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Associations between avian functional guild response and regional landscape properties for conservation planning

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Abstract

This project facilitates a regional approach to conservation planning in Pennsylvania based on avian breeding habitat selection. The objectives were to: (1) determine the sensitivity of spatial pattern in avian diversity to changing thresholds of intra-guild species richness and (2) relate change of spatial pattern in avian diversity with landscape characteristics of bird Atlas blocks. Two state-wide spatial data layers, based on Landsat satellite data were constructed for this study. These regional landscape data were compared to Breeding Bird Atlas data from 1983 to 1989 using a geographic information system. Breeding bird data were recorded from 4928 blocks that form a grid covering Pennsylvania. Correlation analysis reduced landscape variables to 12 originally derived from forest, urban, roads, streams, and topographic data.

Avian functional response guilds were used to analyze associations between breeding bird data and landscape variables. Functional response guilds were created by grouping organisms based on shared habitat preferences or behavioral characteristics. Most of the 18 avian guilds identified for this study were based on shared structural resource characteristics of preferred breeding habitat. Preferred structural resources frequently included the amount and type of forest. For this study, guilds separate resource characteristics by: (1) primary habitat (i.e. forest interior, forest edge), (2) area sensitivity (i.e. forest and grassland), (3) migratory status (i.e. resident, temperate, and tropical), and (4) nest placement (i.e. canopy nester, forest ground nester). Wetland obligate species were treated as a separate guild. Breeding Bird Atlas blocks were tabulated with respect to the number of species present from each guild. For a given guild, the number of its species in a block is termed guild-specific species richness. Sample blocks having high species richness for a given guild often occur adjacent or in close proximity forming spatial clusters in the landscape. Spatial coherence (adjacency/proximity) among the blocks forming these islands is shared guild-specific richness. Spatial clustered blocks of each guild represent areas that presumably possess required resources for members of that guild. Blocks having high intra-guild richness were evaluated with a group of block-level continuous variables using multiple logistic regressions. Logistic regression results indicate that a convincing connection exists between landscape properties of Breeding Bird Atlas blocks and habitat selection characteristics of guild members. Percent of forest cover and mean elevation were the most important habitat characteristics influencing intra-guild richness for most of the guilds tested. Concordance values from logistic regression were used to determine the strength of each guild model. Concordance, the proportion that represents the

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percent of correct guild richness predictions versus incorrect predictions, suggests a relationship between guild-rich clusters and habitat resources required by each guild. The highest concordance was for the exotics guild at 76.3% and the next highest was 74.8% for the grassland area sensitive guild. This signifies a 75% certainty that landscape variables could predict occurrence of a guild-rich block. Eight more guilds had concordance values greater than 65%.

By using a guild approach, this study goes beyond total diversity to the more informative structural and functional diversity of guilds. Spatially clustered blocks of high species richness for a particular guild are more indicative of habitat availability and quality than would be the case for overall species richness. Clusters of blocks having high intra-guild species richness become candidate areas for conservation efforts.

Keywords: Geographic information systems; Functional guilds; Regional landscapes; Breeding Bird Atlas; Gap analysis; Habitat fragmentation; Species richness

1. Introduction

Fragmentation of landscapes has been shown to impact avian habitats as human development causes discontinuities in land cover. Bird species differ in their nesting sensitivities to fragmentation, and changing landscape patterns influence nest-site selection accordingly (Robbins et al., 1989). Investigators have found bird populations to display sensitivities to landscape properties, particularly with respect to forest fragmentation and shrinking forest patch size (Temple, 1984; Blake and Karr, 1987; Van Drop and Opdam, 1987; Robbins et al., 1989; Freemark and Collins, 1992). Forest patches have been demonstrated to have parallels with oceanic islands in the context of Island Biogeography Theory (MacArthur and Wilson, 1967). Just as MacArthur and Wilson (1967) found numbers of species decreasing as island size decreased, so also the number of bird species using a forest patch decreases as patch size decreases (Blake and Karr, 1987; Robbins et al., 1989). Furthermore, Freemark and Collins (1992), while finding the same results for forest interior species, demonstrated that bird species favoring interior-edge habitats increased with forest patch size as well.

The landscape of Pennsylvania serves as an excellent context to explore land use patterns in the eastern United States as they relate to avian diversity. Current patch structures are a direct result of how land use has interacted with physiography over time. The folded Ridge and Valley physiographic province, in Pennsylvania's Appalachian Mountains, cuts diagonally across Pennsylvania separating the Piedmont from the Appalachian Plateaus. Characteristics of physiographic provinces influence both vegetation cover and rates and types of land use change (Bailey, 1995; Miller, 1995). The Appalachian Plateau has sandstone geologic base that weathers to thin erodable and infertile soils that are marginal for both agriculture and urban development thus remaining largely forested. The Ridge and Valley province has long erosion resistant sandstone ridges that discourage agriculture and development interspersed with fertile limestone and shale valleys that are conducive to such development. Lastly, the more subdued topography of rolling hills in the Piedmont arising from weathered metamorphic formations contains the most fertile soils in Pennsylvania as well as much of its population (Miller, 1995). Thus, there is substantial influence of underlying physiography on patterns of landscape fragmentation.

In contrast to previously mentioned avian investigations, this project was designed to address landscape fragmentation (Harris, 1984; Forman and Godron, 1986; Turner, 1989) at a regional scale. Maintaining a regional approach reduces uncertainties that can be introduced when extrapolating locally obtained results to regional levels. As discussed by Bolger et al. (1997), projects, such as Blake and Karr (1987), Robbins et al. (1989), and Freemark and Collins (1992), did not address regional habitat characteristics because their design was site specific.

The approach of this study is based on functional guilds. Guilds group animals according to habitat use or behavioral characteristics (Severinghaus, 1981; Brooks and Croonquist, 1990; O'Connell et al., 1998a). Shifting the response variables from individual species to groups of species that share specific resource and behavioral preferences changes the scope of interpretation. We can infer that where intra-guild