stream, but only xeric understory density increased significantly ($P \leq 0.05$) from 154 m to 454 m. Percent ground cover and xeric overstory density increased to 304 m from the stream and then declined slightly but the trend was not significant from 154 m to 454 m (Table 3). Percent slope did not show any trends from 154 m to 454 m from the stream.

Rhododendron density (X^2 = 9.96, 3 df, P = 0.019) and mesic hardwood understory density (X^2 = 13.94, 3 df, P = 0.003) declined from 4 m to 304 m and then increased at 454 m; however, the 4 m station was significantly different ($P \leq 0.05$) from only the station 304 m from the stream. Overstory canopy cover (X^2 = 9.21, 3 df, P = 0.027) and percent teaberry cover (X^2 = 8.18, 3 df, P = 0.042) were significantly different among distances from the stream but none of the multiple comparisons were significant (P > 0.05). The number of foliage layers (X^2 = 7.57, 3 df, P = 0.056) was lowest near the stream but the station at 4 m was different only from the station at 154 m, so no riparian effect was apparent.

Relationships to first-order streams

When considering only sites where a first-order stream was sampled, white oak overstory density (X^2 = 13.62, 4 df, $\underline{P}$ = 0.009), overstory canopy height (X^2 = 15.20, 4 df, $\underline{P}$ = 0.004), understory canopy height (X^2 = 12.16, 4 df, $\underline{P}$ = 0.016), mesic hardwood overstory density (X^2 = 12.89, 4 df, $\underline{P}$ = 0.012), and mesic hardwood understory density (X^2 = 10.03, 4 df, $\underline{P}$ = 0.040) were highest near the second-order stream (Table 4). Hemlock density (X^2 = 14.07, 4 df, P= 0.007) was highest near the stream but the station 4 m from the stream differed significantly ($\underline{P} \leq$ 0.05) only from the 304 m station. All of these vegetation characteristics exhibited a riparian effect at the first-order stream. For each variable, the 4 m station was not significantly different from the station on the first-order stream, although the station on the first-order stream was not different from the other stations for some of the variables.

Percent ground cover (X^2 = 11.81, 4 df, $\underline{P}$ = 0.019), percent slope (X^2 = 9.50, 4 df, $\underline{P}$ = 0.050), total overstory density (X^2 = 8.48, 4 df, $\underline{P}$ = 0.075), xeric overstory density (X^2 = 7.96, 4 df, $\underline{P}$ = 0.093), and xeric understory density (X^2 = 11.71, 4 df, $\underline{P}$ = 0.02) were greater away from the second-order stream (Table 4). For each variable, excepting slope, the highest value occurred at 454 m from the stream. Only slope and total overstory density did not show a riparian effect (i.e., the station on the first-order stream was different ($\underline{P} \leq$ 0.05) from the station 4 m from the second-order stream).

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Table 4. Mean vegetation characteristics (standard error) at stations from 4 m to a first-order stream near the station 454 m from the second-order stream measured in southwestern Virginia during 1990-1991. Sample size was 5 for each distance.

Variable	Sig.[a]	Distance from the stream				
		4 m	154 m	304 m	454 m	SN454 m[b]
White oak overstory density (#/ha)	0.009	53.3(24.4)A[c]	41.7(26.2)AB	8.3(5.3)AB	1.7(1.7)B	18.3(18.3)AB
Serviceberry understory density (#/ha)	0.843	25.0(15.8)	191.7(127.7)	80.0(55.7)	63.3(20.9)	60.0(32.4)
Rhododendron density (#/ha)	0.211	586.7(457.8)	158.3(103.5)	13.3(9.7)	13.3(13.3)	53.3(20.7)
Percent overstory canopy cover	0.195	80(2)	87(2)	80(5)	88(3)	83(4)
Percent understory canopy cover	0.205	74(3)	50(10)	53(9)	56(7)	62(9)
Percent ground cover (includes litter)	0.019	93(2)A	98(1)AB	98(1)B	100(0)C	96(1)AB
Percent shrub cover	0.155	14(4)	40(10)	47(12)	50(11)	23(5)
Percent fern cover	0.507	1(1)	1(1)	2(1)	1(0)	2(2)
Percent teaberry cover	0.689	1(1)	4(2)	2(1)	4(3)	2(1)
Percent herbaceous cover	0.104	15(7)	4(2)	4(3)	2(1)	6(3)
Percent slope	0.050	15(4)A	40(6)B	30(9)AB	23(10)AB	40(5)B
Small stem density (#/ha)	0.161	4282(1271)	5375(1552)	3755(1241)	6013(1490)	4700(1282)
Overstory canopy height (m)	0.004	23.5(1.9)A	19.0(2.6)AB	18.9(3.4)AB	16.2(2.0)B	25.4(2.8)A
Understory canopy height (m)	0.016	7.5(0.4)A	5.3(1.0)B	5.4(0.8)B	4.2(0.5)B	7.7(1.4)AB
Number of foliage layers	0.624	2.6(0.3)	2.7(0.2)	2.7(0.2)	2.7(0.2)	2.6(0.2)
Total overstory density (#/ha)	0.075	413.3(14.1)A	535.0(131.1)AB	511.7(185.9)AB	716.7(144.0)B	341.7(63.6)B
Total overstory basal area (m²/ha)	0.142	25.4(2.3)	21.6(2.7)	16.2(2.5)	22.8(4.7)	19.1(2.4)
Total understory density (#/ha)	0.865	1460.0(468.2)	956.7(272.0)	968.3(244.6)	1100.0(226.5)	933.3(192.2)
Total understory basal area (m²/ha)	0.451	6.1(1.2)	3.4(1.0)	4.0(1.0)	3.8(0.8)	4.4(1.0)
Mesic hardwood overstory density (#/ha)	0.012	51.7(14.3)A	45.0(43.0)AB	0.0(0.0)B	10.0(10.0)B	48.3(19.4)AB

Results

Table 4. (continued)

Variable	Sig.	4 m	154 m	304 m	454 m	SN454 m²
				Distance from the stream		
Mesic hardwood understory density (#/ha)	0.040	26.7(8.1)A	10.0(10.0)AB	3.3(3.3)B	6.7(3.1)AB	18.3(8.1)AB
Xeric overstory density (#/ha)	0.093	68.3(27.1)AB	181.7(94.8)ABC	205.0(79.7)BC	281.7(64.9)C	71.7(17.8)A
Xeric understory density (#/ha)	0.020	78.3(35.0)A	205.0(114.2)AB	550.0(175.9)B	565.0(138.6)B	166.7(44.8)A
Snag density (#/ha)	0.150	108.3(13.9)	148.3(31.5)	136.7(40.0)	150.0(22.2)	85.0(18.7)
Hemlock density (#/ha)	0.007	198.3(111.5)AB	30.0(22.6)AB	6.7(6.7)A	18.3(16.3)AB	121.7(79.4)AB
Open understory tree density (#/ha)	0.526	296.7(57.7)	291.7(88.8)	233.3(62.6)	191.7(78.0)	360.0(67.8)
Striped maple/hornbeam density (#/ha)	0.256	11.7(5.0)	8.3(6.5)	10.0(6.7)	10.0(10.0)	75.0(31.5)

[a] Significance is based on a Friedman's test.

[b] Station located on a first-order stream near 454 m from the second-order stream.

[c] Means within a row with different letters are significantly different ($P \leq 0.05$, MRPP).

Characteristics of deciduous and hemlock riparian habitats

When all stations were considered, xeric overstory density (delta = -5.23, $\underline{P}$ = 0.002), total overstory density (delta = -3.45, $\underline{P}$ = 0.012), and snag density (delta = -1.55, $\underline{P}$ = 0.078) were higher in areas with deciduous riparian habitats (Table 5). Percent understory canopy cover (delta = -3.30, $\underline{P}$ = 0.014), percent slope (delta = -1.70, $\underline{P}$ = 0.067), understory basal area (delta = -4.86, $\underline{P}$ = 0.003), and hemlock density (delta = -8.15, $\underline{P}$ = 1.8×10^{-3}) were greater in areas with hemlock riparian habitat.

At stations $\leq$ 154 m from the stream, xeric overstory density (delta = -2.98, $\underline{P}$ = 0.013) was higher in deciduous habitats (Table 5). Understory basal area (delta = -1.42, $\underline{P}$ = 0.089) and hemlock density (delta = -8.37, $\underline{P}$ = 1.6×10^{-3}) were higher in hemlock habitats.

At stations > 154 m from the stream, percent shrub cover (delta = -1.64, $\underline{P}$ = 0.070), total overstory density (delta = -3.53, $\underline{P}$ = 0.012), and xeric overstory density (delta = -5.04, $\underline{P}$ = 0.003) were greater in deciduous habitats (Table 5). Percent understory canopy cover (delta = -5.01, $\underline{P}$ = 0.003), understory canopy height (delta = -2.82, $\underline{P}$ = 0.022), percent slope (delta = -2.30, $\underline{P}$ = 0.037), total understory density (delta = -3.77, $\underline{P}$ = 0.009), understory basal area (delta = -7.19, $\underline{P}$ = 1.9×10^{-3}), mesic hardwood understory density (delta = -1.54, $\underline{P}$ = 0.079), and density of mesic mixed understory trees (delta = -1.38, $\underline{P}$ = 0.092) were higher in areas with hemlock riparian habitats.

Xeric overstory density was greater for all 3 tests in areas with

Table 5. Mean vegetation characteristics (standard error) in areas with hemlock or deciduous riparian habitats sampled in southwestern Virginia during 1990-1991.

Variable	All plots combined			Within 154 m of the stream			154 m to SN454 m from the stream		
	Sig.ᵃ	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9
White oak overstory density (#/ha)	0.24	34.4(12.2)	16.2(5.3)	0.29	46.4(14.4)	24.5(9.5)	0.25	25.2(11.7)	9.7(9.2)
Serviceberry understory density (#/ha)	0.23	18.7(7.1)	53.2(25.2)	0.32	17.3(10.8)	70.4(39.3)	0.20	20.4(6.2)	40.3(17.1)
Rhododendron density (#/ha)	0.87	94.1(67.4)	94.7(44.5)	0.85	216.1(165.7)	169.4(83.3)	0.88	11.9(8.8)	27.3(21.5)
Percent overstory canopy cover	0.56	81(4)	79(3)	0.33	79(4)	80(4)	0.81	83(4)	79(4)
Percent understory canopy cover	0.01	49(4)	63(4)	0.68	57(4)	58(5)	<0.01	40(5)	67(4)
Percent ground cover	0.24	96(1)	94(2)	0.74	94(2)	93(2)	0.54	98(1)	96(2)
Percent shrub cover	0.11	34(4)	23(5)	0.68	22(4)	19(3)	0.07	46(7)	27(7)
Percent fern cover	0.54	2(1)	1(1)	0.74	2(1)	2(1)	0.32	2(1)	1(1)
Percent teaberry cover	0.35	1(0)	2(1)	0.15	1(0)	2(1)	0.44	1(0)	2(1)
Percent herbaceous cover	0.30	6(2)	4(1)	0.21	10(3)	5(1)	0.90	4(1)	3(1)
Percent slope	0.07	23(5)	33(3)	0.37	21(3)	27(3)	0.04	24(7)	38(3)
Small stem density (#/ha)	0.57	3213(611)	4169(784)	0.28	2846(723)	4145(811)	1.00	3633(970)	4152(887)
Overstory canopy height (m)	0.71	20.5(1.6)	21.6(1.4)	0.57	23.1(1.3)	22.3(1.5)	0.19	18.1(2.1)	20.9(1.7)
Understory canopy height (m)	0.13	5.3(0.6)	6.3(0.4)	0.72	6.1(0.7)	6.2(0.3)	0.02	4.5(0.6)	6.4(0.6)

Table 5. (continued)

Variable	All plots combined			Within 154 m of the stream			154 m to SN454 m from the stream		
	Sig.[a]	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9
Number of foliage layers	0.60	2.6(0.1)	2.7(0.1)	0.33	2.7(0.2)	2.6(0.1)	0.66	2.6(0.2)	2.7(0.1)
Total overstory density (#/ha)	0.01	560.6(59.7)	391.5(25.4)	0.14	479.2(47.4)	406.9(24.3)	0.01	637.1(76.3)	374.4(45.0)
Total overstory basal area (m²/ha)	0.22	20.4(1.3)	23.6(1.4)	0.42	22.5(1.6)	26.4(2.2)	0.56	18.7(1.5)	20.9(1.4)
Total understory density (#/ha)	0.21	840.0(87.3)	1056.1(112.2)	0.46	1009.5(193.9)	991.2(139.3)	0.01	712.5(32.7)	1111.4(116.0)
Total understory basal area (m²/ha)	<0.01	3.1(0.3)	5.0(0.4)	0.09	3.7(0.6)	4.8(0.4)	<0.01	2.5(0.2)	5.2(0.6)
Mesic hardwood overstory density (#/ha)	0.69	29.6(11.7)	43.0(12.9)	0.57	50.0(19.4)	73.6(21.9)	0.83	11.9(7.7)	13.6(6.5)
Mesic hardwood understory density (#/ha)	0.11	14.5(5.5)	35.3(9.0)	0.48	26.2(10.8)	42.6(11.9)	0.08	3.6(2.5)	28.4(12.9)
Xeric overstory density (#/ha)	<0.01	194.6(28.8)	72.7(15.0)	0.01	131.6(33.4)	46.8(10.0)	<0.01	254.2(34.4)	94.6(21.7)
Xeric understory density (#/ha)	0.30	261.3(49.2)	209.1(65.4)	0.61	126.2(43.7)	82.9(24.7)	0.29	384.3(73.0)	313.0(112.4)
Snag density (#/ha)	0.08	127.6(12.4)	94.7(9.2)	0.39	107.1(19.0)	83.8(7.9)	0.10	148.6(16.7)	105.6(13.5)
Hemlock density (#/ha)	<0.01	18.9(10.2)	122.6(11.2)	<0.01	26.2(19.6)	228.2(17.5)	0.69	10.7(8.5)	24.9(16.9)
Open understory tree density (#/ha)	0.30	295.9(36.2)	372.2(71.1)	0.52	391.7(69.0)	295.8(57.3)	0.09	202.0(48.0)	450.8(126.0)
Striped maple/hornbeam density (#/ha)	0.53	14.8(6.1)	46.9(29.0)	0.87	20.8(12.5)	27.3(13.7)	0.17	7.9(4.6)	64.7(45.1)

[a] Significance is based on an MRPP test.

deciduous riparian habitat. Snag density was greater in areas with deciduous riparian habitats in 1 test and had similar trends in the tests in which it was nonsignificant. Understory basal area was significantly higher in areas with hemlock riparian habitats in all 3 tests. Percent understory canopy cover, percent slope, and hemlock density were significantly higher in areas with hemlock riparian habitats and all showed concordant trends in the tests in which they were nonsignificant.

Trends in relative bird density and species richness

Bird census summary

I recorded a total of 3,864 observations of 62 bird species during the 2-year census period (Appendices D-F). Species with < 20 observations during the 2 years were not included in the analyses because of small sample sizes. The American goldfinch (scientific names are in Appendix G) was not included in the analyses because most observations were of flying birds that were not actually using the habitat. The American redstart was removed from the analyses because of my uncertainty of the accuracy in the identification of this species. Twenty-eight species were used in the analyses.

Red-eyed vireos and ovenbirds were the most commonly recorded species (Table 6). Red-eyed vireos were detected at 65 (94%) stations and ovenbirds were recorded at 64 (93%). Other species occurring at $\geq$

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Table 6. Number of stations (percent) at which each bird species used in the analyses were recorded in southwestern Virginia during 1990-1991.

Species	All plots (69)[b]	Distance from stream				
		4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m[a] (5)
Ruby-throated hummingbird	23 (33)	2 (13)	7 (44)	7 (44)	5 (31)	2 (40)
Downy woodpecker	30 (44)	3 (19)	8 (50)	11 (69)	7 (44)	1 (20)
Pileated woodpecker	25 (36)	2 (13)	7 (44)	7 (44)	9 (56)	0 (0)
Great-crested flycatcher	26 (38)	5 (31)	6 (38)	7 (44)	8 (50)	0 (0)
Eastern wood-pewee	35 (51)	3 (19)	9 (56)	11 (69)	11 (69)	1 (20)
Acadian flycatcher	32 (46)	16 (100)	7 (44)	3 (19)	1 (6)	5 (100)
Blue jay	21 (30)	4 (25)	4 (25)	5 (31)	5 (31)	3 (60)
American crow	20 (30)	5 (31)	6 (38)	4 (25)	2 (13)	3 (60)
Tufted titmouse	41 (59)	11 (69)	9 (56)	8 (50)	11 (69)	2 (40)
Carolina chickadee	44 (64)	12 (75)	10 (63)	9 (56)	9 (56)	4 (80)
White-breasted nuthatch	22 (32)	3 (19)	5 (31)	7 (44)	5 (31)	2 (40)
Carolina wren	18 (26)	6 (38)	2 (13)	5 (31)	3 (19)	2 (40)
Blue-gray gnatcatcher	37 (54)	9 (56)	11 (69)	10 (63)	7 (44)	1 (20)
Wood thrush	30 (44)	8 (50)	6 (38)	7 (44)	8 (50)	1 (20)
American robin	12 (17)	5 (31)	5 (31)	1 (6)	1 (6)	0 (0)
Yellow-throated vireo	38 (55)	7 (44)	5 (31)	12 (75)	11 (69)	3 (60)
Solitary vireo	31 (45)	5 (31)	7 (44)	7 (44)	10 (63)	2 (40)
Red-eyed vireo	65 (94)	14 (88)	16 (100)	15 (94)	15 (94)	5 (100)
Black-and-white warbler	39 (57)	3 (19)	6 (38)	12 (75)	14 (88)	4 (80)
Black-throated blue warbler	10 (15)	4 (25)	2 (13)	2 (13)	2 (13)	0 (0)
Black-throated green warbler	19 (28)	3 (19)	6 (38)	4 (25)	4 (25)	2 (40)
Pine warbler	31 (45)	2 (13)	6 (38)	11 (69)	10 (63)	2 (40)
Hooded warbler	34 (49)	7 (44)	7 (44)	6 (38)	11 (69)	3 (60)
Worm-eating warbler	50 (73)	5 (31)	13 (81)	15 (94)	13 (81)	4 (80)

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Table 6. (continued)

All plots	4 m (69)[b]	Distance from stream				Species
		154 m (16)	304 m (16)	454 m (16)	SN454 m[a] (16)	(5)
Ovenbird	64 (93)	15 (94)	16 (100)	15 (94)	14 (88)	4 (80)
Louisiana waterthrush	25 (36)	15 (94)	7 (44)	0 (0)	0 (0)	3 (60)
Rufous-sided towhee	16 (23)	2 (13)	4 (25)	4 (25)	5 (31)	1 (20)
Scarlet tanager	59 (86)	12 (75)	14 (88)	14 (88)	15 (94)	4 (80)

[a] Station on a first-order stream near the station 454 m from the second-order stream.

[b] Sample size.

35 (51%) stations were the eastern wood-pewee, tufted titmouse, Carolina chickadee, yellow-throated vireo, black-and-white warbler, worm-eating warbler, and scarlet tanager. American robins, black-throated blue warblers, and rufous-sided towhees occurred at $\leq$ 17 (25%) stations. Breeding species recorded during the study but not included in the analyses because they were recorded < 20 times were green heron, turkey vulture, sharp-shinned hawk, red shouldered hawk, broad-winged hawk, red-tailed hawk, ruffed grouse, eastern wild turkey, mourning dove, yellow-billed cuckoo, barred owl, eastern screech-owl, belted kingfisher, red-bellied woodpecker, northern flicker, hairy woodpecker, eastern phoebe, northern raven, cedar waxwing, northern parula, prairie warbler, rose-breasted grosbeak, northern cardinal, indigo bunting, song sparrow, brown-headed cowbird, common grackle, and summer tanager.

Relationships to stream distance 4 m to 454 m

Acadian flycatchers (X^2 = 40.32, 3 df, $\underline{P}$ = 9.1x10^{-9}), American robins (X^2 = 7.13, 3 df, $\underline{P}$ = 0.068), and Louisiana waterthrushes (X^2 = 39.60, 3 df, $\underline{P}$ = 1.3x10^{-8}) were present in highest numbers near the stream edge (Table 7). Acadian flycatchers occurred at progressively lower densities at greater distances from the stream (Fig. 5). The robin occurred most frequently at stations 4 m from the stream but this was not significantly different ($\underline{P}$ > 0.05) than the abundances at 154 m and 454 m. Louisiana waterthrushes occurred at a lower frequency at 154

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Table 7. Mean relative bird abundances[a] (standard error) at each station from 4 m from the stream to 454 m from the stream sampled in southwestern Virginia during 1990-1991. Sample size was 16 for each distance.

Variable	Sig.[b]	Distance from the stream			
		4 m	154 m	304 m	454 m
Ruby-throated hummingbird	0.053	0.01(0.01)A[c]	0.07(0.03)B	0.05(0.02)B	0.03(0.01)AB
Downy woodpecker	0.049	0.04(0.03)A	0.06(0.02)AB	0.11(0.03)B	0.07(0.02)AB
Pileated woodpecker	0.103	0.02(0.01)	0.05(0.02)	0.05(0.02)	0.05(0.01)
Great-crested flycatcher	0.633	0.05(0.02)	0.10(0.04)	0.07(0.02)	0.10(0.03)
Eastern pewee	0.010	0.02(0.01)A	0.14(0.06)B	0.18(0.06)B	0.16(0.05)B
Acadian flycatcher	<0.001	0.86(0.09)A	0.14(0.06)BC	0.04(0.03)BC	0.01(0.01)C
Blue jay	0.702	0.05(0.02)	0.05(0.03)	0.07(0.04)	0.05(0.02)
American crow	0.190	0.07(0.04)	0.05(0.02)	0.04(0.02)	0.01(0.01)
Tufted titmouse	0.555	0.15(0.04)	0.09(0.03)	0.09(0.03)	0.17(0.04)
Carolina chickadee	0.184	0.13(0.03)	0.16(0.04)	0.08(0.03)	0.12(0.04)

Table 7. (continued)

Variable	Sig.	Distance from the stream			
		4 m	154 m	304 m	454 m
White-breasted nuthatch	0.509	0.03(0.02)	0.09(0.03)	0.08(0.03)	0.08(0.04)
Carolina wren	0.105	0.06(0.03)	0.01(0.01)	0.04(0.02)	0.04(0.02)
Blue-gray gnatcatcher	0.468	0.16(0.05)	0.20(0.06)	0.14(0.06)	0.10(0.04)
Wood thrush	0.517	0.15(0.06)	0.07(0.02)	0.05(0.02)	0.05(0.02)
American robin	0.068	0.09(0.05)A	0.04(0.02)AB	0.01(0.01)B	0.02(0.02)AB
Yellow-throated vireo	0.038	0.11(0.05)AB	0.04(0.02)A	0.09(0.02)B	0.12(0.03)B
Solitary vireo	0.185	0.06(0.03)	0.06(0.02)	0.09(0.04)	0.19(0.06)
Red-eyed vireo	0.057	0.59(0.09)	0.73(0.10)	0.53(0.11)	0.47(0.08)
Black-and-white warbler	<0.001	0.04(0.03)A	0.08(0.03)AB	0.15(0.04)BC	0.21(0.04)C
Black-throated blue warbler	0.226	0.15(0.10)	0.10(0.08)	0.01(0.01)	0.02(0.01)
Black-throated green warbler	0.051	0.03(0.02)	0.16(0.07)	0.09(0.05)	0.09(0.05)

Table 7. (continued)

Variable	Sig.	Distance from the stream			
		4 m	154 m	304 m	454 m
Pine warbler	<0.001	0.01(0.01)A	0.07(0.03)B	0.15(0.04)B	0.25(0.07)B
Hooded warbler	0.129	0.06(0.02)	0.10(0.04)	0.08(0.03)	0.14(0.05)
Worm-eating warbler	<0.001	0.04(0.02)A	0.28(0.07)B	0.32(0.06)B	0.30(0.06)B
Ovenbird	0.170	0.36(0.11)	0.61(0.11)	0.63(0.12)	0.68(0.14)
Louisiana waterthrush	<0.001	0.40(0.07)A	0.05(0.02)B	0.00(0.00)C	0.00(0.00)D
Rufous-sided towhee	0.515	0.02(0.02)	0.03(0.01)	0.04(0.02)	0.04(0.02)
Scarlet tanager	0.041	0.13(0.03)A	0.25(0.04)B	0.26(0.05)B	0.27(0.04)B
Species richness	0.197	11.69(0.80)	13.13(0.90)	13.69(0.96)	13.50(0.76)
Total bird density	0.795	3.80(0.41)	3.77(0.29)	3.45(0.25)	3.68(0.30)

[a] Index is the number of birds seen or heard per station per visit for 1990-1991.

[b] Significance is based on a Friedman's test.

[c] Means with different letters within a row are significantly different at $P \leq 0.05$ (all pairwise comparisons with MRPP).
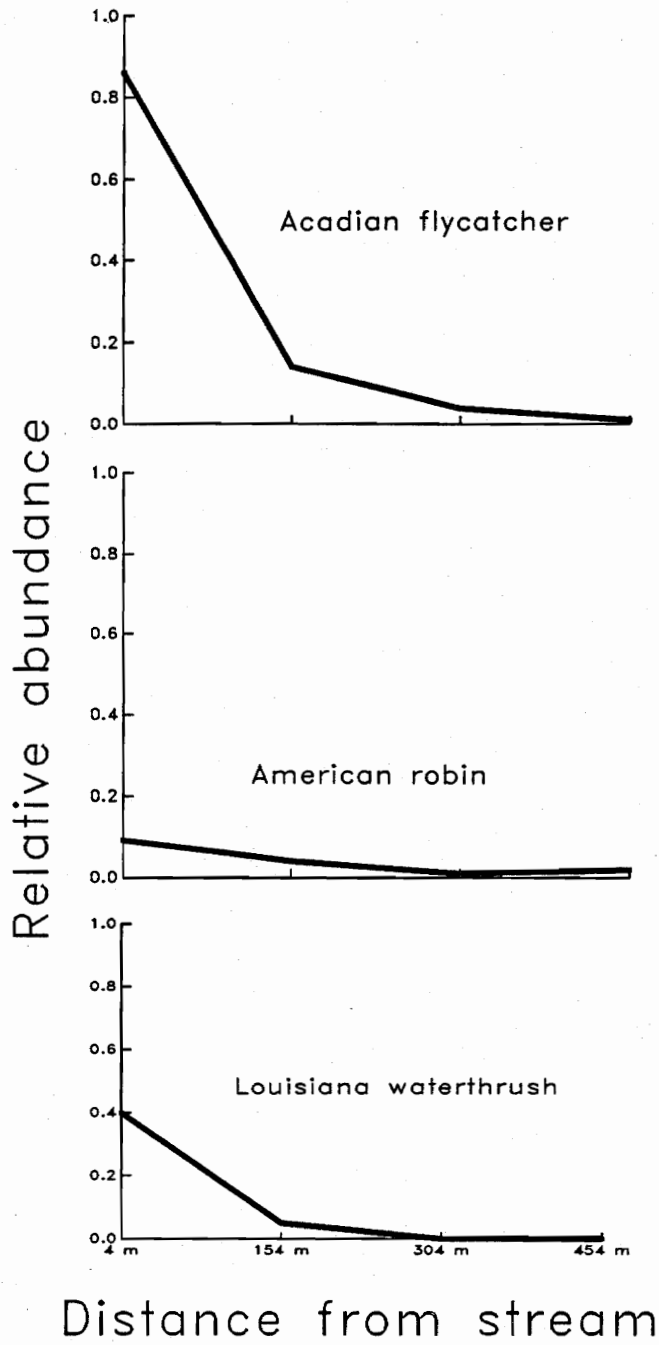
Fig. 5. Mean relative abundances of bird species occurring in greater abundances near the stream edge among stations located 4 m to 454 m from the stream sampled in southwestern Virginia in 1990-1991.

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m than at 4 m from the stream and were not detected at stations > 154 m from the stream (Table 7).

Eastern wood-pewees (X^2 = 11.34, 3 df, $\underline{P}$ = 0.01), black-and-white warblers (X^2 = 19.50, 3 df, $\underline{P}$ = 2.1×10^{-4}), pine warblers (X^2 =16.37, 3 df, $\underline{P}$ = 9.5×10^{-4}), worm-eating warblers (X^2 = 19.87, 3 df, $\underline{P}$ = 1.8×10^{-4}), and scarlet tanagers (X^2 = 8.24, 3 df, $\underline{P}$ = 0.041) were recorded in greater abundances at stations located > 4 m from the stream (Table 7 and Fig. 6). The black-and-white warbler increased steadily in abundance with distance from the stream (Fig. 6). The other species showed no significant trends in abundance among the stations located > 4 m from the stream. However, all but the eastern wood-pewee and worm-eating warbler tended to increase in abundance at each distance from the stream and reached their highest relative abundance 454 m from the stream (Fig 5).

The ruby-throated hummingbird (X^2 = 7.67, 3 df, $\underline{P}$ = 0.053), downy woodpecker (X^2 = 7.89, 3 df, $\underline{P}$ = 0.049), and yellow-throated vireo (X^2 = 8.44, 3 df, $\underline{P}$ = 0.038) differed significantly among the distances from the stream but not in a manner easily attributed to a riparian effect (Fig. 7). Ruby-throated hummingbirds were most common at the 154 m and 304 m plots but these were not different from the 454 m plot and hummingbird abundance at 454 m was not different from the 4 m plot (Table 7). Only the abundance 304 m from the stream was higher than the stream-side station for the downy woodpecker. The yellow-throated vireo showed no apparent pattern with respect to distance from the stream. Although the red-eyed vireo (X^2 = 7.53, 3 df, $\underline{P}$ = 0.057) and

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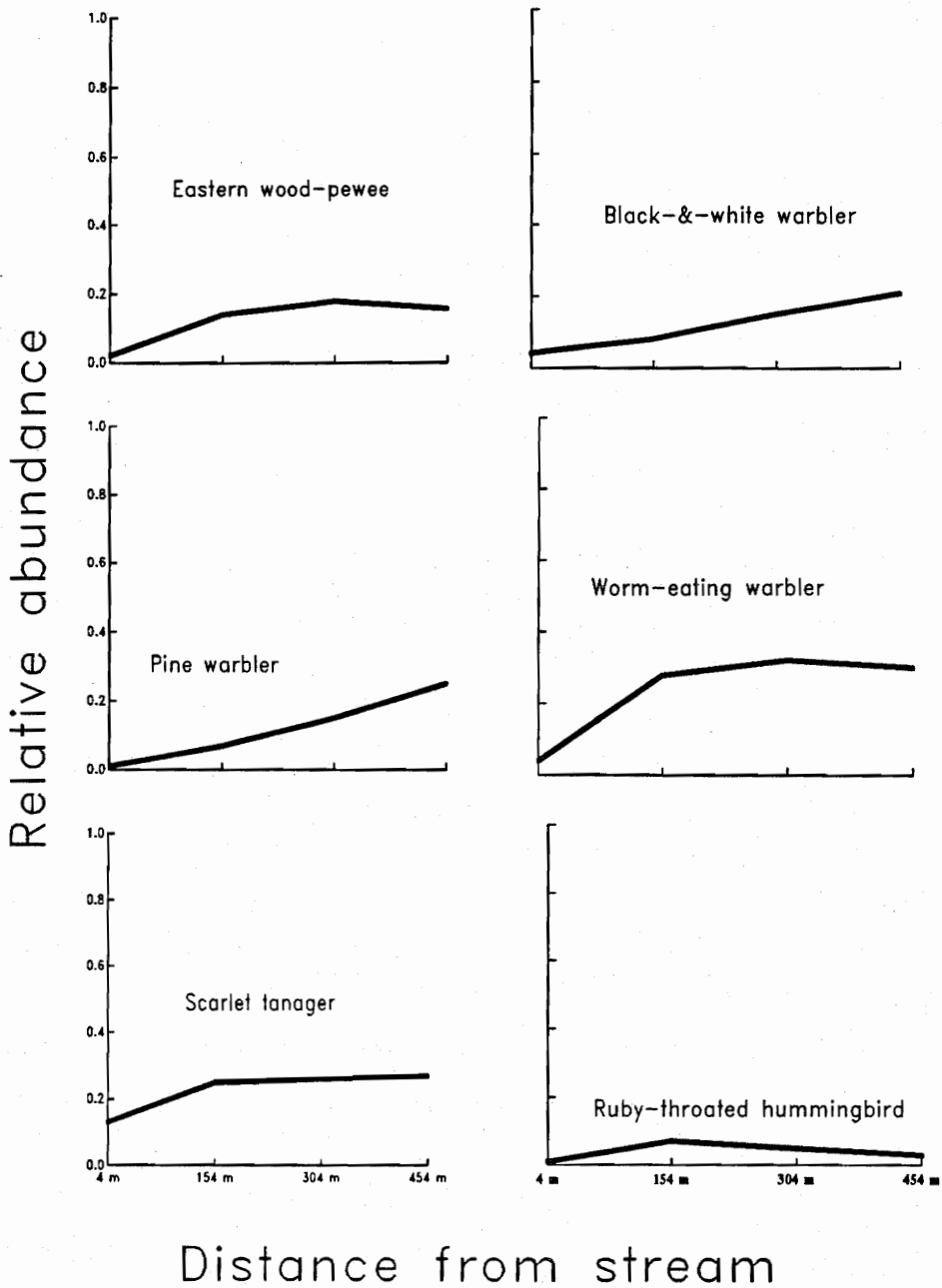
Fig. 6. Mean relative abundances of bird species occurring in greater
abundances away from the stream edge among stations located 4 m
to 454 m from the stream sampled in southwestern Virginia in
1990-1991.

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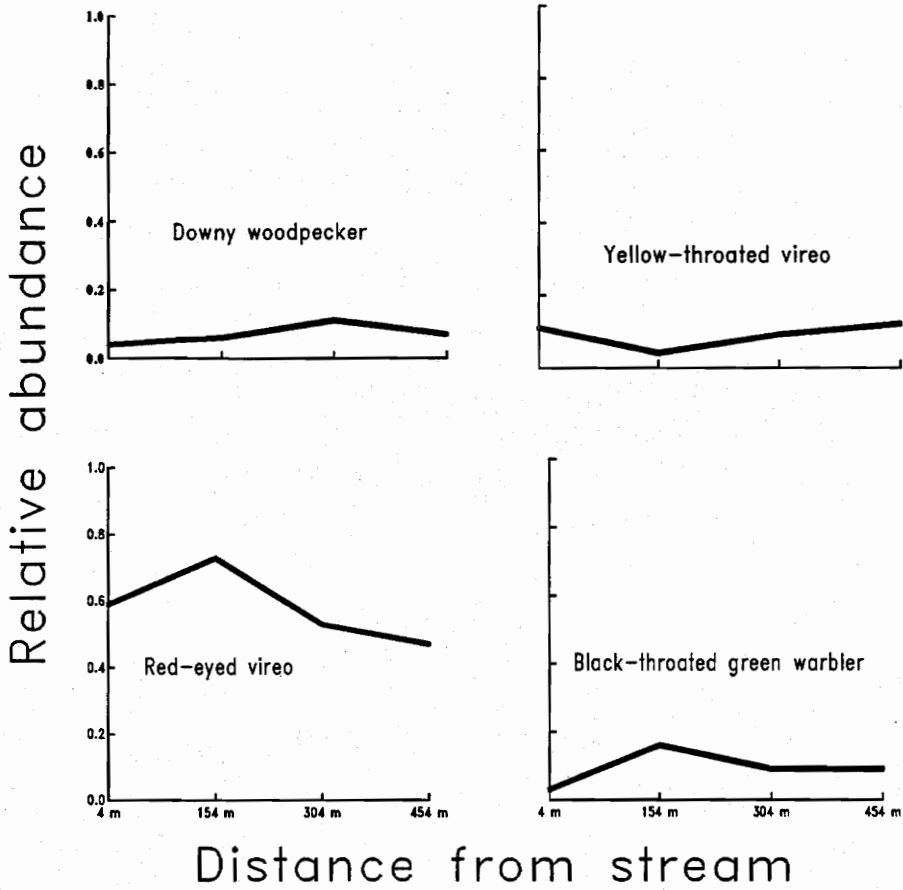
Fig. 7. Mean relative abundances of bird species showing no evident riparian trend among stations located 4 m to 454 m from the stream but were significant among stations sampled in southwestern Virginia in 1990-1991.

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black-throated green warbler (X^2 = 7.78, 3 df, P = 0.051) were significantly different among the distances from the stream none of the pairwise comparisons were significant (P > 0.05).

Relationships to first-order streams

When considering only sites where a first-order stream was sampled, acadian flycatchers (X^2 = 18.23, 4 df, P = 0.001), Carolina wrens (X^2 = 10.00, 4 df, P = 0.04), and Louisiana waterthrushes (X^2 = 16.35, 4 df, P = 0.003) were most common at the riparian plots (Fig. 8). Abundances of acadian flycatchers and Carolina wrens at the stations located 4 m from the stream and on the first-order streams near the 454 m station were different ($P \leq$ 0.05) from the other stations (Table 8) but not from each other. Carolina wrens were detected only at plots near a stream at these 5 sites. Louisiana waterthrushes decreased ($P \leq$ 0.05) from 4 m to 154 m from the stream and were not recorded again except at the station on the first-order stream. Abundances of waterthrushes 154 m from the stream and at the first-order stream were not significantly different ($P \leq$ 0.05) from one another (Table 8).

Eastern wood-pewees (X^2 = 8.50, 4 df, P = 0.075) and black-and-white warblers (X^2 = 10.29, 4 df, P = 0.036) were least common at the station 4 m from the second-order stream (Fig. 8). Pewees were most abundant at 304 m and black-and-white warblers were most abundant at 454 m (Table 8). Both species were lower at the station on the first-order stream than at 4 m but this was not significant. However,
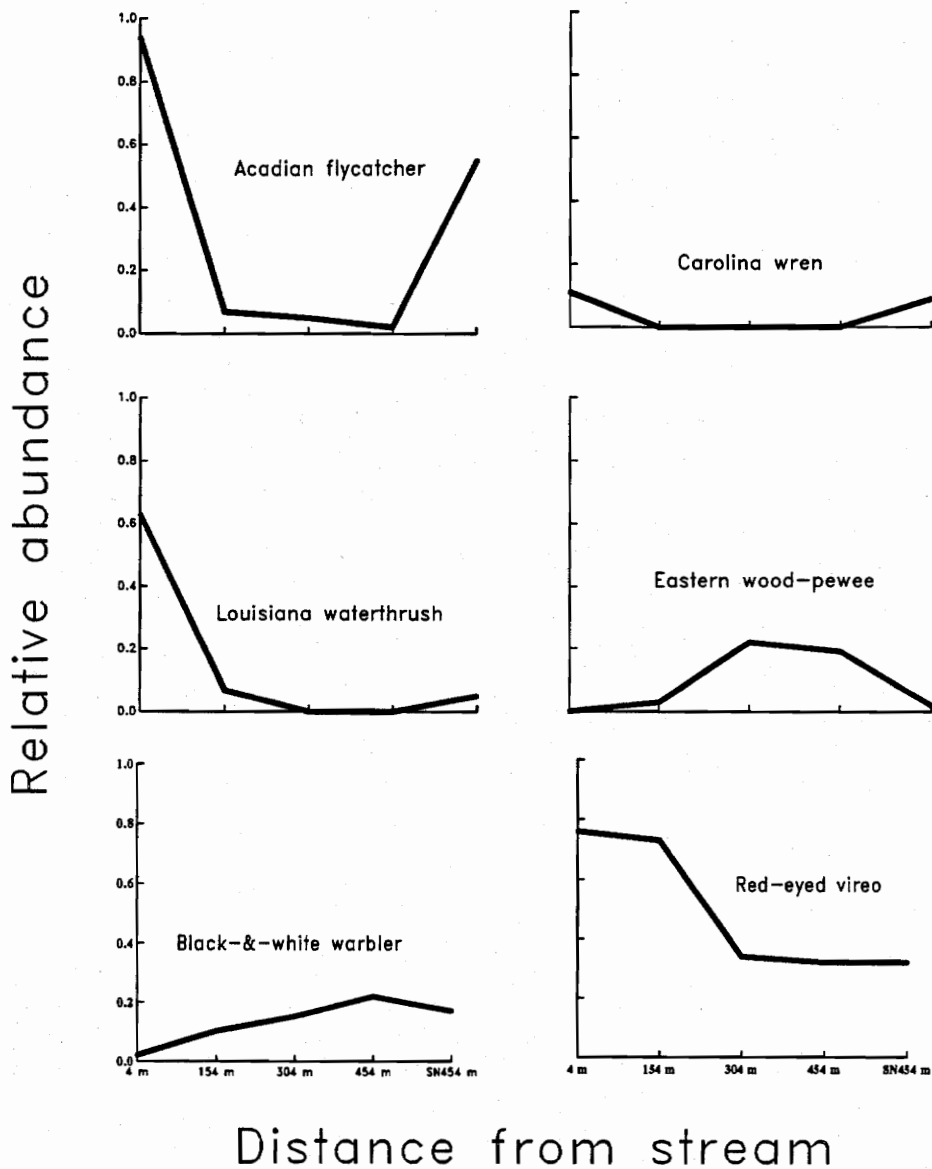
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Fig. 8. Means of bird species at 5 locations showing a riparian trend among stations located 4 m to a first-order stream near 454 m from the primary stream sampled in southwestern Virginia in 1990-1991.

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Table 8. Mean relative bird abundances[a] (standard error) for 5 sampling sites where a fifth station was established on a first-order stream near the 454 m station, Southwestern Virginia, 1990-1991.

Species	Sig.[b]	Distance from the stream				
		4 m	154 m	304 m	454 m	SN454 m[c]
Ruby-throated hummingbird	0.357	0.00(0.00)	0.03(0.03)	0.07(0.03)	0.02(0.02)	0.07(0.04)
Downy-woodpecker	0.895	0.02(0.02)	0.03(0.02)	0.11(0.07)	0.03(0.03)	0.02(0.02)
Pileated woodpecker	0.165	0.02(0.02)	0.05(0.02)	0.07(0.03)	0.02(0.02)	0.00(0.00)
Great-crested flycatcher	0.136	0.07(0.04)	0.23(0.11)	0.05(0.03)	0.07(0.04)	0.00(0.00)
Eastern wood-pewee	0.075	0.00(0.00)A[d]	0.03(0.02)AB	0.22(0.17)B	0.19(0.10)B	0.02(0.02)AB
Acadian flycatcher	0.001	0.94(0.11)A	0.07(0.07)B	0.05(0.05)B	0.02(0.02)B	0.55(0.12)A
Blue jay	0.406	0.03(0.03)	0.03(0.03)	0.10(0.10)	0.00(0.00)	0.07(0.03)
American crow	0.244	0.14(0.11)	0.07(0.04)	0.02(0.02)	0.00(0.00)	0.08(0.05)
Tufted titmouse	0.522	0.19(0.08)	0.05(0.05)	0.03(0.03)	0.07(0.04)	0.10(0.07)
Carolina chickadee	0.525	0.19(0.08)	0.18(0.08)	0.07(0.05)	0.08(0.06)	0.24(0.10)

Table 8. (continued)

Species	Sig.	Distance from the stream				
		4 m	154 m	304 m	454 m	SN454 m[a]
White-breasted nuthatch	0.428	0.07(0.05)	0.00(0.00)	0.04(0.04)	0.11(0.07)	0.05(0.03)
Carolina wren	0.040	0.11(0.07)A	0.00(0.00)B	0.00(0.00)B	0.00(0.00)B	0.09(0.07)AB
Blue-gray gnatcatcher	0.243	0.22(0.09)	0.07(0.05)	0.05(0.03)	0.07(0.03)	0.15(0.15)
Wood thrush	0.657	0.12(0.06)	0.03(0.03)	0.02(0.02)	0.05(0.04)	0.02(0.02)
American robin	0.144	0.09(0.05)	0.07(0.05)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Yellow-throated vireo	0.171	0.02(0.02)	0.02(0.02)	0.07(0.03)	0.03(0.02)	0.17(0.08)
Solitary vireo	0.224	0.02(0.02)	0.03(0.03)	0.07(0.04)	0.18(0.10)	0.05(0.04)
Red-eyed vireo	0.008	0.76(0.18)A	0.73(0.09)A	0.34(0.10)AB	0.32(0.07)B	0.32(0.09)B
Black-and-white warbler	0.036	0.02(0.02)A	0.10(0.05)AB	0.15(0.08)AB	0.22(0.07)B	0.17(0.07)A
Black-throated blue warbler	0.652	0.03(0.03)	0.00(0.00)	0.02(0.02)	0.03(0.03)	0.00(0.00)
Black-throated green warbler	0.615	0.00(0.00)	0.13(0.13)	0.08(0.08)	0.15(0.15)	0.05(0.03)
Pine warbler	0.293	0.03(0.02)	0.12(0.08)	0.19(0.06)	0.35(0.17)	0.23(0.15)

Table 8. (continued)

Species	Sig.[b]	Distance from the stream				
		4 m	154 m	304 m	454 m[c]	SN454 m[a]
Hooded warbler	0.807	0.12(0.05)	0.17(0.11)	0.05(0.05)	0.18(0.14)	0.28(0.14)
Worm-eating warbler	0.175	0.12(0.06)	0.30(0.15)	0.30(0.09)	0.27(0.08)	0.47(0.14)
Ovenbird	0.153	0.37(0.11)	0.74(0.22)	0.82(0.33)	0.92(0.31)	0.35(0.20)
Louisiana waterthrush	0.003	0.63(0.14)A[d]	0.07(0.03)B	0.00(0.00)C	0.00(0.00)C	0.05(0.02)B
Rufous-sided towhee	0.452	0.07(0.05)	0.05(0.03)	0.00(0.00)	0.05(0.03)	0.03(0.03)
Scarlet tanager	0.550	0.12(0.03)	0.24(0.05)	0.25(0.09)	0.18(0.07)	0.19(0.10)
Species richness	0.782	13.60(1.40)	11.60(1.72)	11.00(1.79)	12.00(1.30)	12.60(1.21)
Total bird density	0.285	4.38(0.66)	3.47(0.29)	3.16(0.51)	3.42(0.44)	3.55(0.58)

[a] Index is the number of birds seen or heard per station per visit for 1990-1991.

[b] Significance is based on a Friedman's test.

[c] Station located on a first-order stream near 454 m from the second-order stream.

[d] Means with different letters within a row are significantly different at $P \leq 0.05$ (all pairwise comparisons with MRPP).

their abundances at the first-order streams were not detectably different from their highest levels (Table 8).

Red-eyed vireos declined in abundance (X^2 = 13.78, 4 df, $\underline{P}$ = 0.008) with increasing distance from the stream; but abundances at plots up to 304 m were not significantly different ($\underline{P}$ > 0.05) from one another (Table 8). Red-eyed vireos did not increase in abundance at the first-order stream to levels similar to those found 4 m from the primary stream (Fig. 8). This was the only species differing significantly among distances from the stream for which the plot on the first-order stream was not more similar in abundance to that at the stations at 4 m or 154 m (i.e., did not show a riparian effect at the first-order stream).

Response to deciduous and hemlock riparian habitats

When considering all stations, ruby-throated hummingbirds (delta = -5.44, $\underline{P}$ = 0.002), great-crested flycatchers (MRPP delta = -4.30, $\underline{P}$ = 0.006), white-breasted nuthatches (delta = -2.29, $\underline{P}$ = 0.038), solitary vireos (delta = -2.49, $\underline{P}$ = 0.032), and Louisiana waterthrushes (delta = -1.52, $\underline{P}$ = 0.080) were more abundant in areas with deciduous riparian habitats (Table 9 and Fig. 9). Wood thrushes (delta = -2.071, $\underline{P}$ = 0.044) and black-and-white warblers (delta = -1.39, $\underline{P}$ = 0.093) were more abundant in areas with hemlock riparian habitat.

At stations located $\leq$ 154 m from the stream, ruby-throated hummingbirds (delta = -2.39, $\underline{P}$ = 0.035), pileated woodpeckers (delta =

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Table 9. Mean relative bird abundances[a] (standard error) in areas with deciduous or hemlock riparian habitats sampled in southwestern Virginia during 1990-1991.

Variable	All plots combined			Within 154 m from stream			304 m to N450 m from stream		
	Sig.[b]	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9
Ruby-throated hummingbird	0.002	0.07(0.02)	0.02(0.00)	0.035	0.07(0.02)	0.02(0.01)	0.029	0.07(0.02)	0.02(0.01)
Downy woodpecker	0.728	0.06(0.01)	0.07(0.03)	0.641	0.04(0.01)	0.06(0.04)	0.630	0.08(0.02)	0.09(0.02)
Pileated woodpecker	0.795	0.05(0.02)	0.04(0.01)	0.026	0.07(0.03)	0.01(0.01)	0.134	0.03(0.01)	0.06(0.02)
Great-crested flycatcher	0.006	0.13(0.03)	0.03(0.01)	0.009	0.15(0.05)	0.02(0.01)	0.048	0.13(0.04)	0.04(0.02)
Eastern wood pewee	0.554	0.15(0.05)	0.10(0.03)	0.238	0.13(0.06)	0.04(0.02)	0.859	0.15(0.07)	0.15(0.06)
Acadian flycatcher	0.598	0.29(0.04)	0.27(0.06)	0.846	0.52(0.09)	0.48(0.10)	0.742	0.09(0.05)	0.07(0.03)
Blue jay	0.708	0.05(0.02)	0.06(0.03)	0.781	0.03(0.02)	0.06(0.04)	0.755	0.07(0.03)	0.06(0.04)
American crow	0.755	0.05(0.02)	0.04(0.01)	0.327	0.09(0.05)	0.03(0.02)	0.662	0.02(0.02)	0.04(0.02)
Tufted titmouse	1.000	0.13(0.02)	0.12(0.02)	0.133	0.17(0.04)	0.09(0.02)	0.170	0.10(0.04)	0.16(0.04)
Carolina chickadee	0.386	0.11(0.02)	0.14(0.03)	0.222	0.12(0.02)	0.16(0.05)	0.687	0.10(0.03)	0.12(0.03)
White-breasted nuthatch	0.038	0.09(0.02)	0.05(0.02)	0.007	0.11(0.03)	0.01(0.01)	0.625	0.07(0.03)	0.08(0.05)
Carolina wren	0.490	0.03(0.02)	0.05(0.02)	0.311	0.03(0.03)	0.04(0.02)	0.844	0.04(0.02)	0.06(0.03)
Blue-gray gnatcatcher	0.531	0.18(0.06)	0.13(0.06)	0.528	0.23(0.09)	0.14(0.05)	0.425	0.13(0.05)	0.12(0.08)
Wood thrush	0.044	0.03(0.01)	0.12(0.03)	0.213	0.05(0.03)	0.15(0.06)	0.003	0.01(0.01)	0.08(0.02)
American robin	0.231	0.03(0.01)	0.04(0.03)	0.540	0.07(0.03)	0.06(0.05)	0.824	0.01(0.01)	0.01(0.01)
Yellow-throated vireo	0.945	0.10(0.02)	0.10(0.03)	0.552	0.05(0.03)	0.09(0.05)	0.806	0.13(0.04)	0.11(0.02)
Solitary vireo	0.032	0.15(0.03)	0.06(0.02)	0.330	0.05(0.02)	0.06(0.03)	0.010	0.24(0.07)	0.05(0.02)
Red-eyed vireo	0.890	0.56(0.08)	0.56(0.11)	0.581	0.71(0.08)	0.62(0.11)	0.393	0.45(0.09)	0.54(0.15)
Black-and-white warbler	0.093	0.07(0.03)	0.16(0.04)	0.158	0.02(0.01)	0.09(0.05)	0.072	0.11(0.04)	0.23(0.03)

Table 9. (continued)

Variable	All plots combined			Within 154 m from stream			304 m to N450 m from stream		
	Sig.	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9	Sig.	Deciduous n=7	Hemlock n=9
Black-throated blue warbler	0.166	0.01(0.01)	0.12(0.08)	0.050	0.00(0.00)	0.23(0.16)	0.707	0.01(0.01)	0.01(0.01)
Black-throated green warbler	0.627	0.06(0.06)	0.11(0.07)	0.316	0.05(0.05)	0.12(0.07)	0.828	0.07(0.06)	0.10(0.06)
Pine warbler	0.155	0.18(0.05)	0.08(0.03)	0.846	0.05(0.03)	0.04(0.02)	0.140	0.29(0.08)	0.12(0.05)
Hooded warbler	0.201	0.07(0.03)	0.13(0.04)	0.158	0.04(0.02)	0.12(0.04)	0.376	0.09(0.04)	0.15(0.05)
Worm-eating warbler	0.193	0.19(0.04)	0.29(0.06)	0.273	0.13(0.02)	0.19(0.06)	0.343	0.24(0.07)	0.39(0.08)
Ovenbird	0.192	0.64(0.09)	0.48(0.12)	0.813	0.48(0.10)	0.49(0.14)	0.167	0.79(0.15)	0.46(0.12)
Louisiana waterthrush	0.080	0.13(0.02)	0.08(0.02)	0.090	0.29(0.04)	0.17(0.04)	0.522	0.01(0.01)	0.00(0.00)
Rufous-sided towhee	0.676	0.02(0.02)	0.04(0.02)	0.617	0.03(0.03)	0.02(0.01)	0.411	0.02(0.02)	0.05(0.02)
Scarlet tanager	0.501	0.24(0.05)	0.22(0.02)	0.801	0.20(0.03)	0.18(0.03)	0.898	0.27(0.06)	0.25(0.03)
Species richness	0.277	13.24(0.97)	12.87(0.72)	0.913	12.86(0.97)	12.06(0.91)	0.434	13.69(1.09)	13.72(0.96)
Total bird density	0.697	3.88(0.25)	3.70(0.39)	0.507	3.97(0.31)	3.79(0.53)	0.710	3.82(0.31)	3.64(0.35)

[a] Index is the number of birds seen or heard per station per visit for 1990-1991.

[b] Significance is based on an MRPP test.
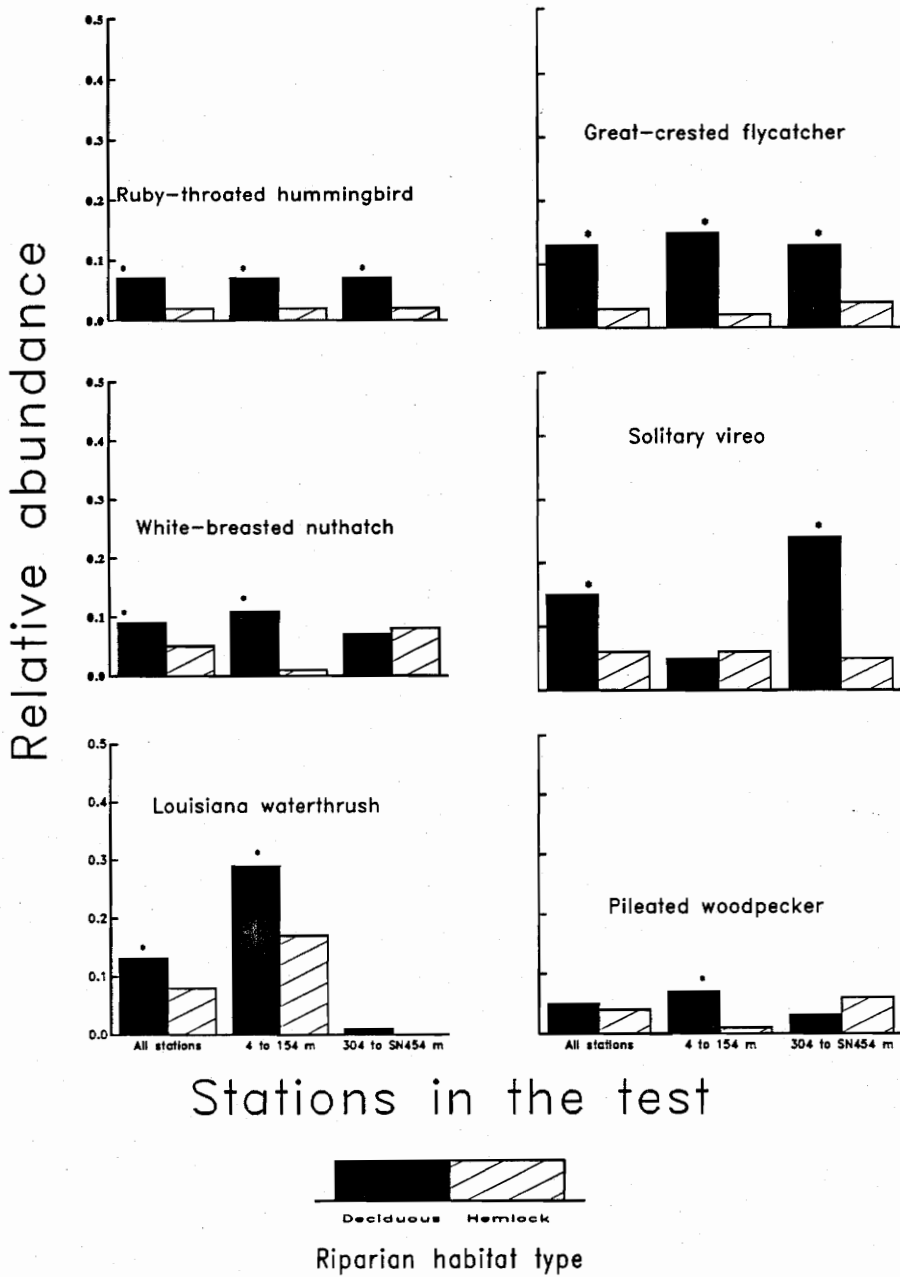
Fig. 9. Mean relative abundances of bird species significant in ≥ 1 of the tests for location differences between deciduous and hemlock riparian habitats at stations sampled in southwestern Virginia in 1990-1991. * indicates a significant (P < 0.10, MRPP) difference.

Results

Fig. 9. (continued).

Results
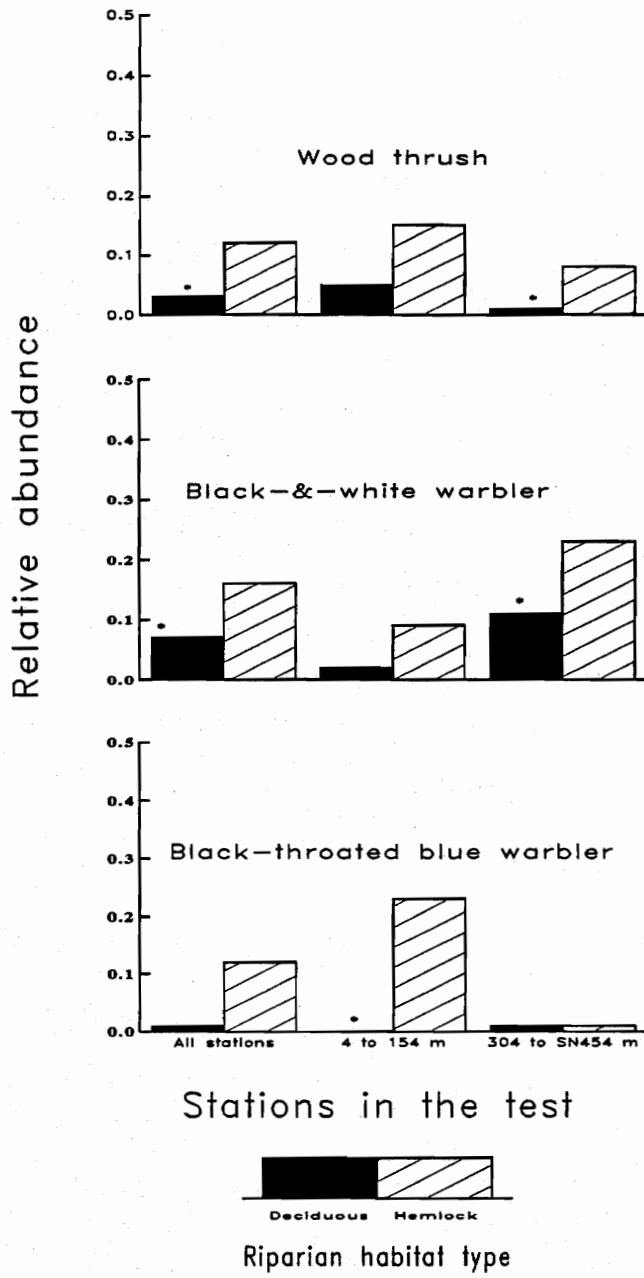
-2.66, P = 0.026), great-crested flycatchers (delta = -3.54, P = 0.009), white-breasted nuthatches (delta = -4.23, P = 0.007) and Louisiana waterthrushes (delta = -1.41, P = 0.090) were more abundant in deciduous habitats than in hemlock habitats (Table 9 and Fig. 9). Black-throated blue warblers (delta = -1.93, P = 0.050) were more abundant in hemlock habitats; they were detected only at stations within 154 m from the stream in areas with hemlock prevalent in the riparian habitat.

At stations located 304 m, 454 m, and on the first-order stream, ruby-throated hummingbirds (delta = -2.57, P = 0.029), great-crested flycatchers (delta = -2.03, P = 0.048), and solitary vireos (delta = -3.51, P = 0.010) occurred in greater numbers in the areas having deciduous riparian habitat (Table 9 and Fig. 9). Black-and-white warblers (delta = -1.64, P = 0.072) and wood thrushes (delta = -4.49, P = 0.003) were more abundant in areas with hemlock habitats next to the second-order stream.

Ruby-throated hummingbirds and great-crested flycatchers were significantly more abundant in areas with deciduous riparian habitats in each of the 3 tests (Table 9). White-breasted nuthatches, solitary vireos, and Louisiana waterthrushes were significantly more abundant in deciduous habitats in 2 of the tests. Wood thrushes and black-and-white warblers were significantly more abundant in areas with hemlock riparian habitat in 2 of the tests.

Species significant in each of the 3 tests between deciduous and hemlock riparian habitats showed the same trend in each test (Table 9). All species significant in $\geq$ 1 of the tests (excepting pileated

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woodpeckers, white-breasted nuthatches, and solitary vireos) showed similar trends in all 3 tests although they were not significant in each test.

Assemblage formation

From the dendrogram resulting from the cluster analysis I identified 5 groups of species exhibiting similar distributions among the 69 census stations (Fig. 10). Since these species may be assumed to have similar habitat requirements I considered these groups to be assemblages (Wiens 1989). Because species within a assemblage may use the habitat in different ways, each assemblage cannot be assumed to represent a separate niche; rather, the assemblages are groups of species using similar habitats.

Assemblage names were derived from the habitat characteristics frequented by the species as determined from logistic and multiple-linear regressions performed on assemblage and vegetation data. The riparian assemblage consisted of the acadian flycatcher and Louisiana waterthrush (Fig. 10). The mature forest generalist assemblage comprised the American crow, tufted titmouse, Carolina chickadee, Carolina wren, blue-gray gnatcatcher, American robin, yellow-throated vireo, black-and-white warbler, hooded warbler, worm-eating warbler, and rufous-sided towhee. The xeric forest assemblage included the great-crested flycatcher, solitary vireo, red-eyed vireo, pine warbler, ovenbird, and scarlet tanager. The mesic hardwoods assemblage was

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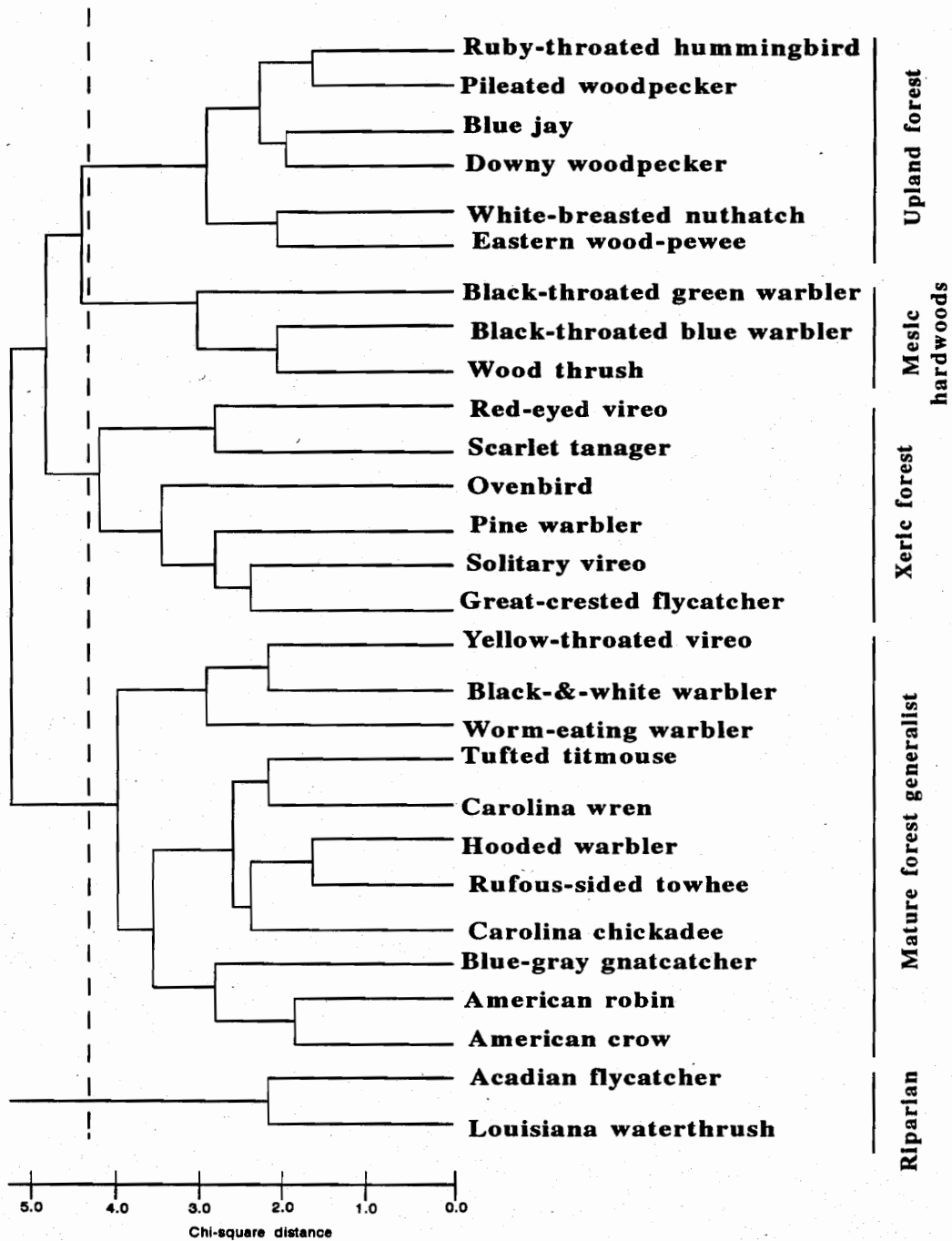
Fig. 10.   Dendrogram of 28 bird species sampled in southwestern Virginia
during 1990-1991 identifying 5 assemblages. Assemblage names
were derived from regressions conducted on the assemblages.
The dashed line indicates the division of the assemblages.

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formed by the wood thrush, black-throated blue warbler, and black-throated green warbler. The upland assemblage comprised the ruby-throated hummingbird, downy woodpecker, pileated woodpecker, eastern wood-pewee, blue jay, and white-breasted nuthatch.

Models of habitat use by assemblages and bird species

Riparian assemblage

The logistic regression model showed that the presence of the riparian assemblage was associated positively with percent understory canopy cover and total overstory density (Table 10). The assemblage was associated negatively with small stem density and stream distance. The model predicted with 96.5 % concordance. Relative abundance of the assemblage at occupied stations was highest at stations nearest the streams (Table 11). The relative abundance also was associated negatively with serviceberry understory density and positively with white oak overstory density. The adjusted R^2 and R^2_{PRESS} were 0.61 and 0.55 respectively.

Presence of the acadian flycatcher was associated positively with total overstory density and percent understory canopy cover and negatively with distance from the stream (Table 10). Concordance for this model was 98.1 %. Relative abundance of acadian flycatchers was associated positively with the number of foliage layers and negatively with stream distance (Table 11). The adjusted R^2 was 0.39 and the R^2_{PRESS} was 0.20 for the regression model.

Louisiana waterthrush presence showed a negative relationship with

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Table 10. Logistic regression models for 5 assemblages and 28 species sampled in southwestern Virginia during 1990-1991. The models were developed to predict the number of species in the assemblage expected to be present or the probability of occurrence for each species at 69 sampling stations.

Assemblage or species	Variable	Coeff.	Concord. (%)
Riparian assemblage	Intercept1	-7.004	96.5
	Intercept2	-11.259	
	% understory canopy cover[a]	13.453	
	Small stem density	-0.0004	
	Stream distance	-0.029	
	Total overstory density	0.010	
Acadian flycatcher	Intercept	-11.732	98.1
	% understory canopy cover	15.862	
	Stream distance	-0.030	
	Total overstory density	0.013	
Louisiana waterthrush	Intercept	0.440	90.4
	% slope	-11.345	
	% herbaceous cover	13.148	
Upland assemblage	Intercept1	1.226	85.2
	Intercept2	-0.092	
	Intercept3	-2.420	
	Mesic hardwoods overstory density	-0.101	
	Mesic hardwoods understory density	0.046	
	Xeric understory density	-0.004	
Ruby-throated hummingbird[b]	Intercept	-3.753	80.4
	Xeric overstory density	0.005	
Pileated woodpecker	Intercept	-4.633	78.8
	Mesic mixed understory density	0.004	
Blue jay	Intercept	-3.111	64.8
	Mesic mixed understory density	0.003	
Downy woodpecker[b]	Intercept	-6.248	78.8
	Understory canopy height	0.113	
	Stream distance	0.006	
White-breasted nuthatch[b]	Intercept	-1.928	88.9
	Small stem density	-0.001	
	Total understory density	0.003	
Eastern wood-pewee	Intercept	8.193	93.3
	% fern cover	-77.259	
	Stream distance	0.011	
	Total overstory density	-0.014	
	Total understory basal area	-1.584	
Mesic hardwoods assemblage	Intercept1	-0.123	77.7
	Intercept2	-2.234	
	% shrub cover	-6.586	
	Mesic hardwoods overstory density	0.010	
Black-throated green warbler	Intercept	-14.008	95.6
	% slope	22.785	
	Mesic hardwoods overstory density	0.053	

Results

Table 10. (continued)

Assemblage or species	Variable	Coeff.	Concord. (%)
Black-throated blue warbler	Intercept	-2.896	86.8
	Hemlock density	0.004	
Wood thrush	Intercept	-0.304	83.4
	Xeric overstory density	-0.039	
Xeric forest assemblage	Intercept1	4.611	75.9
	Intercept2	1.838	
	Intercept3	0.197	
	Intercept4	-2.905	
	Intercept5	-3.891	
	Intercept6	-5.105	
	White oak overstory density	0.015	
	% slope	-2.923	
	Stream distance	0.007	
	Total understory density	-0.002	
	Xeric overstory density	0.004	
Red-eyed vireo	Intercept	-3.127	79.1
	Overstory canopy height	0.065	
Scarlet tanager	Intercept	2.692	72.0
	# of foliage layers	-1.491	
	Stream distance	0.005	
Ovenbird	Intercept	-11.976	63.2
	% ground cover	13.388	
Pine warbler	Intercept	-2.269	82.2
	Xeric understory density	0.005	
Solitary vireo	Intercept	-3.803	68.8
	Stream distance	0.007	
Great-crested flycatcher	Intercept	-1.720	81.3
	% shrub cover	3.893	
	% slope	-5.305	
Mature forest generalist assemblage	Intercept1	-0.987	75.6
	Intercept2	-2.131	
	Intercept3	-3.341	
	Intercept4	-4.521	
	Intercept5	-4.803	
	Intercept6	-6.457	
	White oak overstory density	0.018	
	% slope	6.977	
	Mesic hardwoods overstory density	-0.010	
Yellow-throated vireo[c]			
Black-and-white warbler	Intercept	-4.453	78.6
	% slope	5.475	
	Total understory basal area	0.364	
Worm-eating warbler	Intercept	-2.826	91.7
	Understory canopy height	-0.185	
	% slope	14.074	
	Total understory density	0.002	

Results

Table 10. (continued)

Assemblage or species	Variable	Coeff.	Concord. (%)
Tufted titmouse	Intercept	1.297	85.3
	Mesic hardwoods overstory density	-0.040	
	Xeric overstory density	-0.017	
Carolina wren[b]	Intercept	-3.645	59.6
	Rhododendron density	0.002	
Hooded warbler	Intercept	-3.314	77.0
	Small stem density	0.0004	
Rufous-sided towhee	Intercept	2.915	64.0
	# of foliage layers	-2.129	
Carolina chickadee[b]	Intercept	0.303	80.2
	Serviceberry understory density	0.006	
	Total overstory basal area	-0.158	
	Striped maple/hornbeam density	0.014	
Blue-gray gnatcatcher	Intercept	-2.246	72.4
	White oak overstory density	0.024	
American robin[c]			
American crow	Intercept	-3.791	65.2
	Rhododendron density	0.002	

[a] Variables are listed in order of importance.

[b] Stepwise procedure using $P \leq 0.10$ to select significant predictors.

[c] No predictor variables were significant at $P \leq 0.10$.

Results

Table 11. Multiple linear regression models of relative densities of 5 assemblages and 28 species at occupied stations sampled in southwestern Virginia during 1990-1991. The models were developed to predict relative abundance of a assemblage as a whole or of each species at sites where they occurred.

Assemblage or species	Variable	Coeff.	Adj. R^2	R^2_{PRESS}
Riparian assemblage	Intercept		0.732 0.614	0.546
(n=25, P = 0.0001)	Stream distance[a]	-0.002		
	White oak overstory density	0.005		
	Serviceberry understory density	-0.001		
Acadian flycatcher	Intercept	0.144	0.389	0.199
(n=24, P = 0.002)	Stream distance	-0.001		
	# of foliage layers	0.181		
Louisiana waterthrush	Intercept	0.202	0.650	0.489
(n=11, P = 0.006)	Total understory basal area	0.097		
	Small stem density	-7×10^{-5}		
Upland assemblage	Intercept	0.635	0.326	0.196
(n=24, P = 0.006)	Serviceberry understory density	-0.005		
	Xeric overstory density	0.001		
Ruby-throated hummingbird	Intercept	8.033	1.0000	0.415
(n=4, P=0.002)	% ground cover	-8.012		
	Striped maple/hornbeam density	0.001		
Pileated woodpecker[c]				
Blue jay	Intercept	0.601	0.916	0.734
(n=8, P = 0.001)	Overstory canopy height	-0.006		
	Mesic mixed understory density	9.0×10^{-5}		
Downy woodpecker	Intercept	0.196	0.832	0.790
(n=6, P=0.007)	Rhododendron density	0.001		
White-breasted nuthatch	Intercept	-0.219	1.000	1.000
(n=6, P=0.002)	# of foliage layers	0.084		
	% overstory canopy cover	0.375		
	% teaberry cover	-2.512		
	Mesic hardwoods overstory density	0.0001		
Eastern wood-pewee	Intercept	1.057	0.692	0.564
(n=12, P=0.006)	Total understory basal area	-0.080		
	Total overstory basal area	-0.025		
	Mesic mixed understory density	0.0003		
Mesic hardwoods assemblage	Intercept	0.025	0.758	0.534
(n=18, P = 0.0001)	Small stem density	0.0001		
	% teaberry cover	7.552		
	% fern cover	3.901		
Black-throated green warbler	Intercept	0.995	0.834	0.685
(n=9, P=0.002)	Total understory basal area	-0.089		
	Understory canopy height	-0.013		
Black-throated blue warbler	Intercept	0.555	0.949	0.874
(n=6, P=0.005)	% fern cover	10.252		
	Total overstory basal area	-0.013		
Wood thrush	Intercept	0.158	0.633	0.001
(n=7, P=0.020)	Xeric overstory density	0.007		

Results

Table 11. (continued)

Assemblage or species	Variable	Coeff.	Adj. R^2	R^2_{PRESS}
Xeric forest assemblage	Intercept	0.191	0.354	0.295
(n=67, $\underline{P}$ = 0.0001)	Xeric overstory density	0.001		
	# of foliage layers	0.375		
	% slope	-0.911		
	Snag density	0.002		
Red-eyed vireo	Intercept	0.669	0.228	0.155
(n=51, $\underline{P}$=0.001)	Small stem density	-3×10^{-5}		
	Xeric overstory density	-0.0004		
Scarlet tanager[b]	Intercept	1.071	0.422	0.310
(n=32, $\underline{P}$=0.002)	% understory canopy cover	-0.245		
	Total overstory density	-0.0003		
	% herbaceous cover	-0.444		
	Snag density	0.001		
	Overstory canopy height	-0.003		
	% ground cover	-0.408		
Ovenbird	Intercept	-2.465	0.414	0.342
(n=47, $\underline{P}$=0.0001)	% ground cover	2.643		
	Small stem density	4×10^{-5}		
	% slope	-0.530		
	# of foliage layers	0.162		
Pine warbler	Intercept	0.649	0.200	0.070
(n=19, $\underline{P}$=0.031)	Total overstory basal area	-0.018		
Solitary vireo	Intercept	0.158	0.995	0.981
(n=10, $\underline{P}$=0.0001)	% shrub cover	0.794		
	Total overstory density	-0.0005		
	Mesic hardwoods understory density	0.001		
	Serviceberry understory density	0.001		
Great-crested flycatcher	Intercept	0.176	0.520	0.408
(n=12, $\underline{P}$ = 0.005)	% teaberry cover	4.546		
Mature forest generalist	Intercept	2.016	0.384	0.319
assemblage	Mesic hardwoods overstory density	-0.006		
(n=48, $\underline{P}$ = 0.0001)	Total overstory density	-0.001		
	White oak overstory density	0.005		
	Mesic mixed understory density	-0.001		
Yellow-throated vireo	Intercept	0.011	0.965	0.900
(n=11, $\underline{P}$=0.0001)	% teaberry cover	7.162		
	Mesic hardwoods understory density	0.007		
	Total overstory density	0.0002		
Black-and-white warbler	Intercept	0.119	0.747	0.566
(n=18, $\underline{P}$=0.0004)	Mesic hardwood overstory density	-0.001		
	Mesic mixed understory density	-0.0003		
	% understory canopy cover	0.224		
	% herbaceous cover	1.083		
	Total understory basal area	0.021		
Worm-eating warbler	Intercept	0.345	0.124	0.065
(n=32, $\underline{P}$=0.028)	Serviceberry understory density	0.0004		
Tufted titmouse	Intercept	0.222	0.582	0.512
(n=16, $\underline{P}$=0.0004)	% fern cover	3.827		

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Table 11. (continued)

Assemblage or species	Variable	Coeff.	Adj. R^2	R^2_{PRESS}
Carolina wren[c]				
Hooded warbler[b] (n=12, P=0.040)	Intercept Total understory density Rhododendron understory density	0.073 0.0002 -0.0003	0.402	0.159
Rufous-sided towhee (n=6, P=0.002)	Intercept % slope Xeric understory density Serviceberry understory density % understory canopy cover	0.265 -0.256 8×10^{-5} -0.0002 -0.024	1.000	1.000
Carolina chickadee (n=9, P = 0.001)	Intercept # of foliage layers % herbaceous cover Snag density Stream distance	-0.406 0.366 -3.408 -0.001 -0.0002	0.964	0.939
Blue-gray gnatcatcher (n=13, P = 0.0001)	Intercept Overstory canopy height Rhododendron density % fern cover Snag density Stream distance # of foliage layers Xeric overstory density	-0.578 0.015 -0.001 29.061 -0.002 0.001 0.040 0.0003	0.986	0.969
American robin[c]				
American crow[c]				

[a] Variables are listed in order of importance.

[b] Stepwise procedure using $P \leq 0.10$ to select significant predictors.

[c] No predictor variables were significant at $P \leq 0.10$.

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percent slope and a positive relationship with percent herbaceous cover (Table 10). Stream distance was the first variable to be selected; however, convergence could not be attained as long as stream distancewas in the model. Concordance for the model was 90.4%. Relative abundance of Louisiana waterthrushes at occupied stations was associated positively with total understory basal area and negatively with small stem density (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.65 and 0.49 respectively.

Upland assemblage

Because a maximum of 3 species in the upland assemblage was detected at any individual station, the logistic regression estimated 3 intercept values (Table 10). Presence of the assemblage was associated positively with mesic hardwoods understory density and negatively with mesic hardwoods overstory density and xeric hardwoods understory density. Concordance was 85.2 %. Relative abundance of the assemblage at occupied stations showed a negative association with serviceberry understory density and a positive relationship with xeric overstory density (Table 11). The model had an adjusted R^2 of 0.33 and an R^2_{PRESS} of 0.20.

Presence of the ruby-throated hummingbird was associated positively with xeric overstory density. Concordance was 80.4%. Relative abundance of ruby-throated hummingbirds at stations at which they were present was associated positively with striped maple/hornbeam density and negatively with percent ground cover (Table 11). The

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adjusted R^2 and R^2_{PRESS} were 1.00 and 0.42 respectively, however the high values were expected because of the low sample size.

Presence of the downy woodpecker was related positively with both understory canopy height and stream distance. Concordance for the model was 78.8%. Downy woodpecker relative abundance at occupied stations showed a positive relationship with rhododendron density (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.83 and 0.80 respectively.

White-breasted nuthatch presence was associated negatively with small stem density and positively with total understory density. Concordance for the model was 88.9%. Relative abundance of the white-breasted nuthatch at occupied stations was highest at occupied stations having a high number of foliage layers, high percent overstory canopy cover, low percent teaberry cover, and high mesic hardwoods overstory density (Table 11). The adjusted R^2 was 1.00 and the R^2_{PRESS} was 1.00.

The models for the pileated woodpecker and the blue jay suggested that presence of each of these species was associated positively with mesic mixed understory density (Table 10). Concordance for these models were 78.8 % and 64.8 % respectively. A model for predicting relative abundance of the pileated woodpecker at occupied stations was not developed because none of the habitat variables were significant (P > 0.10). Relative abundance of blue jays at occupied stations had a positive relationship with mesic mixed understory density and a negative relationship with overstory canopy height (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.92 and 0.73 respectively.

Presence of the eastern wood-pewee was associated positively with

stream distance (Table 10). It was negatively associated with percent fern cover, total overstory density, and total understory basal area, indicating a preference for relatively open areas. Concordance was 93.3 % for this model. Relative abundance at occupied stations of eastern wood-pewees was associated positively with mesic mixed understory density and negatively with total overstory and understory basal areas (Table 11). The adjusted R^2 and R^2_{PRESS} for the linear regression model were 0.69 and 0.56 respectively.

Mesic hardwoods assemblage

The most species in the mesic hardwoods assemblage to be detected at an individual station was 2; therefore, 2 intercepts were given in the model for predicting presence of this assemblage (Table 10). Presence of this assemblage was associated positively with mesic hardwood overstory density and negatively with percent shrub cover. Concordance was 77.7 %. Relative abundance of the assemblage at occupied stations was related positively with small stem density, percent teaberry cover, and percent fern cover (Table 11). The adjusted R^2 was 0.76 and the R^2_{PRESS} was 0.53.

Black-throated green warbler presence was associated positively with mesic hardwoods overstory densities and percent slope. Concordance for the logistic model was 95.6 % (Table 10). Relative abundance of black-throated green warblers at occupied stations was related negatively with total understory basal area and understory canopy height (Table 11). The model had an adjusted R^2 of 0.83 and an R^2_{PRESS} of 0.69.

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Presence of the black-throated blue warbler was associated positively with high hemlock densities (Table 10). Concordance was 86.8 %. The linear regression model showed that relative abundance of black-throated blue warblers was associated positively with percent fern cover and negatively with total overstory basal area at occupied stations (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.95 and 0.87 respectively.

Wood thrush presence showed a negative relationship with xeric overstory density (Table 10). Concordance was 83.4 %. Relative abundance of the wood thrush at occupied stations was associated positively with xeric overstory density (Table 11). The adjusted R^2 was 0.63 and the R^2_{PRESS} was 0.001.

Xeric forest assemblage

The greatest number of species in the xeric forest assemblage to be detected at any station was 6, so the logistic model contained 6 intercepts (Table 10). Presence of the assemblage was associated positively with white oak overstory density, stream distance, and xeric overstory density and negatively with percent slope and total understory density. Concordance for the model was 75.9 %. The linear regression model showed that the relative abundance of the xeric forest assemblage was associated positively with xeric overstory density, number of foliage layers, and snag density and negatively with percent slope (Table 11). The model had an adjusted R^2 of 0.35 and an R^2_{PRESS} of 0.30.

Presence of the red-eyed vireo had a positive relationship with

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overstory canopy height (Table 10). Concordance was 79.1 % for the model. The linear regression model indicated that among occupied stations the red-eyed vireo was most abundant at stations with low small stem and xeric overstory densities (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.23 and 0.16 respectively.

Presence of the scarlet tanager was associated positively with stream distance and negatively with the number of foliage layers (Table 10). Concordance for the scarlet tanager model was 72.0 %. Scarlet tanager relative abundance at occupied stations was related positively with snag density and negatively with percent understory canopy cover, total overstory density, percent herbaceous cover, overstory canopy height, and percent ground cover (Table 11). The adjusted R^2 was 0.42 and the R^2_{PRESS} was 0.31.

Ovenbird presence was associated positively with percent ground cover and concordance was 63.2 % (Table 10). Relative abundance of ovenbirds at occupied stations was associated positively with percent ground cover, small stem density, and number of foliage layers and negatively with percent slope (Table 11). The adjusted R^2 was 0.41 and the R^2_{PRESS} was 0.34.

Presence of pine warblers was related positively with xeric understory density (Table 10). Concordance was 82.2 % for this model. The linear regression model showed that pine warbler abundance was associated negatively with total overstory basal area at occupied stations (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.20 and 0.07 respectively.

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Presence of the solitary vireo was related positively with stream distance. The model was 68.8 % concordant (Table 10). Relative abundance of solitary vireos at occupied stations was highest at stations with high percent shrub cover, high mesic hardwoods understory density, high serviceberry understory density, and low total overstory density (Table 11). The adjusted R^2 was 1.00 and the R^2_{PRESS} was 0.98.

Presence of the great-crested flycatcher showed a positive relationship with percent shrub cover and a negative relationship with percent slope (Table 10). Concordance of the model was 81.3 %. Great-crested flycatcher relative abundance at occupied stations was associated positively with percent teaberry cover (Table 11). The adjusted R^2 was 0.52 and R^2_{PRESS} was 0.41.

Mature forest generalist assemblage

The 6 intercepts in the logistic model for the mature forest generalist assemblage result from the fact that the maximum number of species in the assemblage to be detected at a station was 6 (Table 10). Presence of the assemblage was associated positively with white oak overstory density and percent slope and negatively with mesic hardwood overstory density. The model predicted 75.6 % of the observations concordantly. The linear regression model indicated that the relative abundance of mature forest generalists was associated negatively with mesic hardwoods overstory density, total overstory density, and mesic mixed understory density and positively with white oak overstory density (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.38 and 0.32 respectively.

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Presence of the yellow-throated vireo demostrated no significant ($\underline{P} > 0.10$) relationship with any habitat variable; therefore, a logistic regression model was not developed (Table 10). Relative abundance of yellow-throated vireos at occupied stations showed a positive association with percent teaberry cover, mesic hardwood understory density, and total overstory density (Table 11). The adjusted R^2 was 0.97 and the R^2_{PRESS} was 0.90.

Presence of the black-and-white warbler was related positively with percent slope and total understory basal area (Table 10). Concordance for the model was 78.6 %. Black-and-white warbler relative abundance at occupied stations had a positive relationship with percent understory canopy cover, percent herbaceous cover, and total understory basal area and a negative relationship with mesic hardwoods overstory and mesic mixed understory densities (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.75 and 0.57 respectively.

Worm-eating warbler presence was associated positively with percent slope and total understory density and negatively with understory canopy height. Concordance was 91.7 % (Table 10). Relative abundance of worm-eating warblers was associated positively with serviceberry understory density (Table 11). The adjusted R^2 and R^2_{PRESS} were 0.12 and 0.07 respectively.

Tufted titmouse presence was associated negatively with both mesic hardwoods and xeric overstory densities (Table 10). Concordance for the model was   85.3 %. Relative abundance at occupied stations was associated positively with percent fern cover (Table 11). The adjusted

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R^2 was 0.58 and the R^2_{PRESS} was 0.51.

Presence of the Carolina wren was related positively with rhododendron density. Concordance for the model was 59.6% (Table 10). A model for predicting relative abundance of wrens at occupied stations was not developed because none of the habitat variables showed a significant relationship ($\underline{P} > 0.10$) with wren abundance (Table 11).

The logistic model for the hooded warbler suggested its presence was associated positively with small stem density. Concordance was 77.0 % (Table 10). Hooded warbler relative abundance at occupied stations had a positive relationship with total understory density and an negative relationship with rhododendron density. The adjusted R^2 and R^2_{PRESS} were 0.40 and 0.16 respectively (Table 11).

Rufous-sided towhee presence had a negative relationship with the number of foliage layers at the station. Concordance was 64.0 % (Table 10). Relative abundance of towhees at occupied stations was related negatively with percent slope, serviceberry understory density, and percent understory canopy cover and positively with xeric understory density (Table 11). Both the adjusted R^2 and R^2_{PRESS} were 1.00.

Presence of Carolina chickadees was associated positively with serviceberry understory and striped maple/hornbeam densities and negatively with total overstory basal area (Table 10). Concordance was 80.2% for the model. Relative abundance of Carolina chickadees at occupied stations was associated positively with the number of foliage layers and negatively with percent herbaceous cover, snag density, and stream distance (Table 11). The adjusted R^2 was 0.96 and R^2_{PRESS} was

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0.94.

The blue-gray gnatcatcher was present most often at stations having high white oak overstory densities (Table 10). Concordance was 72.4 % for the model. The linear regression model indicated that relative abundance of gnatcatchers was associated positively with overstory canopy height, percent fern cover, stream distance, number of foliage layers and xeric overstory density (Table 11); it was associated negatively with rhododendron density and snag density. The adjusted R^2 and R^2_{PRESS} were 0.99 and 0.97 respectively.

Neither presence nor relative abundance of American robins at occupied stations showed a significant ($\underline{P} > 0.10$) relationship with any of the habitat variables. Therefore, no models were developed for the American robin.

Presence of the American crow was related positively with rhododendron density (Table 10). Concordance for the model was 65.2%. Because none of the habitat variables were significant ($\underline{P} > 0.10$) for predicting relative abundance of crows at occupied station, a model was not developed for relative abundance (Table 11).

Discussion

Vegetation structure

The canopy layers in the riparian habitats were more complex than those in the upland habitats (Tables 3 and 4). Overstory trees in riparian habitats often had dense, wide-spreading crowns occurring at greater heights than those in adjacent habitats. Understory trees grading into the overstory canopy or the presence of a subcanopy layer produced a relatively deep canopy foliage layer. On upland sites, the overstory and understory canopies were closer together (causing them to be more difficult to distinguish) and provided less vertical diversity than on moist sites, a trend also noted by Bond (1957). He observed taller trees and greater canopy coverage in mesic forests in Wisconsin and attributed the greater canopy cover to a higher concentration of branching near the tops of the trees in the mesic forests, which created a distinct overstory canopy layer. Because overstory tree densities were lower in my riparian habitats (Tables 3 and 4), crown structure was most likely responsible for the greater canopy cover in these areas.

The taller, more complex canopies resulted in decreased amounts of sunlight reaching the forest floor. Therefore, ground and low shrub layers were relatively sparse in riparian areas (Tables 3 and 4). The presence of fewer foliage layers present in riparian habitats was due

primarily to the absence of short shrub cover. Because tree mortality creates openings in the overstory canopy that allow light to reach the ground and results in accelerated growth of understory plants, lower snag densities in riparian areas might have influenced the differences in shrub cover between riparian and upland habitats. Herbaceous cover was higher in the riparian areas but was not extensive enough to affect the habitat structure significantly except in a few locations. Ground cover, including leaf litter, also was lower near the streams. Bond (1957) observed that the mesic stands he studied often were barren on the forest floor. He noted that, where plants were present on the forest floor, they were small and reclining and, therefore, inconspicuous.

In the riparian habitats in this study dominated by hardwood species, tulip poplar, cucumber magnolia, sweet birch, and white oak were common overstory species. American beech, ironwood, rhododendron, and saplings of overstory species were common in the understory. These habitats often graded into the upland habitat types.

Riparian habitats with hemlock present occurred on sites having gentler slopes than areas with deciduous riparian habitats. These areas had a denser understory than deciduous habitats (Table 5). Hemlock trees in the understory appeared to have larger bole diameters than deciduous understory trees and might have been responsible for the higher understory basal area. Higher understory tree density and larger tree size accounted for the higher understory canopy cover. Overstory trees also were larger in diameter than those in deciduous habitats.

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Chestnut oaks, scarlet oaks, and Virginia pines were more common in the overstory in these habitats and snags occurred in higher densities than in deciduous riparian habitats. These habitats were similar to the deciduous riparian areas in other respects.

Chestnut and scarlet oaks and Virginia pine dominated the overstory in xeric upland habitats. Sassafras, American chestnut, Allegheny chinkapin, black gum, and saplings of overstory species were characteristic of the understory. Overstory trees were smaller in diameter than those in riparian habitats. The overstory canopy began relatively low on the tree and did not extend far horizontally from the bole of the tree, which is similar to that described by Bond (1957) in xeric forests in Wisconsin. The nature of the canopies formed gaps between trees that allowed sunlight to reach the ground allowing a well-developed shrub layer to be present. A higher density of snags also contributed to the more open canopy and dense shrub cover in these habitats.

The riparian and upland habitats demonstrated trends similar to those described by Smith (1977) and Bond (1957). Smith (1977) found percent canopy cover, average tree height, and density of trees > 38.1 cm dbh were higher in moist forests in Arkansas; Bond (1957) observed similar trends in Wisconsin.

In contrast to my results, Hooper (1991) found larger basal areas and more canopy closure in upland areas than in floodplain habitats in Maine. However, she found no differences in vegetation characteristics with increasing distance from the stream in "upland riparian areas."

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McGarigal and McComb (1992) found cover of all vegetation layers except low shrubs to be higher in riparian habitats in Oregon. Snag density was lower in riparian areas, as in my study. However, the upland habitats in Oregon had higher basal areas than the riparian plots, as in Maine (Hooper 1991). An explanation for the differences between the habitats in Virginia and those studied by McGarigal and McComb (1992) and Hooper (1991) is that the latter two studies were conducted in areas where conifers dominated the upland habitats and hardwoods dominated the riparian areas. Therefore, some of the differences may describe the differences between hardwood and conifer forests more than an influence of the presence of a stream.

Based on vegetation characteristics, the areas on the first-order streams were similar to the habitats on the second-order streams. Trends in vegetation similar to those occurring at the second-order streams were present on these streams; however, the differences between these riparian habitats and the nearby upland habitats were not so great. Often the first-order streams were not significantly different from either the second-order streams or the upland habitats (Table 4). Therefore, a riparian influence did occur at the first-order stream but to a lesser extent than was present at the second-order stream.

Bird communities--species richness and density

Forested riparian habitats have been considered to be critical, unique habitats for bird communities. Emmerich and Vohs (1982) found 30 species using forested riparian habitats and 25 in tree claims (square

or rectangular forested habitats $\geq$ 2 ha in size) in South Dakota. Tubbs (1980) reported that species breeding in riparian areas outnumber any nonriparian group of species in Kansas. Many of these were considered to be woodland species whose presence on the Great Plains was almost entirely due to the presence of forested riparian habitat. Knopf (1985) observed 102 (82%) species in the riparian area of the Platt River in northern Colorado and 22 (18%) species in the adjacent uplands in 1981. Fifty-seven (46%) of the species recorded in the riparian areas were detected only in these habitats. However, at 1 site higher than 1,909 m in elevation, the upland habitat had a more diverse avifauna than did the adjacent riparian zone (Knopf 1985). Species richness in riparian habitats in Iowa was higher in areas with wider riparian habitats (Stauffer and Best 1980).

Riparian habitats also influence bird communities in adjacent upland areas. Szaro and Jakle (1985) observed nearly all of the riparian species in adjacent desert habitat in Arizona. However the permanent residents of the desert upland were never recorded in the riparian habitats. Therefore they stated that riparian areas had a greater impact on the bird communities on adjacent upland habitats than the upland areas had on the riparian habitats.

Bird densities are often higher in riparian habitats than in adjacent habitats. Stauffer and Best (1980) found densities nearly 50% higher in floodplain woodlands than in upland woodlands even though species richness was similar in both habitats. Bird densities in forested riparian habitat were > 3 times those on adjacent desert

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uplands in Arizona (Szaro and Jakle 1985). Dickson (1978) reported breeding densities in riparian zones along the Louisiana-Texas border to be 2 to 4 times higher than the best upland sites.

Neither species richness nor total bird abundance showed any trend with distance from the stream in my study in southwestern Virginia (Tables 6 and 7). Hooper (1991) found no difference in species richness or number of individuals between riparian and adjacent upland habitats in Maine. McGarigal and McComb (1992) found higher species richness and total bird abundance in upland habitats than in the riparian areas. Each of these 3 studies were conducted in areas with forested habitats occurring continuously between the riparian and upland sites.

The studies that showed higher densities or species richness in riparian habitats were conducted in areas having nonforested habitats immediately adjacent to the riparian zone. Riparian habitats studied by Stauffer and Best (1980) were surrounded by agricultural fields. The upland habitats studied by Szaro and Jakle (1985) were Sonoran Desert scrub. In Kansas, the forested riparian zones occurred in areas that were otherwise grassland habitats (Tubbs 1980). Therefore, in the studies that identify riparian habitats as having more diverse or dense bird communities, riparian habitats were very different structurally from adjacent habitats. In some areas the riparian area may contain the only forested habitat in the immediate vicinity. However, in locations in which the upland and riparian areas are similar habitat types and are connected, species richness and overall density trends do not exist or may be opposite of those identified in other areas.

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Various studies have shown that bird diversity is related positively with foliage height diversity (e.g. MacArthur and MacArthur 1961, MacArthur et. al. 1962, Karr and Roth 1971, Noon and Able 1978). This relationship often has been used to explain the higher species richness and densities observed in riparian habitats (Bull 1978, Anderson 1980). Willson (1974) found that the greatest addition in species occurred with the addition of the tree layer. The addition of a tree layer in the riparian areas might have contributed to the riparian effects on species richness and bird density observed in most of the riparian studies. An edge effect also may have contributed to the increased richness and density in the studies in which the riparian habitats were surrounded by open habitats. After a canopy has formed, additional increments in foliage height diversity do not increase the number of bird species present (Willson 1974). This supports the hypothesis that Hooper (1991), McGarigal and McComb (1992), and I found results differing from previous studies because the riparian and upland habitats were contiguous forested habitats. Because a continuous tree layer was present between the riparian and adjacent upland habitats, no increase in species richness or density occurred due to foliage height diversity.

The bird species in this study were mature forest dwellers, and the upland habitat was similar enough in structure to the riparian zone to be equally suitable for many of the species I studied. In many of the previous studies, the riparian habitat provided niches for a forest or edge community, while the uplands contained an open habitat bird

community. Because the upland forest was contiguous with the riparian habitat in my study, no distinct edge effect occurred as would be the case if an open habitat was present between them.

Habitat use by assemblages and their species

Healy (1979) developed models for predicting presence and relative abundance of bird species she studied. Rice et. al. (1986) used discriminant function analyses to predict presence of bird species and used regressions to predict abundance at used sites. The models I developed were similar in concept to both these studies. In situations in which the presence of a species or assemblage is important, the logistic models could provide that information. If relative abundance is desired, the abundance may be estimated from the linear regression models if the logistic models predict the species or assemblage is present. Therefore, two scales of habitat selection were addressed by the 2-step models I developed: 1) habitat variables important for a species or assemblage to use an area and 2) characteristics important for high densities once the species or assemblage is present.

Removal of unoccupied sites from the linear regression analyses for each species or assemblage increased the predictive ability of the model (Rice et. al. 1986). By removing all sites at which relative abundance is 0, the regression analyses fit a line to the relative abundances at the occupied sites without the influence of a large number of observations of relative abundance of 0.

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The models developed in this study encompass a small range of the habitats used by the species or assemblage. Therefore, the models represent habitat selection on a micro-scale. Because of the sampling design was developed for determining whether a riparian influence existed in mature hardwood forests in the central Appalachians, the full range of habitats used by the species or assemblage was not sampled. Therefore, the habitats used by the species or assemblages in this study can not be assumed to be the only suitable habitats.

Riparian assemblage

The riparian assemblage, composed of the acadian flycatcher and the Louisiana waterthrush, was closely associated with the streams (Tables 10 and 11). Both species were most common at the second-order stream and declined in abundance with increasing distance from the stream and were uncommon at the nonriparian stations. Both species showed a significant riparian effect at the first-order stream by increasing in abundance. The acadian flycatcher was present at all of the riparian stations both years; the Louisiana waterthrush was present at most of the riparian stations on the second-order streams both years but was not recorded at any station on a first-order stream both years.

The riparian assemblage used habitats near streams having well-developed overstory and understory canopy layers with a relatively open ground layer under the understory canopy (Tables 10 and 11). Overstory tree densities (especially of white oak) were high in the areas used by the assemblage. This resulted in a dense overstory canopy layer. A

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high percent canopy cover also was characteristic of the habitats used by the riparian assemblage. However, small stem density and serviceberry understory density were low, representing an open layer under the understory canopy. Distance from the stream was the most important variable defining an area to be used by the assemblage.

Acadian flycatchers occurred in habitats very similar to those used by the assemblage. The only variable important in describing habitats used by acadian flycatchers that was not important for the assemblage was the number of foliage layers present. Acadian flycatchers were more abundant in riparian habitats having a high number of foliage layers present. Giffen (1984) found the acadian flycatcher to be more abundant in hemlock bottomland habitats than in northern hardwood upland habitats in Maryland, thus indicating a riparian preference. Shugart and James (1973) found the acadian flycatcher to be confined to mesic forests containing white and black oaks in Arkansas. Stauffer (1978) found the acadian flycatcher to be more abundant in the upland woodlands; however, he noted that they were more common in the mesic areas of the habitat. The riparian assemblage in my study showed a positive relationship with white oak overstory density also. Smith (1977) found acadian flycatchers only in moist forests and they favored areas with larger trees and low densities of small diameter trees. However, he found a negative correlation between acadian flycatcher abundance and white oak, contradicting my results.

No clear evidence for explaining or building a hypothesis for why the acadian flycatcher was a riparian species was found. No specialized

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food habits were found that would require the species to live near streams. Bent (1963a) suggested the acadian flycatcher required overhanging branches over streams for building its nest. The only hypothesis for explaining the trends shown by the acadian flycatcher is that the structure of the riparian habitat is, in some way, critical for the acadian flycatcher to inhabit a habitat. In my study, only riparian habitats exhibited those structure characteristics. In Wisconsin (Bond 1957) and Arkansas (Smith 1977) these characteristics were found in forested habitats other than riparian habitats.

Bent (1963b) described the habitat of the Louisiana waterthrush as damp forests along clear, fast-flowing streams or along bodies of standing water, though running water appears to be preferred. Although the Louisiana waterthrush may be found in areas where streams are not present, the presence of water appears to be a vital habitat component for the waterthrush (Bent 1963). While developing the logistic model for the Louisiana waterthrush, distance from the stream was the first habitat variable selected. However, because the modelling process could not converge with this variable included it was removed from the model. But, because distance from the stream was selected by the stepwise selection procedure, it was important in determining the presence or absence of this species. Louisiana waterthrushes were more abundant in riparian habitats having high understory basal areas.

One hypothesis for why the Louisiana waterthrush was closely linked to the streams is that it might forage on the aquatic invertebrates in the stream. It often foraged on rocks in the stream or

along the edge (person. observ.). Bent (1963) also described this foraging behavior. Bent (1963) described the stomach contents of 9 waterthrushes and aquatic insects, small mollusks, snails, and a fish were some of the food items found. Further research is needed to determine why the Louisiana waterthrush is a riparian species but I hypothesize that its diet is a large factor causing it to be found near streams.

Upland forest assemblage

The upland forest assemblage was typical of the forested uplands in general. The eastern wood-pewee showed a strong trend of being more abundant away from the streams (Tables 10 and 11). The ruby-throated hummingbird and downy woodpecker abundances were significantly different among distances from the stream but the relationship was not clearly due to any riparian influence. Three of the species, ruby-throated hummingbird, pileated woodpecker, and white-breasted nuthatch, were more abundant in areas with deciduous riparian habitats than areas with hemlock present (Table 9).

The assemblage used areas having low densities of tulip poplar, cucumber magnolia, and sweet birch in the overstory and low densities of black gum, chestnut oak, sassafras, American chestnut, chinkapin, scarlet oak, black oak, and serviceberry in the understory (Table 10 and 11). Scarlet oak, chestnut oak, black oak, and Virginia pine dominated the overstory with cucumber magnolia, sweet birch, and tulip poplar common in the understory. These habitats were often more moist and

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complex than the xeric upland habitats. They appeared to be an intermediate habitat type between the xeric upland habitats and riparian habitats.

Ruby-throated hummingbirds occurred in areas having less ground cover and with striped maple and hornbeam present (Table 10 and 11). However, because so few hummingbirds were recorded and at only a few stations, their habitat use could not be well described.

The only habitat characteristic that described the usage by pileated woodpeckers was high densities of red and sugar maples, white oak, white pine, flowering and roundleaf dogwoods, and sourwood in the understory (Tables 10 and 11). However, the sampling design of this study was not suitable for describing habitat use of pileated woodpeckers due to the large home range of the species.

The downy woodpecker used areas away from the stream edge having high densities of rhododendron and a tall understory canopy. Anderson and Shugart (1974) stated that the downy woodpecker selected habitats based on the understory vegetation and could be considered as an understory specialist. They found a higher density of saplings in areas used by downy woodpeckers as did Tonkovich (1989). Smith (1977) found a positive relationship of downy woodpeckers with canopy cover and average tree height. All of these studies support the results of my study. The high rhododendron densities indicated a dense understory of small diameter stems and the high understory canopy suggested a high average tree height, at least in the understory.

Blue jays occurred in habitats with high densities of maples,

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white oak, white pine, dogwoods, and sourwood in the understory (Tables 10 and 11). Density of these species was important for predicting both presence and relative abundance at occupied stations of blue jays. Low overstory canopy height also was characteristic of habitats used by blue jays. Anderson and Shugart (1974) found the blue jay to be associated with a dense understory of large trees under a well-developed overstory canopy.

White-breasted nuthatches were found in areas dominated by tulip poplar, cucumber magnolia, and sweet birch in the overstory (Tables 10 and 11); this is opposite of the trend observed for the assemblage as a whole. A dense overstory canopy and high densities of understory trees created a relatively sparse tall shrub layer as shown by the negative relationship with small stem density. However, relative abundance was associated positively with the number of foliage layers present indicating the presence of a low shrub layer (< 1 m in height) or, more likely, a subcanopy between the overstory and understory canopies. The nuthatch was least abundant in xeric stands and most abundant in stands at an intermediate position along the moisture gradient sampled by Bond (1957) in Wisconsin but showed no clear trend. Smith (1977) classified the white-breasted nuthatch with xeric forests and found it to be associated with mixed hardwood forests composed of relatively small trees. Beals (1960) found the nuthatch to be common in pine and hemlock forests; however, in this study the nuthatch was more abundant in deciduous habitats. Giffen (1984) also found the nuthatch to be more abundant in habitats with shrub and understory layers dominated by

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deciduous species.

Eastern wood-pewees were characteristic of upland areas having small diameter trees in the overstory and understory. The overstory density was low and the understory was dominated by maples, dogwoods, white oak, white pine, and sourwood. Percent cover by ferns was low; indicating a more xeric habitat type. Although the eastern wood-pewee was slightly more abundant in the xeric stands, Bond (1957) found no clear trend in pewee abundance along the moisture gradient. Beals (1960) and Shugart and James (1973) also found the eastern wood-pewee to be widely distributed and detected no pattern of habitat use. Giffen (1984) found the pewee to be more abundant in northern hardwood upland habitats than in hemlock bottomlands. He stated that the pewee was rare in the bottomlands supporting my results showing a trend for the pewee to occur away from the streams. Stauffer (1978) also showed pewees to be more abundant in uplands than in riparian habitats. Contrary to my results, Beals (1979) and Stauffer (1978) stated that the pewee seemed to prefer areas having larger trees. Healy (1979) found pewees to be associated with areas having high distances between overstory trees indicating a low density of overstory trees, agreeing with my results showing a negative relationship between presence of the pewee and overstory density (Table 10).

The eastern wood-pewee and acadian flycatcher appeared to be mutually exclusive in their habitat use. The pewee was not present at any station at which the acadian flycatcher was present. An explanation for this is the hypothesis that the 2 species are ecological equivalents

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and may compete for similar resources. The acadian flycatcher is better
able to compete in riparian habitats and the eastern wood-pewee out-
competes the acadian flycatcher on upland sites. This hypothesis needs
to be tested to provide a clear explanation of this relationship.

Mesic hardwoods assemblage

The mesic forest assemblage demonstrated a preference for habitats
exhibiting mesic forest characteristics (Tables 10 and 11) but showed no
pronounced riparian influence (Tables 7 and 8). Habitat characteristics
associated with this assemblage were not found exclusively near the
streams (Tables 3 and 4). At some locations, habitats having
characteristics of a mesic forest occurred at even the most upland
stations. Tulip poplar, cucumber magnolia, and sweet birch dominated
the overstories in these habitats. These areas often had high overstory
basal areas primarily because of the presence of large diameter trees.
Understory canopies were usually lower than in the riparian habitats,
creating a distinct canopy layer below the overstory canopy with
relatively open space between the canopies. Small stem densities were
high with relatively tall, but small diameter understory trees and
greenbriar being common. Percent fern cover and teaberry cover were
high, but low shrub cover was sparse. The ground layer was dominated by
ferns and sprouting overstory species. Striped maple was common in the
understory of these areas.

Black-throated green warblers occurred in areas having a low
understory composed of small diameter trees on areas with steep slopes

(Tables 10 and 11). Density of mesic overstory trees was high. Black-throated blue warblers were closely associated with the presence of hemlock in the habitat. At stations within 154 m of the second-order stream, black-throated blue warblers were recorded only in areas with hemlock present (Table 9). Low overstory basal areas and high fern cover also were characteristic of their habitats. Wood thrushes also were more abundant in areas having hemlock present. However, the only variable significant in the 2 models for the wood thrush was xeric overstory density and the models for presence or absence and relative abundance at occupied sites showed conflicting relationships with this habitat characteristic. Presence of the wood thrush was more common in areas having low densities of xeric overstory trees but relative abundance was higher at occupied stations with relatively higher densities of xeric overstory trees. I do not know why the models showed this type of relationship for the wood thrush; these results could be statistical artifacts.

Thompson and Capen (1988) placed the wood thrush and black-throated green warbler in closed-canopy assemblages. However, the species were not included in the same assemblage in their study. The density of coniferous trees present separated the assemblages in which these species were placed. The wood thrush was classified in the closed canopy deciduous assemblage and the black-throated green warbler was in the closed-canopy mixed deciduous-coniferous assemblage. Giffen (1984) showed the black-throated green warbler was evenly distributed throughout the hemlock bottomland and northern hardwood habitats in

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Maryland. I found no difference in black-throated green warbler abundance between areas having hemlock present and those lacking it, supporting the findings of Giffen (1984). However, Beals (1960) found a significant positive correlation between black-throated green warbler abundance and hemlock density. Giffen (1984) found the black-throated blue warbler to be most abundant near the stream and the wood thrush to be more abundant in the hemlock bottomland habitat than in the northern hardwood upland habitats. Because the habitat near the stream was hemlock bottomland, these results agreed with mine, indicating these species were more abundant in areas with hemlock present. Beals (1960) also found the black-throated blue warbler to be associated with hemlock habitats. Shugart and James (1973) found the wood thrush to be confined to mesic forests and Healy (1979) found a trend toward higher wood thrush densities in cove forests than in more xeric mixed oak-pine forests.

Xeric forest assemblage

The xeric forest assemblage was associated with the xeric upland habitats. Low overstories of small diameter trees and dense low shrub cover were characteristics common to these habitats. The common trees were chestnut oak, scarlet oak, and Virginia pine in the overstory and sassafras, black gum, American chestnut, Allegheny chinkapin, and small individuals of the overstory species in the understory. Common shrubs included huckleberry, blueberry, and mountain laurel. These habitats were most common on ridgetops. Three of the species, red-eyed vireo,

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scarlet tanager, and ovenbird, in this assemblage were grouped into the same assemblage by Thompson and Capen (1988).

The inclusion of the red-eyed vireo in the xeric forest assemblage appears to disagree with much of the literature regarding the habitat use of this species. In fact, the models developed in this study for the red-eyed vireo also appear to link the species with habitat characteristics more common in habitat types other than xeric forests (Tables 10 and 11). A high overstory canopy, low small stem density, and low density of xeric overstory species were characteristic of habitats resembling a more mesic forest habitat. The red-eyed vireo has been found in a wide range of forested habitats but was more common in intermediate or mesic deciduous forests (Bond 1957, Smith 1977, Healy 1979). However, Giffen (1984) found greater abundances of red-eyed vireos in northern hardwood upland habitats than in hemlock bottomlands and Beals (1960) found this species to be ubiquitous. In my study, red-eyed vireos were more abundant near the second-order stream at the five locations having a first-order stream present and Stauffer (1978) found them to be most abundant in floodplain habitats in Iowa. Therefore, the inclusion of this species in the xeric forest assemblage most likely represents a relationship too subtle to be easily interpreted from my data. The models for presence and relative abundance of the red-eyed vireo show trends similar to those noted by other authors. Smith (1977) found the red-eyed vireo to be negatively correlated with post oaks and black oaks, which were characteristic of habitats similar to those described by the xeric forest overstory in my study, and positively

correlated with average tree height. Anderson and Shugart (1974) and Healy (1979) also found the red-eyed vireo to be associated with high overstory canopies. In addition to the variables shown to be important to the red-eyed vireo, studies have shown them to be highly associated with dense, closed overstory canopy layers (Anderson and Shugart 1974, Smith 1977, Thompson and Capen 1988).

Bond (1957) found the scarlet tanager to be most common in the xeric forests in Wisconsin and Giffen (1984) found it to be more common in upland habitats in Maryland, both studies agreeing with my results showing the species to be more abundant away from the streams (Tables 6 and 7). Stauffer (1978) also found the tanager to be more abundant in upland woodlands than in forested riparian habitats in Iowa. Anderson and Shugart (1974) showed the scarlet tanager to be associated with dense overstory canopies but also stated that the scarlet tanager appeared to select habitat based on many variables. Beals (1960) also found scarlet tanagers to be associated with fairly dense forests. My models for the scarlet tanager (Tables 10 and 11) appear to generally describe the xeric forest habitat described previously. But no association with overstory canopy cover other than a negative association with total overstory density is evident in my models. The model for the relative abundance at occupied stations appears to agree with Anderson and Shugart (1974) in that the scarlet tanager responds to many attributes when selecting its habitat. An alternative hypothesis would be that the scarlet tanager uses a broad range of habitats and, therefore, a wide spectrum of habitat variables are associated with its

presence or abundance even though the species may not select the habitat based on those characteristics. Healy (1979) stated that the scarlet tanager was not highly selective. My data were not appropriate for testing this hypothesis.

As with the red-eyed vireo, the inclusion of the ovenbird in the xeric forest assemblage may be debatable. Smith (1977) found the ovenbird to be most common in stands in an intermediate position along the moisture gradient and Bond (1957) found the ovenbird to be > 2 times as abundant in mesic stands than in xeric stands. Shugart and James (1973) showed the ovenbird to be confined to mesic stands. However, Healy (1979) found higher densities in mixed oak-pine forests having a lower canopy than in the more mesic cove forests in Virginia. In my study the ovenbird showed no trends among distance from the stream or between areas having hemlock or deciduous habitat present at the stream. Therefore, at the scale at which this study was conducted the ovenbird appears to use the habitat along the riparian-upland gradient uniformly. Perhaps the xeric sites in my study did not have all the characteristics of the xeric sites in the other studies so the ovenbird could still use them extensively. Giffen (1984) also found the ovenbird to be distributed evenly along a gradient from hemlock bottomland to northern hardwood upland habitats. My models for the ovenbird support the findings by Anderson and Shugart (1974) and Healy (1979) indicating that ovenbirds used areas having a dense understory layer and shrub layers. Stauffer (1978) also found ovenbirds to be more abundant in areas with high densities of saplings. The models developed in this study show the

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ovenbird to be more abundant in areas having high percent ground cover, small stem density, and number of foliage layers (Table 11). These variables represent a well-developed or dense understory layer.

The pine warbler fits easily into the description of this assemblage. It was more abundant at stations away from the streams (Tables 6 and 7) and Virginia pines were often prevalent in these habitats. Anderson and Shugart (1974) found the pine warbler to be more abundant in areas having high densities of canopy trees of above average diameters over a sparse understory composed of smaller than average trees. The models for the pine warbler in this study contradict the relationship with overstory basal area. The model for pine warbler presence indicates a relationship with a relatively dense understory composed of xeric forest species, contradicting the findings of Anderson and Shugart (1974) that pine warblers prefer a sparse understory. The relationship with xeric forest understory density simply may be indicating that the pine warbler uses xeric forest habitats rather than indicating a positive association with a dense understory. However, Healy (1979) found the pine warbler to be most abundant in areas with an open overstory canopy and a dense understory with pines being prevalent. Therefore, the relationship between the pine warbler and understory density in the xeric forests in southwestern Virginia is most likely real.

The solitary vireo appears to use slightly more mesic sites than is indicated by the model for the assemblage as indicated by the relationship with mesic hardwoods density in the understory (Table 11).

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However the rest of variables in the models seem to describe a habitat with xeric forest characteristics. These results contradict those found by Giffen (1984). He found the solitary vireo to be more abundant near the stream. Since the bottomlands in his study were hemlock habitats, the results of my study also contradict their findings in that the solitary vireo was more abundant in deciduous habitats in my study (Table 9). Healy (1979) found the solitary vireo to be present in areas with a large percentage of the canopy 11 to 14 m in height. This relationship suggests an explanation for distance from the stream being important in predicting the presence status of the solitary vireo in my study since overstory canopy height was lower at stations away from the stream (Tables 3 and 4).

Bond (1957) found no clear trend in great-crested flycatcher abundance along the moisture gradient he sampled in Wisconsin; their abundance peaked in both the xeric and mesic stands, demonstrating high usage of stands at the extremes of the continuum. The peak in abundance in xeric stands appears to support the inclusion of this species in the xeric forest assemblage. The great-crested flycatcher appears to select its habitat based on the ground cover or possibly the understory characteristics of the habitat. Both vegetative variables used in the models describe the vegetative layer near the ground (Tables 10 and 11). Healy (1979) found the great-crested flycatcher to be associated with several variables describing a dense understory layer. However, the variables in my models may have only been the result of a more important underlying habitat characteristic. For example, the great-crested

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flycatcher may not select habitat based on high shrub and teaberry cover but rather on relatively open, patchy overstory and understory canopies which, in turn, allow more sunlight to reach the forest floor and result in a dense ground layer.

Mature hardwoods generalist assemblage

Because of the nature of the sampling design, this study can only describe in detail the habitat use of species or assemblages responding directly to the riparian-upland habitat gradient. Because the primary objective of the study was to investigate the differences between the riparian and upland habitats, our goal was achieved. All other descriptions of habitat use were an attempt to separate species based on very subtle, and possibly biologically meaningless, differences. This assemblage could have been better modeled and described by a study designed specifically for that purpose, as could some of the other assemblages. Therefore, the descriptions of habitat use were very general and seemingly contradictory of other studies and some of the relationships may have little true meaning.

The mature hardwoods generalist assemblage was distributed relatively evenly among the sampling stations. No distinct habitat selection was readily identified. Habitat use of several of the species could not be described by modelling because none of the habitat characteristics measured showed any relationship to either the presence or relative abundance at occupied stations of the species. Therefore, the habitat selection of some of the species in this assemblage may

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occur at a scale much larger than the one at which the habitat was measured for this study.

The yellow-throated vireo was relatively uncommon on the study area and showed no distinct habitat selection within the range of habitats sampled. It was most often present in areas having dense overstories with mesic hardwoods in the understory (Tables 10 and 11). Bond (1957) found that the yellow-throated vireo was more common in areas intermediate on the moisture continuum he sampled.

The black-and-white warbler appears to use characteristics of the understory in selecting its habitat. The habitats used most commonly by the black-and-white warbler had a well-defined understory canopy layer composed of large diameter understory trees (Tables 10 and 11), characteristics common in areas with hemlock present (Table 5). Healy (1979) found a positive relationship between black-and-white warbler presence and high mean tree diameter. Thompson and Capen (1988) found this species to be associated with areas having high understory densities of trees 8-15 cm dbh and an intermediate overstory canopy cover. Beals (1960) also found the black-and-white warbler in areas with high understory densities, especially of deciduous trees. However, my models suggest that black-and-white warblers were more common in areas with lower densities of understory trees, and Healy (1979) found similar results in southwestern Virginia.

The worm-eating warbler also appears to select its habitat on the basis of the understory structure present. All but one (3 of 4) of the variables associated with worm-eating warbler presence or relative

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abundance at occupied stations describes the vegetation in the understory or ground layer (Tables 10 and 11). A low, dense understory appears to be the most commonly used habitat within the mature deciduous hardwood forests in this study. In contrast to the findings of Shugart and James (1973), the worm-eating warbler was more abundant in upland habitats than in riparian habitats (Table 7). Healy (1979) found higher densities of this species in cove forests than in more xeric mixed oak-pine forests. The variables in the models I developed do not contradict her findings. She also found worm-eating warblers in areas with high percent slopes and large overstory trees. She found a positive relationship with understory density but the understory species were primarily evergreen rather than serviceberry, as in my results.

The tufted titmouse appears to be a habitat generalist within the forested habitats sampled in this study. No clear habitat association was found for the distribution of the titmouse among the stations. Bond (1957) and Anderson and Shugart (1974) could not characterize the habitat use of the titmouse and Shugart and James (1973) found the titmouse in all of the forested habitats they studied. Smith (1977) stated that the titmouse has a broad niche and, therefore, utilizes a wide range of habitats. Giffen (1984) found the titmouse to be more abundant in hemlock bottomlands than in northern hardwood upland habitats. However, Smith (1977) classified the titmouse as a dry forest species. The titmouse showed no trends along the riparian-upland gradient in this study.

The only variable related to Carolina wren presence or abundance

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was rhododendron density (Table 10). Anderson and Shugart (1974) found Carolina wrens in areas having high densities of small diameter overstory and subcanopy trees. The presence of thick rhododendron thickets may have created structure characteristics similar to the habitats in which Anderson and Shugart (1974) found the wrens to be most abundant. The association of wren presence with rhododendron density may have been the reason they were found only in riparian stations at the sites having a first-order stream nearby. However, no variables were useful for predicting relative abundance of the wren at occupied stations. Tonkovich (1989) observed the Carolina wren at 120 of 121 stations, yet was unable to describe the habitat selection of the species.

The hooded warbler seemed to select its habitat according to the characteristics of the understory. It was most abundant in areas having dense understory vegetation and high small stem densities but not in areas in which rhododendron was dominant in the understory (Tables 10 and 11). Anderson and Shugart (1974) also found the hooded warbler in areas with dense shrub and understory cover present. Garrison (1986) demonstrated an increase in hooded warbler abundance in thinned stands in which the understory density increased. Bond (1957) and Smith (1977) found the hooded warbler to be more abundant in the mesic forests but it showed no trend among the distances from the stream in my study.

The rufous-sided towhee was relatively uncommon on my study sites (present both years at 6 of 69 stations) (Table 11). Bond (1957) and Beals (1960) also found it to be uncommon in the mature forests they

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sampled. The towhee showed no clear trends in its habitat use among my sampling stations.

The Carolina chickadee used stations having high densities of small diameter trees in the understory (Table 10). Anderson and Shugart (1974) recorded the Carolina chickadee at only one site and it was characterized by an open understory composed of small trees. The relative abundance of Carolina chickadees at occupied stations showed no clear relationship with any habitat type, although several habitat variables were related to their relative abundance (Table 11).

Blue-gray gnatcatchers appeared to use habitats with characteristics of both the mesic and xeric habitats. Their association with white oaks in the overstory, high overstory canopies, and percent fern cover indicate use of a mesic forest (Tables 10 and 11). Healy (1979) found higher densities of gnatcatchers in cove forests than in more xeric mixed oak-pine forests in Virginia. However, their positive relationship with the number of foliage layers and overstory density of xeric forest species demonstrated characteristics common in the xeric upland forests. No riparian trend was evident for this species. These results suggest that the blue-gray gnatcatcher uses habitats exhibiting a blend of characteristics from the mesic and xeric forest types. Bond (1957) and Smith (1977) found the blue-gray gnatcatcher to be most common in stands in an intermediate position along the moisture gradients they studied and Shugart and James (1973) recorded the gnatcatcher in all of the forested habitats they sampled.

No trends in habitat use could be identified for the American

robin and American crow. The robin was uncommon on the study area and showed no relationship with any of the measured habitat variables. The sampling design was the wrong scale for adequately sampling a bird with a home range as large as that of the American crow.

Management Implications

Because riparian habitats have been considered to contain higher
bird densities and more species, managers have been encouraged to retain
buffer strips along streams in an attempt to minimize the impacts of
timber harvest or other activities on the communities in these areas.
Based on the results of this study, the protection of riparian habitats
because of the trends toward higher density and species richness of
nongame birds is unfounded. The riparian habitats supported neither
higher species richness nor total bird abundances than the upland
habitats.

However, this study did demostrate a distinct riparian influence
on several bird species, especially the acadian flycatcher and the
Louisiana waterthrush. Therefore, although the protection or retention
of a buffer strip along streams may not be warranted for total bird
density or local species richness, the retention of these species in the
bird community is dependent on the presence of high quality riparian
habitat. The method of testing whether species richness differed
between riparian or upland habitats utilized species richness on a small
scale. The results indicated that riparian habitats were not more
important than the upland habitats in terms of the number of species
present. However, if the species richness of a larger area is

considered, riparian habitats supported 2 bird species that were nearly absent in the surrounding habitats. Because the riparian areas composed a much smaller proportion of the total habitat present, the species dependent on these habitats will be more sensitive to habitat alteration than the upland species because there is less habitat for them to relocate to if an area becomes unsuitable.

The acadian flycatcher and Louisiana waterthrush both appeared to be dependent upon the presence of a stream, or riparian habitat, for both presence of the species and for high relative abundance. Both of these species are neotropical migrants, of which many have been reported to be declining during the last several years. Because these species were found almost exclusively near the stream, caution must be used to minimize impacts of management actions on their habitat or their populations might quickly decline.

The retention of buffer strips is a possibility for minimizing the impact of timber harvest or other silvicultural practices on this assemblage. Triquet et. al. (1990) found the Louisiana waterthrush using a buffer strip 15 m wide along a stream in Kentucky. However, the acadian flycatcher, which was observed on all plots before the clearcutting and on the control plots after harvest, was absent from the buffer strip. Both species were absent from the plot in which no buffer strip along the stream was retained. The 15 m-wide buffer strip may have been too narrow to provide an adequate amount of suitable habitat for the acadian flycatcher. Stauffer and Best (1980) noted that the number of species using the riparian habitats increased as the width of

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the riparian habitat increased. A wider buffer strip might have been suitable for acadian flycatchers. However, this study cannot determine a width necessary for either the acadian flycatcher or the Louisiana waterthrush. During the field season, the Louisiana waterthrush appeared to use the habitat immediately adjacent to the stream (< 5 m) while the acadian flycatcher tended to use the whole riparian habitat. This could explain why the Louisiana waterthrush was able to utilize the buffer strip 15 m wide but the acadian flycatcher could not in Kentucky (Triquet et. al. 1990). If this observation is valid, the acadian flycatcher may be more sensitive to habitat alteration than the Louisiana waterthrush.

The policies set forth by the Forest Service (USDA For. Serv. 1985) state that clearcutting is prohibited within 30.5 m of a perennial trout stream or within 15.2 m of all other perennial streams. No analysis to determine whether trout streams different from other streams in their value for terrestrial wildlife was conducted. However, I doubt there would be any difference in the bird communities present between the classifications in perennial streams. The 15.2 m strip along perennial streams in which clearcutting is not allowed is clearly too small for acadian flycatcher use based on the results of Triquet et. al. (1990). Because the acadian flycatcher tended to use much of the floodplain area along the streams, the 30.5 m area along perennial trout streams may be too narrow for acadian flycatchers to occupy; however, additional data would be required to determine the proper width of habitat necessary to maintain acadian flycatcher populations.

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In the definitions of riparian habitats recognized by the Forest
Service (USDA For. Serv. 1985), only 15.2 m from either bank of the
lower 304.8 m or 50 percent of intermittent streams flowing into a trout
fishery is considered to be riparian habitat. Because acadian
flycatchers often were present near the first-order streams 454 m from
the second-order stream and the habitats along these streams showed
riparian influences on other bird species and vegetation
characteristics, the definition of riparian habitats for intermittent
streams is not inclusive enough. Again, I do not believe any difference
exists between intermittent streams entering a trout stream or those
entering a non-trout stream. The riparian habitat along the
intermittent streams appeared to be more constricted to the stream edge;
therefore, a narrower buffer strip may support acadian flycatchers. But
further research is needed to provide reliable and sound
recommendations.

Single tree selection and group selection cuts are permitted
within the riparain zones. Group selection cuts open the canopy and may
cause declines in the populations of acadian flycatchers. The clearcuts
studied by Triquet et. al. (1990) were > 10 ha. Therefore, the impacts
of group selection cuts on acadian flycatchers cannot be determined at
this point. However, the flycatchers used areas with a complex canopy
cover and any action that might open the canopy has the potential for
causing the populations to decline. Bakesley and Reese (1988) found
that the presence of campgrounds in riparian habitats affected the bird
species that were present. Ground foragers and nesters declined or were

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absent in riparian habitats having a campground. These results indicate that campgrounds may have an impact on the Louisiana waterthrush since it nests near the ground and forages on the ground (Bent 1963).

I recommend that a series of monitoring stations be located along selected first- and second-order streams to monitor the presence of the riparian assemblage. Both species in this assemblage have distinct songs and are easily identified. Verner (1988) recommends a minimum of 200 stations > 300 m apart for monitoring bird populations. He recommends counts at each station of no more than 10 minutes. However, shorter time periods may be used. In this study I used 8 minutes of counting time. Monitoring stations could be established along streams adjacent to group selection cuts to determine the impact of the harvest on the riparian assemblage and determine the size of buffer strips necessary for maintaining the assemblage.

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Appendices

Appendix A. Plant species sampled in the overstory of sampling
            stations in southwestern Virginia in 1990-1991.

Common name	Scientific name
Red maple	_Acer rubrum_
Sugar maple	_Acer saccharum_
Serviceberry	_Amelanchier_ spp.
Sweet birch	_Betula lenta_
Pignut hickory	_Carya glabra_
Shagbark hickory	_Carya ovata_
Mockernut hickory	_Carya tomentosa_
Flowering dogwood	_Cornus florida_
American beech	_Fagus grandifolia_
White ash	_Fraxinus americana_
Green ash	_Fraxinus pennsylvanica_
Butternut	_Juglans cinerea_
Tulip poplar	_Liriodendron tulipifera_
Cucumber magnolia	_Magnolia acuminata_
Black gum	_Nyssa sylvatica_
Hornbeam	_Ostrya virginiana_
Sourwood	_Oxydendrum arboreum_
Pitch pine	_Pinus rigida_
White pine	_Pinus strobus_
Virginia pine	_Pinus virginiana_
Eastern sycamore	_Platanus occidentalis_

Appendix A.   (continued)

Common name	Scientific name
Black cherry	_Prunus serotina_
American mountain ash	_Pyrus americana_
White oak	_Quercus alba_
Scarlet oak	_Quercus coccinea_
Blackjack oak	_Quercus marilandica_
Chestnut oak	_Quercus prinus_
Black oak	_Quercus velutina_
Black locust	_Robinia pseudoacacia_
Sassafrass	_Sassafras albidum_
American basswood	_Tilia americana_
Eastern hemlock	_Tsuga canadensis_
Grape	_Vitis_ spp.

Appendix B. Plants in the understory measured in sampling
stations in southwestern Virginia in 1990-1991.

Common name	Scientific name
Box elder	_Acer negundo_
Striped maple	_Acer pensylvanicum_
Red maple	_Acer rubrum_
Sugar maple	_Acer saccharinum_
Yellow buckeye	_Aesculus octandra_
Smooth alder	_Alnus serrulata_
Serviceberry	_Amelanchier_ spp.
Common pawpaw	_Asimina triloba_
Ironwood	_Carpinus caroliniana_
Pignut hickory	_Carya glabra_
Shagbark hickory	_Carya ovata_
Mockernut hickory	_Carya tomentosa_
Chestnut	_Castanea dentata_
Allegheny chinkapin	_Castanea pumila_
Flowering dogwood	_Cornus florida_
Roundleaf dogwood	_Cornus rugosa_
American beech	_Fagus grandifolia_
White ash	_Fraxinus americana_
Green ash	_Fraxinus pennsylvanica_
Witch-hazel	_Hamamelis virginiana_
American holly	_Ilex opaca_
Black walnut	_Juglans nigra_

Appendices

Appendix B. (continued)

Common name	Scientific name
Mountain laurel	_Kalmia latifolia_
Common spicebush	_Lindera benzoin_
Tulip poplar	_Liriodendron tulipifera_
Cucumber magnolia	_Magnolia acuminata_
Domestic apple	_Malus sylvestris_
Black gum	_Nyssa sylvatica_
Hornbeam	_Ostrya virginiana_
Sourwood	_Oxydendrum arboreum_
White pine	_Pinus strobus_
Virginia pine	_Pinus virginiana_
American plum	_Prunus americana_
Black cherry	_Prunus serotina_
Choke cherry	_Prunus virginiana_
Red chokeberry	_Pyrus arbutifolia_
White oak	_Quercus alba_
Scarlet oak	_Quercus coccinea_
Bear oak	_Quercus ilicifolia_
Blackjack oak	_Quercus marilandica_
Chestnut oak	_Quercus prinus_
Post oak	_Quercus stellata_
Black oak	_Quercus velutina_
Great rhododendron	_Rhododendron maximum_

Appendix B. (continued)

Common name	Scientific name
Black locust	_Robinia pseudoacacia_
Sassafrass	_Sassafras albidum_
American basswood	_Tilia americana_
Eastern hemlock	_Tsuga canadensis_
Slippery elm	_Ulmus rubra_
Smooth blackhaw	_Viburnum prunifolium_

Appendix C. Plants in the shrub layer measured in sampling
             stations in southwestern Virginia in 1990-1991.

Common name	Scientific name
Striped maple	<u>Acer pensylvanicum</u>
Red maple	<u>Acer rubrum</u>
Serviceberry	<u>Amelanchier</u> spp.
Sweet birch	<u>Betula lenta</u>
Ironwood	<u>Carpinus caroliniana</u>
Chestnut	<u>Castanea dentata</u>
Allegheny chinkapin	<u>Castanea pumila</u>
Flowering dogwood	<u>Cornus florida</u>
Roundleaf dogwood	<u>Cornus rugosa</u>
Red osier	<u>Cornus stolonifera</u>
Hawthorne	<u>Crataegus</u> spp.
American beech	<u>Fagus grandifolia</u>
Ash	<u>Fraxinus</u> spp.
Huckleberry	<u>Gaylussacia</u> spp.
Witch-hazel	<u>Hamamelis virginiana</u>
American holly	<u>Ilex opaca</u>
Mountain laurel	<u>Kalmia latifolia</u>
Common spicebush	<u>Lindera benzoin</u>
Tulip poplar	<u>Liriodendron tulipifera</u>
Cucumber magnolia	<u>Magnolia acuminata</u>
Black gum	<u>Nyssa sylvatica</u>
Hornbeam	<u>Ostrya virginiana</u>

Appendix C. (continued)

Common name	Scientific name
Sourwood	Oxydendrum arboreum
Virginia creeper	Parthenocissus quinquefolia
White pine	Pinus strobus
Virginia pine	Pinus virginiana
Black cherry	Prunus serotina
Red chokeberry	Pyrus arbutifolia
White oak	Quercus alba
Scarlet oak	Quercus coccinea
Bear oak	Quercus ilicifolia
Chestnut oak	Quercus prinus
Gooseberry	Ribes spp.
Great rhododendron	Rhododendron maximum
Azalea	Rhododendron spp.
Raspberry	Rubus spp.
Sassafrass	Sassafras albidum
Greenbriar	Smilax spp.
Virginia spirea	Spiraea virginiana
Eastern hemlock	Tsuga canadensis
Blueberry	Vaccinium spp.
Tall deerberry	Vaccinium stamineum
Mapleleaf viburnum	Viburnum acerifolium
Smooth blackhaw	Viburnum prunifolium
Grape	Vitis spp.

Appendix D. Number of observations of birds during 6 censuses at stations in southwestern Virginia in 1990. Number of stations is in parentheses.

	Distance from stream				
Species	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m[a] (5)
Green heron	1	--	--	--	--
Turkey vulture	--	--	--	2	1
Red-shouldered hawk	--	1	--	1	--
Broad-winged hawk	1	--	--	1	--
Red-tailed hawk	--	--	1	--	--
Ruffed grouse	--	9	4	--	--
Eastern wild turkey	--	1	5	4	--
Yellow-billed cuckoo	--	--	1	--	1
Barred owl	2	1	--	--	--
Ruby-throated hummingbird	1	5	3	2	--
Red-bellied woodpecker	--	2	1	--	--
Northern flicker	--	--	1	2	--
Downy woodpecker	4	9	14	11	1
Hairy woodpecker	--	1	3	1	1
Pileated woodpecker	--	9	13	19	--
Great-crested flycatcher	3	14	11	12	--
Eastern wood-pewee	3	22	22	25	1
Eastern phoebe	5	3	2	--	1
Acadian flycatcher	80	23	7	--	17
Blue jay	5	10	9	8	2

Appendices

Appendix D.   (continued)

Species	Distance from stream				
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
American crow	12	21	14	3	5
Northern raven	--	3	2	--	--
Tufted titmouse	22	23	18	24	4
Carolina chickadee	13	23	10	16	6
White-breasted nuthatch	3	12	9	10	3
Carolina wren	4	--	3	3	1
Blue-gray gnatcatcher	16	19	14	10	1
Wood thrush	18	16	12	11	1
American robin	11	9	--	3	--
Cedar waxwing	--	--	4	3	--
Solitary vireo	4	6	9	21	1
Red-eyed vireo	54	108	69	55	10
Northern parula	4	3	--	--	--
Black-and-white warbler	1	9	21	29	4
Black-throated blue warbler	15	16	2	1	--
Magnolia warbler	--	--	1	--	--
Black-throated green warbler	1	20	16	19	1
Prairie warbler	--	--	1	2	--
Pine warbler	1	8	14	24	5
Hooded warbler	8	12	14	17	7

Appendix D.   (continued)

Species	Distance from stream				
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
Worm-eating warbler	4	34	38	35	17
Ovenbird	21	67	59	71	10
Louisiana waterthrush	33	13	--	1	2
American redstart	2	1	4	3	--
Rose-breasted grosbeak	--	--	1	--	--
Northern cardinal	7	--	--	1	--
Indigo bunting	--	--	4	2	--
Rufous-sided towhee	2	3	5	8	1
Song sparrow	1	--	--	1	--
Brown-headed cowbird	--	--	1	1	--
Common grackle	--	2	2	1	1
Scarlet tanager	15	36	48	52	8
Summer tanager	--	1	2	1	--
American goldfinch	5	12	7	12	4

[a] Station located on a first-order stream near the 454 m station.

Appendices

Appendix E. Number of observations of birds during 6 censuses at
            stations in southwestern Virginia in 1991. Number of
            stations is in parentheses.

	Distance from stream				
Species	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m[a] (5)
Turkey vulture	--	--	--	2	1
Sharp-shinned hawk	1	--	--	--	--
Red-shouldered hawk	--	1	--	--	--
Broad-winged hawk	--	2	--	--	--
Ruffed grouse	--	--	1	--	--
Eastern wild turkey	--	1	--	--	--
Mourning dove	--	--	1	--	--
Yellow-billed cuckoo	--	--	--	1	--
Barred owl	2	--	--	--	--
Eastern screech-owl	1	1	--	--	--
Ruby-throated hummingbird	1	9	5	3	3
Belted kingfisher	2	--	--	--	--
Red-bellied woodpecker	--	2	--	--	--
Northern flicker	--	2	--	--	--
Downy woodpecker	1	6	6	6	--
Hairy woodpecker	1	2	1	2	--
Pileated woodpecker	2	6	4	6	--
Great-crested flycatcher	4	6	5	12	--
Eastern wood-pewee	--	12	11	8	--
Eastern phoebe	1	--	--	--	--

Appendix E.   (continued)

Species	Distance from stream				
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
Acadian flycatcher	76	17	4	1	18
Blue jay	4	4	7	5	2
American crow	9	12	4	1	1
Northern raven	--	1	--	--	--
Tufted titmouse	9	8	7	18	1
Black-capped chickadee	--	--	--	1	--
Carolina chickadee	9	9	5	7	5
White-breasted nuthatch	2	7	7	8	--
Carolina wren	6	2	11	7	4
Blue-gray gnatcatcher	10	20	12	8	3
Wood thrush	15	5	5	5	1
American robin	2	--	1	--	--
Cedar waxwing	2	2	3	2	--
Solitary vireo	4	7	13	18	1
Red-eyed vireo	70	74	53	46	11
Northern parula	9	1	--	1	--
Black-and-white warbler	4	9	12	17	6
Black-throated blue warbler	14	8	1	3	--
Black-throated green warbler	5	16	9	6	2
Prairie warbler	--	1	--	--	--
Pine warbler	3	7	17	23	5

Appendices

Appendix E.   (continued)

| Species | Distance from stream | | | | |
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
Connecticut warbler	--	--	--	1	--
Hooded warbler	3	12	9	14	8
Worm-eating warbler	2	26	38	33	15
Ovenbird	36	71	73	66	12
Louisiana waterthrush	33	2	--	--	1
American redstart	1	6	5	5	3
Rose-breasted grosbeak	--	--	2	--	--
Northern cardinal	1	3	--	--	--
Indigo bunting	--	1	3	--	--
Rufous-sided towhee	2	5	9	13	1
Song sparrow	1	--	--	--	--
Brown-headed cowbird	--	1	2	2	--
Common grackle	--	1	1	--	--
Scarlet tanager	12	23	28	33	2
Summer tanager	--	1	2	1	--
American goldfinch	2	7	13	12	1

[a] Station located on a first-order stream near the 454 m station.

Appendices

Appendix F. Total number of observations of birds during 12 censuses
stations in southwestern Virginia in 1990-1991. Number of
stations is in parentheses.

Species	Distance from stream				
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m[a] (5)
Green heron	1	--	--	--	--
Turkey vulture	--	--	--	2	1
Sharp-shinned hawk	1	--	--	--	--
Red-shouldered hawk	--	2	--	1	--
Broad-winged hawk	1	2	--	1	--
Red-tailed hawk	--	--	1	--	--
Ruffed grouse	--	9	5	--	--
Eastern wild turkey	--	2	5	4	--
Mourning dove	--	--	1	--	--
Yellow-billed cuckoo	--	--	1	1	1
Barred owl	4	1	--	--	--
Eastern screech-owl	1	1	--	--	--
Ruby-throated hummingbird	2	14	8	5	3
Belted kingfisher	2	--	--	--	--
Red-bellied woodpecker	--	4	1	--	--
Northern flicker	--	2	1	2	--
Downy woodpecker	5	15	20	17	1
Hairy woodpecker	1	3	4	3	1
Pileated woodpecker	2	15	17	25	--
Great-crested flycatcher	7	20	16	24	--

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Appendix F. (continued)

| Species | Distance from stream | | | | |
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
Eastern wood-pewee	3	34	33	33	1
Eastern phoebe	6	3	2	--	1
Acadian flycatcher	156	40	11	1	35
Blue jay	9	14	16	13	4
American crow	21	33	18	4	6
Northern raven	--	4	2	--	--
Tufted titmouse	31	32	25	42	5
Black-capped chickadee	--	--	--	1	--
Carolina chickadee	22	32	15	23	11
White-breasted nuthatch	5	19	16	18	3
Carolina wren	10	2	14	10	5
Blue-gray gnatcatcher	26	39	26	18	43
Wood thrush	33	21	17	16	2
American robin	13	9	1	3	--
Cedar waxwing	2	2	7	5	--
Solitary vireo	8	13	22	39	2
Red-eyed vireo	124	182	122	101	21
Northern parula	13	4	--	1	--
Black-and-white warbler	5	18	33	46	10
Black-throated blue warbler	29	24	3	4	--
Magnolia warbler	--	--	1	--	--

Appendices

Appendix F.   (continued)

Species	Distance from stream				
	4 m (16)	154 m (16)	304 m (16)	454 m (16)	SN454 m (5)
Black-throated green warbler	6	36	25	25	3
Prairie warbler	--	1	1	2	--
Pine warbler	4	15	31	47	10
Connecticut warbler	--	--	--	1	--
Hooded warbler	11	24	23	31	15
Worm-eating warbler	6	60	76	68	32
Ovenbird	57	138	132	137	22
Louisiana waterthrush	66	15	--	1	3
American redstart	3	6	9	8	3
Rose-breasted grosbeak	--	--	3	--	--
Northern cardinal	8	3	--	1	--
Indigo bunting	--	1	7	2	--
Rufous-sided towhee	4	8	14	21	2
Song sparrow	2	--	--	1	--
Brown-headed cowbird	--	1	3	3	--
Common grackle	--	3	3	1	1
Scarlet tanager	27	59	76	85	10
Summer tanager	--	1	2	1	--
American goldfinch	7	19	20	24	5

[a] Station located on a first-order stream near the 454 m station.

Appendix G.   Common and scientific names of bird species recorded
              in riparian and adjacent habitats in southwestern
              Virginia in 1990-1991.

Common name	Scientific name
Green heron	Butorides striatus
Turkey vulture	Cathartes aura
Sharp-shinned hawk	Accipiter striatus
Red-shouldered hawk	Buteo lineatus
Broad-winged hawk	Buteo platypterus
Red-tailed hawk	Buteo jamaicensis
Ruffed grouse	Bonasa umbellus
Eastern wild turkey	Meleagris gallopavo
Mourning dove	Zenaida macroura
Yellow-billed cuckoo	Coccyzus americanus
Barred owl	Strix various
Eastern screech-owl	Otus asio
Ruby-throated hummingbird	Archilochus colubris
Belted kingfisher	Ceryle alcyon
Red-bellied woodpecker	Melanerpes carolinus
Northern flicker	Colaptes auratus
Downy woodpecker	Picoides pubescens
Hairy woodpecker	Picoides villosus
Pileated woodpecker	Dryocopus pileatus
Great-crested flycatcher	Myiarchus crinitus
Eastern wood-pewee	Contopus virens

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Appendix G.   (continued)

Common name	Scientific name
Eastern phoebe	_Sayornis phoebe_
Acadian flycatcher	_Empidonax virescens_
Blue jay	_Cyanocitta cristata_
American crow	_Corvus brachyrhynchos_
Northern raven	_Corvus corax_
Tufted titmouse	_Parus bicolor_
Black-capped chickadee	_Parus atricapillus_
Carolina chickadee	_Parus carolinensis_
White-breasted nuthatch	_Sitta carolinensis_
Carolina wren	_Thryothorus ludovicianus_
Blue-gray gnatcatcher	_Polioptila caerulea_
Wood thrush	_Hylocichla mustelina_
American robin	_Turdus americanus_
Cedar waxwing	_Bombycilla cedrorum_
Yellow-throated vireo	_Vireo flavifrons_
Solitary vireo	_Vireo solitarius_
Red-eyed vireo	_Vireo olivaceous_
Northern parula	_Parula americana_
Black-and-white warbler	_Mniotilta varia_
Black-throated blue warbler	_Dendroica caerulescens_
Magnolia warbler	_Dendroica magnolia_
Black-throated green warbler	_Dendroica virens_

Appendix G.   (continued)

Common name	Scientific name
Prairie warbler	Dendroica discolor
Pine warbler	Dendroica pinus
Conneticut warbler	Oporornis agilis
Hooded warbler	Wilsonia citrina
Worm-eating warbler	Helmitheros vermivorus
Ovenbird	Seiurus aurocapillus
Louisiana waterthrush	Seiurus motacilla
American redstart	Setophaga ruticilla
Rose-breasted grosbeak	Pheucticus ludovicianus
Northern cardinal	Cardinalis cardinalis
Indigo bunting	Passerina cyanea
Rufous-sided towhee	Pipilo erythrophthalmus
Song sparrow	Melospiza melodia
Brown-headed cowbird	Molothrus ater
Common grackle	Quiscalus quiscula
Scarlet tanager	Piranga olivacea
Summer tanager	Piranga rubra
American goldfinch	Carduelis tristis

Vita

The author was born in Wichita, Kansas on 29 November, 1966. In 1977 he moved to Ava, Missouri and attended Mt. Zion Bible School until he graduated from high school in 1985. That fall he entered Southwest Missouri State University where he majored in wildlife management. In 1987 he transferred to the University of Missouri-Columbia where he completed a Bachelor of Science degree in wildlife management in December 1988. While at the University of Missouri-Columbia he entered data from survey forms onto computer tape for Missouri Department of Conservation. Upon graduation he worked for the Missouri Department of Conservation as a deer trapper. In August 1989 he began a Master's program in the Department of Fisheries and Wildlife Sciences at Virginia Polytechnic Institute and State University. While there he conducted research to determine the influence of riparian habitats on nongame birds in the central Appalachian hardwood forests. He finished the research in 1992. The author is happily married to the former Sheila Joann Hosier of Ava, Missouri and was blessed with the arrival of their son, Dwight Allen Murray, during the summer of 1992.