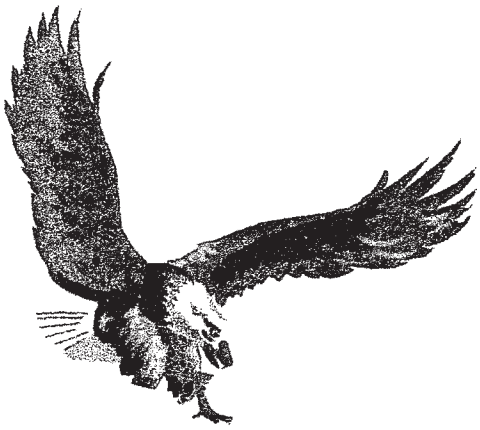

Bird Inventory of Monocacy National Battlefield, Frederick County, Maryland 1999-2000

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Abstract

A total of 83 points were identified as representative of the forest interior, forest edge, field, riparian, and fencerow habitats present in the park in 1999. Point counts were carried out at these points twice during two breeding seasons (May-June and July 1999, 2000). Seventy-one species of birds were identified on park property in the 1999 breeding season, and 80 species in 2000. In each breeding season, riparian habitats had the highest bird species richness, followed by fencerow and forest interior; these three habitats differed significantly in species richness and abundance. Fall 1999 and Winter 2000 counts were carried out along line transects, with 55 bird species observed in fall and 46 species observed in winter. Species richness was highest in riparian and fencerow habitats in fall, but in riparian and forest interior habitats in winter. The Worthington area of the park is especially diverse, but other areas of the park also contribute to bird species diversity. Special counts for owls and woodcock were carried out in 2000. In addition, GPS locations and 10 vegetation variables were measured in a 0.04 ha area centered at each point (July-August 1999). These variables were summarized by habitat type and bird-habitat associations were identified using CANOCO. Forty-nine species were identified in the tree category and 37 species in the shrub category in the park. Fencerow and forest edge had the highest density of exotic tree species (mean 22% and 14%, respectively). Vine density, density of exotic vegetation, several ground cover variables, tree basal area, and vegetation layer heights appear to be important determinants of bird species abundance patterns. Fencerow bird species diversity was not strongly affected by several habitat characteristics, but surrounding landscape may be important. Management recommendations include maintenance of riparian corridors and forest interior areas for breeding and wintering species, removal of exotics from areas of high density, maintenance of fencerow habitat complexity and connectivity to other habitat types, enhancement of grassland habitat and forest interior understory. Several monitoring schedules can achieve a detection of at least a 3% decline in species richness during the breeding season using established point locations, and monitoring may also be desirable during winter and migration.

Acknowledgements

We would like to thank the personnel of Monocacy National Battlefield and Ed Wenschof of Antietam National Battlefield for their assistance, and for the opportunity to carry out this project. We would especially like to thank Tom Kopczyk for his assistance in providing access to all park areas, information, logistical support, and interest in our work. Some equipment and vehicle support were provided by Frostburg State University.

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OVERVIEW OF METHODS

Monocacy National Battlefield includes a variety of habitats that are used by different species of birds throughout the year. The purpose of this study was to estimate bird species abundance and richness, and identify bird-habitat associations. This information was necessary to recommend management strategies and a long-term monitoring program for birds within the park. To obtain a representative sample of the bird species using the area, we located as many sampling points as possible within or adjacent to all habitat types (field, forest interior, forest edge, riparian, and fenecerow). All sampling points were at least 250 m apart, and a total of 83 points were sampled twice during two breeding seasons (1999, 2000) and once during Fall 1999 and Winter 2000. During the breeding season, bird abundance was estimated using 10-minute point counts, with species within and beyond 50 m noted. For fall and winter counts, we counted birds occurring along strip transects that were within or beyond 50 m. Attempts were made in early Spring 2000 to locate displaying American Woodcock (observations at dusk) and owls (playback of taped calls). Estimates of species density and relative abundance were calculated using standard formulas and species richness (number of species present) was estimated using the CAPTURE program. Species richness and abundance during the breeding season were compared across habitats using an analysis of variance, and richness was mapped across the park to identify "hotspots" for all seasons. Species presence and relative abundance were summarized by habitat and season, and by park area and season. A list of additional species likely to occur in the park was compiled from data on winter and breeding birds in the surrounding area. The program MONITOR yielded sampling effort needed for future detection of declines in species richness. In July and August 1999, habitat measurements were recorded within a 0.04 ha plot centered around each of the 83 points. At wooded sites, species and diameter at breast height of all trees, number of short and tall woody stems, canopy cover, percentage ground cover, heights of vertical layers, and an estimate of vine abundance were noted. At grassy sites, vertical structure and litter depth were estimated. Habitat data were summarized by habitat type, and areas of high exotic species density were mapped. Bird-habitat associations were examined using canonical correspondence analysis (CANOCO). Spatial characteristics of fencerows were quantified using FRAGSTATS and their effect on bird diversity was examined using stepwise regression.

OVERVIEW OF RESULTS

Breeding season counts yielded 71 and 80 species for 1999 and 2000, respectively. Riparian habitats had significantly higher bird species richness and abundance per point during the breeding season, followed by fencerow and forest interior. A total of 55 bird species were observed in fall and 46 in winter. Species richness was highest in riparian and fencerow habitats in fall, but in riparian and forest interior habitats in winter. Estimates of species richness were generally higher from SPECRICH2 (CAPTURE), indicating that more sampling effort may yield additional species. Species composition varied somewhat between seasons and between different areas of the park, but several species were common year-round. Riparian and forest interior habitats in park areas particularly contribute to bird species diversity. Forty-nine species were identified in the tree category and 37 species in the shrub category in the park. Fencerow and forest edge had the highest density of exotic species (mean 22% and 14%, respectively). Vine density, density of exotic vegetation, several ground cover variables, tree basal area, and vegetation layer heights appear to be important determinants of bird species abundance patterns. Areas of high exotic vegetation density tended to have low to moderate bird diversity, and the replacement of these species would probably be helpful to bird populations. Fencerow connectivity to other habitats and their structural diversity positively affect bird diversity. Maintaining high snag density and improving understory in forest interior, maintaining structurally diverse riparian and fencerow corridors, and improving grassland habitat will also benefit bird species.

INTRODUCTION

Monocacy National Battlefield, located southeast of the city of Frederick in Frederick Co, Maryland, consists of approximately 667 has of deciduous woodland, agricultural fields, and riparian zones along the Monocacy River and Bush Creek (tributary). Elevations range from approximately 61 to 122 m and slopes within the park vary in both degree and aspect. Although some areas of the park are contiguous, some parcels are more isolated or separated by county roads or state highways. As the demands of a growing population further fragment and change the surrounding landscape, the diverse habitats that comprise the park may provide an important refuge for both resident and migratory bird species. Areas within the park are managed by the National Park Service to preserve biotic diversity in addition to historic and cultural resources. Previously completed studies within the park on vegetation and selected animals (Maryland DNR 1998) provide information on which to base management decisions for these organisms, but very little information is available for bird populations at the battlefield. Occasional counts by local bird club members, area Audubon Christmas Counts, nearby Breeding Bird Survey routes, and sightings by Maryland DNR personnel indicate that there is the potential for species of concern or locally rare species to be present at the park. A baseline inventory, including data on bird species occurrence/abundance and habitat associations, is needed to provide information for sound management decisions, plan a monitoring scheme for birds, and clarify the role of the park in preserving and enhancing regional bird communities.

METHODS

Bird Inventory

Three major habitat types, forest, riparian, and fencerow, were identified by using a USGS aerial photo and by touring all park areas. Point count locations for birds were then placed within the park in such a way as to assure that all major habitats were sampled according to their relative area (samples stratified by habitat type). In addition, field points were sampled from adjacent forest edge, riparian, or fencerow locations. Sample points were located systematically at least 250 m apart in all but dense forest, where points were placed 150 m apart (Ralph et al. 1995). Starting points for counts were chosen at random within each set of habitat points. A total of 83 points were marked with plastic flagging and flags, and point locations were recorded using a GPS receiver.

Bird counts were carried out from sunrise to a maximum of four hours after sunrise to avoid bias from pre-dawn song activity and to capture the most active period (Ralph et al. 1995). Counts were not conducted under rainy or windy conditions, and observers waited a few minutes after arriving at the point location before noting the species present. In addition, habitat type was noted for a counted individual if different from the habitat type of the count point. During the breeding season, birds seen or heard at each sample point within 10 minutes were noted, with their distance recorded as $\leq$ 50 m, > 50 m, or flyover. Birds counted in the first 3 minutes, 3-5 minutes after start, and 5-10 minutes after start were recorded separately. Two counts were carried out in each breeding season, one early season and one later season count. Fall and winter counts were performed within strip transects along routes defined by marked points. Birds were noted as the observer walked slowly but steadily along a transect, and birds were recorded as being within or beyond 50 m.

Nocturnal surveys were carried out in February and March 2000. During these surveys, we spent time at dusk in appropriate habitat areas for American Woodcock male display activity (open areas adjacent to shrubs, especially wet areas) along Bush Creek and along the Monocacy River (Worthington Farm area). Beginning one hour after sunset at the earliest, we played the calls of Eastern Screech-Owl, Barred Owl, and Great Horned Owl along forest edges in the same areas.

Incidental occurrences of birds were also recorded to maximize the list of species present in the park. Additional bird species likely to occur in the area were determined by reviewing records for the area in winter (Hatfield et al. 1994; National Audubon Christmas Count data 1989-98), breeding season (Robbins and Blom 1996; Breeding Bird Survey data 1988-98), and year-round (Iliff et al. 1996).

Habitat Measurements

Habitat sample plots were centered at each of the 83 bird point count locations, with methods adapted from James and Shugart 1970, Noon 1981, Ralph et al. 1993, and Bibby et al. 1992. Each plot contained 0.04 ha. Circular plots (radius 11.3 m) were used at forest edge, riparian, and forest interior sites, and rectangular plots (10 x 40 m) were used at fencerow sites due to their more linear shape. For the wooded portion of a habitat sample plot (n = 83 plots), we recorded the species, diameter at breast height (dbh), and vertical layer of every woody stem $\geq$ 2.5 cm in diameter (considered to be trees); number of stems and dominant species for short (0.5-1.5 m) and tall (>1.5 m) woody stems < 2.5 cm dbh; canopy cover at four compass points using a concave, spherical densiometer; percentage ground cover for bare ground, forbs, ferns, moss/lichen, grass, and downed wood; heights of major vertical layers using a clinometer; and a score of vine abundance (0 = none, 1 = on a few trees; 2 = on few to half of trees, 3 = on over half of trees). For the grassy portion of a habitat sample plot (if present), we recorded the number of vegetation contacts at 10-cm intervals (to 1 m) on a vertical dowel placed at each end of two crossed, randomly located 2-m long poles (total four sets of measurements). Litter depth was measured with a meter stick at the end of each pole (total four measurements).

Data Analysis

When analyzing breeding season bird counts, only the maximum number of a species at a point was used for each year. Abundance values and densities for breeding season bird counts were calculated only from birds counted within 50 m of the point to assure a closer correspondence with measured habitat data. Density was calculated by dividing the total number of birds seen or heard within 50 m by the total area covered by points in which the species occurred (#points x 0.785 ha). All species seen or heard were used to create species lists by area and for the breeding season. An analysis of variance (ANOVA) was used to look for differences in species abundance and richness between forest interior, riparian, and fencerow habitats.

For fall and winter, all data were used to calculate bird abundance and density. Density was calculated by using the formula:

$$\text{density} = \frac{n_1 + n_2}{2rl} \log_e \frac{n_1 + n_2}{n_2}$$

where r = 50 m; n_1 = #birds counted within 50 m; n_2 = #birds counted beyond 50 m; and l = length of transect (Buckland et al. 1992).

Species richness (number of species present) was calculated by habitat type for fall and winter, and by habitat type and area for the breeding season, as the number of species present in a habitat type, and by using SPECRICH2 from the program CAPTURE (White et al. 1978, Rexstad and Burnham 1991). Data from the two breeding seasons was used as input for MONITOR4 (Gibbs 1995) to determine the level of sampling effort needed to detect declines in species richness as part of a monitoring program.

Grass vegetation heterogeneity indices were calculated as described in Bibby et al. (1992). Relationships between bird abundance and habitat variables were examined using canonical

correspondance analysis (CANOCO; ter Braak 1986) after highly correlated variables were removed from the analysis. The fencerow-bird species diversity relationship was investigated as follows. Bird species diversity was calculated using the Shannon-Weiner index. After importing data from an aerial photo into a Geographic Information System (IDRISI32), landscape-level variables for fencerows were quantified by the program FRAGSTATS (McGarical and Marks 1995). The data used from this program included the area of each fencerow, the shape index, and the fractal dimension. The shape index is a measure of patch shape in relation to a square (McGarical and Marks 1995). Fractal dimension is a measure of the complexity of the perimeter of the patch. Volume was calculated as a product of fencerow height and area. All statistical analysis for was performed in MINITAB 11.0. A Pearson-Product Moment correlation matrix was calculated using the variables described above in order to determine strength of correlation between variables. We omitted any variable with a correlation coefficient less than 0.1. We used simple linear regression to analyze the relationship between the remaining variables and species diversity. From this analysis, two outliers were dropped in order to increase the strength of the relationships. We used stepwise regression for the remaining fencerows and independent variables to develop the final model.

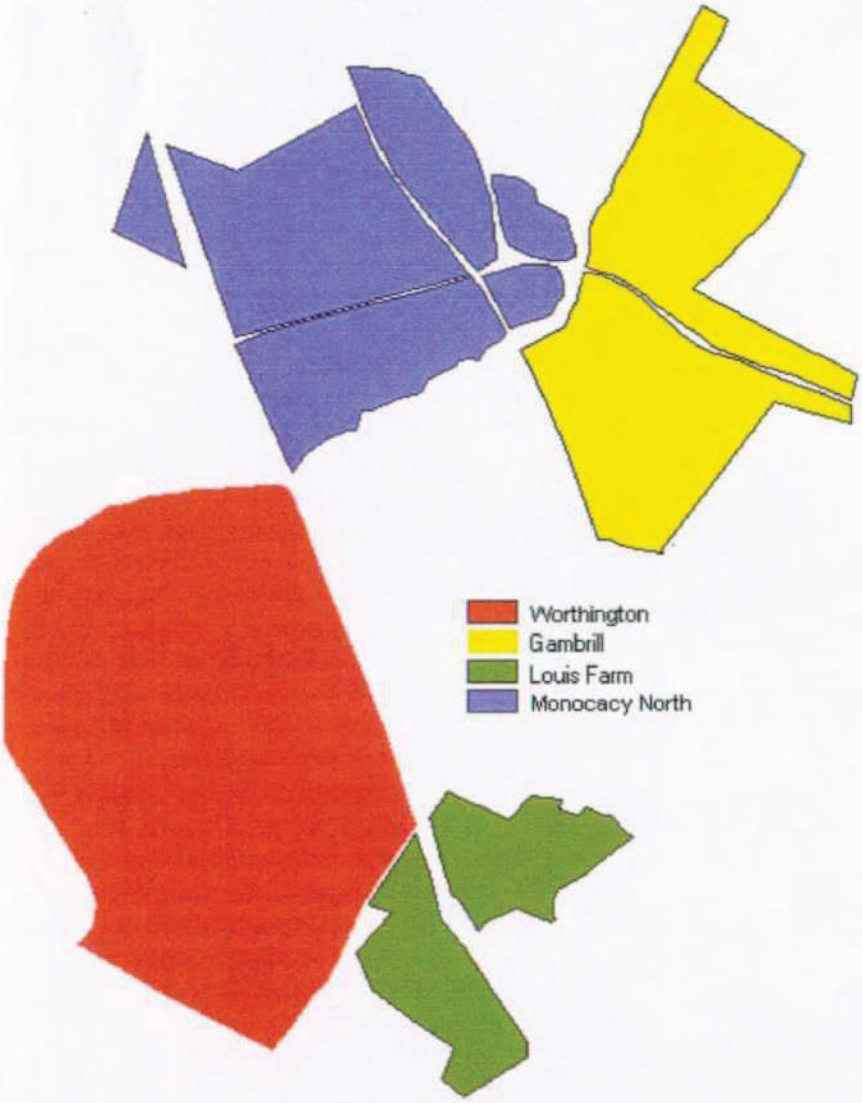
RESULTS AND DISCUSSION

Bird Inventory

General

The total number of sample points per habitat was 24 for forest interior, 25 for riparian, 8 for forest edge, and 26 for fencerow. Birds were noted in field habitats from 25 of the 83 sample points. Counts took approximately 72 hours total in each breeding season and were carried out June 8-16, July 8-16 in 1999 and May 30-June 7, June 26-July 5 in 2000. Fall counts took approximately 16 hours and winter counts 18 hours. Fall and winter counts were carried out September 12-22, 1999 and February 10-17, 2000, respectively. Scientific names of bird species noted in the park are included in Appendix A. The park was divided into areas to examine patterns on a finer scale (Figure 1).

Figure 1. Park areas used in analyses.



The distribution of habitat types within the park is pictured in Figure 2 (see next page).

Bird Species Presence/Richness

A total of 98 species was noted in the park, with 80 during the breeding season, 53 during fall, and 46 during winter in the park (Appendix B). No American Woodcock were found in surveyed areas. No owls responded to owl tapes in the survey areas, although two Barred Owls were noted during winter counts. Species noted only during the breeding season were: Green Heron, Wood Duck, Northern Harrier, American Kestrel, Yellow-billed Cuckoo, Ruby-throated Hummingbird, Great-crested Flycatcher, Eastern Kingbird, White-eyed Vireo, Warbling Vireo, Barn Swallow, Blue-gray Gnatcatcher, Northern Parula, Blackpoll Warbler, American Redstart, Worm-eating Warbler, Louisiana Waterthrush, Kentucky Warbler, Scarlet Tanager, Eastern Towhee, Chipping Sparrow, Vesper Sparrow, Grasshopper Sparrow, Blue Grosbeak, Red-winged Blackbird, Eastern Meadowlark, Common Grackle, Brown-headed Cowbird, Orchard Oriole, and Baltimore Oriole. Five species were only noted during fall counts (Broad-

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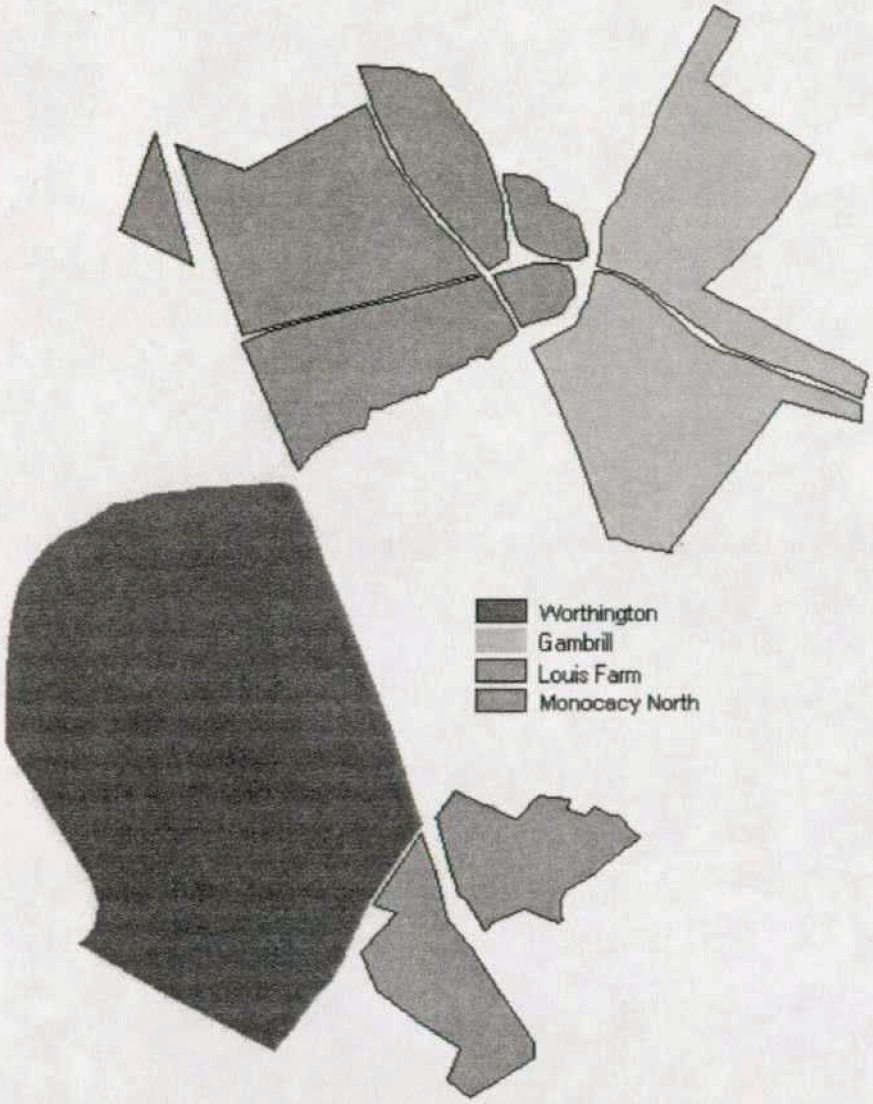

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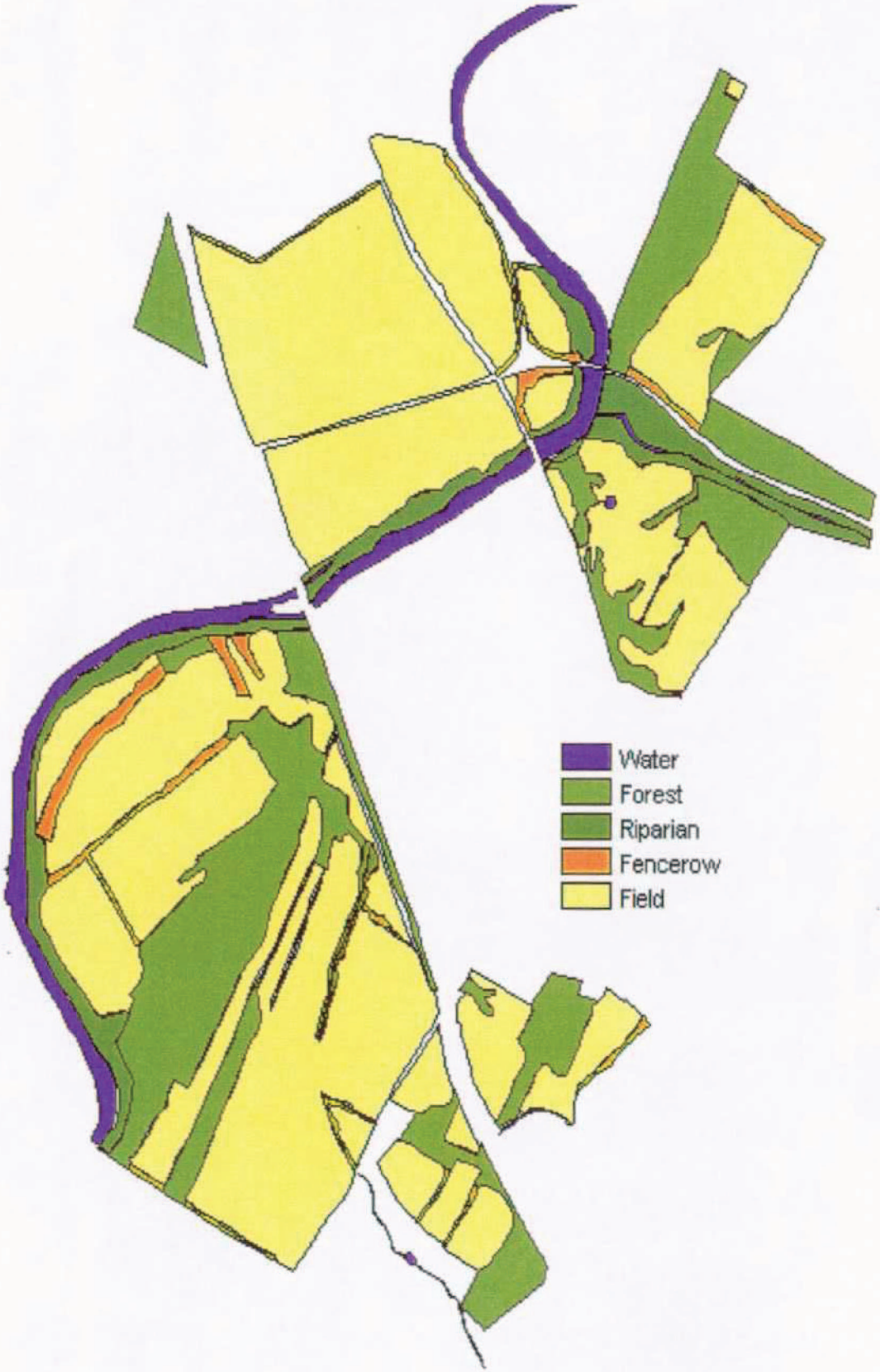
Figure 2. Distribution of habitat types within Monocacy National Battlefield.

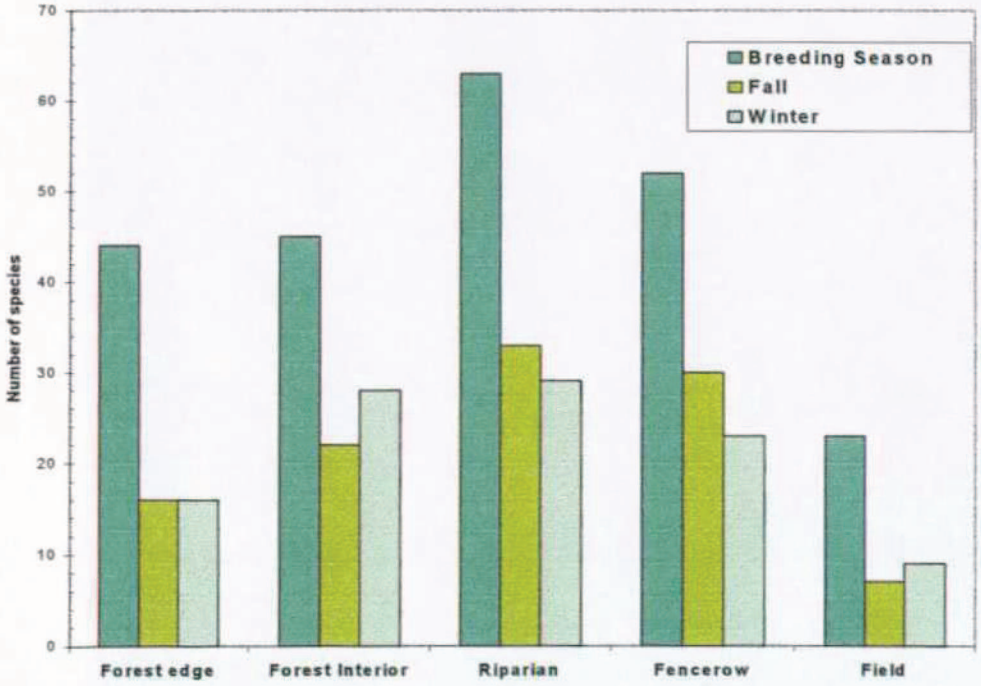

Water
Forest
Riparian
Fencerow
Field

winged Hawk, Spotted Sandpiper, Philadelphia Vireo, Nashville Warbler, Magnolia Warbler). Species noted only during winter were American Black Duck, Lesser Scaup, Hooded Merganser, Common Merganser, Bald Eagle, Ring-billed Gull, Barred Owl, Yellow-bellied Sapsucker, Brown Creeper, Ruby-crowned Kinglet, Yellow-rumped Warbler, White-throated Sparrow, and Dark-eyed Junco. A number of species were expected to be present in all seasons, but were only seen in one or two seasons: Black Vulture, Wood Duck, Mallard, Killdeer, Rock Dove, Wild Turkey, Barred Owl, Brown Creeper, Cedar Waxwing, Eastern Towhee, Red-winged Blackbird, Brown-headed Cowbird, American Goldfinch, and House Sparrow.

Potential species, not noted during surveys or other times (*seen in another season only) include the following:
Migrants (fall or spring)- Sharp-shinned Hawk, Veery, Swainson's Thrush, Hermit Thrush, Blue-winged Warbler, Chestnut-sided Warbler, Black-throated Blue Warbler, Black-throated Green Warbler, Blackburnian Warbler, Pine Warbler, Prairie Warbler, Palm Warbler, Bay-breasted Warbler, Cerulean Warbler, Ovenbird, Northern Waterthrush, Hooded Warbler;
Breeding Season- *Green Heron, Cooper's Hawk, American Woodcock, Great Horned Owl, Eastern Screech-Owl, Yellow Warbler, Yellow-throated Warbler;
Winter- Winter Wren, Golden-crowned Kinglet, White-crowned Sparrow, American Tree Sparrow, and Fox Sparrow.

The number of species by habitat type seen during the breeding season varied from 23 to 63, for fall 7-33, and for winter 9-29 (Appendix C). The highest number of species was found in riparian habitats during all seasons (Figure 3). Fencerow habitats contained a relatively large number of species during the breeding season and fall, while forest interior habitats appeared to be more important during winter. The relatively high number of species found on the forest edge during the breeding season probably reflects the presence of forest interior birds in these areas, but the presence of species in this habitat type dropped dramatically during fall and winter whereas species presence in forest interior increased.

Figure 3. Number of species present during counts in each habitat type by season.



When examining these habitats in terms of number of species per point, riparian habitats were again highest, followed by forest interior and fencerow (Table 1). This reinforces the importance of riparian and forest interior habitats to breeding birds in the park.

Table 1. Means (standard deviations) per point of number of bird species and abundance for fencerow, forest interior, and riparian habitats within Monocacy National Battlefield during the breeding season. Asterisks indicate a significant difference in bird response between that habitat and one or more of the others (P<0.05).

	Fencerow	**Forest Interior**	**Riparian**
Number of Species	11.23 (3.29)	12.56 (2.82)	16.29 (3.39)*
Abundance	18.23 (6.42)	18.74 (4.29)	22.33 (4.79)**

*Number of species greater than both fencerow and forest interior
**Abundance greater than fencerow

Estimates of species richness (number of species present) using the program CAPTURE were generally larger than counts of the number of species observed for all count periods (Table 2). These estimates take into account the possibility that species may be missed by a survey technique, but also some of these counts have large confidence intervals. The M_h jackknife model estimator fit a number of, but not all, of the data sets. It was not possible to calculate estimates for two data sets, possibly due to the distribution of the data or other program limits. Breeding season estimates could not be calculated by habitat type alone due to data input size limits. At least three points were necessary to generate an estimate.

Table 2. Species richness by habitat type using program CAPTURE (includes data from within and beyond 50 m).

Fall 1999

Habitat type	Number of species observed	Estimated number of species (SE)	95% confidence interval	Model estimator
Forest edge	16	18 (1.4)	17-24	M_t Darroch
Forest interior	22	28 (4.4)	23-43	M_h jackknife
Riparian	33	*	*	*
Fencerow	30	37 (5.0)	32-54	M_{th} Chao
Field	7	9 (2.3)	7-18	M_h jackknife

*program would not calculate estimate

Winter 2000

Habitat type	Number of species observed	Estimated number of species (SE)	95% confidence interval	Model estimator
Forest edge	16	19 (2.6)	16-29	M_t Darroch
Forest interior	28	28 (0.5)	28-31	M_t Darroch
Riparian	29	29 (0.7)	29-31	M_{bh} removal
Fencerow	23	30 (5.2)	24-48	M_{th} Chao
Field	9	12 (3.4)	9-26	M_h jackknife

Breeding Season (using maximum from two seasons)

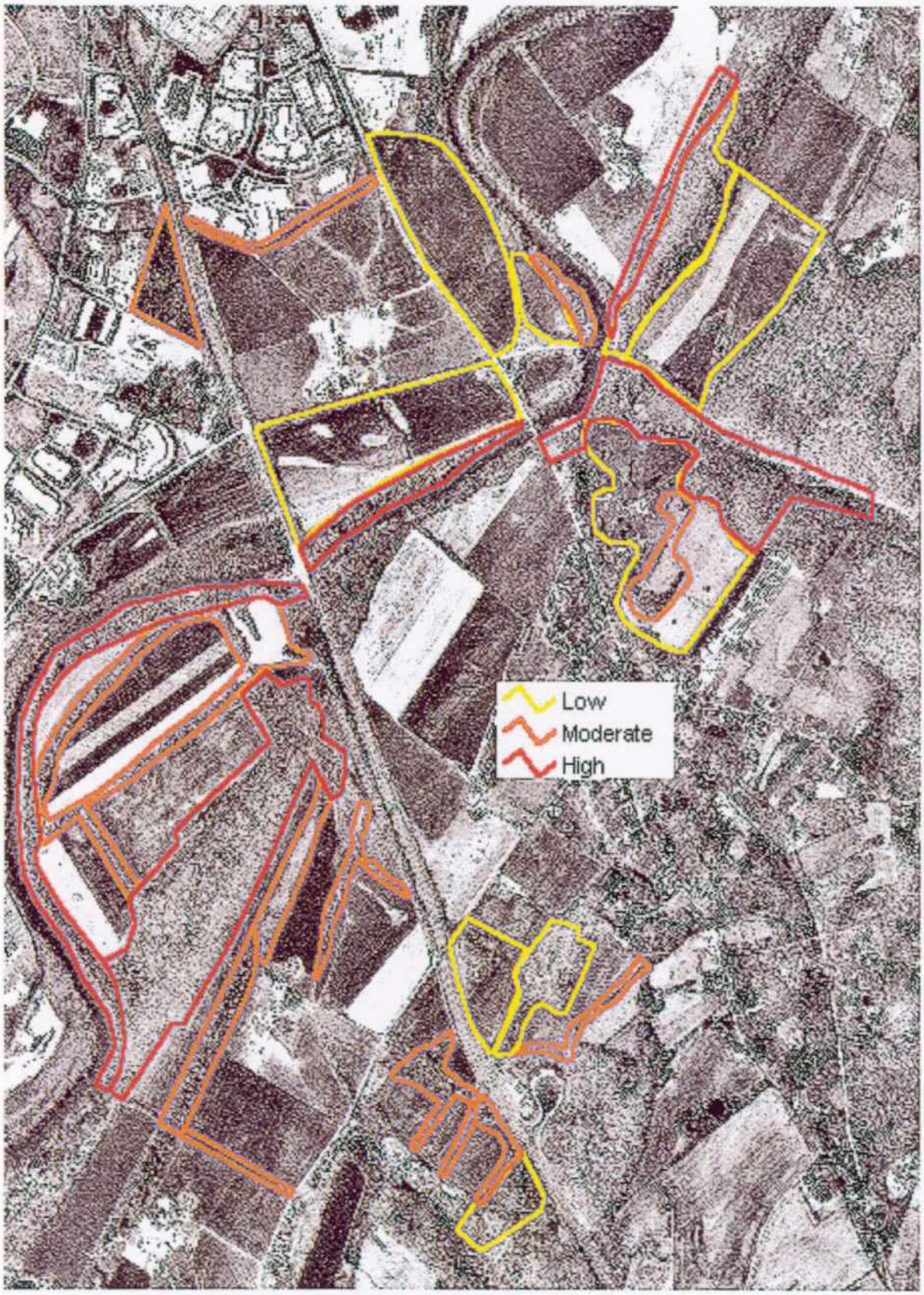
Habitat type (N = total number of species)	Location (# points)	Number of species counted	Estimated number of species (SE)	95% confidence interval	Model estimator
Forest edge (N = 44)	Louis Farm (2)	20	---	---	---
	Worthington (1)	7	---	---	---
	Gambrill (6)	37	44 (4.44)	39-58	M_h jackknife
Forest interior (N = 45)	Louis Farm (5)	26	32 (4.33)	27-47	M_h jackknife
	Worthington (14)	47	53 (4.49)	49-69	M_h jackknife
	Gambrill (4)	27	27 (0.34)	27-30	M_t Darroch
	Monocacy North (1)	10	---	---	---
Riparian (N = 63)	Gambrill (7)	49	56 (4.57)	51-71	M_h jackknife
	Worthington (13)	58	60 (2.31)	58-69	M_b Zippin
	Monocacy North (5)	38	43 (3.91)	39-57	M_h jackknife
Fencerow (N = 52)	Louis Farm (7)	36	*	*	*
	Worthington (12)	48	57 (6.90)	50-82	M_b Zippin
	Gambrill (3)	28	54 (22)	34-137	M_{th} Chao
	Monocacy North (5)	38	41 (2.51)	38-48	M_o null
Field (N = 23)	Worthington (12)	10	10 (2.78)	10-28	M_h jackknife
	Gambrill (9)	8	9 (1.64)	8-17	M_o null
	Monocacy North (4)	8	9 (1.88)	8-17	M_o null

*program would not calculate estimate

Due to species habitat preferences and natural history, not all species were found in all habitat types (Appendix C). Some of these patterns may reflect real species preferences and habitat limitations such that these species may be most affected when a certain habitat is altered, or their presence may be limited by the presence of this habitat. In this study, species noted only in forest edge were White-eyed Vireo, Philadelphia Vireo, and Kentucky Warbler; in forest interior: Ruby-crowned Kinglet, Yellow-rumped Warbler, and Blackpoll Warbler; in riparian areas: Great Blue Heron, Green Heron, Wood Duck, American Black Duck, Mallard, Lesser Scaup, Hooded Merganser, Common Merganser, Bald Eagle, Spotted Sandpiper, Belted Kingfisher, American Redstart, Louisiana Waterthrush, and Blue Grosbeak; in fencerows: Northern Harrier, Nashville Warbler, and Black-and-white Warbler; and in fields Broad-winged Hawk, American Kestrel, Killdeer, Grasshopper Sparrow, and Eastern Meadowlark.

Park areas differed in the estimated number of species by habitat (Table 2) and by season (Figure 4). The highest number of species over all counts was found in the Worthington area of the park (Appendix D). The large area of this section and the diversity of habitats that it contains contributed to its high species richness, especially in fencerow, riparian, and forest interior habitats. The Gambrill area also had a high number of species present. Maps of species richness as low, moderate, and high for each count period show where the "hotspots" of species richness occurred across the landscape of the park (Figures 5-7, following pages). In fall and winter, riparian and forest areas in the Worthington and Gambrill sections were consistently moderate to high, Louis Farm varied from low to moderate, and Monocacy North had higher species richness in fall. Richness along riparian areas was moderate to high during both count periods. For breeding season counts, it was possible to map species richness on a finer scale, approximating the locations of sample points (Figure 7). This map shows a relatively high number of species occurring along riparian areas, but also some fencerow and forest interior sites. Almost all points in Gambrill had either high or moderate species richness during the breeding season, while those in other park areas were more variable.

Figure 5. Species richness for birds from strip transect routes surveyed in Fall 1999. Routes are superimposed over an aerial photograph of the area. Number of species = 0-7 for low, 8-12 for moderate, and 14-21 for high.


Low
Moderate
High

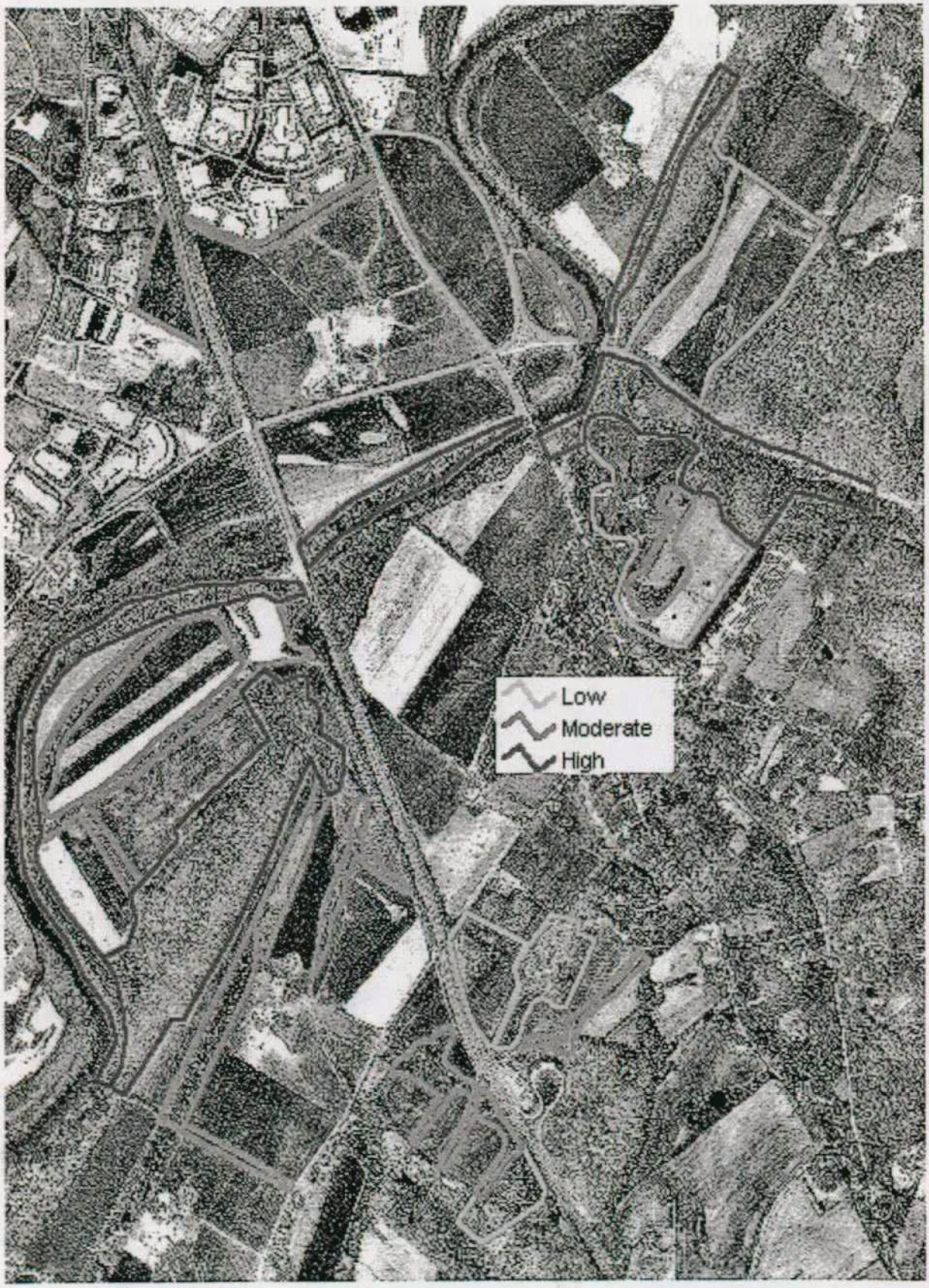
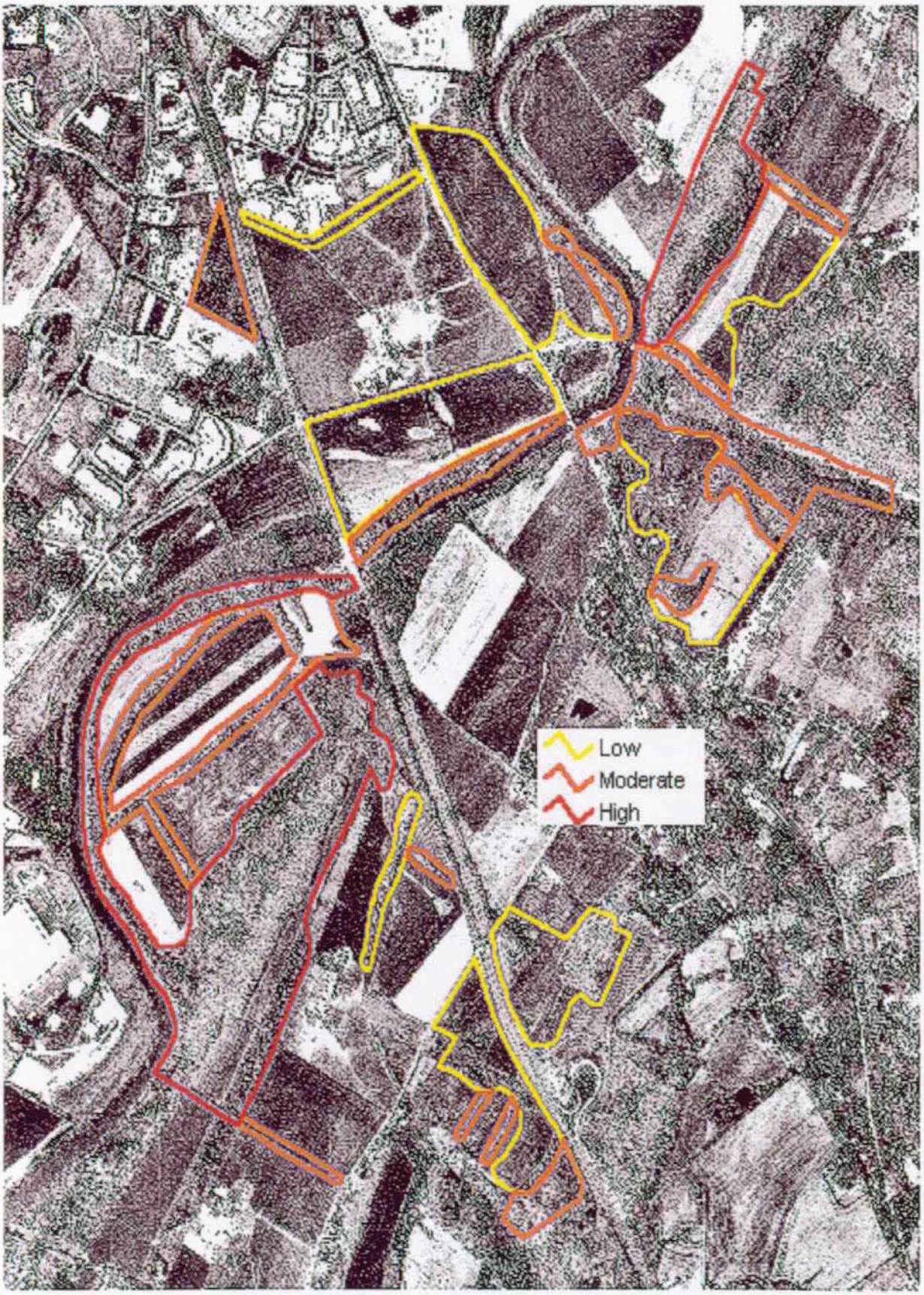

Low
Moderate
High

Figure 6. Species richness for birds from strip transect routes surveyed in Winter 2000. Routes are superimposed over an aerial photograph of the area. Number of species = 0-7 for low, 8-10 for moderate = 8-10, 11-22 for high.


Low
Moderate
High

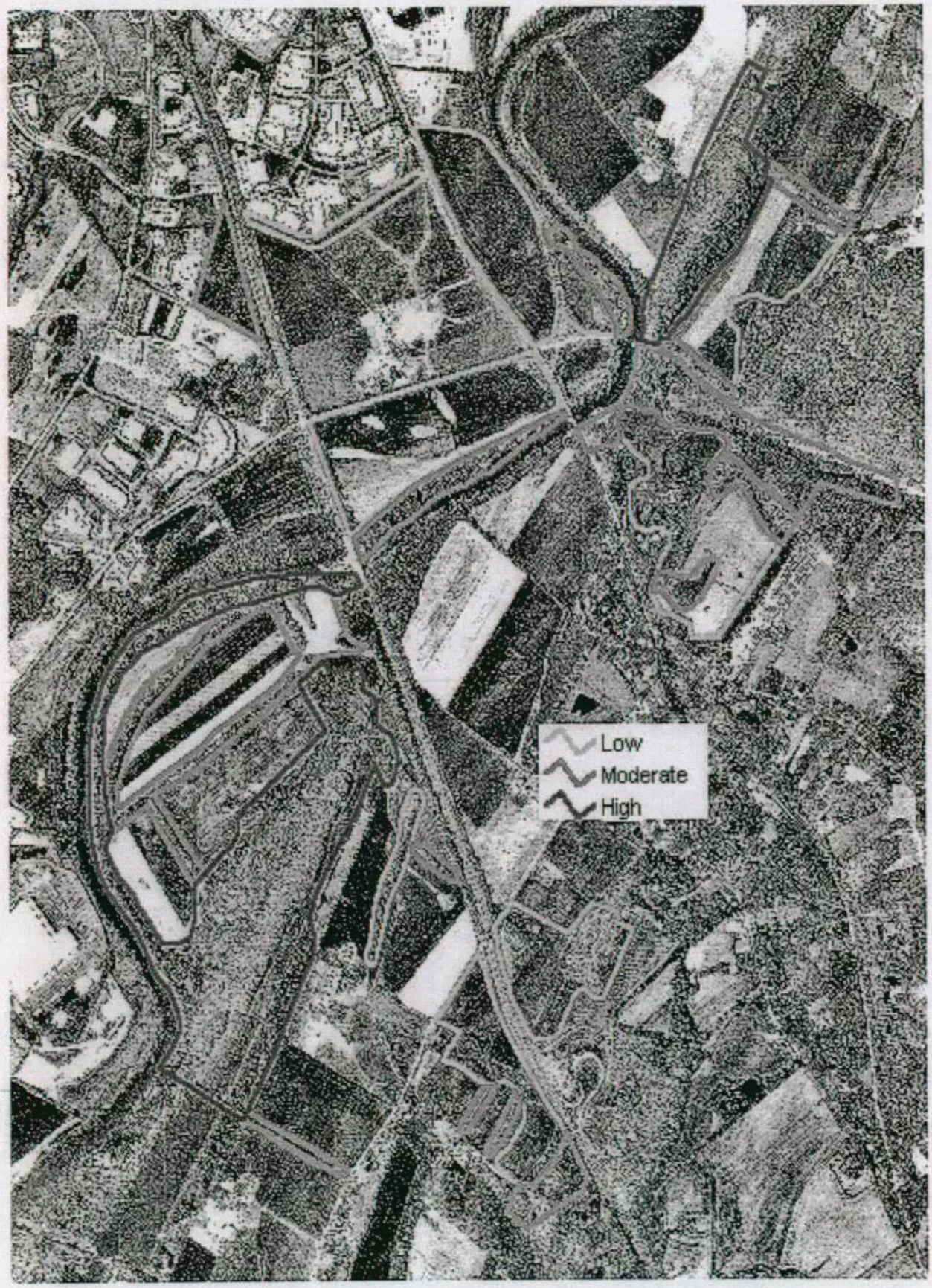

Low
Moderate
High

Figure 7. Species richness for birds from point counts, surveyed in breeding season (1999, 2000). Counts represent the maximum from the two years. Points are superimposed over an aerial photograph of the area. Number of species = 6-10 for low, 11-15 for moderate, and 16-25 for high.

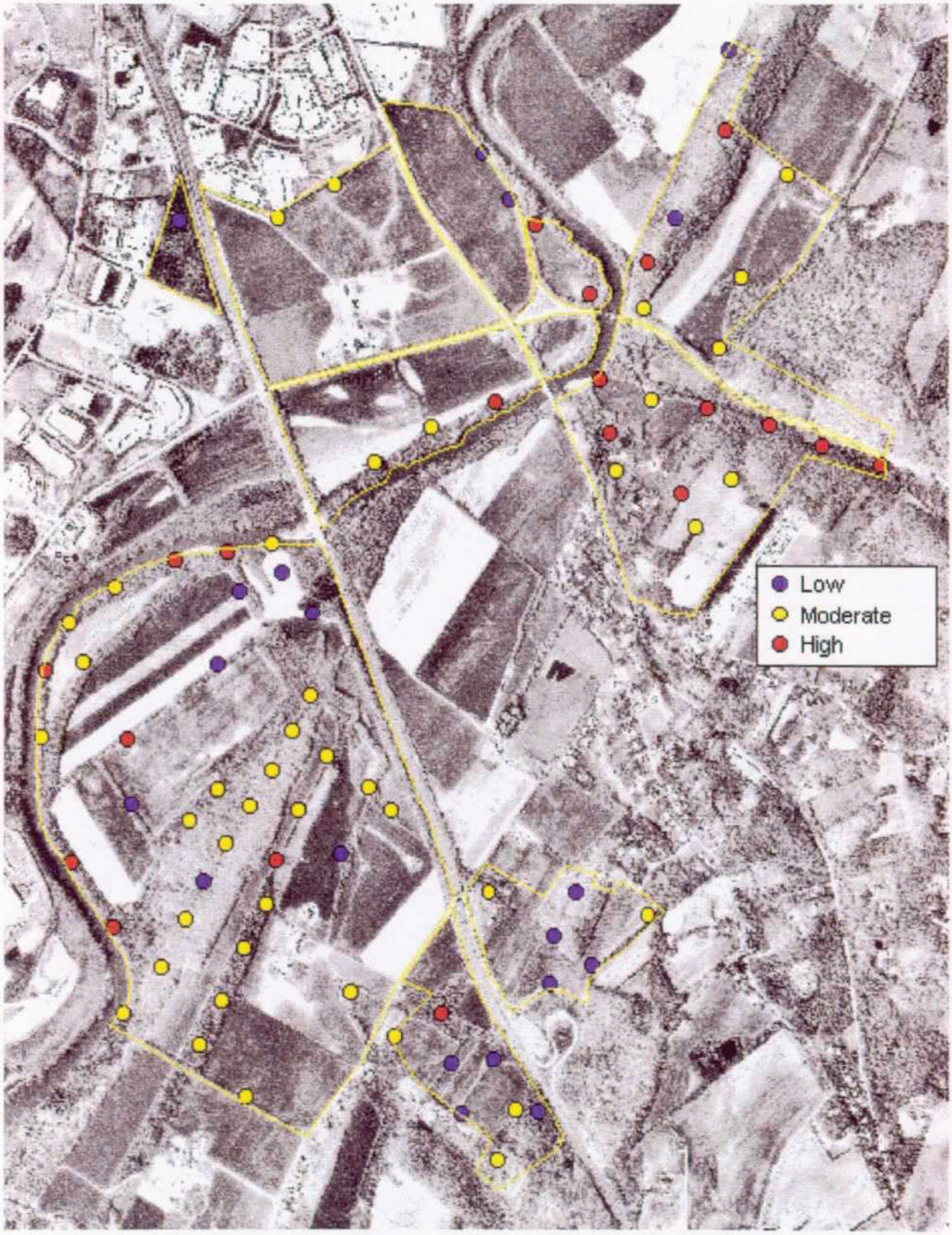
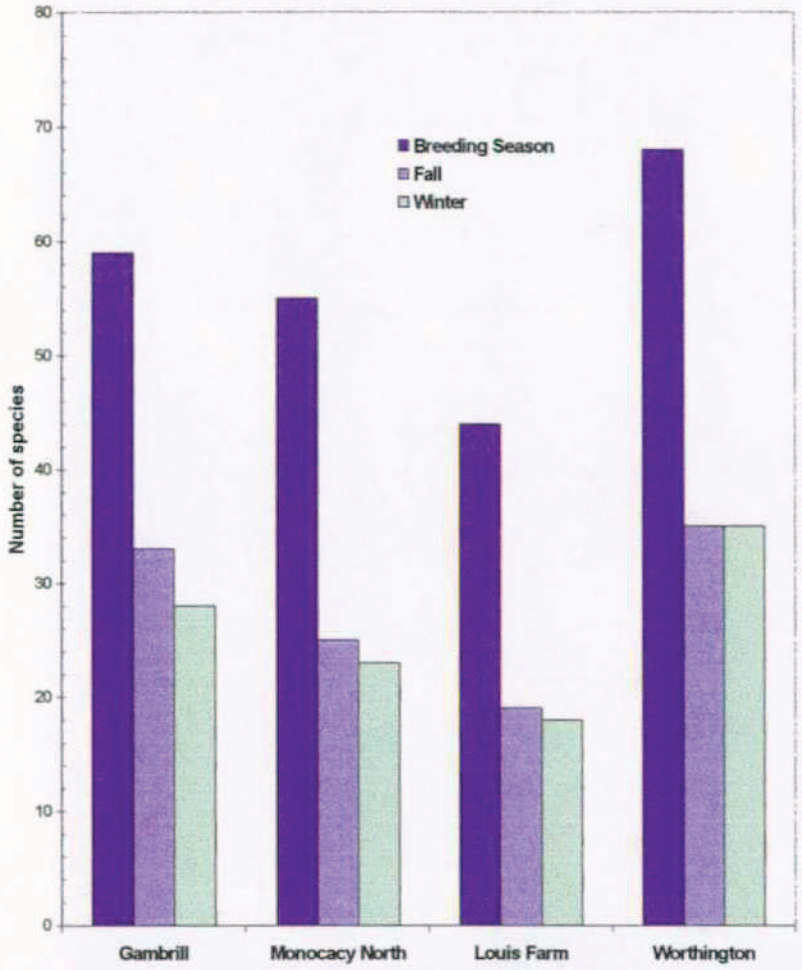

Low
Moderate
High

Figure 4. Number of species by park area by season.



Not all species were present in all park areas (Appendix D), and some of these differences may reflect important species limits. Species found only at Gambrill were Green Heron, Broad-winged Hawk, Spotted Sandpiper, Yellow-throated Vireo, Philadelphia Vireo, Louisiana Waterthrush, and Kentucky Warbler; at Monocacy North: Hooded Merganser, Nashville Warbler, Blue Grosbeak, and Eastern Meadowlark; at Louis Farm: Northern Harrier and White-eyed Vireo; and at Worthington: Wood Duck, American Black Duck, Lesser Scaup, Common Merganser, Bald Eagle, Wild Turkey, Blackpoll Warbler, American Redstart, Vesper Sparrow, and Orchard Oriole.

Bird Species Relative Abundance and Density

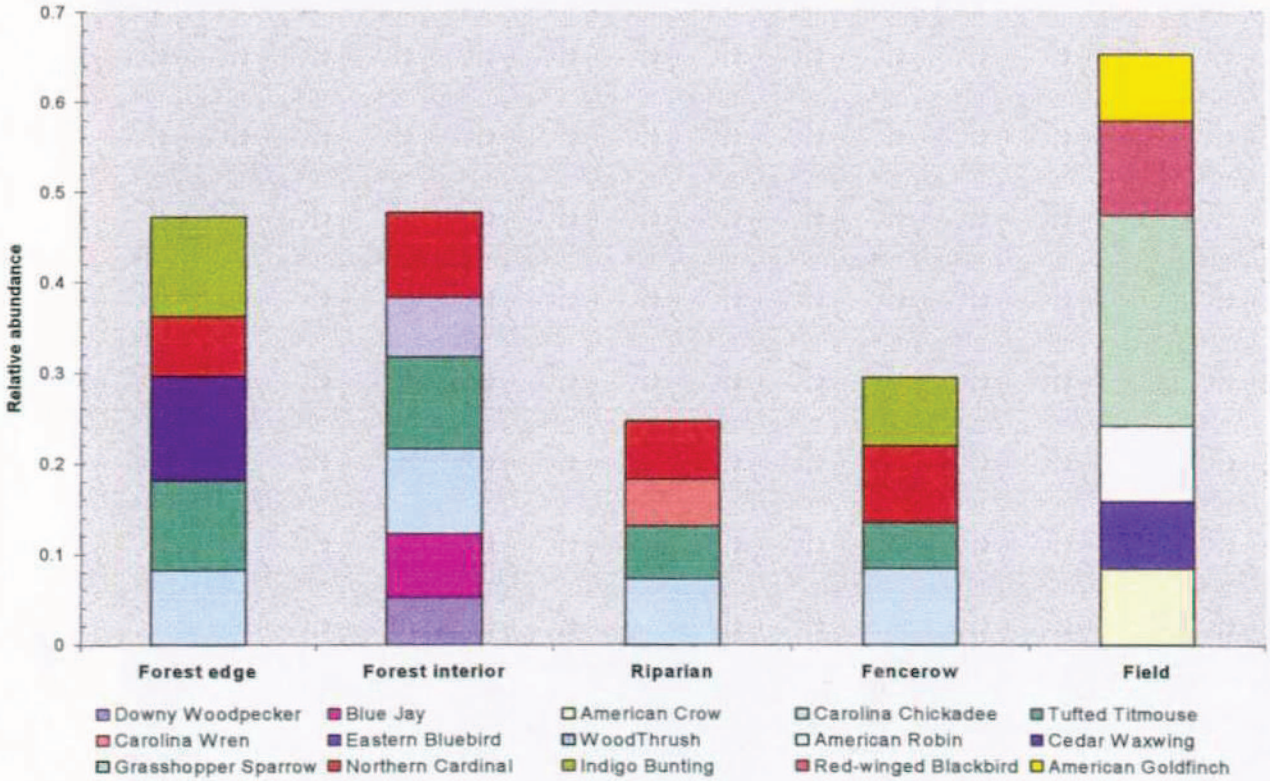
Examining the relative abundance and density of a species allows us to identify the most common species in a habitat or area. Some species, like Downy Woodpecker, Blue Jay, American Crow, Carolina Chickadee, Tufted Titmouse, White-breasted Nuthatch, Carolina Wren, and Northern Cardinal, were common/abundant year-round in a range of habitats, while others were more common or limited to one or a few habitat types (Appendix E). Over breeding season (B), fall (F), and winter (W), forest edge habitats had high relative abundance of Chimney Swift (B), American Robin (W), House Wren (F), and Cedar

Waxwing (B). Forest interior had high relative abundance for Wood Thrush (B), American Robin (F), and Dark-eyed Junco (W). For riparian areas, Canada Goose and Mallard were common in winter. Fencerows had high relative abundance of Cedar Waxwing (F) and Indigo Bunting (B). Field habitats had high relative abundance of Canada Goose during winter; Eastern Bluebird, American Robin, Grasshopper Sparrow, Red-winged Blackbird, and American Goldfinch during the breeding season, and Tree Swallow during fall. Patterns of density were similar (Appendix F), with higher densities in general during the breeding season as is typical of many temperate bird communities.

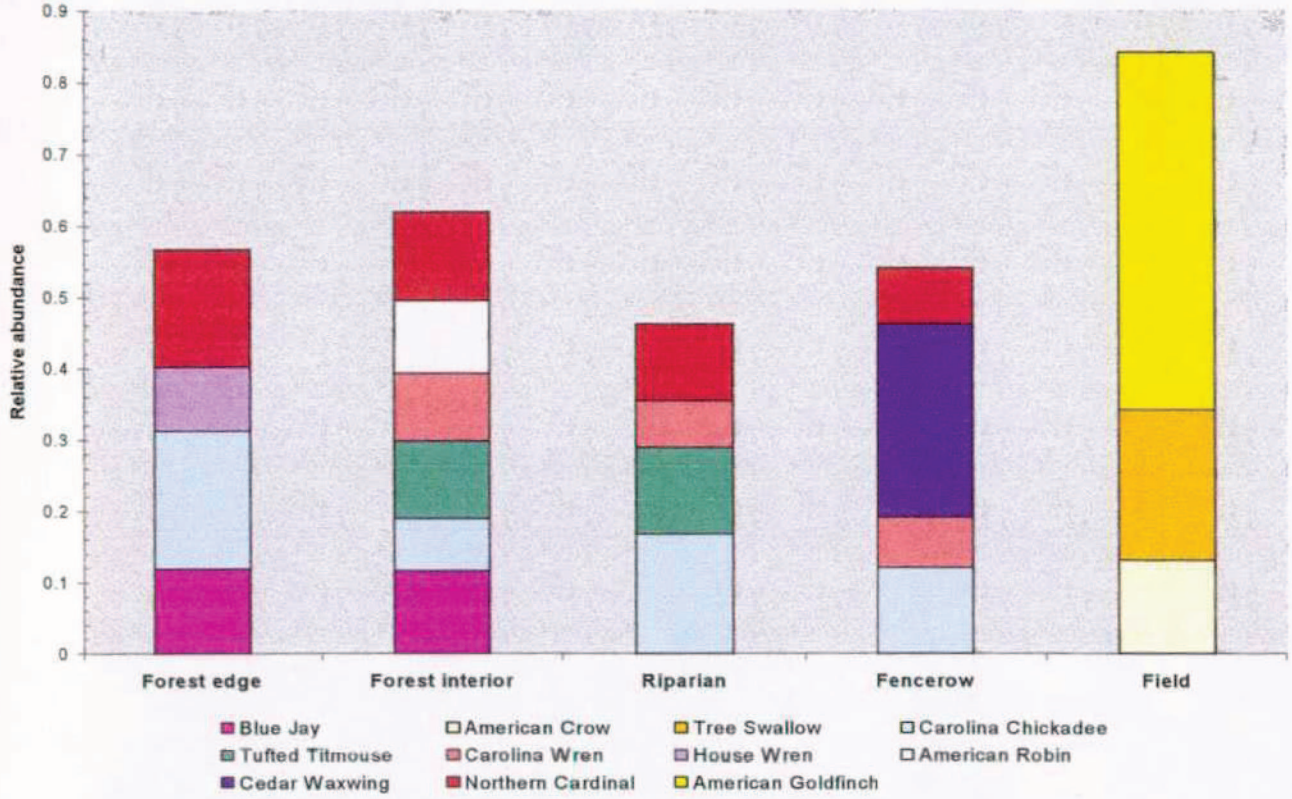
Patterns of relative abundance also changed between seasons by habitat type (Figure 8). Although the previously-noted common species were present during most seasons in most habitats, the relative composition of the bird communities reflects the presence of common breeding species, migratory species (fall) and overwintering species. Changes between the seasons were especially seen in forest interior, riparian, and field habitats due to the presence of particular breeding birds (Wood Thrush, Indigo Bunting, Grasshopper Sparrow, Red-winged Blackbird), fall migrants (American Goldfinch, Tree Swallow), and overwintering residents and migrants (Canada Goose, Mallard, Dark-eyed Junco, White-throated Sparrow). Cedar Waxwing were more common in forest edge in the breeding season and fencerows during fall. Assuming an equal chance for detection in all seasons, Tufted Titmouse and American Robin were more widely distributed in the breeding season, and Northern Cardinal and Carolina Chickadee had a more restricted distribution during winter.

Figure 8. Highest relative abundance values by habitat type for birds found during counts. Magnitude indicates abundance relative to other species within that habitat type.

Breeding season



Fall


0.9
0.8
0.7
0.6
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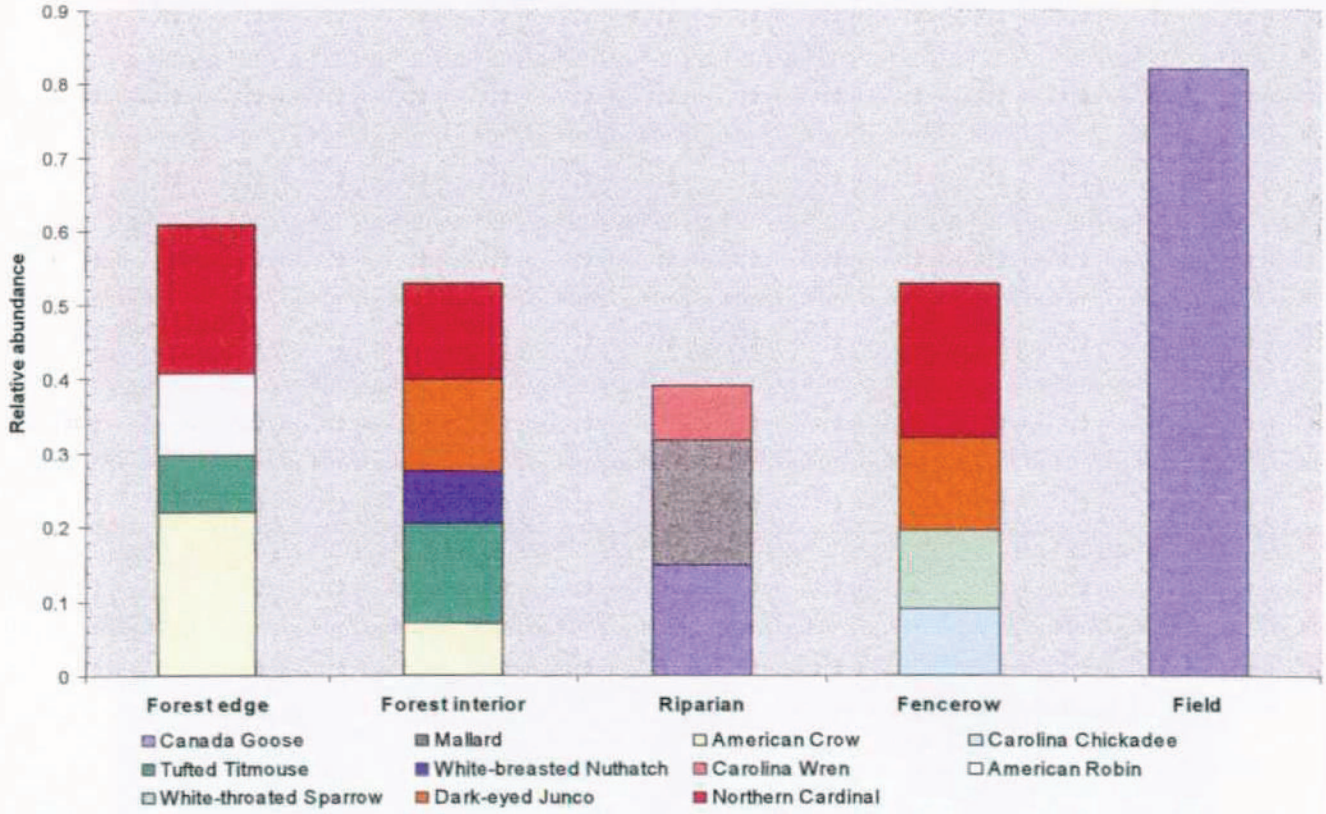
0.4
0.3
0.2
0.1
0
Relative abundance
Forest edge
Forest interior
Riparian
Fencerow
Field
Blue Jay
American Crow
Tree Swallow
Carolina Chickadee
Tufted Titmouse
Carolina Wren
House Wren
American Robin
Cedar Waxwing
Northern Cardinal
American Goldfinch

Winter


0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Relative abundance
Forest edge
Forest interior
Riparian
Fencerow
Field
Canada Goose
Mallard
American Crow
Carolina Chickadee
Tufted Titmouse
White-breasted Nuthatch
Carolina Wren
American Robin
White-throated Sparrow
Dark-eyed Junco
Northern Cardinal

Within park areas, relative abundance was high for all areas (and for most seasons) for Blue Jay, American Crow, Carolina Chickadee, Tufted Titmouse, and Northern Cardinal (Appendix G). Carolina Wren and Cedar Waxwing also tended to be more common. In addition to these species, breeding season populations of American Robin, Indigo Bunting, Red-winged Blackbird, and Common Grackle were relatively large at Monocacy North, and Cedar Waxwing at Louis Farm. Fall relative abundance was high for American Goldfinch at Gambrill, American Robin and Cedar Waxwing at Monocacy North, and Downy Woodpecker at Louis Farm. Common overwintering birds were Eastern Bluebird at Gambrill, Canada Goose at Monocacy North and Worthington, and Dark-eyed Junco at Worthington.

Habitat Variables

General

Habitat variables were measured during July (8-29) and August (3-12), 1999 over a total of approximately 70 hours. Wooded areas were measured on all 83 points, and grass areas were sampled at 18 points (6 riparian, 4 forest edge, 7 fencerow, 1 other). We did not take measurements in crop fields that fell within a habitat sample, but noted crop type and approximate height when birds were counted. Scientific names of plant species encountered in habitat sample plots are listed in Appendix H.

Tree and Shrub Relative Abundance, Frequency, Density, and Species Richness

A total of 50 species of tree and 40 shrub species were found in our sample plots. American elm, black cherry, black locust, box elder, green ash, silver maple, and tree of heaven were relatively most abundant in at least two habitat types (Table 3). Other relatively common trees within their habitat type were chestnut oak (forest interior), hackberry (fencerow), ironwood (riparian), musclewood (forest interior), and red maple (forest interior).

Table 3. Relative abundance of tree and sapling species present within each habitat type. Bold numbers indicate the highest values within that habitat type.

Species	Forest Edge (N=201)	Forest Interior (N=760)	Riparian (N=607)	Fencerow (N=1200)
American basswood	0	0	0	0.005
American beech	0	0.06	0.02	0
American elm	0.07	0.05	**0.05**	**0.06**
Apple	0	0	0	0.0008
Bitternut hickory	0	0	0	0
Black cherry	0.005	**0.08**	0.03	**0.17**
Black gum	0	0.03	0	0
Black locust	**0.16**	0.02	0.007	**0.07**
Black walnut	0.07	0.008	0.02	0.0008
Bladdernut	0	0	0.005	0.003
Box elder	**0.11**	0.05	**0.32**	**0.11**
Chestnut oak	0.005	**0.10**	0.002	0
Choke cherry	0	0.001	0	0.004
Common catalpa	0.01	0	0	0
Common spicebush	0.005	0.007	0.02	0.0008

Species	Forest Edge (N=201)	Forest Interior (N=760)	Riparian (N=607)	Fencerow (N=1200)
Cottonwood	0	0	0	0.0008
Flowering dogwood	0.02	0.04	0.007	0.004
Green ash	**0.10**	0.05	**0.06**	0.01
Hackberry	0.01	0.05	0.04	**0.15**
Honey locust	0	0	0.002	0
Ironwood	0	0	**0.06**	0
Mockernut hickory	0.03	0.07	0.03	0.002
Mountain laurel	0	0.001	0	0
Musclewood	0	**0.07**	0.03	0
Osage orange	0	0.008	0.01	0.04
Paw paw	0	0	0.01	0
Pear	0	0	0	0.002
Persimmon	0	0	0	0.0008
Pin oak	0	0	0	0.0008
Princess tree	0	0.003	0	0
Red ash	0	0	0	0.0008
Red maple	0.01	**0.14**	0.02	0.003
Red mulberry	0.06	0.001	0.007	0.04
Red oak	0.005	0.02	0.005	0.002
Sassafras	0.005	0.001	0	0.03
Serviceberry	0	0.02	0	0
Shagbark hickory	0	0	0.002	0
Silver maple	**0.19**	0	**0.18**	0.02
Spruce	0	0	0	0
Staghorn sumac	0	0	0	0.01
Sugar maple	0	0	0.01	0
Sycamore	0.005	0.003	0.007	0
Tree of heaven	**0.11**	**0.08**	0.03	**0.25**
Tulip poplar	0.01	0.03	0.03	0
Virginia pine	0	0.001	0	0
White ash	0	0.004	0	0
White oak	0.03	0.01	0.002	0
White pine	0	0	0	0.01
Witch hazel	0	0	0.01	0
Yellow birch	0	0	0.007	0

Common short and tall woody stems (high frequency of occurrence) included box elder, common spice bush, multiflora rose, and tree of heaven (Table 4). In addition, American beech (forest interior), blackberry (forest edge and fencerow), green ash (forest edge and interior), hackberry (fencerow), honeysuckle (fencerow), paw paw (forest interior and riparian), red maple (forest interior), sassafras (forest edge), and silver maple (riparian) had relatively high frequencies within these habitat types.

Table 4. Frequency of shrub species (short and tall stems) within each habitat type. Bold numbers indicate the highest values within that habitat type.

Species	Forest Edge-short stems (N=9 plots)	Forest Edge-tall stems (N=9 plots)	Forest Interior-short stems (N=23 plots)	Forest Interior-tall stems (N=23 plots)	Riparian-short stems (N=24 plots)	Riparian- tall stems (N=24 plots)	Fencerow-short stems (N=25 plots)	Fencerow- tall stems (N=25 plots)
American basswood	0	0	0	0	0	0.04	0	0
American beech	0	0.11	0.04	**0.30**	0.04	0.04	0	0
American chestnut	0	0	0	0.04	0	0	0	0
American elm	0.11	0	0	0	**0.13**	0.08	0.04	0.08
Barberry	0.11	0	0.04	0	0.08	0	0	0
Black cherry	0	0.11	**0.17**	0.09	0.04	0.08	0.12	0.12
Black gum	0	0.11	0	0.09	0	0	0	0
Black locust	0.11	0	0	0	0	0	0.08	0.04
Black walnut	0.11	0	0	0	0	0	0	0
Blackberry	**0.33**	0.11	0.04	0	0.04	0	**0.24**	0.08
Bladdernut	0	0	0	0	0.04	0.08	0.04	0.04
Box elder	0.11	**0.22**	0.04	**0.17**	**0.21**	**0.33**	0	**0.24**
Chestnut oak	0	0	0.09	0	0	0	0	0
Common catalpa	0	0.11	0	0	0	0	0	0
Common spicebush	**0.33**	**0.22**	**0.26**	**0.17**	**0.46**	**0.29**	0	0
Cottonwood	0	0	0	0	0	0.04	0.04	0.04
Flowering dogwood	0.11	0	0.04	**0.13**	0	0	0	0.04
Green ash	**0.22**	0.11	0.04	**0.17**	0.04	0.08	0	0
Hackberry	0	0	0	0.09	0	0.08	0.12	**0.36**
Honey locust	0	0	0	0	0	0.04	0	0.04
Honeysuckle	0	0.11	0	0	0.08	0.08	**0.16**	0.04
Juniper	0.11	0	0	0	0	0	0	0
Mapleleaf viburnum	0.11	0	0	0	0	0	0	0
Mockernut hickory	0	0.11	0.09	**0.13**	0.08	0.04	0	0
Mountain laurel	0	0	0.04	0	0	0	0	0

Species	Forest Edge-short stems (N=9 plots)	Forest Edge-tall stems (N=9 plots)	Forest Interior-short stems (N=23 plots)	Forest Interior-tall stems (N=23 plots)	Ripari an-short stems (N=24 plots)	Ripari an- tall stems (N=24 plots)	Fencero w-short stems (N=25 plots)	Fencero w- tall stems (N=25 plots)
Multiflora rose	**0.67**	**0.33**	**0.13**	0.04	**0.17**	0.08	**0.60**	0.12
Musclewood	0	0	0	0.09	0	**0.13**	0	0
Northern red oak	0.11	0.11	0	0	0	0	0	0
Osage orange	0	0	0	0	0	0	0	0.04
Paw paw	0	0	**0.17**	0.09	**0.17**	0.08	0	0
Red maple	0.11	0.11	0.09	**0.30**	0	0.04	0	0.08
Red mulberry	0	0	0	0	0	0.08	0.12	**0.20**
Sassafras	**0.22**	**0.22**	0	0	0	0	0.08	**0.16**
Serviceberry	0	0	0.09	0.09	0	0	0	0
Silver maple	0	0.11	0	0	**0.13**	**0.29**	0	0
Staghorn sumac	0	0	0	0	0	0	0.04	0.04
Sycamore	0	0	0	0	0	0.04	0	0
Tree of heaven	**0.44**	**0.33**	**0.57**	**0.48**	0.08	0.04	**0.64**	**0.16**
Tulip poplar	0.11	0.11	0	0	0	0	0	0
Willow sp.	0	0	0	0	0	0.04	0	0
Witch hazel	0	0	0	0.04	0.04	**0.13**	0	0

Short stems were most dense at forest edges, and tall stems were most dense in fencerows (Table 5). Overall stem density was highest at these two habitats. Patterns of stem species richness followed those of stem density. Of note are the low stem densities of forest interior sites, possibly due to overbrowsing by deer.

Table 5. Stem density and species richness.

Habitat type	Mean stem density (per ha)			Mean stem richness		
	Short stems	Tall stems	Total	Short stems	Tall stems	Total
Forest edge	**1240**	550	**1791**	**3.38**	2.63	**4.50**
Forest interior	408	341	749	1.96	2.65	3.39
Riparian	639	501	1140	1.83	2.25	3.13
Fencerow	1000	**707**	**1707**	2.36	**2.96**	3.84

Tree basal area and density were highest in fencerows, in part due to the large number of trees that tended to crowd these areas. Tree species richness, however, was highest in forest interior, as was the presence

and density of snags. Snags provide an important resource for woodpeckers, bark-gleaning species, and hole nesters.

Table 6. Tree and snag species richness, basal area, and density.

Habitat type	Total number of trees	Mean for trees			Total number of snags	Mean for snags		Total tree and snag	
		Basal area (m^2/ha)	Density (per ha)	Richness		Basal area (m^2/ha)	Density (per ha)	Basal area (m^2/ha)	Density (per ha)
Forest edge	201	10.8	544	5.25	18	2.4	69	13.2	613
Forest interior	760	24.7	826	**7.74**	**215**	**3.2**	**234**	27.9	1060
Riparian	607	25.8	633	5.92	65	1.4	68	27.2	701
Fencerow	**1200**	**35.8**	**1243**	6.12	157	**3.1**	154	**38.9**	**1397**

Additional Habitat Variables

Ground cover was highest overall in forest interior, with larger percentages of forbs and leaf litter (Table 7A). Forest edge had more ferns, lichens, and mosses, and riparian habitats had the highest percentage of bare ground. Vertical layers were most numerous and highest in riparian areas, with a mean canopy height of almost 30 m (Table 7B). Percent canopy cover was highest in forest interior, and vine scores were highest for fencerows. Riparian areas had the highest degree of heterogeneity in terms of grassy vegetation, and litter depth was lowest for fencerows (Table 7C).

Table 7. Vegetation summary data by habitat type. Bold numbers indicate the highest values within the column category. Mean values are per point unless otherwise indicated.

A. Ground cover:

Habitat type	Mean % bare ground	Mean % forbs	Mean % downed wood	Mean % leaf litter	Mean % ferns, mosses, lichens	Mean % total ground cover
Forest edge	13	22	4	15	**46**	87
Forest interior	6	**47**	7	**37**	2	**93**
Riparian	**17**	28	5	13	37	83
Fencerow	12	35	6	12	36	88

B. Vertical layers, canopy cover, and presence of vines (0 = no vines present; 1 = vines on a few trees; 2 = vines on few-half of trees; 3 = vines dense, on over half of trees):

Habitat type	Mean #vertical layers	Mean height of layer 1 (m)	Mean height of layer 2 (m)	Mean % canopy cover	Mean Vine score
Forest edge	2.63	21.3	7.6	63.4	1.88
Forest interior	2.70	25.9	7.3	**81.0**	1.04
Riparian	**3.13**	**29.9**	**11.5**	78.6	0.96
Fencerow	2.56	18.8	2.0	73.9	**2.20**

C. Grass samples: litter depth and vegetation heterogeneity index:

Adjacent habitat type	Number of points (total samples within points)	Mean litter depth in cm (SE)	Mean vegetation heterogeneity index (SE)
Forest Edge	4 (9)	**0.78 (0.16)**	0.12 (0.05)
Riparian	6 (11)	**0.76 (0.16)**	**0.40 (0.09)**
Fencerow	7 (16)	0.52 (0.10)	0.27 (0.03)

Exotic Vegetation

As noted above, exotic species such as tree of heaven, multiflora rose, and honeysuckle were prevalent in some habitat types as trees and/or shrubs (Tables 3 and 4). The exotic tree component is especially high in fencerow habitats (Table 8). Exotic vegetation reaches high mean densities in the Louis Farm area, and a few fencerow sites in Worthington, Gambrill, and Monocacy North (Figure 9, following page). In general, riparian areas and many forest sites had low to no exotics.

Table 8. Exotic and native tree density.

Habitat type	Mean Density (per ha)			Mean % Density	
	Exotic spp.	Native spp.	Tree of Heaven	Exotic spp.	Native spp.
Forest edge	71.9	471.9	71.9	14	86
Forest interior	73.9	752.2	67.4	8	**92**
Riparian	24	609.4	16.7	3	**97**
Fencerow	**344**	**899**	**293**	**22**	78

Bird/Habitat Relationships

Although further study is needed to support more robust conclusions about the relationships between bird species and habitat variables, several trends are evident. Riparian areas, with high vertical diversity and low exotic tree density, appear to be important locations for breeding birds, and also act as corridors during fall (and probably spring) migration. A number of species were unique to this habitat type. Forest interior sites also had low exotic tree density, and have high tree species diversity and snag density, and high canopy and ground cover percentages. Forest interior areas have the highest species densities and relative abundances for certain species that rely on these habitat features, and this habitat appears to be especially important during the winter. The lack of understory layers and high stem densities, however, probably negatively affects shrub and ground-nesting species. Fencerow habitats are characterized by dense stands of trees and shrubs, high snag density, high vine scores, and high percentages of exotic species. They also have high bird species diversity, although less so during the winter. Their proximity to wooded and field areas, snags, and vertical complexity contribute to higher bird diversity, but the presence of exotic vegetation may make this habitat less useful, especially at certain times of year.

A canonical correspondence analysis showed that several ground cover variables (leaf litter, downed wood, and bare ground), exotic vegetation, tree basal area, vine score, and heights of vertical layers affected bird species distribution across park habitats (Figure 10). Species associated with the large height layer values found along riparian areas included Louisiana Waterthrush and Wood Duck. Associated with large trees (basal area) were Northern Parula and Blue-gray Gnatcatcher. High percentages of leaf litter and downed wood, found in forest interior areas, were associated with species such as Scarlet Tanager, Wood Thrush, Northern Flicker, Hairy Woodpecker, White-breasted Nuthatch,

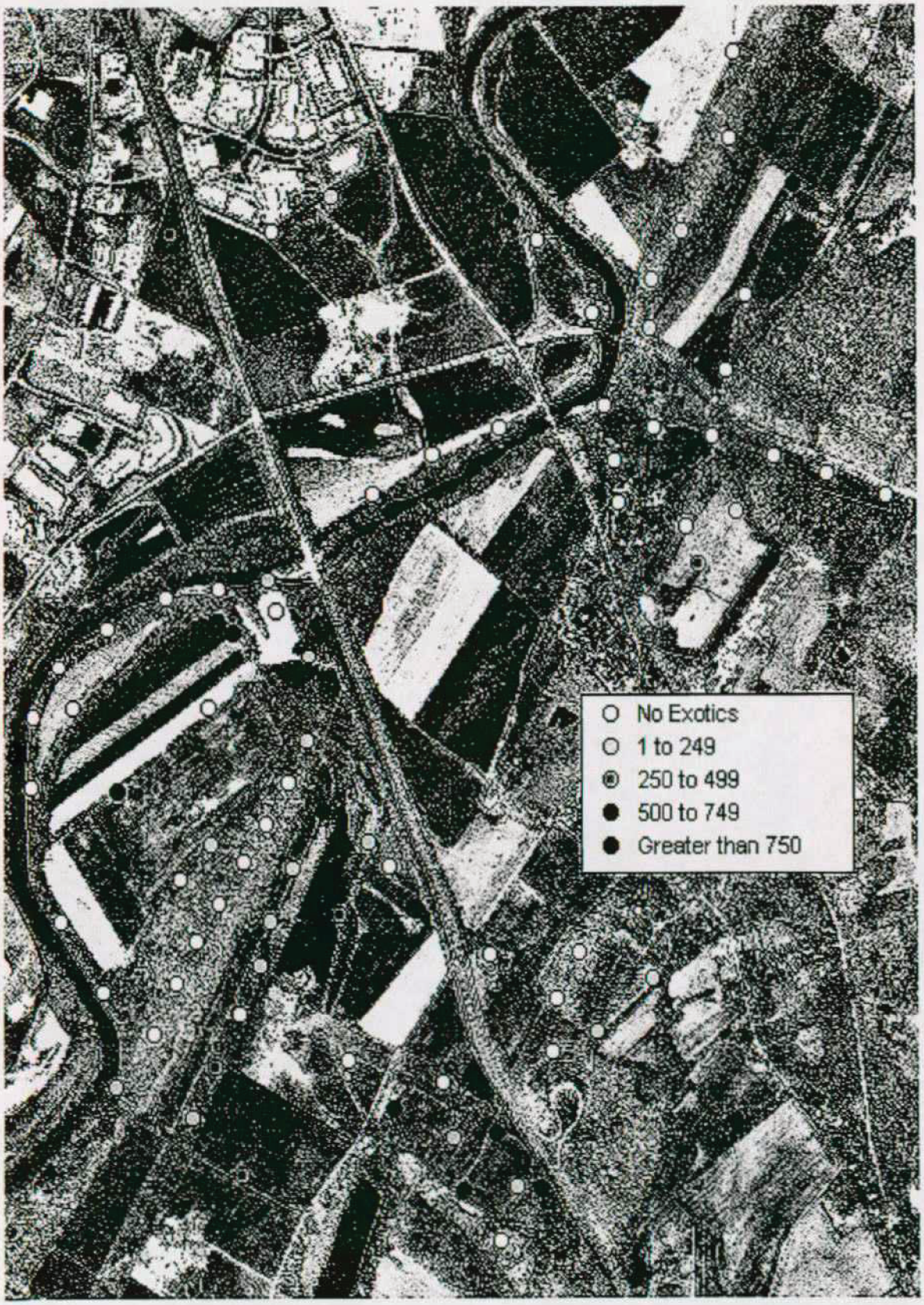

No Exotics
1 to 249
250 to 499
500 to 749
Greater than 750

Figure 9. Mean density per hectare of exotic tree species noted at habitat sample points in 1999. Points are superimposed over an aerial photograph of the area.

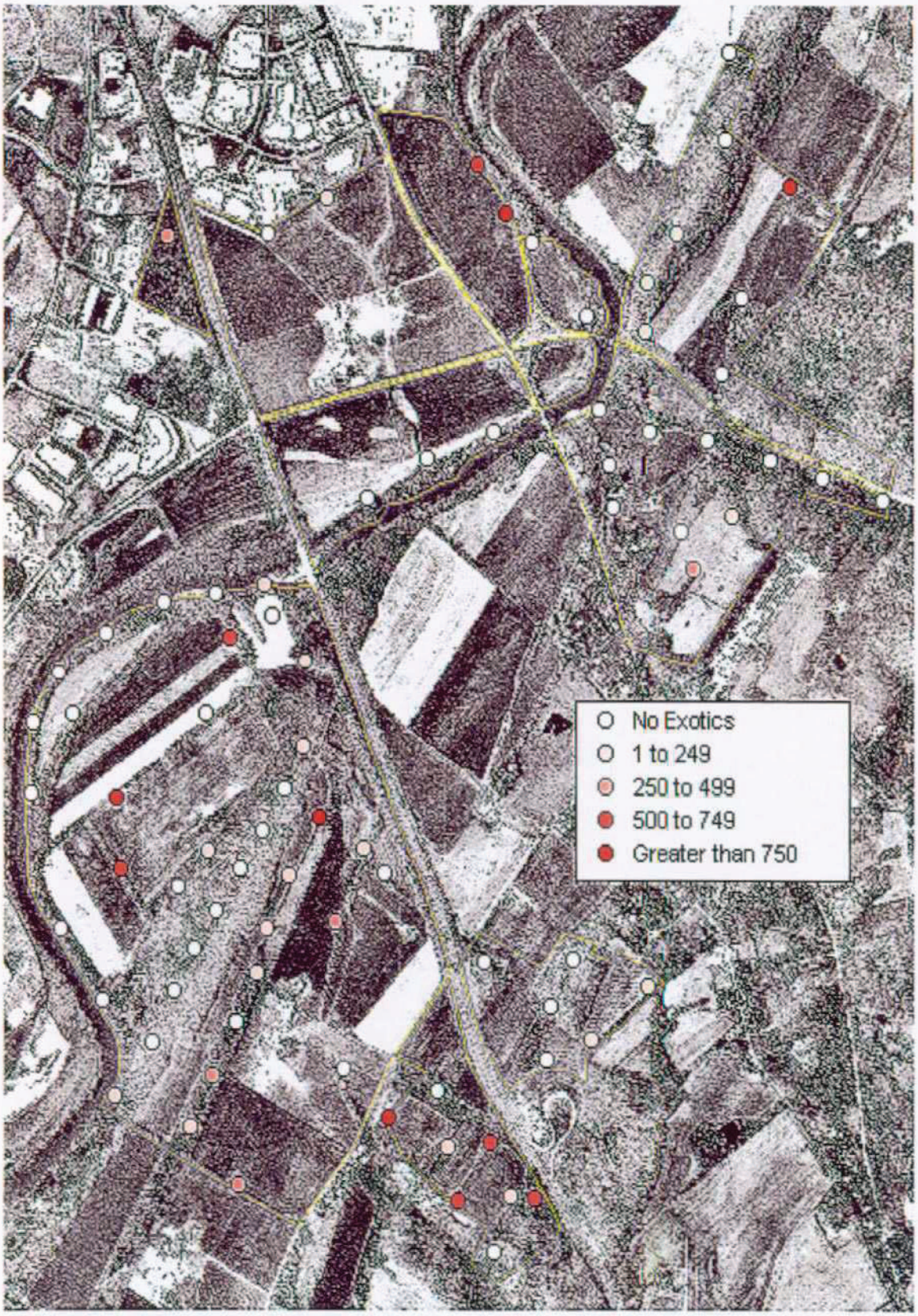
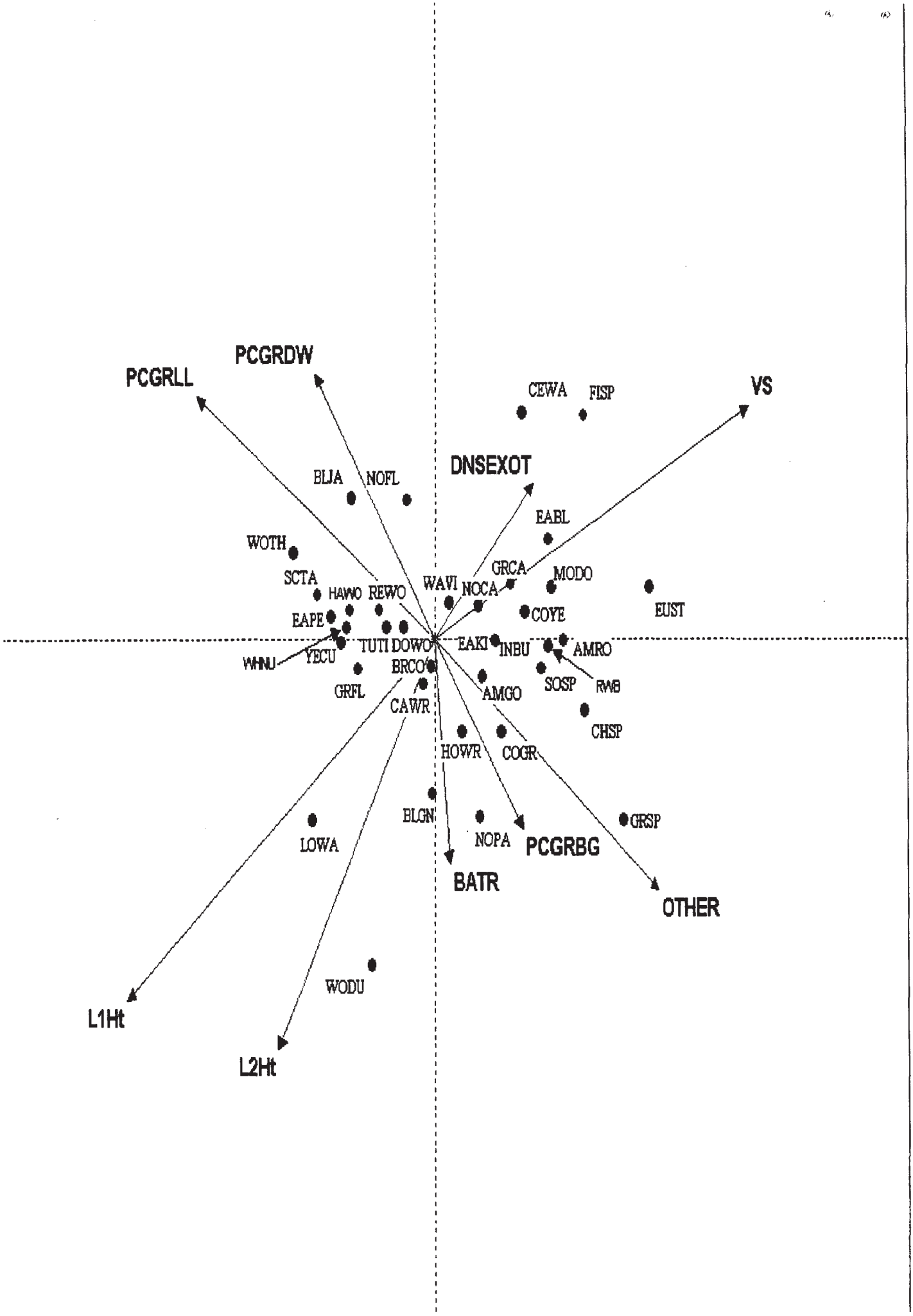

No Exotics
1 to 249
250 to 499
500 to 749
Greater than 750

Figure 10. Canonical correspondence analysis results, indicating bird-habitat relationships. Vectors indicate habitat variables: PCGRLL= percent leaf litter, PCGRDW= percent downed wood, PCGRBG= percent bare ground, OTHER= percent other ground cover, DNSEXOT= total density of exotic vegetation, VS= vine score, BATR= tree basal area, L1Ht=height of vertical layer 1 (canopy), and L2Ht= height of vertical layer 2 (subcanopy). See text for more information on habitat variables. Bird species are considered to be affected by a habitat variable if they are located close to that habitat vector but distant from the origin (center point) of the vectors. More generalist species appear near the center of the diagram where the vectors cross. Bird species abbreviations are (in alphabetical order): AMGO- American Goldfinch, AMRO- American Robin, BLGN- Blue-gray Gnatcatcher, BLJA- Blue Jay, BRCO- Brown-headed Cowbird, CAWR- Carolina Wren, CEWA- Cedar Waxwing, CHSP- Chipping Sparrow, COGR- Common Grackle COYE- Common Yellowthroat, DOWO- Downy Woodpecker, EABL- Eastern Bluebird, EAKI- Eastern Kingbird, EAPE- Eastern Wood-Pewee, EUST- European Starling, FISP- Field Sparrow, GRCA- Gray Catbird, GRFL- Great Crested Flycatcher, GRSP- Grasshopper Sparrow, HAWO- Hairy Woodpecker, HOWR- House Wren, INBU- Indigo Bunting, LOWA- Louisiana Waterthrush, MODO- Mourning Dove, NOCA- Northern Cardinal, NOFL- Northern Flicker, NOPA- Northern Parula, REWO- Red-bellied Woodpecker, RWB- Red-winged Blackbird, SCTA- Scarlet Tanager, SOSP- Song Sparrow, TUTI- Tufted Titmouse, WAVI- Warbling Vireo, WHNU- White-breasted Nuthatch, WODU- Wood Duck, WOTH- Wood Thrush, and YECU- Yellow-billed Cuckoo.


PCGRDW
PCGRLL
VS
CEWA
FISP
DNSEXOT
BLJA
NOFL
EABL
WOTH
GRCA
MODO
SCTA
HAWO
REWO
WAVI
NOCA
EUST
COYE
EAPE
TUTI
DOWO
EAKI
INBU
AMRO
WHNU
YECU
BRCO
SOSP
RWB
GRFL
AMGO
CAWR
CHSP
HOWR
COGR
BLGN
GRSP
LOWA
NOPA
PCGRBG
BATR
OTHER
WODU
L1Ht
L2Ht

Eastern Wood-Pewee, and Yellow-billed Cuckoo. Gray Catbird, Field Sparrow, and Common Yellowthroat were among the species associated with high vine scores. This analysis demonstrates the need to maintain these important habitat features as part of forest interior and riparian areas.

Bird/Landscape-level Influences

No landscape variables showed strong correlations with species diversity for fencerows. Species diversity was most highly correlated with the number of layers in a fencerow; however this correlation coefficient was negative (-0.261), which was unexpected. No relationship was found between species diversity and area ($R^2 = 0.008$), species diversity and volume ($R^2 = 0.020$), species diversity and layers ($R^2 = 0.097$), or species diversity and fractal dimension ($R^2 = 0.041$). The final stepwise regression model was:

DIVERSITY= 1.88 – 0.000639 (AREA) + 0.000033 (VOLUME) – 0.494 (LAYERS) + 1.45 (FRACTAL DIMENSION) with $R^2 = 39.7\%$.

These results suggest that birds may not be responding to fencerow spatial characteristics, at least at the scale observed in this study. In fact, bird species diversity was negatively correlated with foliage height diversity. This suggests that birds may be responding to within patch (fencerow) characteristics such as vegetation density, diversity, or plant species presence. Considering the surrounding landscape, though, may explain some of the outliers that were dropped from this analysis. Even though our final model was not a strong predictor of species diversity, we were still able to attribute 40% of the variation to only spatial characteristics of the fencerows. We believe that including floristics and some spatial characteristics of the surrounding landscape would dramatically increase the predictive power of this model. In addition, we believe that larger sample sizes are necessary to obtain a complete picture of fencerow use by birds. It may be useful to examine fencerow selection by individual species because species diversity may not be a good response variable in this case.

MANAGEMENT RECOMMENDATIONS AND MONITORING PLAN

Data from this study show the importance of this area to birds in all seasons of the year. The park as a refuge for these species will continue to become more important as land use continues to change in the surrounding area. Although all habitat types did provide areas for birds during all count periods, riparian and fencerow habitats were particularly important during migration, and forest interior and riparian habitats during the breeding season. A number of potential species, especially shrub- and ground-nesting birds and grassland birds, could use this area if habitat becomes more suitable through proper management. For example, in shrub areas, Yellow-breasted Chat, Yellow Warbler, and wintering Fox Sparrow, White-crowned Sparrow, and Winter Wren would be more likely. In forest areas, Ovenbird, Kentucky Warbler, Eastern Towhee, and American Woodcock would benefit, among other forest interior nesting species. Grassland sites could see more regular Northern Harrier, and also Savanna Sparrow, and even Dickcissel in a year when high numbers of this species are in the area (noted in southern Frederick Co. in Spring 2000).

To maintain and improve all park habitats for the bird species present, and to enhance these habitats for birds, we recommend:

1. removal of exotics, but replacement with or encouragement of appropriate native species to maintain vertical structural plant diversity in fencerows and forest interior;
2. maintenance of high snag density in forest interior and fencerows;

3. maintenance of current patch sizes of forest interior, riparian, and fencerow habitats, including maintaining or enhancing connectivity between fencerows and riparian and forest habitats, and the improvement of mechanically altered habitat along Bush Creek;
4. increasing vertical structural diversity and habitat for shrub- and ground-nesting birds by improving the shrub layer in forest interior areas (reduction of deer browse impacts);
5. use of warm-season grasses, hay fields, etc. in open fields rather than corn crops and cattle to improve grasslands and discourage intensive deer use of area. The harvest schedule needs to be sensitive to bird nesting cycles, i.e. wait as late as possible into summer before harvesting, or at least until mid-July.

Monitoring Plan

MONITOR4 yielded various combinations of sample size and frequency that allow the detection of at least 3% declines in species richness over varying periods of time (Table 9). All values presented here meet the recommended power level (>0.80) to detect a 3% or smaller decline. To use the chart, the investigator decides on the desired detection level (1-3% decline in species richness), time period (decline detected by end of 4, 5, or 10 years), number of plots (point count points), and number of counts per year (total number of points to be surveyed for birds). Whichever of these is the limiting factor or desired outcome should be the criteria used in the table. It may be helpful to note that in this study, we found that 81 point count plots should require about 18 hours total time, possible over 4.5 count mornings (for one person, assuming 4 hours of counting per day with present plot locations). For example, if the investigator has enough resources to sample only 40 plots, to detect a 3 % decline, the investigator will need to do one survey every other year for 10 years (total 200 point counts), two surveys per year for five years (total 400 point counts), or two surveys per year, every other year for 10 years (total 400 counts, 2% detection level achieved). In this case, the counts at 200 points would take a total of about 9 hours per year, or 45 hours over the five years, and 400 counts would take a total of about 90 hours over the 10 or 5 years chosen, with a total of 18 hours needed for each year in which there is a count.

Table 9. Power levels for number of plots to be surveyed to detect trends (% decline)in species richness (from MONITOR4). # of counts indicates the number of sample points that need to be surveyed.

# of plots	Survey frequency									
	One survey per year for:				Two surveys per year for:					
	5 years	# of counts	10 years (every other year)	#of counts	4 years	# of counts	5 years	#of counts	10 years (every other year)	# of counts
40	---	---	-3% 1.0 -2% 0.89	200	---	---	-3% 0.95	400	-3% 1.0 -2% 0.99	400
50	-3% 0.80	250	-3% 1.0 -2% 0.95	250	-3% 0.84	400	-3% 0.98 -2 % 0.79	500	-3% 1.0 -2% 1.0 -1% 0.80	500
60	-3% 0.84	300	-3% 1.0 -2% 0.98	300	-3% 0.87	480	-3% 0.99 -2% 0.86	600	-3% 1.0 -2% 1.0 -1% 0.87	600
81	-3% 0.93	405	-3% 1.0 -2% 0.99	405	-3% 0.93	648	-3% 1.0 -2% 0.93	810	-3% 1.0 -2% 1.0 -1% 0.95	810

Given the rapid change in land use of the surrounding area, we recommend that two surveys be conducted per year for the next five years at the outset, to detect a 2% change in species richness by the end of that time period. To achieve the recommended power level, we recommend the survey of 50-60 points, depending on the resources available (500-600 total points surveyed = 22.5-27 hours per year for five years). An alternative to this scheme would be to conduct one survey every year for the next 5 years in at least 50 points in the park (total 250 points surveyed = 11.25 hours per year for five years), or if results are needed sooner, two surveys every year for the next 4 years in at least 50 points (total 400 points surveyed = 22.5 hours per year for 4 years). Detections of a 1% change in species richness would require two surveys every other year for the next 10 years (total 600 points surveyed = 27 hours per year). Detection goals and resources available will determine the preferred monitoring plan.

We are happy to provide further information and assistance in developing more specific management and monitoring programs according to park priorities.

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Appendix A. Scientific names of bird species noted at Monocacy National Battlefield.

Common Name	Scientific Name
Acadian Flycatcher	*Empidonax virescens*
American Black Duck	*Anas rubripes*
American Crow	*Corvus brachyrhynchos*
American Goldfinch	*Carduelis tristis*
American Kestrel	*Falco sparverius*
American Redstart	*Setophaga ruticilla*
American Robin	*Turdus migratorius*
Bald Eagle	*Haliaeetus leucocephalus*
Baltimore Oriole	*Icterus galbula*
Barn Swallow	*Hirundo rustica*
Barred Owl	*Strix varia*
Belted Kingfisher	*Ceryle alcyon*
Black Vulture	*Coragyps atratus*
Black-and-white Warbler	*Mniotilta varia*
Blackpoll Warbler	*Dendroica striata*
Blue Grosbeak	*Guiraca caerulea*
Blue Jay	*Cyanocitta cristata*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Brown Creeper	*Certhia americana*
Brown Thrasher	*Toxostoma rufum*
Brown-headed Cowbird	*Molothrus ater*
Canada Goose	*Branta canadensis*
Carolina Chickadee	*Poecile carolinensis*
Carolina Wren	*Thryothorus ludovicianus*
Cedar Waxwing	*Bombycilla cedrorum*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow	*Spizella passerina*
Common Grackle	*Quiscalus quiscula*
Common Merganser	*Mergus merganser*
Common Yellowthroat	*Geothlypis trichas*
Downy Woodpecker	*Picoides pubescens*
Eastern Bluebird	*Sialia sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern Meadowlark	*Sturnella magna*
Eastern Phoebe	*Sayornis phoebe*
Eastern Towhee	*Pipilo erythrophthalmus*
Eastern Wood-Pewee	*Contopus virens*
European Starling	*Sturnus vulgaris*
Field Sparrow	*Spizella pusilla*
Fish Crow	*Corvus ossifragus*
Grasshopper Sparrow	*Ammodramus savannarum*
Gray Catbird	*Dumetella carolinensis*
Great Blue Heron	*Ardea herodias*

Common Name	Scientific Name
Great Crested Flycatcher	*Myiarchus crinitus*
Green Heron	*Buteroides striatus*
Hairy Woodpecker	*Picoides villosus*
Hooded Merganser	*Lophodytes cucullatus*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*
Kentucky Warbler	*Oporornis formosus*
Killdeer	*Charadrius vociferus*
Lesser Scaup	*Aythya affinis*
Louisiana Waterthrush	*Seiurus motacilla*
Magnolia Warbler	*Dendroica magnolia*
Mallard	*Anas platyrhynchos*
Mourning Dove	*Zenaida macroura*
Nashville Warbler	*Vermivora ruficapilla*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyaneus*
Northern Mockingbird	*Mimus polyglottos*
Northern Parula Warbler	*Parula americana*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Orchard Oriole	*Icterus spurius*
Philadelphia Vireo	*Vireo philadelphicus*
Pileated Woodpecker	*Dryocopus pileatus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Red-eyed Vireo	*Vireo olivaceus*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoniceus*
Ring-billed Gull	*Larus delawarensis*
Rock Dove	*Columba livia*
Ruby-crowned Kinglet	*Regulus calendula*
Ruby-throated Hummingbird	*Archilochus colubris*
Scarlet Tanager	*Piranga olivacea*
Song Sparrow	*Melospiza melodia*
Spotted Sandpiper	*Actitis macularia*
Tree Swallow	*Tachycineta bicolor*
Tufted Titmouse	*Baeolophus bicolor*
Turkey Vulture	*Cathartes aura*
Vesper Sparrow	*Pooecetes gramineus*
Warbling Vireo	*Vireo gilvus*
White-breasted Nuthatch	*Sitta carolinensis*

Common Name	Scientific Name
White-eyed Vireo	*Vireo griseus*
White-throated Sparrow	*Zonotrichia albicollis*
Wild Turkey	*Meleagris gallopavo*
Wood Duck	*Aix sponsa*
Wood Thrush	*Hylocichla mustelina*
Worm-eating Warbler	*Helmitheros vermivora*
Yellow-bellied Sapsucker	*Sphyrapicus varius*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-rumped Warbler	*Dendroica coronata*
Yellow-throated Vireo	*Vireo flavifrons*

Appendix B. Bird species list by season for Monocacy National Battlefield. Birds that only flew over the area are indicated by FO.

Species	Breeding Season	Fall	Winter
Great Blue Heron	X	X	X
Green Heron	FO		
Black Vulture	X	FO	X
Turkey Vulture	X	X	X
Canada Goose	X	FO	X
Wood Duck	X		
American Black Duck			X
Mallard	X		X
Lesser Scaup			X
Hooded Merganser			X
Common Merganser			X
Bald Eagle			FO
Northern Harrier	FO		
Red-tailed Hawk	X	X	X
Red-shouldered Hawk	X	X	X
Broad-winged Hawk		X	
American Kestrel	X		
Wild Turkey	X	X	
Killdeer	X	X	FO
Spotted Sandpiper		X	
Ring-billed Gull			FO
Rock Dove	X	FO	FO
Mourning Dove	X	X	X
Yellow-billed Cuckoo	X		
Barred Owl			X
Chimney Swift	X	X	
Ruby-throated Hummingbird	X		
Belted Kingfisher	X	X	X
Red-bellied woodpecker	X	X	X
Yellow-bellied Sapsucker			X
Downy Woodpecker	X	X	X
Hairy Woodpecker	X	X	X
Northern Flicker	X	X	X
Pileated Woodpecker	X	X	X
Eastern Wood-Pewee	X	X	
Acadian Flycatcher	X	X	
Eastern Phoebe	X	X	
Great-crested Flycatcher	X		
Eastern Kingbird	X		
White-eyed Vireo	X		
Yellow-throated Vireo	X	X	
Warbling Vireo	X		
Philadelphia Vireo		X	
Red-eyed Vireo	X	X	
Blue Jay	X	X	X

Appendix B, continued. Bird species list by season for Monocacy National Battlefield.

Species	Breeding Season	Fall	Winter
American Crow	X	X	X
Fish Crow	X	X	X
Tree Swallow	FO	X	
Northern Rough-winged Swallow	X	X	
Barn Swallow	X		
Carolina Chickadee	X	X	X
Tufted Titmouse	X	X	X
White-breasted Nuthatch	X	X	X
Brown Creeper			X
Carolina Wren	X	X	X
House Wren	X	X	
Ruby-crowned Kinglet			X
Blue-gray Gnatcatcher	X		
Eastern Bluebird	X	X	X
Wood Thrush	X	X	
American Robin	X	X	X
Gray Catbird	X	X	
Northern Mockingbird	X	X	X
Brown Thrasher	X	X	
European Starling	X	X	X
Cedar Waxwing	X	X	
Nashville Warbler		X	
Northern Parula	X		
Magnolia Warbler		X	
Yellow-rumped Warbler			X
Blackpoll Warbler	X		
Black-and-white Warbler	X	X	
American Redstart	X		
Worm-eating Warbler	X		
Louisiana Waterthrush	X		
Kentucky Warbler	X		
Common Yellowthroat	X	X	
Scarlet Tanager	X		
Eastern Towhee	X		
Chipping Sparrow	X		
Field Sparrow	X	X	X
Vesper Sparrow	X		
Grasshopper Sparrow	X		
Song Sparrow	X	X	X
White-throated Sparrow			X
Dark-eyed Junco			X
Northern Cardinal	X	X	X
Blue Grosbeak	X		

Appendix B, continued. Bird species list by season for Monocacy National Battlefield.

Species	Breeding Season	Fall	Winter
Indigo Bunting	X	X	
Red-winged Blackbird	X		
Eastern Meadowlark	X		
Common Grackle	X		
Brown-headed Cowbird	X		
Orchard Oriole	X		
Baltimore Oriole	X		
House Finch	X	X	X
American Goldfinch	X	X	FO
House Sparrow	X		X

Appendix C. Bird species lists by habitat type for Monocacy National Battlefield (including data from all seasons). Birds that only flew over the area are indicated by FO.

Species	Forest Edge	Forest Interior	Riparian	Fencerow	Field
Great Blue Heron			X	FO	
Green Heron			FO		
Black Vulture	FO		X	FO	X
Turkey Vulture	FO	FO	X	X	X
Canada Goose	FO	FO	X	FO	X
Wood Duck			X		
American Black Duck			X		
Mallard			X		
Lesser Scaup			X		
Hooded Merganser			X		
Common Merganser			X		
Bald Eagle			FO		
Northern Harrier				FO	
Red-tailed Hawk	X	X	X	X	X
Red-shouldered Hawk	X	FO	X	FO	
Broad-winged Hawk					X
American Kestrel				FO	X
Wild Turkey		X	X		
Killdeer		FO	FO	FO	X
Spotted Sandpiper			X		
Ring-billed Gull		FO	FO	FO	FO
Rock Dove	X	FO	FO	X	X
Mourning Dove	X	X	X	X	X
Yellow-billed Cuckoo		X	X		
Barred Owl		X	X		
Chimney Swift	X		X	FO	
Ruby-throated Hummingbird	X	X	X		
Belted Kingfisher			X		
Red-bellied woodpecker	X	X	X	X	
Yellow-bellied Sapsucker		X	X		
Downy Woodpecker	X	X	X	X	
Hairy Woodpecker	X	X	X	X	
Northern Flicker	X	X	X	X	X
Pileated Woodpecker	X	X	X	X	
Eastern Wood-Pewee	X	X	X	X	
Acadian Flycatcher		X	X		
Eastern Phoebe	X		X	X	
Great-crested Flycatcher	X	X	X	X	
Eastern Kingbird			X	X	X
White-eyed Vireo	X				
Yellow-throated Vireo		X	X		
Warbling Vireo		X	X		
Philadelphia Vireo	X				

Appendix C, continued. Bird species lists by habitat for Monocacy National Battlefield (including data from all seasons).

Species	Forest Edge	Forest Interior	Riparian	Fencerow	Field
Red-eyed Vireo	X	X	X	X	
Blue Jay	X	X	X	X	
American Crow	X	X	X	X	X
Fish Crow	X	X	X	X	X
Tree Swallow	FO		X	FO	X
Northern Rough-winged Swallow			X	X	X
Barn Swallow	FO	FO	FO	X	X
Carolina Chickadee	X	X	X	X	
Tufted Titmouse	X	X	X	X	
White-breasted Nuthatch	X	X	X	X	
Brown Creeper		X	X		
Carolina Wren	X	X	X	X	
House Wren	X	X	X	X	
Ruby-crowned Kinglet		X			
Blue-gray Gnatcatcher	X	X	X	X	
Eastern Bluebird	X	X	X	X	X
Wood Thrush	X	X	X	X	
American Robin	X	X	X	X	X
Gray Catbird	X	X	X	X	
Northern Mockingbird	X	X	X	X	
Brown Thrasher			X	X	
European Starling	FO	X	X	X	
Cedar Waxwing	X	X	X	X	
Nashville Warbler				X	
Northern Parula	X	X	X	X	
Magnolia Warbler		X		X	
Yellow-rumped Warbler		X			
Blackpoll Warbler		X			
Black-and-white Warbler				X	
American Redstart			X		
Worm-eating Warbler		X	X		
Louisiana Waterthrush			X		
Kentucky Warbler	X				
Common Yellowthroat	X		X	X	X
Scarlet Tanager	X	X	X	X	
Eastern Towhee	X	X	X	X	
Chipping Sparrow		X	X	X	
Field Sparrow	X	X	X	X	
Vesper Sparrow				X	X
Grasshopper Sparrow			X	X	X
Song Sparrow	X	X	X	X	
White-throated Sparrow	X	X	X	X	
Dark-eyed Junco		X	X	X	

Appendix C, continued. Bird species lists by habitat for Monocacy National Battlefield (including data from all seasons).

Species	Forest Edge	Forest Interior	Riparian	Fencerow	Field
Northern Cardinal	X	X	X	X	
Blue Grosbeak			X		
Indigo Bunting	X	X	X	X	X
Red-winged Blackbird			X	X	X
Eastern Meadowlark					X
Common Grackle	X	X	X	X	X
Brown-headed Cowbird	X	X	X	X	X
Orchard Oriole	X		X	X	
Baltimore Oriole	X	X	X	X	
House Finch	X	X	X	X	X
American Goldfinch	X	X	X	X	X
House Sparrow		X		X	X

Appendix D. Bird species lists by area for Monocacy National Battlefield (including data from all seasons). Birds that only flew over the area are indicated by FO. See Figure 1 for area locations.

Species	Gambrill	Monocacy North	Louis Farm	Worthington
Great Blue Heron	X	X		X
Green Heron	FO			
Black Vulture	FO	X	FO	X
Turkey Vulture	X	X	FO	X
Canada Goose	FO	X	FO	X
Wood Duck				X
American Black Duck				X
Mallard	X	X		X
Lesser Scaup				X
Hooded Merganser		X		
Common Merganser				X
Bald Eagle				FO
Northern Harrier			FO	
Red-tailed Hawk	X	X	X	X
Red-shouldered Hawk	X	X	FO	X
Broad-winged Hawk	X			
American Kestrel	X	FO		
Wild Turkey				X
Killdeer	FO	X		X
Spotted Sandpiper	X			
Ring-billed Gull	FO	FO		FO
Rock Dove		FO	FO	X
Mourning Dove	X	X	X	X
Yellow-billed Cuckoo	X		X	X
Barred Owl		X		X
Chimney Swift	X	X	X	FO
Ruby-throated Hummingbird	X	X		X
Belted Kingfisher	X			X
Red-bellied woodpecker	X	X	X	X
Yellow-bellied Sapsucker	X			X
Downy Woodpecker	X	X	X	X
Hairy Woodpecker	X	X	X	X
Northern Flicker	X	X	X	X
Pileated Woodpecker	X	X	X	X
Eastern Wood-Pewee	X	X	X	X
Acadian Flycatcher	X	X		X
Eastern Phoebe	X	X	X	X
Great-crested Flycatcher	X	X	X	X
Eastern Kingbird	X	X		X
White-eyed Vireo			X	
Yellow-throated Vireo	X			
Warbling Vireo	X	X		X
Philadelphia Vireo	X			

Appendix D, continued. Bird species lists by area for Monocacy National Battlefield (including data from all seasons).

Species	Gambrill	Monocacy North	Louis Farm	Worthington
Red-eyed Vireo	X	X	X	X
Blue Jay	X	X	X	X
American Crow	X	X	X	X
Fish Crow	X	X	X	X
Tree Swallow	FO	X	FO	X
Northern Rough-winged Swallow		X	X	X
Barn Swallow	FO	X	FO	X
Carolina Chickadee	X	X	X	X
Tufted Titmouse	X	X	X	X
White-breasted Nuthatch	X	X	X	X
Brown Creeper	X		X	X
Carolina Wren	X	X	X	X
House Wren	X	X	X	X
Ruby-crowned Kinglet	X	X		
Blue-gray Gnatcatcher	X	X	X	X
Eastern Bluebird	X	X	X	X
Wood Thrush	X		X	X
American Robin	X	X	X	X
Gray Catbird	X	X	X	X
Northern Mockingbird	X	X	X	X
Brown Thrasher			X	X
European Starling	X	X	X	X
Cedar Waxwing	X	X	X	X
Nashville Warbler		X		
Northern Parula	X	X		X
Magnolia Warbler		X		X
Yellow-rumped Warbler	X			X
Blackpoll Warbler				X
Black-and-white Warbler	X		X	
American Redstart				X
Worm-eating Warbler	X			X
Louisiana Waterthrush	X			
Kentucky Warbler	X			
Common Yellowthroat	X	X		X
Scarlet Tanager	X		X	X
Eastern Towhee	X		X	X
Chipping Sparrow	X	X	X	X
Field Sparrow	X		X	X
Vesper Sparrow				X
Grasshopper Sparrow	X	X		X
Song Sparrow	X	X	X	X
White-throated Sparrow	X	X	X	X
Dark-eyed Junco	X	X	X	X

Appendix D, continued. Bird species lists by area for Monocacy National Battlefield (including data from all seasons).

Species	Gambrill	Monocacy North	Louis Farm	Worthington
Northern Cardinal	X	X	X	X
Blue Grosbeak		X		
Indigo Bunting	X	X	X	X
Red-winged Blackbird	X	X		X
Eastern Meadowlark		X		
Common Grackle	X	X	X	X
Brown-headed Cowbird	X	X	X	X
Orchard Oriole				X
Baltimore Oriole	X	X	X	X
House Finch	X	X	X	X
American Goldfinch	X	X	X	X
House Sparrow	X	X		X

Appendix E. Relative abundance by habitat type for Breeding Season, Fall, and Winter surveys. Bold numbers indicate the highest values for each habitat type during that season (> 0.04). Breeding Season values include only birds within 50m of the count point; "> 50m" indicates birds only detected > 50m from the count point. "FO" indicates only noted to fly over the area.

Species	Habitat type	Breeding Season	Fall	Winter
Great Blue Heron	Riparian	0.015	0.017	0.020
	Fencerow	FO		
Green Heron	Riparian	FO		
Black Vulture	Forest Edge	FO	FO	
	Riparian	0.011	FO	
	Fencerow	FO		0.004
	Field	> 50m		0.037
Turkey Vulture	Forest Edge	FO		
	Forest Interior	FO		
	Riparian	0.004	FO	FO
	Fencerow	0.004	FO	0.004
	Field	> 50m	0.026	0.037
Canada Goose	Forest Edge	FO	FO	
	Forest Interior	FO		
	Riparian	*	FO	**0.149**
	Fencerow	FO		
	Field	> 50m	FO	**0.820**
Wood Duck	Riparian	0.011		
American Black Duck	Riparian			0.045
Mallard	Riparian	0.002		**0.168**
Lesser Scaup	Riparian			0.010
Hooded Merganser	Riparian			0.030
Common Merganser	Riparian			0.010
Bald Eagle	Riparian			FO
Northern Harrier	Fencerow	FO		
Red-tailed Hawk	Forest Edge		0.015	
	Forest Interior	0.007	0.029	0.004
	Riparian	0.002	0.004	0.005
	Fencerow	0.002		0.004
	Field	> 50m		0.008
Red-shouldered Hawk	Forest Edge			0.016
	Forest Interior	FO		
	Riparian	0.002	0.004	
	Fencerow	FO	FO	
Broad-winged Hawk	Field		0.053	
American Kestrel	Fencerow	FO		
	Field	> 50m		
Wild Turkey	Forest Interior	0.002	0.007	
	Riparian	> 50m		

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Killdeer	Forest Interior	FO		
	Riparian	FO		
	Fencerow	FO		
	Field	> 50m	0.026	FO
Spotted Sandpiper	Riparian		0.004	
Ring-billed Gull	Forest Interior			FO
	Riparian			FO
	Field			FO
Rock Dove	Forest Edge	0.005		FO
	Forest Interior	FO		
	Riparian	FO	FO	
	Fencerow	0.002*		FO
	Field	0.011	FO	
Mourning Dove	Forest Edge	0.005		
	Forest Interior	0.012	0.015	0.004
	Riparian	0.002	0.043	0.005
	Fencerow	0.025	0.032	FO
	Field	0.032		
Yellow-billed Cuckoo	Forest Interior	0.005		
	Riparian	0.007		
Barred Owl	Forest Interior			0.004
	Riparian			0.005
Chimney Swift	Forest Edge	0.011		
	Riparian		0.043	
	Fencerow	FO		
Ruby-throated Hummingbird	Forest Edge	0.011		
	Forest Interior	0.002		
	Riparian	0.002		
Belted Kingfisher	Riparian	0.009	0.004	0.005
Red-bellied woodpecker	Forest Edge	0.016	0.030	
	Forest Interior	0.037	0.029	0.025
	Riparian	0.021	0.048	0.035
	Fencerow	0.019	0.025	0.018
Yellow-bellied Sapsucker	Forest Interior			0.004
	Riparian			0.005
Downy Woodpecker	Forest Edge	0.016	0.060	0.031
	Forest Interior	**0.052**	0.066	0.061
	Riparian	0.034	0.048	0.045
	Fencerow	0.034	0.032	0.031
Hairy Woodpecker	Forest Edge	0.016	0.030	
	Forest Interior	0.019	0.044	0.008
	Riparian	0.006	0.004	0.005
	Fencerow	0.006	0.007	

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Northern Flicker	Forest Edge	>50 m		
	Forest Interior	0.009	0.007	0.012
	Riparian	0.007	0.013	
	Fencerow	0.006	0.007	0.004
	Field	0.011		0.016
Pileated Woodpecker	Forest Edge	0.011		0.031
	Forest Interior	>50 m	0.015	0.012
	Riparian	0.002	0.004	
	Fencerow	0.002		0.02
Eastern Wood-Pewee	Forest Edge	0.022		
	Forest Interior	0.044	0.015	
	Riparian	0.024	0.022	
	Fencerow		0.004	
Acadian Flycatcher	Forest Interior	0.005		
	Riparian	0.041	0.004	
Eastern Phoebe	Forest Edge	0.005		
	Riparian	0.004	0.004	
	Fencerow		0.011	
Great-crested Flycatcher	Forest Edge	0.027		
	Forest Interior	0.028		
	Riparian	0.013		
	Fencerow	0.004		
Eastern Kingbird	Riparian	0.007		
	Fencerow	0.017		
	Field	0.042		
White-eyed Vireo	Forest Edge	0.005		
Yellow-throated Vireo	Forest Interior	0.005		
	Riparian	0.007	0.004	
Warbling Vireo	Forest Interior	0.005		
	Riparian	0.007		
Philadelphia Vireo	Forest Edge		0.015	
Red-eyed Vireo	Forest Edge	0.027		
	Forest Interior	0.040		
	Riparian	0.034	0.013	
	Fencerow	0.008		
Blue Jay	Forest Edge	0.011	**0.119**	0.016
	Forest Interior	**0.070**	**0.117**	0.020
	Riparian	0.013	0.030	0.015
	Fencerow	0.032	0.046	0.022
American Crow	Forest Edge	0.049	0.060	**0.219**
	Forest Interior	0.037	0.036	**0.070**
	Riparian	0.024	0.030	0.059
	Fencerow	0.036	0.025	**0.084**
	Field	**0.084**	**0.132**	FO

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Fish Crow	Forest Edge			0.016
	Forest Interior			0.012
	Riparian	0.002	0.004	0.005
	Fencerow	0.006		
	Field			0.004
Tree Swallow	Forest Edge	FO		
	Riparian		0.013	
	Fencerow	FO		
	Field		**0.211**	
Northern Rough-winged Swallow	Riparian	0.004	0.009	
	Fencerow	0.004		
	Field	0.042		
Barn Swallow	Forest Edge	FO		
	Forest Interior	FO		
	Riparian	FO		
	Fencerow	0.002		
	Field	0.011		
Carolina Chickadee	Forest Edge	**0.082**	**0.194**	0.047
	Forest Interior	**0.094**	0.073	**0.143**
	Riparian	**0.073**	**0.169**	0.010
	Fencerow	**0.084**	**0.121**	**0.089**
Tufted Titmouse	Forest Edge	**0.099**	0.015	**0.078**
	Forest Interior	**0.101**	**0.109**	**0.135**
	Riparian	**0.058**	**0.121**	0.040
	Fencerow	0.051	0.036	**0.080**
White-breasted Nuthatch	Forest Edge	0.022	0.045	0.016
	Forest Interior	0.049	0.051	**0.070**
	Riparian	0.026	0.026	0.020
	Fencerow	0.013	0.018	0.013
Brown Creeper	Forest Interior			0.016
	Riparian			0.010
Carolina Wren	Forest Edge	0.033	0.075	0.063
	Forest Interior	0.035	**0.095**	0.029
	Riparian	**0.052**	0.065	**0.074**
	Fencerow	0.021	0.071	0.013
House Wren	Forest Edge	0.011	**0.090**	
	Forest Interior	0.007	0.022	
	Riparian	0.024		
	Fencerow	0.021	0.011	
Ruby-crowned Kinglet	Forest Interior			0.008
Blue-gray Gnatcatcher	Forest Edge	0.022		
	Forest Interior	0.019		
	Riparian	0.047		
	Fencerow	0.027		

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Eastern Bluebird	Forest Edge	0.027		0.047
	Forest Interior	0.002		0.012
	Riparian	0.006	0.013	0.010
	Fencerow	0.023	0.039	0.049
	Field	**0.074**	**0.22**	**0.32**
Wood Thrush	Forest Edge	0.022		
	Forest Interior	**0.066**	0.015	
	Riparian	0.017		
	Fencerow	0.004		
American Robin	Forest Edge	0.016		**0.109**
	Forest Interior	0.009	**0.102**	0.004
	Riparian	0.006	0.035	0.030
	Fencerow	0.023	0.007	
	Field	**0.084**		
Gray Catbird	Forest Edge	0.016	0.045	
	Forest Interior	0.012	0.015	
	Riparian	0.024		
	Fencerow	0.040	0.014	
Northern Mockingbird	Forest Edge			0.047
	Forest Interior	0.002		0.008
	Riparian			0.005
	Fencerow	0.021	0.036	0.036
Brown Thrasher	Riparian	0.002		
	Fencerow	0.004	0.007	
European Starling	Forest Edge			FO
	Forest Interior			0.008
	Riparian	0.004	FO	0.005
	Fencerow	0.027*	0.039	0.013
Cedar Waxwing	Forest Edge	**0.115**	0.015	
	Forest Interior	0.012		
	Riparian	0.015	0.043	
	Fencerow	0.030	**0.271**	
Nashville Warbler	Fencerow		0.004	
Northern Parula	Forest Edge	0.005		
	Forest Interior	>50 m		
	Riparian	0.015		
	Fencerow	0.002		
Magnolia Warbler	Forest Interior		0.007	
	Fencerow		0.004	
Yellow-rumped Warbler	Forest Interior			0.016
Blackpoll Warbler	Forest Interior	0.007		
Black-and-white Warbler	Fencerow	> 50m	0.004	
American Redstart	Riparian	0.002		

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Worm-eating Warbler	Forest Interior	0.002		
	Riparian	0.004		
Louisiana Waterthrush	Riparian	0.011		
Kentucky Warbler	Forest Edge	0.005		
Common Yellowthroat	Forest Edge	0.005		
	Riparian	0.009	0.017	
	Fencerow	0.015	0.014	
	Field	0.011		
Scarlet Tanager	Forest Edge			
	Forest Interior	0.021		
	Riparian	0.007		
	Fencerow	0.002		
Eastern Towhee	Forest Edge	0.005		
	Forest Interior	0.009		
	Riparian	0.002		
	Fencerow	0.011		
Chipping Sparrow	Forest Interior	0.002		
	Riparian	0.002		
	Fencerow	0.013		
Field Sparrow	Forest Edge	0.011		
	Forest Interior	0.002		0.012
	Fencerow	0.013	0.007	0.004
	Field	0.053		
Vesper Sparrow	Fencerow	0.008		
	Field	0.032		
Grasshopper Sparrow	Riparian	0.002		
	Fencerow	0.013		
	Field	**0.232**		
Song Sparrow	Forest Edge	0.005		
	Forest Interior			0.012
	Riparian	0.017		0.029
	Fencerow	0.013	0.007	0.040
White-throated Sparrow	Forest Edge			0.031
	Forest Interior			0.049
	Riparian			0.035
	Fencerow			**0.107**
Dark-eyed Junco	Forest Interior			**0.123**
	Riparian			0.010
	Fencerow			**0.124**
Northern Cardinal	Forest Edge	**0.066**	**0.164**	**0.203**
	Forest Interior	**0.094**	**0.124**	**0.131**
	Riparian	**0.064**	**0.108**	0.035
	Fencerow	**0.084**	0.079	**0.209**
Blue Grosbeak	Riparian	0.004		

Appendix E, continued. Relative abundance by habitat type for species counted during Breeding Season, Fall, and Winter surveys.

Species	Habitat type	Breeding Season	Fall	Winter
Indigo Bunting	Forest Edge	**0.110**		
	Forest Interior	0.023		
	Riparian	0.041		
	Fencerow	**0.076**	0.007	
	Field	0.021		
Red-winged Blackbird	Riparian	0.045		
	Fencerow	0.023		
	Field	**0.105**		
Eastern Meadowlark	Field	> 50m		
Common Grackle	Forest Edge	0.005		
	Forest Interior	0.002		
	Riparian	0.034		
	Fencerow	0.036		
	Field	0.032		
Brown-headed Cowbird	Forest Edge	0.005		
	Forest Interior	0.012		
	Riparian	0.013		
	Fencerow	0.015		
	Field	0.053		
Orchard Oriole	Forest Edge	>50 m		
	Riparian	0.004		
	Fencerow	0.002		
Baltimore Oriole	Forest Edge	0.016		
	Forest Interior	0.019		
	Riparian	0.017		
	Fencerow	0.021		
House Finch	Forest Edge	0.005	0.030	0.031
	Forest Interior	0.005		FO
	Riparian	0.004	0.017	
	Fencerow	0.002		0.022
	Field			0.029
American Goldfinch	Forest Edge	0.049	FO	
	Forest Interior	0.019	0.007	FO
	Riparian	0.036	0.013	
	Fencerow	0.036	0.014	
	Field	**0.074**	**0.50**	
House Sparrow	Forest Interior	0.005		0.008
	Fencerow	0.008		0.022
	Field			0.016

* 84 Canada Geese, 75 Rock Doves, and 16 European Starlings were dropped from breeding season fencerow calculations to provide more representative relative abundance values.

Appendix F. Density (per hectare) by habitat type for species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50m of the count point. See text for formulas used to calculate densities. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Great Blue Heron	Riparian	0.42	0.012	0.12
Black Vulture	Riparian	0.32		
	Fencerow			0.02
	Field			0.36
Turkey Vulture	Riparian	0.11		
	Fencerow	0.10		0.02
	Field		0.11	0.36
Canada Goose	Riparian	*		**0.63**
	Field			**8.04**
Wood Duck	Riparian	0.32		
American Black Duck	Riparian			0.19
Mallard	Riparian	0.053		**1.7**
Lesser Scaup	Riparian			0.042
Hooded Merganser	Riparian			0.13
Common Merganser	Riparian			0.042
Red-tailed Hawk	Forest Edge		0.071	
	Forest Interior	0.17	0.14	0.03
	Riparian	0.053	0.022	0.021
	Fencerow	0.049		0.02
	Field			0.08
Red-shouldered Hawk	Forest Edge			0.083
	Riparian	0.053	0.022	
Broad-winged Hawk	Field		0.22	
Wild Turkey	Forest Interior	0.055	0.035	
Killdeer	Field		0.11	
Spotted Sandpiper	Riparian		0.022	
Rock Dove	Fencerow	0.049*		
Mourning Dove	Forest Edge	0.16		
	Forest Interior	0.28	0.049	0.03
	Riparian	0.053	0.22	0.021
	Fencerow	0.59	0.19	
Yellow-billed Cuckoo	Forest Interior	0.11		
	Riparian	0.21		
Barred Owl	Forest Interior			0.03
	Riparian			0.021
Chimney Swift	Forest Edge	0.32		
	Riparian		0.22	
Ruby-throated Hummingbird	Forest Edge	0.16		
	Forest Interior	0.055		
	Riparian	0.053		

Appendix F, continued. Density (per hectare) by habitat type of species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50 m of the count point. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Belted Kingfisher	Riparian	0.27	0.022	0.021
Red-bellied woodpecker	Forest Edge	0.48	0.14	
	Forest Interior	**0.89**	0.19	0.33
	Riparian	0.58	0.24	0.15
	Fencerow	0.44	0.19	0.08
Yellow-bellied Sapsucker	Forest Interior			0.03
	Riparian			0.021
Downy Woodpecker	Forest Edge	0.48	0.28	0.17
	Forest Interior	**1.22**	**0.47**	**0.92**
	Riparian	**0.95**	**0.41**	**0.41**
	Fencerow	0.78	0.19	0.27
Hairy Woodpecker	Forest Edge	0.48	0.098	
	Forest Interior	0.44	0.21	0.061
	Riparian	0.16	0.022	0.021
	Fencerow	0.15	0.03	
Northern Flicker	Forest Interior	0.22	0.035	0.091
	Riparian	0.21	0.027	
	Fencerow	0.15	0.03	0.02
	Field			0.16
Pileated Woodpecker	Forest Edge	0.32		0.17
	Forest Interior		0.049	0.10
	Riparian	0.053	0.022	
	Fencerow	0.049		0.02
Eastern Wood-Pewee	Forest Edge	0.64		
	Forest Interior	**1.05**	0.07	
	Riparian	0.69	0.18	
	Fencerow		0.022	
Acadian Flycatcher	Forest Interior	0.11		
	Riparian	1.17	0.022	
Eastern Phoebe	Forest Edge	0.16		
	Riparian	0.106	0.022	
	Fencerow		0.065	
Great-crested Flycatcher	Forest Edge	**0.80**		
	Forest Interior	0.66		
	Riparian	0.37		
	Fencerow	0.098		
Eastern Kingbird	Riparian	0.21		
	Fencerow	0.39		
White-eyed Vireo	Forest Edge	0.16		
Yellow-throated Vireo	Forest Interior	0.11		
	Riparian	0.21	0.022	

Appendix F, continued. Density (per hectare) by habitat type of species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50 m of the count point. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Warbling Vireo	Forest Interior	0.11		
	Riparian	0.21		
Philadelphia Vireo	Forest Edge		0.071	
Red-eyed Vireo	Forest Edge	**0.80**		
	Forest Interior	**0.94**		
	Riparian	**0.95**	0.066	
	Fencerow	0.20		
Blue Jay	Forest Edge	0.32	**0.57**	0.083
	Forest Interior	**1.66**	**1.17**	0.15
	Riparian	0.37	0.19	0.063
	Fencerow	0.73	**0.53**	0.051
American Crow	Forest Edge	**1.43**	0.39	**1.78**
	Forest Interior	**0.89**	0.28	**0.75**
	Riparian	0.69	0.15	0.27
	Fencerow	**0.83**	0.29	**0.51**
	Field		**0.56**	
Fish Crow	Forest Edge			0.083
	Forest Interior			0.10
	Riparian	0.053	0.022	0.021
	Fencerow	0.15		
	Field			0.04
Tree Swallow	Riparian		0.066	
	Field		**0.89**	
Northern Rough-winged Swallow	Riparian	0.106	0.044	
	Fencerow	0.098		
Barn Swallow	Fencerow	0.049		
Carolina Chickadee	Forest Edge	**2.39**	**0.92**	0.17
	Forest Interior	**2.21**	**0.56**	**2.3**
	Riparian	**2.07**	**0.64**	**0.42**
	Fencerow	**1.96**	**0.73**	**0.42**
Tufted Titmouse	Forest Edge	**2.86**	0.071	**0.41**
	Forest Interior	**2.38**	**0.53**	**1.3**
	Riparian	**1.64**	**0.62**	0.23
	Fencerow	**1.18**	0.22	**0.64**
White-breasted Nuthatch	Forest Edge	0.64	0.21	0.083
	Forest Interior	**1.16**	0.25	**0.52**
	Riparian	0.74	0.13	0.083
	Fencerow		0.11	0.06
Brown Creeper	Forest Interior			0.12
	Riparian			0.042

Appendix F, continued. Density (per hectare) by habitat type of species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50 m of the count point. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Carolina Wren	Forest Edge	**0.95**	0.35	0.17
	Forest Interior	**0.83**	0.35	0.21
	Riparian	**1.49**	**0.53**	**0.41**
	Fencerow	0.49	**0.70**	0.051
House Wren	Forest Edge	0.32	**0.43**	
	Forest Interior	0.17	0.11	
	Riparian	0.69		
	Fencerow	0.49	0.065	
Ruby-crowned Kinglet	Forest Interior			0.042
Blue-gray Gnatcatcher	Forest Edge	0.64		
	Forest Interior	0.44		
	Riparian	**1.33**		
	Fencerow	0.64		
Eastern Bluebird	Forest Edge	**0.80**		0.27
	Forest Interior	0.055		0.091
	Riparian	0.16	0.066	0.042
	Fencerow	0.54	0.24	0.22
	Field		0.22	0.32
Wood Thrush	Forest Edge	0.64		
	Forest Interior	**1.55**	0.070	
	Riparian	0.48		
American Robin	Forest Edge	0.48		**0.58**
	Forest Interior	0.22	**0.49**	0.030
	Riparian	0.16	0.12	0.13
	Fencerow	0.54	0.030	
Gray Catbird	Forest Edge	0.48	0.21	
	Forest Interior	0.28	0.070	
	Riparian	0.69		
	Fencerow	**0.93**	0.03	
Northern Mockingbird	Forest Edge			0.25
	Forest Interior	0.055		0.061
	Riparian			0.021
	Fencerow	0.49	0.22	0.33
Brown Thrasher	Riparian	0.053		
	Fencerow	0.098	0.043	
European Starling	Forest Interior			0.061
	Riparian	0.106	0.022	0.021
	Fencerow	0.64*	0.24	0.06
Cedar Waxwing	Forest Edge	**3.34**	0.071	
	Forest Interior	0.28		
	Riparian	0.42	0.22	
	Fencerow	0.69	**1.64**	
Nashville Warbler	Fencerow		0.022	

Appendix F, continued. Density (per hectare) by habitat type of species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50 m of the count point. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Northern Parula	Forest Edge	0.16		
	Riparian	0.42		
	Fencerow	0.049		
Magnolia Warbler	Forest Interior		0.035	
	Fencerow		0.022	
Yellow-rumped Warbler	Forest Interior			0.12
Blackpoll Warbler	Forest Interior	0.17		
Black-and-white Warbler	Fencerow		0.022	
American Redstart	Riparian	0.053		
Worm-eating Warbler	Forest Interior	0.055		
	Riparian	0.106		
Louisiana Waterthrush	Riparian	0.32		
Kentucky Warbler	Forest Edge	0.16		
Common Yellowthroat	Forest Edge	0.16		
	Riparian	0.27	0.088	
	Fencerow	0.34	0.086	
Scarlet Tanager	Forest Edge	0.32		
	Forest Interior	0.50		
	Riparian	0.21		
	Fencerow	0.049		
Eastern Towhee	Forest Edge	0.16		
	Forest Interior	0.22		
	Riparian	0.053		
	Fencerow	0.24		
Chipping Sparrow	Forest Interior	0.055		
	Riparian	0.053		
	Fencerow	0.29		
Field Sparrow	Forest Edge	0.32		
	Forest Interior	0.055		
	Fencerow	0.29	0.043	0.02
Vesper Sparrow	Fencerow	0.20		
Grasshopper Sparrow	Riparian	0.053		
	Fencerow	0.29		
Song Sparrow	Forest Edge	0.16		
	Forest Interior			0.091
	Riparian	0.48		0.029
	Fencerow	0.29	0.043	**0.40**
White-throated Sparrow	Forest Edge			0.17
	Forest Interior			0.36
	Riparian			0.15
	Fencerow			**1.52**

Appendix F, continued. Density (per hectare) by habitat type of species counted during Breeding Season, Fall, and Winter surveys. Breeding Season densities include only birds within 50 m of the count point. Bold numbers indicate densities > 0.8/ha for Breeding Season and > 0.4/ha for Fall and Winter.

Species	Habitat type	Breeding Season	Fall	Winter
Dark-eyed Junco	Forest Interior			**0.91**
	Riparian			0.042
	Fencerow			**0.56**
Northern Cardinal	Forest Edge	**1.91**	**0.78**	**1.55**
	Forest Interior	**2.21**	**1.03**	**2.3**
	Riparian	**1.80**	**0.55**	0.18
	Fencerow	**1.96**	**0.48**	**1.56**
Blue Grosbeak	Riparian	0.106		
Indigo Bunting	Forest Edge	**3.18**		
	Forest Interior	0.55		
	Riparian	**1.17**		
	Fencerow	**1.76**	0.043	
Red-winged Blackbird	Riparian	**1.27**		
	Fencerow	0.54		
Common Grackle	Forest Edge	0.16		
	Forest Interior	0.055		
	Riparian	**0.95**		
	Fencerow	**0.83**		
Brown-headed Cowbird	Forest Edge	0.16		
	Forest Interior	0.28		
	Riparian	0.37		
	Fencerow	0.34		
Orchard Oriole	Riparian	0.106		
	Fencerow	0.049		
Baltimore Oriole	Forest Edge	0.48		
	Forest Interior	0.44		
	Riparian	0.48		
	Fencerow	0.49		
House Finch	Forest Edge	0.16	0.14	0.17
	Forest Interior	0.11		
	Riparian	0.106	0.088	
	Fencerow	0.049		0.092
	Field			0.28
American Goldfinch	Forest Edge	**1.43**		
	Forest Interior	0.44	0.035	
	Riparian	**1.01**	0.066	
	Fencerow	**0.83**	0.086	
	Field		**2.1**	
House Sparrow	Forest Interior	0.11		0.001
	Fencerow	0.20		0.10
	Field			0.28

* 84 Canada Geese, 75 Rock Doves, and 16 European Starlings were dropped from fencerow calculations to provide more representative density values

Appendix G. Relative abundance for breeding season, fall and winter by park area. Bold numbers indicate the highest values within each season. Magnitude indicates abundance relative to other species within that habitat type, within that park area. Breeding Season values include only birds within 50m of the count point; "> 50m" indicates birds only detected > 50m from the count point. "FO" indicates only noted to fly over the area.

Gambrill:

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Great Blue Heron	0.005	0.011		Tufted Titmouse	**0.073**	0.056	**0.078**
Green Heron	FO			White-breasted Nuthatch	0.036	0.045	0.052
Black Vulture	FO			Brown Creeper		0.010	
Turkey Vulture	0.005	0.006	FO	Carolina Wren	**0.041**	0.045	0.052
Canada Goose	FO	FO	FO	House Wren	0.012	0.010	
Mallard	0.002		0.026	Ruby-crowned Kinglet			0.005
Red-tailed Hawk	0.002	0.006	0.005	Blue-gray Gnatcatcher	0.029		
Red-shouldered Hawk	0.002	0.006	0.005	Eastern Bluebird	0.027	0.034	**0.104**
Broad-winged Hawk		0.011		Wood Thrush	0.027		
American Kestrel	> 50m			American Robin	0.012	0.022	0.036
Killdeer			FO	Gray Catbird	0.010	0.017	
Spotted Sandpiper		0.006		Northern Mockingbird	0.007	0.006	0.026
Ring-billed Gull			FO	European Starling	0.002	0.022	0.005
Mourning Dove	0.002	0.017		Cedar Waxwing	0.015	0.006	
Yellow-billed Cuckoo	0.007			Northern Parula	0.010		
Chimney Swift		0.017		Yellow-rumped Warbler			0.016
Ruby-throated Hummingbird	0.005			Black-and-white Warbler	> 50m		
Belted Kingfisher	0.007	0.006		Worm-eating Warbler	0.002		
Red-bellied woodpecker	0.024	0.039	0.005	Louisiana Waterthrush	0.015		
Yellow-bellied Sapsucker			0.005	Kentucky Warbler	0.002		
Downy Woodpecker	0.036	0.034	0.052	Common Yellowthroat	0.005		

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Hairy Woodpecker	0.015	0.034	0.010	Scarlet Tanager	0.015		
Northern Flicker	0.010	0.017	0.021	Eastern Towhee	> 50m		
Pileated Woodpecker	0.005		0.021	Chipping Sparrow	0.005		
Eastern Wood-Pewee	0.029	0.017		Field Sparrow	0.002		
Acadian Flycatcher	0.022			Grasshopper Sparrow	> 50m		
Eastern Phoebe	0.005			Song Sparrow	0.002		0.021
Great-crested Flycatcher	0.029			White-throated Sparrow			0.057
Eastern Kingbird	0.012			Dark-eyed Junco			0.021
Yellow-throated Vireo	0.015	0.006		Northern Cardinal	**0.063**	0.056	**0.078**
Warbling Vireo	0.002			Indigo Bunting	0.051		
Philadelphia Vireo		0.006		Red-winged Blackbird	0.005		
Red-eyed Vireo	0.034			Common Grackle	0.024		
Blue Jay	0.041	**0.073**	0.016	Brown-headed Cowbird	0.024		
American Crow	0.027	0.045	**0.145**	Baltimore Oriole	0.022		
Fish Crow	0.002		0.016	House Finch	0.007	0.034	0.057
Tree Swallow	FO			American Goldfinch	0.029	**0.118**	
Barn Swallow	FO			House Sparrow			0.021
Carolina Chickadee	**0.078**	**0.152**	0.041				

Monocacy North:

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Great Blue Heron	0.010		0.003	Carolina Chickadee	0.041	**0.070**	0.037
Black Vulture	0.031		0.003	Tufted Titmouse	0.041	0.051	0.006
Turkey Vulture			0.027	White-breasted Nuthatch	0.016		
Canada Goose	*		**0.613**	Carolina Wren	**0.052**	0.028	0.024
Mallard	> 50m		0.052	House Wren	0.005		
Hooded Merganser			0.018	Ruby-crowned Kinglet			0.003
Red-tailed Hawk	> 50m	0.005	FO	Blue-gray Gnatcatcher	0.021		
Red-shouldered Hawk	> 50m			Eastern Bluebird	0.016	0.005	0.006
American Kestrel	FO			American Robin	**0.057**	**0.065**	0.018
Killdeer	> 50m	0.005		Gray Catbird	0.016		
Ring-billed Gull			FO	Northern Mockingbird	0.005	0.019	0.012
Rock Dove	*	FO	FO	European Starling	0.036*	0.033	
Mourning Dove	0.036	0.051	0.003	Cedar Waxwing	> 50m	**0.353**	
Barred Owl			0.003	Nashville Warbler		0.005	
Chimney Swift		0.033		Northern Parula	0.010		
Ruby-throated Hummingbird	0.005			Magnolia Warbler		0.005	
Red-bellied woodpecker	0.010	0.019	0.015	Common Yellowthroat	0.010		
Downy Woodpecker	0.036	0.019	0.006	Chipping Sparrow	0.005		
Hairy Woodpecker	0.005			Grasshopper Sparrow	0.016		
Northern Flicker	0.005	0.009		Song Sparrow	0.016	0.009	0.012
Pileated Woodpecker	> 50m			White-throated Sparrow			0.030
Eastern Wood-Pewee	0.010	0.009		Dark-eyed Junco			0.009
Acadian Flycatcher	0.010			Northern Cardinal	0.062	0.056	**0.067**
Eastern Phoebe	> 50m			Blue Grosbeak	0.010		

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Great-crested Flycatcher	0.010			Indigo Bunting	**0.073**		
Eastern Kingbird	> 50m			Red-winged Blackbird	**0.073**		
Warbling Vireo	0.010			Eastern Meadowlark	> 50m		
Red-eyed Vireo	0.016	0.005		Common Grackle	**0.052**		
Blue Jay	0.010	0.019	0.006	Brown-headed Cowbird	0.010		
American Crow	0.042	0.042	0.015	Baltimore Oriole	0.010		
Fish Crow	0.016			House Finch	> 50m		
Tree Swallow		0.037		American Goldfinch	0.042	0.014	
Northern Rough-winged Swallow	0.010			House Sparrow	0.021		
Barn Swallow	0.005						

*84 Canada Geese, 75 Rock Doves, and 16 European Starlings were dropped from calculations to provide more representative relative abundance values.

Louis Farm:

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Black Vulture		FO		White-breasted Nuthatch	0.015	0.057	0.022
Turkey Vulture	FO	FO		Brown Creeper		0.015	
Canada Goose	FO			Carolina Wren	0.037	**0.105**	0.015
Northern Harrier	FO			House Wren	0.007	0.057	
Red-tailed Hawk	0.004		0.007	Blue-gray Gnatcatcher	0.022		
Red-shouldered Hawk		FO		Eastern Bluebird	0.007	0.019	
Rock Dove	FO			Wood Thrush	0.033		
Mourning Dove	0.007	0.019		American Robin	0.004		0.007
Yellow-billed Cuckoo	> 50m			Gray Catbird	0.022		
Chimney Swift	0.007			Northern Mockingbird	0.011	0.010	0.022
Red-bellied woodpecker	0.022	0.019	0.022	Brown Thrasher		0.019	

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Downy Woodpecker	0.037	**0.086**	0.029	European Starling	0.015	FO	0.022
Hairy Woodpecker	0.004	0.029		Cedar Waxwing	**0.121**		
Northern Flicker	0.007		0.007	Black-and-white Warbler		0.010	
Pileated Woodpecker	> 50m			Scarlet Tanager	0.004		
Eastern Wood-Pewee	0.011			Eastern Towhee	0.018		
Eastern Phoebe	0.004			Chipping Sparrow	0.011		
Great-crested Flycatcher	0.007			Field Sparrow	0.015		
White-eyed Vireo	0.007			Song Sparrow	0.004		0.015
Red-eyed Vireo	0.011			White-throated Sparrow			0.059
Blue Jay	0.026	**0.086**	0.037	Dark-eyed Junco			0.066
American Crow	**0.084**	0.029	**0.081**	Northern Cardinal	**0.076**	**0.181**	**0.235**
Fish Crow	> 50m		FO	Indigo Bunting	0.070	0.010	
Tree Swallow	FO			Common Grackle	0.004		
Northern Rough-winged Swallow	> 50m			Brown-headed Cowbird	0.007		
Barn Swallow	FO			Baltimore Oriole	0.011		
Carolina Chickadee	**0.081**	**0.219**	**0.184**	House Finch	0.004		0.022
Tufted Titmouse	**0.088**	0.029	0.132	American Goldfinch	0.040	0.019	FO

Worthington:

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Great Blue Heron	0.005	0.008	0.009	Carolina Chickadee	**0.094**	**0.122**	**0.101**
Black Vulture		FO	0.028	Tufted Titmouse	**0.071**	**0.118**	**0.089**
Turkey Vulture	0.003	FO	0.003	White-breasted Nuthatch	0.031	0.027	0.037
Canada Goose	0.001		**0.092**	Brown Creeper		0.006	
Wood Duck	0.008			Carolina Wren	0.030	**0.110**	0.031
American Black Duck			0.028	House Wren	0.026	0.012	
Mallard	> 50m		0.037	Blue-gray Gnatcatcher	0.037		
Lesser Scaup			0.006	Eastern Bluebird	0.008	0.024	0.015
Common Merganser			0.006	Wood Thrush	0.030	0.008	
Bald Eagle			FO	American Robin	0.007	0.024	FO
Red-tailed Hawk	0.004	0.016	0.009	Gray Catbird	0.035	0.024	
Red-shouldered Hawk	> 50m			Northern Mockingbird	0.007	0.016	0.006
Killdeer	> 50m		FO	Brown Thrasher	0.004		
Ring-billed Gull			FO	European Starling	0.004		0.006
Wild Turkey	0.001	0.004		Cedar Waxwing	0.012	0.038	
Rock Dove	0.001		FO	Northern Parula	0.005		
Mourning Dove	0.012	0.020	0.003	Magnolia Warbler		0.004	
Yellow-billed Cuckoo	0.004			Yellow-rumped Warbler			0.003
Barred Owl			0.003	Blackpoll Warbler	0.004		
Chimney Swift	FO			American Redstart	0.001		
Ruby-throated Hummingbird	> 50m			Worm-eating Warbler	0.003		
Belted Kingfisher	0.001		0.003	Common Yellowthroat	0.012		
Red-bellied woodpecker	0.028	0.043	0.025	Scarlet Tanager	0.012		
Yellow-bellied Sapsucker			0.003	Eastern Towhee	0.008		

Species	Breeding Season	Fall	Winter	Species	Breeding Season	Fall	Winter
Downy Woodpecker	0.037	0.055	0.052	Chipping Sparrow	0.005		
Hairy Woodpecker	0.012	0.008	0.003	Field Sparrow	0.005	0.008	0.003
Northern Flicker	0.005	0.004	0.009	Vesper Sparrow	0.005		
Pileated Woodpecker	0.003	0.012	0.006	Grasshopper Sparrow	0.005		
Eastern Wood-Pewee	0.025	0.012		Song Sparrow	0.014		0.012
Acadian Flycatcher	0.017	0.008		White-throated Sparrow			0.049
Eastern Phoebe	0.001	0.008		Dark-eyed Junco			**0.135**
Great-crested Flycatcher	0.013			Northern Cardinal	**0.114**	**0.133**	**0.092**
Eastern Kingbird	0.012			Indigo Bunting	0.045	0.004	
Warbling Vireo	0.005			Red-winged Blackbird	0.025		
Red-eyed Vireo	0.031	0.008		Common Grackle	0.025		
Blue Jay	0.037	0.071	0.012	Brown-headed Cowbird	0.008		
American Crow	0.018	0.031	0.055	Orchard Oriole	0.004		
Fish Crow	> 50m	0.004	0.009	Baltimore Oriole	0.021		
Tree Swallow	> 50m	0.012		House Finch	0.003		
Northern Rough-winged Swallow	0.003	0.008		American Goldfinch	0.029	0.004	
Barn Swallow	> 50m			House Sparrow	0.003		0.012

Appendix H. Scientific names of tree and shrub species mentioned in text.

Common Name	Scientific Name
American basswood	*Tilia americana*
American beech	*Fagus grandifolia*
American chestnut	*Castanea dentata*
American elm	*Ulmus americana*
Apple	*Pyrus malus*
Barberry	*Berberis* sp.
Bitternut hickory	*Carya cordiformis*
Black cherry	*Prunus serotina*
Black gum	*Nyssa sylvatica*
Black locust	*Robinia psuedoacacia*
Black walnut	*Juglans nigra*
Blackberry	*Rubus allegheniensis*
Bladdernut	*Staphylea trifolia*
Box elder	*Acer negundo*
Chestnut oak	*Quercus montana*
Choke cherry	*Prunus virginiana*
Common catalpa	*Catalpa bignonioides*
Common spicebush	*Lindera benzoin*
Cottonwood	*Populus deltoides*
Flowering dogwood	*Cornus florida*
Green ash	*Fraxinus pennsylvanica* var. *subintegerrima*
Hackberry	*Celtis occidentalis*
Honey locust	*Gleditsia triacanthos*
Honeysuckle	*Lonicera* sp.
Ironwood	*Ostrya virginiana*
Juniper	*Juniperus* sp.
Mapleleaf viburnum	*Viburnum acerifolium*
Mockernut hickory	*Carya tomentosa*
Mountain laurel	*Kalmia latifolia*
Multiflora rose	*Rosa multiflora*
Musclewood	*Carpinus caroliniana*
Northern red oak	*Quercus rubra*
Osage orange	*Maclura pomifera*
Paw paw	*Asimina triloba*
Pear	*Pyrus communis*
Persimmon	*Diospyros virginiana*
Pin Oak	*Quercus palustris*
Princess tree	*Paulownia tomentosa*
Red ash	*Fraxinus pennsylvanica*
Red maple	*Acer rubrum*
Red mulberry	*Morus rubra*
Tulip poplar	*Liriodendron tulipifera*

Common Name	Scientific Name
Sassafras	*Sassafras albidum*
Serviceberry	*Amelanchier arborea*
Shagbark hickory	*Carya ovata*
Silver maple	*Acer saccharinum*
Spruce	*Picea* sp.
Staghorn sumac	*Rhus typhina*
Sugar maple	*Acer saccharum*
Sycamore	*Platanus occidentalis*
Tree of heaven	*Ailanthus altissima*
Tulip poplar	*Liriodendron tulipifera*
Virginia pine	*Pinus virginiana*
White ash	*Fraxinus americana*
White oak	*Quercus alba*
White pine	*Pinus strobus*
Willow sp.	*Salix* sp.
Witch hazel	*Hamamelis virginiana*
Yellow birch	*Betula lutea*