# Use of Avian and Mammalian Guilds as Indicators of Cumulative Impacts in Riparian–Wetland Areas

**MARY JO CROONQUIST***
**ROBERT P. BROOKS**
School of Forest Resources,
Forest Resources Laboratory
Pennsylvania State University,
University Park, Pennsylvania 16802, USA

ABSTRACT / A new method of assessing cumulative effects of human activities on bird and mammal communities of riparian–wetland areas was developed by using response guilds to reflect how species theoretically respond to habitat disturbance on a landscape level. All bird and mammal species of Pennsylvania were assigned values for each response guild, using documented information for each species, to reflect their sensitivity to disturbances; high guild scores corresponded to low tolerance toward habitat disturbance. We hypothesized that, given limited time and resources, determining how wildlife communities change in response to environmental impacts can be done more efficiently with a response-guild approach than a single-species approach. To test the model, censuses of birds and mammals were conducted along wetland and riparian areas of a protected and a disturbed watershed in central Pennsylvania. The percent of bird species with high response-guild scores (i.e., species that had specific habitat requirements and/or were neotropical migrants) remained relatively stable through the protected watershed. As intensity of habitat alteration increased through the disturbed watershed, percentage of bird species with high response-guild scores decreased. Only 2%–3% of the neotropical migrants that had specific habitat requirements were breeding residents in disturbed habitats as compared to 17%–20% in reference areas. Species in the edge and exotic guild classifications (low guild scores) were found in greater percentages in the disturbed watershed. Composition of mammalian guilds showed no consistent pattern associated with habitat disturbance. Avian response guilds reflected habitat disturbance more predictively than mammalian response guilds.

Riparian areas, which encompass the 100-yr floodplain along waterways, and wetlands adjacent to waterways are among the most productive and valuable natural systems on earth (Hunt 1985), but many of these areas have been degraded or otherwise altered by human activities. The diversity and productivity of these systems are largely attributable to biotic and nutrient exchanges with aquatic and upland areas. Therefore, aquatic, wetland, and upland areas generally form integrated ecosystems (Hunt 1985). Degradation and/or fragmentation of one affects quality and functions of the others, which, in turn, affects the associated plant and wildlife community, thereby preventing the productivity and value of these systems from being realized. Because restoring the functions of existing riparian–wetland areas is one way of supporting the "no net wetland loss and long-term gain policies" (Conservation Foundation 1988), we need to determine the feasibility of restoration. We also need to understand how wildlife communities respond to disturbances of watersheds so that our restoration efforts can be concentrated on management of the community types in greatest need.

Bird and mammal communities have been shown to serve as indicators of various types and accumulations of impacts through landscapes (e.g., MacMahon 1976, Severinghaus 1981, Landres 1983, Verner 1983, 1984, Block and others 1984, Mannan and others 1984). Therefore, we hypothesized that responses of bird and mammal communities are predictable (Severinghaus 1981) and can be quantified via response guilds (Brooks and Croonquist 1990). A guild, as defined by Root (1967), is "a group of species that exploit the same class of environmental resources in a similar way." We adopted the concepts of management guilds (Verner 1984) and response guilds (Szaro 1986), groups of species that respond in a similar manner to habitat perturbations, to determine if our approach of response guilds effectively assessed riparian–wetland environments. Verner (1984) felt that his "operational" definition of guilds did not violate the spirit or intent of Root's (1967) "functional" definition because even management (or response) guilds can be delineated in a way that retains some measure of functional associations among the members. Mannan and others (1984) had difficulty with Verner's (1983, 1984) guild-unit approach because they felt these guild units may be untenable if populations of species within the guild respond differently to environmental perturbations. We

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*Author to whom correspondence should be addressed.

attempted to negate this problem by grouping species a priori on the basis of their similarity in responses to environmental change. We focused on developing relatively inexpensive methods consistent over whole regions (Brooks and others 1991). Response guilds used in this study take into account species' dependency on wetlands, foraging requirements, habitat requirements, relative anthropogenic importance, and, for birds, migratory status. Species are given scores of 0–5 for each guild to reflect each species' sensitivity and degree of response to human-related disturbance in riparian–wetland habitats (Brooks and Croonquist 1990). Species that are not adversely affected by habitat disturbance receive low guild scores; sensitive species receive high scores. This scoring system is somewhat similar to the Habitat Evaluation Procedures (USDI 1980) in that higher scores are more desirable for habitat protection or mitigation planning. Species with high guild scores theoretically dominate undisturbed reference areas, whereas disturbed areas should be dominated by species with low guild scores.

Our objectives were to determine how anthropogenic disturbances along riparian–wetland areas of watersheds affect the structure of wildlife communities and to determine if response guilds reflect this change in community structure. We also compared mammal and bird similarity indices to response guilds to determine the level of effort required to quantify the degree of disturbance in watersheds.

## Study Area

We selected two watersheds in the Ridge and Valley Province of central Pennsylvania, a relatively undisturbed, reference watershed and one disturbed by agricultural and residential development. Selection was based on watershed comparability; watersheds were in the same ecoregion and had the same direction of flow, similar gradients, potential natural vegetation, watershed area, and mean annual discharge (Croonquist 1990). The reference watershed, White Deer Creek, (WDC, 89 $km^2$) has limited forestry operations, seasonal sport fishing, and hunting as the primary activities. Access to WDC is limited by dirt roads, not maintained during winter. Forest covers 94% of the watershed (84% deciduous, 5% coniferous, 5% mixed), 1% is wetland, 4% is partially disturbed land-use types (shrub/brush and old field), and 1% is disturbed land-use types (gravel pit, barren, and minor agriculture; Croonquist 1990). Dominant tree species are *Tsuga canadensis*, *Acer rubrum*, and *Quercus* species. Dominant shrubs are *Tsuga canadensis*, *Alnus rugosa*, *Kalmia latifolia*, and *Rhododendron maxima*, with a nonvegetated or moss-dominated ground cover in coniferous areas, or very dense herbaceous cover of grasses and sedges in emergent wetlands.

Little Fishing Creek (LFC, 109 $km^2$), the disturbed watershed, also is protected within state forest along headwaters, but LFC receives more hunting pressure than WDC due to its proximity to residential areas. LFC flows into agricultural and residential areas along midreach and mainstem sections where riparian and wetland zones have been altered substantially. Livestock freely roam in and out of the stream, causing bank erosion and siltation. Human and livestock waste and chemical fertilizers also have degraded water quality (Croonquist 1990). Forest covers 70% of the watershed (48% deciduous, 11% coniferous, 12% mixed), 57% of which is in upper, undisturbed, sections. Undisturbed wetlands comprise <1%, 46% of which is in upper sections. Partially disturbed land-use types (shrub/brush, old fields, and partially disturbed wetlands) cover 4%. Over 25% is disturbed land-use types (agriculture, residential, commercial), 94% of which is in middle and mainstem, disturbed sections (Croonquist 1990). Dominant tree species in undisturbed, upper sections are *Tsuga canadensis*, *Betula lenta*, and *Acer rubrum;* dominant shrub species are *Rhododendron maxima*, *Tsuga canadensis*, and *Hamamelis virginiana*. Forested areas have sparse to moss ground cover. Dominant trees species in disturbed, lower sections are *Fraxinus americana*, *Tilia americana*, and *Viburnum lentago;* dominant shrub species are *Lindera benzoin* and *Salix sericea*. Ground cover is either nonvegetated or a thick cover of grasses and sedges.

## Methods

Watersheds were divided into four hierarchical sections (three sites per section, 12 sites per watershed) according to mean annual discharge and stream order: headwater, second-order tributary, midreach, and mainstem. Typical habitats were selected to allow sampling of overall watershed characteristics (Hughes and others 1986) and because random selection of three sites per section may not adequately characterize watersheds. Some sites within the middle hierarchical sections of LFC were confounded by habitat disturbance, whereas other sites were relatively undisturbed. Preliminary analyses (see Croonquist 1990 for details) showed that wildlife community similarities were affected more by changes in land use than stream order. Tributary and midreach sites of LFC, therefore, were regrouped as undisturbed middle and disturbed middle sections. Each site contained two, 100-m transects in an L-shaped pattern with sampling plots 25 m apart to facilitate small mammal trapping (see Croonquist 1990 for detailed description of study sites). The riparian transect was located along the riparian zone (0–2 m from the bank) parallel with the stream channel. The wetland transect began at one end of the riparian transect, so the center plot was shared by both transects, and extended 100 m from and perpendicular to the channel through the adjacent wetland/upland zone (nine sample plots per site).

Species richness of wildlife was determined at all 24 sites 12 times from October 1987 to September 1988 (mammals and birds), and three times from April 1989 to September 1989 (birds). Sampling intensity corresponded with seasonal and biological events (e.g., breeding, migration). Bird surveys consisted of 5-min point counts (Conner and Dickson 1980, Mikol 1980) at every other sample plot (25-m radius) yielding a 1-ha sample area per site. Surveys of owl species potentially found in the region were conducted during their midwinter to late spring breeding season (1988) using a 3-min taped vocalization of each species (Cornell Library of Natural Sounds, Ithaca, New York), followed by a 5-min silent response period for each species (Foster 1965, Springer 1978, Fuller and Mosher 1981, Morrell and Yahner 1990). One calling station was located at the center of each site. Data from bird surveys were pooled over the two years.

Kirkland and others (1988) found that the effectiveness of sampling small mammal communities is somewhat dependent on trap type. We were interested in mammal community composition, so we used six trapping methods to reduce trapping bias, yielding 592 trap nights per site. Small mammals were trapped with museum special snap and box traps placed together at each sample plot, as well as three pit traps connected by drift fencing placed toward the center of each transect (Brooks and others 1991, Croonquist 1990). Medium-sized mammals were trapped with box traps placed along animal paths toward the center of each transect, but away from pit traps. Presence of medium-sized and large mammals was determined by signs (e.g., tracks, droppings) and scent stations, one per site (Linscombe and others 1983, Brooks and others 1991). Bats were sampled from midsummer to early autumn (1989) with two-tier mist nets (8 m high) erected directly over the stream. We netted bats at each site for two nonconsecutive nights, which decreased likelihood of bat habituation and improved capture success (O'Farrell and Bradley 1970, Lacki 1980, Croonquist 1990). Flying squirrels and other arboreal species may have been misrepresented because only three flying squirrels were recorded even though they are considered common in central Pennsylvania woodlands (Doutt and others 1977).

National Wetlands Inventory maps, color infrared aerial photographs, and field reconnaissance were used to generate a geographic information system (GIS), via pcArcInfo., to quantify land use and major cover types within each watershed and hierarchical section. The GIS data were compared to bird and mammal data to assess changes in community composition induced by human-caused alterations of the landscape. Differences between headwaters and tributaries were not distinguishable with the GIS and, therefore, were digitized together as upper sections. We grouped all land-use and cover types into three disturbance categories: (1) undisturbed (forested, wetlands), (2) partially disturbed (shrub/brush, old field, lacustrine or emergent wetlands in middle and mainstem sections of LFC), and (3) disturbed (agriculture, residential, commercial).

We used three levels of analyses to determine intensity of land-use disturbances on bird and mammal communities: species richness (number of species observed per sampling unit), Jaccard's coefficient of community (CC) (Jaccard 1912, Leong and Holmes 1981, Brower and Zar 1984), and response guilds (Brooks and Croonquist 1990). The CC index uses presence/absence data and, therefore, is a binary index. CC values range from 0 to 1.00. Small values indicate different communities, large values show community affinity with the breakpoint chosen to be 0.50 because species should be found together in somewhat more than half of their recorded occurrences if they are to be grouped together as communities (Fager and McGowan 1963, Hill 1986, modified from Barbour and others 1980). The median of all pairwise comparisons of CC values within each watershed was calculated and compared between watersheds to determine if biotic communities through LFC were more variable than those through WDC. CC's also were calculated for each hierarchy for qualitative comparisons within and between watersheds.

We scored all Pennsylvania birds and mammals from 0 to 5 for each response guild, using known and documented information for each species. We had two- to three-person teams rank each taxonomic group (Brooks and Croonquist 1990) (Table 1). Statistical analyses were performed with a two-factor, one-response log-linear model via the CATMOD procedure (SAS Institute 1985) to determine how well each guild reflected the degree of habitat disturbance. The log-linear model tested which guild type(s) provided the most information [i.e., which guild type(s) were significant, $P < 0.10$] for distinguishing between undisturbed and disturbed environments. Log-linear model is similar to analysis of variance (ANOVA), except the log of the expected cell frequency replaces the expected value in ANOVA. Moreover, the log-linear model provides a description of structural relationships among response and explan-

Table 1. Explanations of response guilds for bird and mammal communities[a]

| Response guilds | Scores | Response guilds | Scores |
|---|---|---|---|
| Wetland dependency | | Habitat specificity | |
| Obligate species (>99% in wetlands) | 5 | Alpha species—stenotypic, specialist | 5 |
| Facultative wet (usually in or near wetlands) | 3 | Gamma species—landscape dependent | 3 |
| Facultative (wetlands not essential) | 1 | Beta species—generalist, edge | 1 |
| Facultative dry (occasional or no use) | 0 | | |
| Upland (>99% in uplands) | 0 | | |
| Trophic level | | Seasonality (birds only) | |
| Carnivore, specialist (restricted diet) | 5 | Neotropical migrant | 5 |
| Carnivore, generalist | 4 | Short-distance migrant | 4 |
| Herbivore, specialist (e.g., nuts, nectar) | 3 | Year round resident | 3 |
| Herbivore, generalist | 2 | Non-breeding-season resident only | 2 |
| Omnivore (plants or animals) | 1 | Migratory transient | 1 |
| | | Occasional | 0 |
| Species status | | | |
| Endangered, endemic, of concern | 5 | | |
| Commercial, recreational value | 3 | | |
| Other native species | 1 | | |
| Exotic | 0 | | |

[a]Brooks and Croonquist (1990).

atory variables without assigning a dependency to any variables (Fienberg 1987). The model was designed to determine, statistically, if the response variable (number of species comprising the guild score) for each explanatory variable (hierarchy and watershed) was distributed differently, given different explanatory variables. Each guild type was analyzed separately. The model, however, did not address how interactions of guild types reflected overall sensitivities of groups of species. Therefore, guilds that showed significant differences between disturbed and undisturbed areas were grouped together to determine how combinations of guilds varied among disturbed and undisturbed sections within and between watersheds.

## Results

### Land Use

Changes in land use through the WDC watershed were minor and only a small amount of land area was slightly disturbed. Small forest openings that were present provided habitat diversity in a landscape dominated by forest. All watershed sections of WDC were >90% forested. Partially disturbed habitats ranged from 1% to 6% of each section, but disturbed cover types were <1% of each (Table 2). Upper sections (headwater and tributary) of both watersheds were dominated by undisturbed land-use types (93% for both watersheds). Similarities in land use between upper sections of the two watersheds provided baseline information for comparisons between lower (midreach and mainstem) sections where differences in land-use occurred (Table 2). Percent of disturbed land-use types at LFC increased from upper to midreach sections (from 7% to 34%) and almost doubled from midreach to mainstem sections (from 34% to 65%). Differences were most prominent between mainstems where the dominant land use of LFC changed to disturbed habitats (65%), and WDC remained virtually all undisturbed (99%; Table 2). Ground reconnaissance supported the patterns shown by the GIS.

### Species Richness

Species richness of each hierarchical section show that bird species richness generally was higher along LFC than WDC, perhaps due to the abundance of edge habitats along the former as topography and ecoregions were similar (Table 3). Species richness of mammals did not differ as much between watersheds, especially at the mainstem. See Appendix A for a list of bird and mammal species recorded by hierarchical section of each watershed.

### Community Coefficients

Frequency distribution graphs of the bird and mammal CC values for all pairwise comparisons of study sites

Table 2. Area (ha) and percent area (%) of each land-use type[a]

| | Upper | | | | Midreach | | | | Mainstem | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | WDC | | LFC | | WDC | | LFC | | WDC | | LFC | |
| Land-use type | ha | (%) | ha | (%) | ha | (%) | ha | (%) | ha | (%) | ha | (%) |
| Undisturbed | | | | | | | | | | | | |
| Forested | 3683 | (93) | 4390 | (93) | 3176 | (95) | 2477 | (66) | 1500 | (98) | 817 | (35) |
| Wetland | 9 | (<1) | 13 | (<1) | 49 | (2) | 5 | (<1) | 15 | (1) | 10 | (<1) |
| Total undisturbed | 3692 | (93) | 4403 | (93) | 3226 | (97) | 2482 | (66) | 1515 | (99) | 827 | (35) |
| Partially disturbed | | | | | | | | | | | | |
| Wetland | 0 | | 0 | | 0 | | 11 | (<1) | 0 | | 13 | (<1) |
| Shrub/brush | 238 | (6) | 137 | (3) | 82 | (3) | 73 | (2) | 17 | (1) | 145 | (6) |
| Old field | 0 | | 0 | | 1 | (<1) | 17 | (<1) | 0 | | 0.3 | (<1) |
| Total partially disturbed | 238 | (6) | 137 | (3) | 83 | (3) | 101 | (2) | 17 | (1) | 158 | (7) |
| Disturbed | | | | | | | | | | | | |
| Residential | 0 | | 0 | | 0 | | 139 | (4) | 0 | | 94 | (4) |
| Agricultural | 57 | (1) | 173 | (4) | 23 | (1) | 1062 | (28) | 7 | (<1) | 1287 | (54) |
| Total disturbed | 57 | (1) | 173 | (4) | 23 | (1) | 1201 | (32) | 7 | (<1) | 1381 | (58) |
| Watershed total | 3987 | | 4713 | | 3332 | | 3784 | | 1539 | | 2366 | |

[a]Land-use types are undisturbed, partially disturbed, and disturbed. Results are given for each hierarchical section of White Deer Creek (WDC) and Little Fishing Creek (LFC), as determined from aerial photographs.

Table 3. Species richness of birds and mammals[a]

| Hierarchical section | Mammals | Birds |
|---|---|---|
| White Deer Creek | | |
| Headwater | 24 | 59 |
| Tributary | 23 | 53 |
| Midreach | 24 | 72 |
| Mainstem | 25 | 49 |
| Total | 35 | 94 |
| Little Fishing Creek | | |
| Headwater | 28 | 70 |
| Undisturbed middle | 27 | 60 |
| Disturbed middle | 30 | 70 |
| Mainstem | 24 | 65 |
| Total | 39 | 110 |

[a]Values are grouped by hierarchical section for White Deer Creek and Little Fishing Creek (October 1987–August 1989).

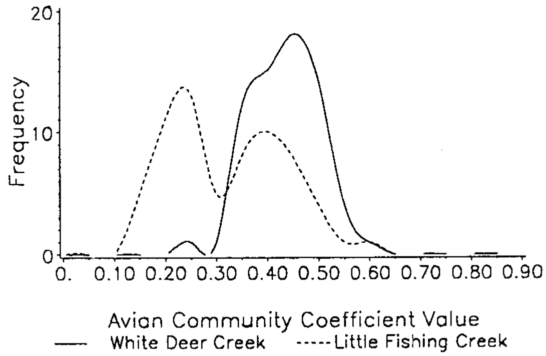


**Figure 1.** Frequency distribution of bird community coefficient (CC) values. CC values represent all pairwise comparisons among study sites within White Deer Creek and within Little Fishing Creek. CC values were rounded to the nearest tenth. Median CC value for White Deer Creek (42.75) was higher than that of Little Fishing Creek (33.65; i.e., communities within White Deer Creek were similiar to each other whereas communities within Little Fishing Creek varied in species composition).

within each watershed showed that the median CC values for WDC were higher than those for LFC (Figures 1 and 2). CCs of LFC produced a bimodal graph for birds and mammals with mammal CC values being slightly more variable. The group of higher CC values represented comparisons between undisturbed sites and between disturbed sites within LFC, and the group of lower CC values represented the dissimilar communities from comparisons between undisturbed and disturbed sites. We can infer that species composition through the reference watershed, WDC, remained more consistent than that through LFC due to the change in land use through LFC.

Comparisons of CC values between watersheds at each hierarchical section showed that watersheds contained somewhat similar bird communities in upper sec-

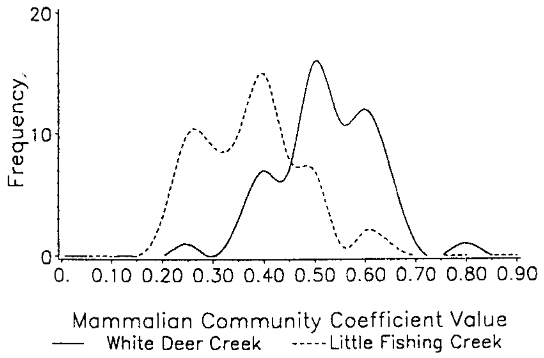


**Figure 2.** Frequency distribution of mammal community coefficient (CC) values. CC values represent all pairwise comparisons among study sites within White Deer Creek and within Little Fishing Creek. CC values were rounded to the nearest tenth. Median CC value for White Deer Creek (54.4) was higher than that of Little Fishing Creek (40.0; i.e., communities within White Deer Creek were similar to each other whereas communities within Little Fishing Creek varied in species composition).

tions (mean CC = 0.52 ± 0.02), but decreased in similarity as habitat perturbation increased along the two lower sections of LFC (mean CC = 0.38 ± 0.06; Table 4). Mammal communities showed slighter trends between watersheds; the mean CC value of upper sections was 0.67 ± 0.07 and decreased to only 0.56 ± 0.11 for lower sections (Table 4). The steady decline in CC values from headwater to mainstem, however, showed that mammal communities diversified down the watersheds.

### Response Guilds

Differences in response guilds of mammals were not significant between or within watersheds. LFC had more species than WDC for most hierarchical sections. Thus, the percent of species within each guild score for each hierarchical section provided a better comparison of watersheds than species richness of each guild score. Percent composition of mammalian response guilds also did not differ substantially between watersheds (Table 5). The habitat specificity guild showed inconsistent results. Wetland dependency scores did not differ in percentages within or between watersheds. About 50% of the mammal population consisted of wetland-dependent species (wetland dependency > 0). Approximately 50% also were common species throughout Pennsylvania (status = 1). The only differences in guild composition were higher percentages of species with low response-guild scores (i.e., species less affected by habitat disturbances) at LFC than WDC, for mainstem sections. These guilds consisted of species that preferred both uplands (wetland dependency = 0) and edge environments (habitat specificity = 1), as well as species that were both herbivorous (trophic level = 2) and edge species (i.e., generalists; Table 5).

Table 4. Bird and mammal community coefficient (CC) values[a]

| Watershed section | Bird CC value | Mammal CC value |
|---|---|---|
| Headwater | 0.54 | 0.63 |
| Tributary[b] | 0.51 | 0.72 |
| Midreach[c] | 0.42 | 0.64 |
| Mainstem | 0.34 | 0.49 |

[a]Values represent comparisons of species composition between White Deer Creek and Little Fishing Creek by hierarchical section.

[b]Comparison between White Deer Creek tributary and Little Fishing Creek undisturbed middle section.

[c]Comparison between White Deer Creek midreach and Little Fishing Creek disturbed middle section.

Exotic bird species (status = 0; Table 6) were observed at all sections of LFC, but only one section of WDC (European starling observed at one headwater site, scientific names given in Appendix A). Edge species were found in higher percentages at LFC than WDC, especially along lower sections. Permanent residents (seasonality = 3) that were edge species also formed a higher percentage of the LFC community, with largest differences between lower sections. These species included great horned owl, mourning dove, common grackle, song sparrow, and house finch.

Log-linear analyses showed that bird habitat specificity and seasonality guilds were the only guilds that significantly reflected the presence of habitat disturbance ($P$ = 0.005 and 0.086, respectively). Percent composition of response guilds showed that over 50% of all species at WDC and approximately 50% along upper sections of LFC had high habitat specificity scores (i.e., 5 or 3; Table 6). Percentages decreased to one-third along lower sections of LFC. Almost 40% of all birds through WDC and undisturbed areas of LFC were neotropical migrants (seasonality = 5). Percentages decreased only through LFC, to 20% at the mainstem, less than half of the percentage at the mainstem of WDC. We expected the same trend between watersheds for the wetland dependency guild due to the loss of wetland habitat in LFC. However, percent wetland-dependent species remained approximately one-third through both watersheds.

The trophic level guild was dominated by carnivores and omnivores (scores of 4 and 1, respectively; Table 6). Percentage of carnivores decreased slightly through both watersheds, but was slightly higher along WDC

Table 5. Percent composition (%) of selected response guilds of mammals[a]

| | Headwater | | Tributary[b] | | Midreach[c] | | Mainstem | |
|---|---|---|---|---|---|---|---|---|
| | WDC | LFC | WDC | LFC | WDC | LFC | WDC | LFC |
| Habitat specific (habitat specificity = 5 or 3) | 55 | 42 | 48 | 52 | 39 | 43 | 48 | 36 |
| Wetland dependent (wetland dependency = 1, 3, or 5) | 50 | 54 | 43 | 44 | 48 | 50 | 57 | 50 |
| Upland + edge (wetland dependency = 0, habitat specificity = 1) | 32 | 38 | 38 | 40 | 39 | 39 | 30 | 41 |
| Herbivore + edge (trophic level = 2, habitat specificity = 1) | 5 | 12 | 14 | 8 | 17 | 21 | 9 | 27 |

[a]Results are grouped by hierarchical section of White Deer Creek (WDC) and Little Fishing Creek (LFC). Numbers underlined represent large differences in percent composition between watersheds. Percent composition does not sum to 100% for each hierarchical section because irrelevant guild scores are omitted.

[b]Tributary section of White Deer Creek and undisturbed middle section of Little Fishing Creek.

[c]Midreach section of White Deer Creek and disturbed middle section of Little Fishing Creek.

than LFC. Furthermore, the decrease in percent of carnivores that had specific habitat requirements was greater through LFC (from 29% to 15%) than WDC (from 37% to 29%). Herbivores (score of 2) were a small part of both watershed cmmunities, but percentages were slightly higher through LFC than WDC, suggesting that herbaceous cover was more abundant along LFC.

Percent of species that had specific habitat requirements that also were neotropical migrants decreased through LFC from 23% along headwaters to less than 10% along lower sections with only five species represented, four at midreach, and four at mainstem (Table 6). Four species (80%) were migrant transients through the disturbed areas: spotted sandpiper, blue gray gnatcatcher, Swainson's thrush, and pine warbler. The percentage of species in these guilds remained relatively stable through WDC, ranging from 29% at headwaters to a low of 19% along the midreach. Only two of 16 species (13%) along lower sections of WDC were migrant transients—yellow-bellied sapsucker and blackpoll warbler; their breeding ranges begin north of the study region. Excluding migrants, we determined that percentages of breeding residents with high guild scores for the habitat specificity or seasonality guilds remained relatively stable through WDC, but decreased considerably through LFC (Table 7). The same was true for species that were both habitat-specific and neotropical migrants (Table 7). Species in these guilds contributed only 3% of the midreach community at LFC and 2% of the mainstem community (represented by the tree swallow, a species that requires open areas). Along lower sections of WDC, over 75% of the species in these guilds were probable breeders, whereas percentages decreased through LFC to less than one-third.

## Discussion

Biological and physical indicators were used successfully to document changes in habitat structure and in functional characteristics of animal communities on a watershed basis. These changes were caused by human perturbations of the landscape. Community coefficient indices reflected the changes incurred on the wildlife communities as a result of land-use changes more so than species richness. The pairwise comparison graphs of WDC with higher median scores than those of LFC reflected the greater variation in land use within LFC and showed that community composition through the undisturbed watershed was more uniform than that of the disturbed watershed. These varying degrees of wildlife community similarities in LFC were correlated with changes in landscape patterns more than with changes in stream order. Community composition was similar along upper, undisturbed sections of both watersheds. Along lower sections, where land uses differed, bird species composition differed between watersheds. The CC index quantified what was intuitively expected; it measured changes in biological structure associated with human perturbations of the landscape (Brooks and others 1991). However, the index did not provide information as to how the functional structure of communities changed. Thus, similarity indices provided only a broad perspective of the effects of habitat disturbance on the wildlife community. Analyses with avian response guilds revealed which groups of species were

Table 6. Percent composition (%) of selected response guilds of birds[a]

| | Headwater | | Tributary[b] | | Midreach[c] | | Mainstem | |
|---|---|---|---|---|---|---|---|---|
| | WDC | LFC | WDC | LFC | WDC | LFC | WDC | LFC |
| Exotic (status = 0) | 2 | 4 | 0 | <u>3</u> | 0 | <u>7</u> | 0 | <u>8</u> |
| Edge (habitat specificity = 1) | 39 | <u>51</u> | 42 | 47 | 46 | <u>66</u> | 55 | <u>68</u> |
| Permanent resident + edge (seasonality = 3, habitat specificity = 1) | 19 | <u>29</u> | 21 | <u>28</u> | 25 | <u>41</u> | 31 | <u>45</u> |
| Omnivore (trophic level = 1) | 42 | 44 | 43 | 43 | 46 | 47 | 47 | 45 |
| Habitat specific (habitat specificity = 5 or 3) | 61 | <u>49</u> | 58 | 53 | 54 | <u>34</u> | 45 | <u>32</u> |
| Neotropical migrant (seasonality = 5) | 41 | 40 | 42 | <u>32</u> | 32 | <u>24</u> | 41 | <u>20</u> |
| Wetland dependent (wetland dependency = 5, 3, or 1) | 36 | 37 | 32 | 35 | 33 | 30 | 33 | 31 |
| Carnivore (trophic level = 4 or 5) | 51 | 46 | 49 | 47 | 40 | 37 | 41 | 39 |
| Carnivore + habitat specific (trophic level = 4 or 5, habitat specificity = 5 or 3) | 37 | 29 | 36 | 32 | 28 | 20 | 29 | <u>15</u> |
| Habitat specific + neotropical migrant (habitat specificity = 5 or 3, seasonality = 5) | 29 | 23 | 28 | <u>18</u> | 19 | <u>9</u> | 22 | <u>6</u> |

[a]Results are given by hierarchical section of White Deer Creek (WDC) and Little Fishing Creek (LFC). Numbers underlined represent large differences in percent composition between watersheds. Percent composition does not sum to 100% for each hierarchical section because irrelevant guild scores are omitted.

[b]Tributary section of White Deer Creek and undisturbed middle section of Little Fishing Creek.

[c]Midreach section of White Deer Creek and disturbed middle section of Little Fishing Creek.

most sensitive to habitat perturbations (high guild scores) and which groups benefited from, or were not affected by, environmental disturbance (low guild scores). Mammalian response guilds did not show this sensitivity.

Neotropical migrant birds and species that had specific habitat requirements were the guilds most sensitive to anthropogenic disturbances. These guilds were represented in high percentages along upper sections of both watersheds, and included warblers, vireos, and forest interior species. Along lower sections, percentages of these species decreased through LFC, but remained relatively stable through WDC. That is, the functional characteristics of the bird community within WDC remained more consistent than those through LFC. Carnivores that had specific habitat requirements also were less common in disturbed than undisturbed habitats. However, most of the species in this guild combination were represented in the combination of neotropical migrants that had specific habitat requirements for which differences were greater. Therefore, we feel the later combination provided more conclusive results. Edge and exotic species were found in greater abundance in the disturbed watershed, reflecting a more resilient community structure in areas of perturbation.

Neotropical migrants that had specific habitat requirements were breeding residents in undisturbed areas. Disturbed areas of LFC that contained partial riparian cover were the only areas in disturbed sections that supported a few species in this guild combination, but four of five were only migrants. Verner (1984) suggested that separating resident breeders, migratory breeders, and migratory transients may provide insight into whether changes in numbers of species or birds in a guild result from conditions locally or elsewhere. Migrant breeders were found in undisturbed habitats more than disturbed habitats and, therefore, their presence is likely a function of local conditions. Even though species in these guilds used the perturbed areas for only short periods, our results showed that riparian corridors, even if partially disturbed, are vital travel corridors for uncommon, sensitive species. These degraded areas retain value as necessary stopover habitat in areas where natural vegetation remain. Robbins and others (1989) showed that ecosystem preservation requires large tracts (≥3000 ha) of undisturbed habitat to main-

Table 7. Percent composition (%) of response guilds for breeding resident birds[a]

| | Headwater | | Tributary[b] | | Midreach[c] | | Mainstem | |
|---|---|---|---|---|---|---|---|---|
| | WDC | LFC | WDC | LFC | WDC | LFC | WDC | LFC |
| Habitat specific (habitat specificity = 5 or 3) | 47 | 43 | 45 | 48 | 47 | <u>23</u> | 41 | <u>23</u> |
| Neotropical migrant (seasonality = 5) | 32 | 31 | 28 | 23 | 25 | <u>14</u> | 31 | <u>8</u> |
| Neotropical migrant + habitat specific (seasonality = 5, habitat specificity = 5 or 3) | 20 | 20 | 17 | 13 | 17 | <u>3</u> | 18 | <u>2</u> |

[a]Results are given by hierarchical section of White Deer Creek (WDC) and Little Fishing Creek (LFC). Numbers underlined represent large differences in percent composition between watersheds.

[b]Tributary section of White Deer Creek and undisturbed middle section of Little Fishing Creek.

[c]Midreach section of White Deer Creek and disturbed middle section of Little Fishing Creek.

tain all species of forest breeding avifauna of the mid-Atlantic states. Where preservation of such large contiguous tracts is not possible, they offer an alternative of preserving two or more smaller tracts in proximity, which may serve to attract or retain sensitive species, especially if the habitat includes wetlands and/or riparian areas. Some disturbed sites in the middle sections of LFC were in proximity to undisturbed tracts. These sites should be primary targets for restoration programs such as streambank fencing projects that some state agencies are beginning, especially along the Chesapeake Bay (Holmquist and Brittingham 1990). Thus, restoring these small and partially degraded riparian–wetland areas could provide adequate breeding habitat for area-sensitive species and not just serve as migration corridors.

Block and others (1984) warned there is a bias in assigning guild scores a priori on the basis of literature because species often differ in patterns of resource use from those explained in the literature. They redefined their guilds on the basis of field observations as recommended by Jaksic (1981). We understand this bias may exist; however, we are interested in regional application of response guilds and, therefore, must recognize the general responses of species throughout their geographic range. Guild scores may need adjustments among ecoregions but should remain consistent within each ecoregion.

We feel avian response guilds are useful tools for detecting the degree of degradation or suitability of riparian–wetland regions for several reasons. First, large sample sizes of birds are easily obtained. In contrast, relatively unbiased sampling of the mammal community required six trapping methods, which was not cost effective due to small sample sizes and low variability in community composition. Second, large existing and historical data bases are available for bird communities such as the Breeding Bird Survey and breeding bird atlases. This information is especially useful for watershed or regional studies. Lastly, avian response guilds show a continuum of sensitivity from the most sensitive to most resilient groups. Mammals may be less sensitive to habitat alterations than birds because mammals are somewhat sedentary and must have more flexible habitat requirements to survive, whereas birds can readily disperse to suitable habitats (Adams and Barrett 1976). Furthermore, the most sensitive mammals (for example, water shrew, recorded once on WDC) were rarely observed along either watershed, indicating their rarity even in suitable habitat and/or their low susceptibility to trapping (Croonquist 1990).

Based on these findings, biological monitoring using avian response guilds, in conjunction with analyses of landscape patterns, is an efficient way to analyze changes in the functional characteristics of wildlife communities in response to environmental changes that occur subtly, but cumulatively through watersheds. Mannan and others (1984) stated that foraging and nesting guilds (Short and Burnham 1982, Verner 1984) may show inconsistent responses when man-induced habitat alterations are only slight to moderate. Therefore, additional sampling from the same ecoregion is necessary to incorporate more partially disturbed and disturbed habitats to test the overall consistency of response guilds as indicators of types and intensities of habitat disturbances (Croonquist 1990).

We understand, as Mannan and others (1984) cautioned, that management activities designed to maintain viable populations of endemic species should not rely solely on guild analyses for information on impacts of perturbations in the forest environment. However, response guilds, which are based on habitat requirements, can serve as a screening tool for identifying habitat stability and, as Szaro (1986) stated, "helping us to determine which habitat factors are important in management decisions." Ultimately, by determining the degree to which an area is disturbed or protected, through examination of response guilds and landscape patterns, regulators and managers can distinguish among those areas on which they should focus attention for habitat restoration programs. For managers with time and budget constraints, response guilds may be more cost-effective than population censuses for determining how wildlife communities change in response to environmental impacts (Brooks and others 1991).

By understanding the functional attributes of avian species (i.e., how groups of species respond to environmental perturbations) we can determine what aspects of the habitat must be restored in order for such guilds to recolonize deteriorated landscapes in an effort to reverse the effects of cumulative impacts. However, we must implement restoration efforts before changes in guild structure have become significant, at which point restoration efforts become too costly or ecologically unattainable. Furthermore, we still do not know at what stage during resotration sensitive species return and effectively out-compete generalists. Periodic monitoring during different phases of restoration projects is necessary to determine overall effectiveness of restoration with respect to avian communities.

## Appendix A

### Species Recorded by Hierarchical Section of Watershed

| | | Response guilds[a] | | | | | WDC[b] | | | | LFC[c] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Scientific name | Wetl. Dep. | Hab. Spec. | Trop. Lev. | Status | Season. | 1[d] | 2[e] | 3[f] | 4[g] | 1 | 2 | 3 | 4 |
| Birds | | | | | | | | | | | | | | |
| Green-backed heron | *Butorides striatus* | 5 | 3 | 4 | 1 | 4 | | | X | | | | X | X |
| Mallard | *Anas platyrhynchos* | 5 | 1 | 1 | 3 | 3 | | | X | X | | X | X | X |
| Muscovy duck | *Cairina moschata* | 5 | 1 | 1 | 0 | 3 | | | | | | | | X |
| Wood duck | *Aix sponsa* | 5 | 5 | 3 | 3 | 4 | | | | | | | X | X |
| Turkey vulture | *Cathartes aura* | 0 | 1 | 4 | 1 | 3 | | X | | | X | | X | X |
| Northern goshawk | *Accipiter gentilis* | 0 | 3 | 4 | 5 | 3 | | | X | | | | | |
| Sharp-shinned hawk | *Accipiter striatus* | 0 | 3 | 4 | 5 | 3 | X | | | | | X | | |
| Red-tailed hawk | *Buteo jamaicensis* | 0 | 1 | 4 | 1 | 3 | | | X | | X | X | X | X |
| American kestrel | *Falco sparverius* | 0 | 5 | 4 | 1 | 3 | | | | | | | X | X |
| Ruffed grouse | *Bonasa umbellus* | 0 | 3 | 1 | 3 | 3 | X | X | X | | | X | | |
| Ring-necked pheasant | *Phasianus colchicus* | 0 | 1 | 1 | 0 | 3 | | | | | | | X | |
| Wild turkey | *Meleagris gallopavo* | 0 | 3 | 1 | 3 | 3 | | X | X | | | X | | |
| Killdeer | *Charadrius vociferous* | 0 | 1 | 4 | 1 | 3 | | | | | | | X | X |
| American woodcock | *Scolopax minor* | 5 | 3 | 5 | 3 | 4 | X | | | | | | X | |
| Spotted sandpiper | *Actitis macularia* | 5 | 3 | 4 | 1 | 5 | X | | | | | | X | X |
| Solitary sandpiper | *Tringa solitaria* | 5 | 3 | 4 | 1 | 1 | X | | | | | | | X |
| Semipalmated sandpiper | *Calidris pusilla* | 5 | 3 | 4 | 1 | 1 | | | | | | | | X |
| Mourning dove | *Zenaida macroura* | 0 | 1 | 2 | 0 | 3 | | | | | X | X | X | X |
| Yellow-billed cuckoo | *Coccyzus americanus* | 0 | 1 | 1 | 1 | 5 | | | X | | X | X | X | |
| Black-billed cuckoo | *Coccyzus erythropthalmus* | 0 | 1 | 1 | 1 | 5 | | X | | | X | | | |
| Eastern screech-owl | *Otus asio* | 0 | 5 | 4 | 1 | 3 | X | | | | | X | X | |
| Great horned owl | *Bubo virginianus* | 0 | 1 | 4 | 1 | 3 | | | | | X | X | X | X |
| Barred owl | *Strix varia* | 3 | 5 | 4 | 1 | 3 | X | X | X | | X | X | | |
| Chimney swift | *Chaetura pelagica* | 0 | 1 | 4 | 1 | 5 | | | | | X | | X | X |
| Ruby-throated hummingbird | *Archilochus colubris* | 1 | 1 | 3 | 1 | 5 | | | X | X | X | | | |
| Belted kingfisher | *Ceryle alcyon* | 5 | 5 | 5 | 1 | 3 | | X | X | X | | X | X | X |
| Northern flicker | *Colaptes auratus* | 0 | 3 | 1 | 1 | 3 | X | X | X | X | | | | X |
| Pileated woodpecker | *Dryocopus pileatus* | 0 | 5 | 4 | 1 | 3 | | X | | X | X | X | | |
| Red-bellied woodpecker | *Melanerpes carolinus* | 1 | 3 | 1 | 1 | 3 | | | | | X | | X | X |
| Red-headed woodpecker | *Melanerpes erythrocephalus* | 1 | 3 | 1 | 5 | 3 | | | | | | | | X |
| Yellow-bellied sapsucker | *Sphyrapicus varius* | 0 | 5 | 1 | 5 | 5 | X | X | X | | X | | | |
| Hairy woodpecker | *Picoides villosus* | 0 | 3 | 4 | 1 | 3 | X | X | X | X | X | X | X | X |
| Downy woodpecker | *Picoides pubescens* | 0 | 1 | 4 | 1 | 3 | X | X | X | X | X | X | X | X |
| Eastern kingbird | *Tyrannus tyrannus* | 0 | 1 | 1 | 1 | 5 | | | | | | | X | |
| Great-crested flycatcher | *Myiarchus crinitus* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | X | | |
| Eastern phoebe | *Sayornis phoebe* | 0 | 1 | 4 | 1 | 4 | X | | X | | X | X | X | X |
| Acadian flycatcher | *Empidonax virescens* | 3 | 3 | 4 | 1 | 5 | X | | X | | X | X | | |
| Least flycatcher | *Empidonaz minimus* | 0 | 1 | 4 | 5 | 5 | X | | | | | | X | |
| Eastern wood-pewee | *Contopus virens* | 0 | 1 | 4 | 1 | 5 | X | | | X | | | X | X |
| Tree swallow | *Tachycineta bicolor* | 1 | 5 | 4 | 1 | 5 | | | | | | | X | X |
| Barn swallow | *Hirundo rustica* | 0 | 1 | 4 | 1 | 5 | | | | | | | X | X |
| Blue jay | *Cyanocitta cristata* | 0 | 1 | 2 | 1 | 3 | X | X | X | X | X | X | X | X |
| Common raven | *Corvus corax* | 1 | 3 | 1 | 1 | 3 | | | X | | X | X | | |

Appendix A. *Continued.*

| | | Response guilds[a] | | | | | WDC[b] | | | | LFC[c] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Scientific name | Wetl. Dep. | Hab. Spec. | Trop. Lev. | Status | Season. | 1[d] | 2[e] | 3[f] | 4[g] | 1 | 2 | 3 | 4 |
| American crow | *Corvus brachyrhynchos* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Black-capped chickadee | *Parus atricapillus* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Tufted titmouse | *Parus bicolor* | 1 | 3 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| White-breasted nuthatch | *Sitta carolinensis* | 0 | 5 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Red-breasted nuthatch | *Sitta canadensis* | 0 | 5 | 1 | 1 | 3 | X | X | X | | | X | | |
| Brown creeper | *Certhia americana* | 1 | 5 | 4 | 1 | 3 | X | X | X | X | X | X | | |
| House wren | *Troglodytes aedon* | 0 | 1 | 4 | 1 | 4 | | X | X | | | X | X | X |
| Winter wren | *Troglodytes troglodytes* | 3 | 3 | 4 | 1 | 3 | | | X | | X | X | | |
| Carolina wren | *Thryothorus ludovicianus* | 0 | 1 | 4 | 1 | 3 | | | X | | | | | |
| Northern mockingbird | *Mimus polyglottos* | 0 | 1 | 1 | 1 | 3 | | | | X | | | X | X |
| Gray catbird | *Dumetella carolinensis* | 1 | 1 | 1 | 1 | 3 | X | | X | X | X | X | X | X |
| Brown thrasher | *Toxostoma rufum* | 0 | 1 | 1 | 1 | 3 | | | | | | | X | X |
| American robin | *Turdus migratorius* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Wood thrush | *Hylocichla mustelina* | 0 | 3 | 1 | 1 | 5 | X | X | X | X | X | X | | |
| Hermit thrush | *Catharus guttatus* | 1 | 3 | 1 | 1 | 3 | X | X | X | X | X | X | | |
| Swainson's thrush | *Catharus ustulatus* | 1 | 3 | 1 | 1 | 5 | X | | | | | | X | |
| Veery | *Catharus fuscescens* | 3 | 3 | 1 | 1 | 5 | | X | X | X | | | | |
| Eastern bluebird | *Sialia sialis* | 0 | 5 | 1 | 5 | 3 | | | X | | X | X | X | X |
| Blue-gray gnatcatcher | *Polioptila caerulea* | 1 | 3 | 4 | 1 | 5 | | X | X | | X | X | X | X |
| Golden-crowned kinglet | *Regulus satrapa* | 1 | 3 | 4 | 1 | 3 | X | X | X | X | X | X | X | |
| Ruby-crowned kinglet | *Regulus calendula* | 1 | 3 | 1 | 1 | 2 | X | X | X | X | X | X | | X |
| Cedar waxwing | *Bombycilla cedrorum* | 0 | 1 | 3 | 1 | 3 | | X | X | X | X | | X | X |
| European starling | *Sturnus vulgaris* | 0 | 3 | 1 | 0 | 3 | X | | | | X | X | X | X |
| Solitary vireo | *Vireo solitarius* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | X | X | |
| Red-eyed vireo | *Vireo olivaceus* | 0 | 1 | 4 | 1 | 5 | X | X | X | X | X | X | X | X |
| Philadelphia vireo | *Vireo philadelphicus* | 0 | 1 | 4 | 1 | 1 | X | | | | | | | |
| Warbling vireo | *Vireo gilvus* | 0 | 1 | 4 | 1 | 5 | | | | | | | | X |
| Black-and-white warbler | *Mniotilta varia* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | | X | |
| Prothonotary warbler | *Protonotaria citrea* | 5 | 5 | 4 | 1 | 5 | X | | | | | | | |
| Tennessee warbler | *Vermivora peregrina* | 0 | 1 | 4 | 1 | 1 | | | | | | | | X |
| Nashville warbler | *Vermivora ruficapilla* | 1 | 1 | 4 | 1 | 5 | | | | | X | | | |
| Yellow warbler | *Dendroica petechia* | 1 | 1 | 4 | 1 | 5 | | X | X | | | X | X | X |
| Magnolia warbler | *Dendroica magnolia* | 0 | 1 | 4 | 1 | 5 | | X | X | X | X | X | | |
| Black-throated blue warbler | *Dendroica caerulescens* | 1 | 3 | 4 | 1 | 5 | X | | | X | X | X | | |
| Yellow-rumped warbler | *Dendroica coronata* | 1 | 3 | 1 | 1 | 5 | X | | X | | X | | | |
| Black-throated green warbler | *Dendroica virens* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | X | | |
| Cerulean warbler | *Dendroica cerulea* | 3 | 3 | 4 | 1 | 5 | | X | | | | | | |
| Blackburnian warbler | *Dendroica fusca* | 1 | 5 | 4 | 1 | 5 | X | X | X | | X | X | | |
| Chestnut-sided warbler | *Dendroica pensylvanica* | 0 | 1 | 4 | 1 | 5 | | | | | | X | | |
| Blackpoll warbler | *Dendroica striata* | 0 | 3 | 4 | 1 | 1 | X | X | X | | X | | X | |
| Pine warbler | *Dendroica pinus* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | X | | X |
| Ovenbird | *Seiurus aurocapillus* | 0 | 3 | 4 | 1 | 5 | X | X | X | X | X | X | | |
| Northern waterthrush | *Seiurus noveboracensis* | 5 | 3 | 4 | 1 | 5 | X | X | | X | X | | | |
| Louisiana waterthrush | *Seiurus motacilla* | 5 | 3 | 4 | 1 | 5 | | X | | | X | X | | |
| Kentucky warbler | *Oporornis formosus* | 3 | 3 | 4 | 1 | 5 | | | | | X | | | |
| Common yellowthroat | *Geothlypis trichas* | 3 | 1 | 4 | 1 | 4 | X | X | X | X | X | | X | X |
| Hooded warbler | *Wilsonia citrina* | 3 | 3 | 4 | 1 | 5 | X | X | X | X | | | | |
| Wilson's warbler | *Wilsonia pusilla* | 3 | 3 | 4 | 1 | 1 | | | X | | | | X | |
| Canada warbler | *Wilsonia canadensis* | 1 | 1 | 4 | 1 | 5 | X | X | | X | X | X | | |
| American redstart | *Setophaga ruticilla* | 0 | 1 | 4 | 1 | 5 | X | | X | X | X | | | X |
| House sparrow | *Passer domesticus* | 0 | 1 | 1 | 0 | 3 | | | | | | | X | X |
| Eastern meadowlark | *Sturnella magna* | 0 | 1 | 1 | 1 | 3 | | | | | | | X | X |
| Red-winged blackbird | *Agelaius phoeniceus* | 3 | 1 | 1 | 1 | 3 | | | | | | | X | X |
| Northern oriole | *Icterus galbula* | 0 | 1 | 1 | 1 | 5 | | | X | | | | X | X |
| Rusty blackbird | *Euphagus carolinus* | 3 | 3 | 1 | 1 | 1 | X | | | | X | X | X | |
| Common grackle | *Quiscalus quiscula* | 0 | 1 | 1 | 1 | 3 | | | X | X | X | X | X | X |
| Brown-headed cowbird | *Molothrus ater* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Scarlet tanager | *Piranga olivacea* | 0 | 1 | 1 | 1 | 5 | X | X | X | X | X | X | | |
| Northern cardinal | *Cardinalis cardinalis* | 0 | 1 | 2 | 1 | 3 | X | | X | X | X | X | X | X |
| Rose-breasted grosbeak | *Pheucticus ludovicianus* | 0 | 1 | 1 | 1 | 5 | X | X | X | X | X | | X | |
| Indigo bunting | *Passerina cyanea* | 1 | 1 | 1 | 1 | 5 | | | | X | X | X | X | X |
| Evening grosbeak | *Coccothraustes vespertinus* | 0 | 3 | 2 | 1 | 2 | | | X | | | | | X |
| Purple finch | *Carpodacus purpureus* | 0 | 1 | 2 | 1 | 3 | | | | | | X | X | X |
| House finch | *Carpodacus mexicanus* | 0 | 1 | 2 | 0 | 3 | | | | | X | | X | X |
| Pine grosbeak | *Pinicola enucleator* | 0 | 3 | 2 | 1 | 2 | | | X | | | | | |
| Pine siskin | *Carduelis pinus* | 0 | 3 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| American goldfinch | *Carduelis tristis* | 0 | 1 | 2 | 1 | 3 | X | X | X | X | X | X | X | X |
| Red crossbill | *Loxia curvirostra* | 0 | 3 | 3 | 1 | 2 | | | X | | | | | |
| Rufous-sided towhee | *Pipilo erythrophthalmus* | 0 | 1 | 1 | 1 | 4 | X | X | X | X | X | | X | |

Appendix A. *Continued.*

| | | Response guilds[a] | | | | | WDC[b] | | | | LFC[c] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Scientific name | Wetl. Dep. | Hab. Spec. | Trop. Lev. | Status | Season. | 1[d] | 2[e] | 3[f] | 4[g] | 1 | 2 | 3 | 4 |
| Dark-eyed junco | *Junco hyemalis* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| American tree sparrow | *Spizella arborea* | 0 | 1 | 2 | 1 | 2 | | | X | | | | X | X |
| Chipping sparrow | *Spizella passerina* | 0 | 1 | 1 | 1 | 4 | X | X | X | X | X | X | X | X |
| Field sparrow | *Spizella pusilla* | 0 | 1 | 1 | 1 | 3 | | | X | | X | | X | X |
| White-throated sparrow | *Zonotrichia albicollis* | 0 | 1 | 1 | 1 | 3 | X | X | X | X | X | | X | X |
| Swamp sparrow | *Melospiza georgiana* | 5 | 3 | 1 | 1 | 3 | | | X | | X | | X | |
| Song sparrow | *Melospiza melodia* | 1 | 1 | 1 | 1 | 3 | | | X | | X | X | X | X |

| | | Response guilds[a] | | | | WDC[b] | | | | LFC[c] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Common name | Scientific name | Wetl. Dep. | Hab. Spec. | Trop. Lev. | Status | 1[d] | 2[e] | 3[f] | 4[g] | 1 | 2 | 3 | 4 |
| Mammals | | | | | | | | | | | | | |
| Virginia oppossum | *Didelphis virginiana* | 1 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Masked shrew | *Sorex cinereus* | 1 | 3 | 4 | 1 | X | X | X | X | X | X | X | X |
| Water shrew | *Sorex palustris* | 5 | 5 | 5 | 5 | X | | | | | | | |
| Smoky shrew | *Sorex fumeus* | 1 | 3 | 4 | 1 | | | | | X | | | |
| Long-tailed shrew | *Sorex dispar* | 1 | 3 | 4 | 1 | X | | | | | | | |
| Pygmy shrew | *Sorex hoyi* | 1 | 1 | 4 | 5 | | | | X | | | | |
| Northern short-tailed shrew | *Blarina brevicauda* | 0 | 1 | 4 | 1 | X | | X | X | X | X | X | X |
| Star-nosed mole | *Condylura cristata* | 3 | 3 | 4 | 1 | | | | X | X | | | |
| Little brown myotis | *Myotis lucifugus* | 1 | 3 | 5 | 1 | X | X | X | X | X | X | X | X |
| Northern myotis | *Myotis septentrionalis* | 1 | 5 | 5 | 5 | | X | | | X | X | | |
| Silver-haired bat | *Lasionycteris noctivagans* | 1 | 5 | 5 | 5 | | | | | | X | | |
| Eastern pipistrelle | *Pipistrellus subflavus* | 1 | 5 | 5 | 1 | | | X | | | | X | |
| Big brown bat | *Eptesicus fuscus* | 1 | 3 | 5 | 1 | | | | X | | | X | X |
| Red bat | *Lasiurus borealis* | 1 | 5 | 5 | 1 | | | | X | | X | X | X |
| Hoary bat | *Lasiurus cinereus* | 1 | 5 | 5 | 5 | | | X | | | | X | |
| Eastern cottontail | *Sylvilagus floridanus* | 0 | 1 | 2 | 3 | | | | | | X | X | X |
| Eastern chipmunk | *Tamias striatus* | 0 | 1 | 1 | 1 | X | X | X | X | X | X | | X |
| Woodchuck | *Marmota monax* | 0 | 1 | 2 | 3 | | X | X | | X | | X | X |
| Gray squirrel | *Sciurus carolinensis* | 0 | 5 | 3 | 3 | X | X | X | X | X | X | X | X |
| Red squirrel | *Tamiasciurus hudsonicus* | 0 | 5 | 3 | 1 | X | X | X | X | X | X | X | |
| Southern flying squirrel | *Glaucomys volans* | 0 | 5 | 3 | 1 | X | X | | | | X | X | |
| Beaver | *Castor canadensis* | 5 | 5 | 3 | 3 | | | | | | X | | |
| Deer mouse | *Peromyscus maniculatus* | ,0 | 1 | 1 | 1 | X | X | X | X | X | X | | |
| White-footed mouse | *Peromyscus leucopus* | 0 | 1 | 1 | 1 | X | X | X | X | X | X | X | X |
| Eastern woodrat | *Neotoma floridana* | 0 | 5 | 2 | 5 | | | | | | | | X |
| Southern red-backed vole | *Clethrionomys gapperi* | 1 | 3 | 1 | 1 | X | X | X | X | X | X | X | X |
| Meadow vole | *Microtus pennsylvanicus* | 1 | 1 | 2 | 1 | | X | X | X | X | | X | X |
| Muskrat | *Ondatra zibethicus* | 5 | 1 | 2 | 3 | | | X | | | | X | X |
| House mouse | *Mus musculus* | 0 | 1 | 1 | 0 | | | | | | | X | |
| Meadow jumping mouse | *Zapus hudsonius* | 1 | 1 | 1 | 1 | | | X | X | X | | X | X |
| Woodland jumping mouse | *Napaeozapus insignis* | 1 | 3 | 1 | 1 | X | X | X | X | X | X | X | |
| Porcupine | *Erethizon dorsatum* | 0 | 3 | 3 | 1 | X | X | X | X | | X | | |
| Red fox | *Vulpes vulpes* | 0 | 1 | 1 | 0 | X | X | X | X | X | X | X | |
| Black bear | *Ursus americanus* | 1 | 3 | 1 | 3 | X | X | | X | X | X | | |
| Raccoon | *Procyon lotor* | 3 | 1 | 1 | 3 | X | X | X | X | X | X | X | X |
| Ermine | *Mustela erminea* | 1 | 1 | 4 | 3 | X | | | | X | | | |
| Mink | *Mustela vison* | 5 | 3 | 4 | 3 | X | | | | X | | X | X |
| Striped skunk | *Mephitis mephitis* | 0 | 1 | 1 | 3 | | X | | X | X | X | X | X |
| White-tailed deer | *Odocoileus virginianus* | 0 | 1 | 2 | 3 | X | X | X | X | X | X | X | |
| Domestic cow | *Bos taurus* | 0 | 1 | 2 | 3 | | | | | | | X | X |
| Domestic dog | *Canis familiaris* | 0 | 1 | 4 | 0 | X | X | X | | X | X | X | X |
| Domestic cat | *Felis domestica* | 0 | 1 | 4 | 0 | | | | | X | X | X | X |

[a]Wetl. Dep. = wetland dependency, Hab. Spec. = habitat specificity, Trop. Lev. = trophic level, Season. = seasonality.

[b]WDC = White Deer Creek.

[c]LFC = Little Fishing Creek.

[d]1 = headwater.

[e]2 = tributary/undisturbed middle.

[f]3 = midreach/disturbed middle.

[g]4 = mainstem.

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