



MAIA Project Summary

Birds Indicate Ecological Condition of the Mid-Atlantic Highlands

General Information on the Mid-Atlantic Integrated Assessment can be found through the World Wide Web at <http://www.epa.gov/maia>. The research supporting this document was funded by the U.S. EPA Office of Research and Development under Interagency Agreement Number DW14936411-01-2 with the U.S. Fish and Wildlife Service. It has been subjected to EPA's peer and administrative review. The management recommendations were developed by EPA Region 3. The full research report, *The Bird Community Index: A Tool for Assessing Biotic Integrity in the Mid-Atlantic Highlands*, Report Number 98-4, the Penn State Cooperative Wetlands Center, can be obtained at www.wetlands.cas.psu.edu.

The Mid-Atlantic Integrated Assessment (MAIA) is an interagency, multi disciplinary research, monitoring and assessment program to develop high-quality scientific information on the region's natural resources: current condition, stressors, trends, and vulnerabilities. MAIA results and information are intended to satisfy a broad group of stakeholders' needs, convey important information relevant to their assessment questions and issues, and be useful in making management decisions.

OVERVIEW

During the spring breeding season, more than a hundred songbird species conduct a birds-eye assessment of the Mid-Atlantic highlands to determine suitable habitat for mating and raising young.

Different bird species require different habitats for food, shelter and breeding. Some species need extensive areas of dense forest. Others prefer fringe areas with a mix of trees, shrubs, grasses, and farmland. Still others are adapted to more developed urban and suburban landscapes. This brochure explains that the types of birds found in an area are an indication of its ecological condition; it also demonstrates the linkages between bird communities and land use/land cover. (See the graphic on the back cover as an example of the types of birds indicative of various ecological conditions and the types of land cover they represent.)

The types of birds found in an area indicate the ecological condition of that area. Bird communities and ecological condition are also linked to land cover. As the land cover of an area changes, so do the types of birds in that area (See Figure 1).

The quality of our environment affects our health, our economy, and the future of our children. Environmental scientists have long suspected that ecological condition is linked to changing land-use patterns brought on by increasing population and economic development.

The U.S. Environmental Protection Agency and the Penn State Cooperative Wetlands Center have found associations among songbirds, where they live, and environmental health or condition in the Mid-Atlantic highlands area (65,000 square miles; see Figure 2).

We can now measure how the distribution of various birds changes as land use is altered. This association allows birds to be used in



Photo by: G. Bradley

Figure 1. Relationship between birds, land cover, and ecological condition.

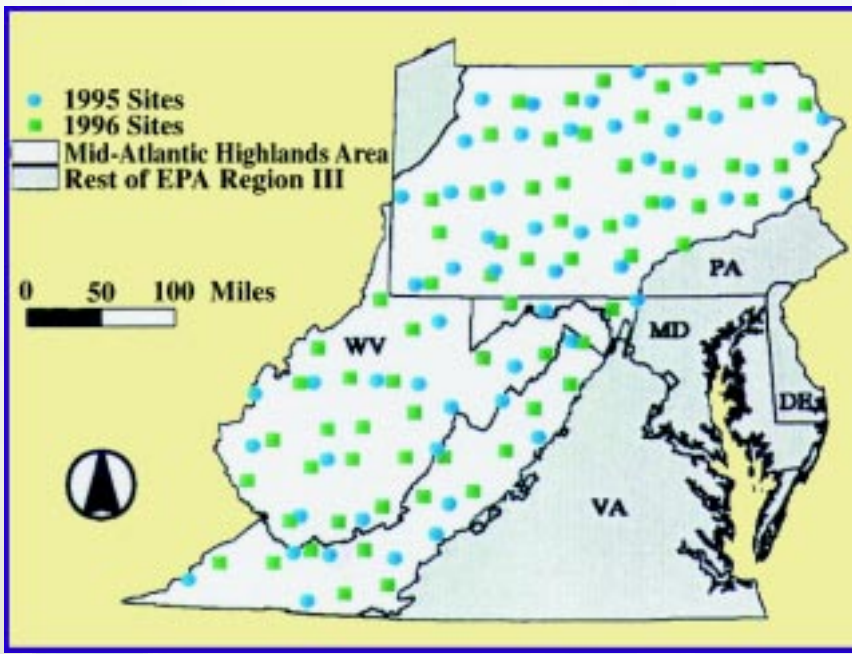


Figure 2. The songbird study surveyed 126 sites that were randomly distributed across the highlands (65,000 sq. mi.).

Most of the Mid-Atlantic highlands is forested. A forest is an area thickly covered with trees and distinguished by the types of trees and plants, their density, and the soil type. Forests are also divided into vertical layers: the canopy, the shrub layer, and the forest floor. Clearing forests not only removes the trees, but also the crucial habitat needed by non-woody plants, insects, birds, and other wildlife in each forest layer. Forest clearing also degrades aquatic systems and water quality by increasing erosion and light penetration.

In the absence of human activity, the geology, climate, rainfall, and frequency of natural disturbances in the Mid-Atlantic highlands support naturally-occurring forests. Therefore, mature forests represent the highest ecological condition potentially attainable in the

conjunction with other indicators to estimate ecological condition.

The presence or absence of particular birds across the study area indicates that:

- **16% of the highlands is in excellent ecological condition;**
- **another 27% is in good condition;**
- **36% is in fair ecological condition; and**
- **a total of 21% (5% urban and 16% rural) is in poor condition.**

It was also found **within the 200-acre survey sites** that ecological condition was closely associated with the amount and age of forest and other land-cover. For example:

- **Sites in good or excellent ecological condition were usually associated with an average of 87% forest cover.**
- **Sites in excellent condition had a taller and more closed tree canopy (a mature forest) than sites in good condition.**
- **Sites in poor ecological condition were usually associated with less than 28% forest cover.**
- **Sites in poor ecological condition were also observed when agricultural/non-woody-plant cover exceeded 61%, or urban/residential cover exceeded 29%.**

region. Human activity creates habitats such as lawns, agricultural fields, forest edges, and forests with only a few species of trees. These areas represent a lower ecological condition than a mature forest.

Obviously, the entire Mid-Atlantic highlands cannot be returned to its highest ecological condition. This would require destruction of many human amenities and, in some cases, take hundreds of years to accomplish. However, areas can be identified that are moving toward a lower level of ecological condition. **See the APPLICATIONS section on page 7 for what can be done to lessen the impact of this decline.**

ECOLOGICAL INDICATORS

Our understanding of how living things interact and how these interactions contribute to healthy surroundings is limited. To better understand these interactions and improve efforts to protect the environment, we need to measure characteristics which reflect the condition of ecological resources and the impacts which adversely affect them. These characteristics are called **ecological indicators**.

BIRDS ARE SENSITIVE ECOLOGICAL INDICATORS

Birds exhibit numerous traits that make them good ecological indicators at regional and national scales.

INDICATORS:

- *An indicator is a sign that relays a complex message in a simplified and useful manner.*
- *An ecological indicator is a measure that describes the condition of an ecosystem or one of its critical components.*

Example – The presence of trout in a stream indicates cool, well-oxygenated water, with lots of aquatic life; therefore, the presence or absence of trout is an indicator of stream condition.



Photo by: USGS BRD

The authors of this study have analyzed and combined information on the variety of species of birds present in the Mid-Atlantic highlands area to create a regional indicator of ecological condition. This indicator was developed and tested here as part of EPA's Environmental Monitoring and Assessment Program (EMAP).

It is important to recognize that both the highest ecological condition and the bird species that indicate that condition may differ in other regions. Therefore, the bird based ecological indicator for the Mid-Atlantic highlands is intended for use solely in this study area. It is anticipated that a similar indicator can be developed for almost any region, based on the region's birdlife.

PROCEDURE

In the early 1990s, 34 sites in central Pennsylvania were selected and ranked according to their degree of ecological decline or degradation (human disturbance gradient). The degree of degradation was based on an intensive study of soil type; amount of soil deposited by erosion; plant, amphibian, and wildlife communities; and where each site fits into the general landscape pattern. Sites were ranked from nearly pristine to severely degraded.

Next, an independent ranking of these sites using only bird species data was developed. Birds were surveyed at each of the sites, thus determining the bird composition (community) at each site. The bird community at each site is comprised of multiple life history groups (species that require similar habitat, food, nest location, or other elements for survival) that also reflect condition. The separate rankings of the sites based on the original human disturbance gradient and the bird communities were compared. This comparison satisfactorily demonstrated that ecological condition, as indicated by the bird community, closely matched the ecological condition determined previously by other physical and biological characteristics of each survey site.

Sixteen specific groups of bird species, such as omnivores, bark probers, residents, migrants, shrub nesters, etc., were ultimately selected as representative of the mostly forested Mid-Atlantic highlands area (Table 1). Of the 16 groups, nine were "specialists" and seven

They are everywhere, and different species vary in their sensitivity to physical, chemical, and biological threats. Each species also exhibits life history traits (e.g., ground nester – nests on the ground; temperate migrant – migrates south of the Mid-Atlantic highlands, but within North America; omnivore – feeds on both animal and plant material) that link to multiple environmental characteristics. Recording bird species within a designated area is relatively easy and inexpensive; birds have strong public appeal; bird species are well known; there are many trained field observers available; and no laboratory analysis is required. Additionally, survey methods harm neither birds nor the survey sites, and long-term records and ongoing programs are available to provide or augment data. Because of the unique role of every bird species in its habitat, the composition of the birds in an area is a multi-faceted indicator of ecological condition.

EPA's EMAP develops indicators and other research tools to track status and trends in the condition of the nation's ecological resources. These resources include estuaries, wetlands, inland lakes and streams, forests, and mixed landscapes.



were “generalists”; for example, insectivores are specialists and omnivores are generalists. Placement of specific bird species within each group was based on a review of scientific publications. Species may be assigned to several groups as well as to both specialist and generalist groups simultaneously. In general, a high proportion of birds with specialized requirements indicates healthy natural habitat that provides ecological benefits at local and larger scales.

Birds and vegetation were surveyed across the entire Mid-Atlantic highlands within sites sufficiently large (200 acres) to represent most of the habitat elements that are required by breeding birds. Use of EPA’s EMAP survey design guaranteed that data from the 126 sample sites were representative of the entire highlands area.

MAJOR FINDINGS

ECOLOGICAL CONDITION IS LINKED TO BIRD COMMUNITY ATTRIBUTES

Five levels of ecological condition (Figure 3) were clearly distinguishable across the study region from the types of birds found at each site. Examples of these birds are listed on page 6 and in the figure on the back cover.

Highland areas in excellent condition are dominated by birds that, among other traits:

- eat insects exclusively,
- seek food on the ground and in tree bark,
- reproduce only once per year, and
- migrate from distant wintering grounds.

Such characteristics tell us that these areas also support upper levels of the food chain, structurally complex habitat, relative protection from non-native predators and competitors, and continental-scale lifecycles. In the Mid-Atlantic highlands, an extensive mature hardwood or mixed-hardwood forest provides the maximum amount of these ecological features and benefits.

Many of the same bird species occur in areas of good ecological condition. However, they do not dominate the community as fully, while other species appear that are less specialized, for example, in what and where they eat. The bird community in these areas still reflects forest habitat, but it is not as physically or biologically complex.

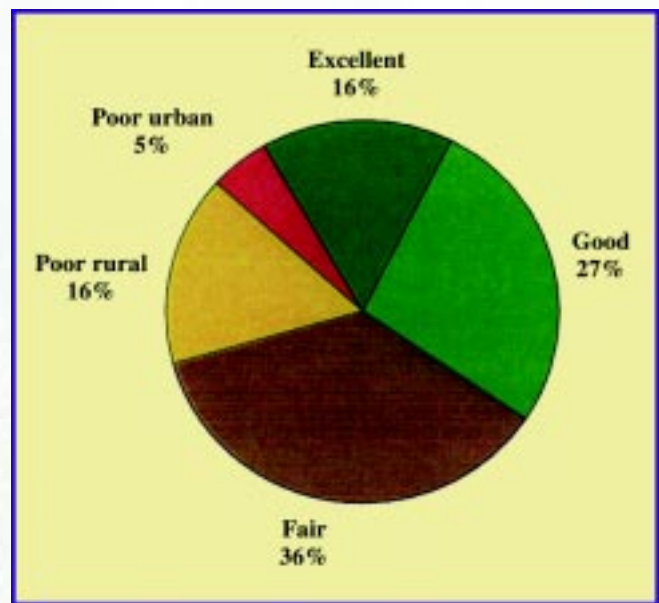


Figure 3. The bird community indicator classified the highlands area into five categories of ecological condition.

These distinctions in the bird data were supported by vegetation measurements: **Areas in excellent condition support a taller (~80 feet) and more closed (~61%) tree canopy than areas in good condition (~65-foot canopy height and ~47% canopy closure).** The forests are no bigger at the sites in excellent condition, but the trees are.

The bird community in areas of fair ecological condition indicates a significant decline in the provision of protective ground cover as well as upper-canopy feeding and nesting habitats. At the same time, non-native species begin to appear, signaling aggressive competition with native birds for food and shelter. With increasing shrub and grassland species, this community signals a shift from the native ecosystem to a mix of forest and the introduced habitats of agricultural and residential areas.

Analysis separated areas of poor condition into two classes — rural and urban — based on the distinct bird groups observed in each landscape type. In both cases, highland areas in poor ecological condition have birds that:

- are non-native
- do not have specialized diets
- reproduce multiple times per season
- parasitize or prey on the nests of other birds.

This is a classic profile of opportunistic behavior, and is observed in both plant and animal species when

habitats are simplified or otherwise disturbed by human or other events. Habitats supporting these bird groups are generally not sustainable. They are maintained by intensive vegetation control, the addition of nutrients, and other manipulations. These activities halt the process of plant succession, disrupt the natural food chain, and render these areas inhospitable to many native species.

BIRD COMMUNITIES ARE LINKED TO LANDSCAPE PATTERN

The term “landscape” refers to the spatial pattern or structure of a land area and the repeating patterns associated with dominant land uses. The relative proportion of forest, agriculture and urban land cover contained in an area also defines a landscape as does the interrelationship between them. The MAIA landscape ranges from wilderness areas to major cities, yet the patterns and processes of human and natural activity within the landscape are interconnected in many different ways and at many different scales.

The five categories of ecological condition as defined by the bird communities were highly related to the configuration of land cover in the 200-acre sites.

Figure 4 provides examples of these landscape patterns, which were characterized from aerial photography.

“Excellent ecological condition” conveys the sense of an undisturbed, self-sustaining natural area. In the Mid-Atlantic highlands, most undisturbed areas develop into mature forest communities. Therefore, it is not surprising that this study finds ecological condition, as indicated by bird composition, to be positively correlated with percent forest cover and measures of mature forest vegetation. **What may be surprising is that less than one-fifth of the Mid-Atlantic highlands remains in excellent condition, and that labels of fair to poor describe more than half of the region.**

This study begins to define the critical thresholds of land-cover change where shifts in ecological condition take place. At the 200-acre scale, **both good and excellent ecological condition were associated with an average of 87% forest cover. Poor ecological condition was observed when agricultural/non-woody-plant cover exceeded 61%, or urban/residential cover exceeded 29%.**

One interpretation of these results is to consider areas in good ecological condition as desirable by society, and to

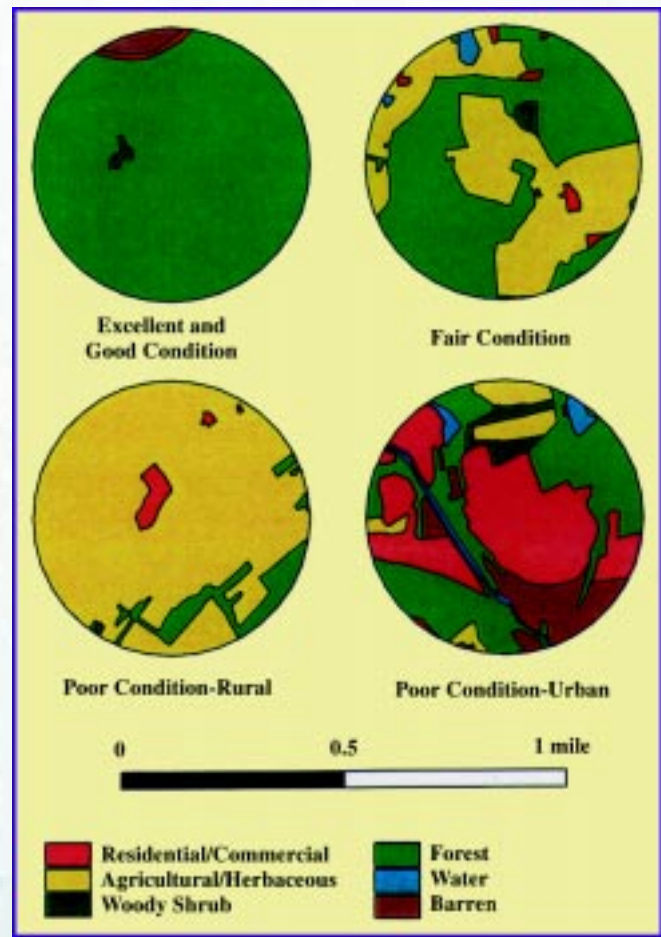


Figure 4. Ecological condition, as indicated by songbird communities, is highly correlated with land-cover composition.

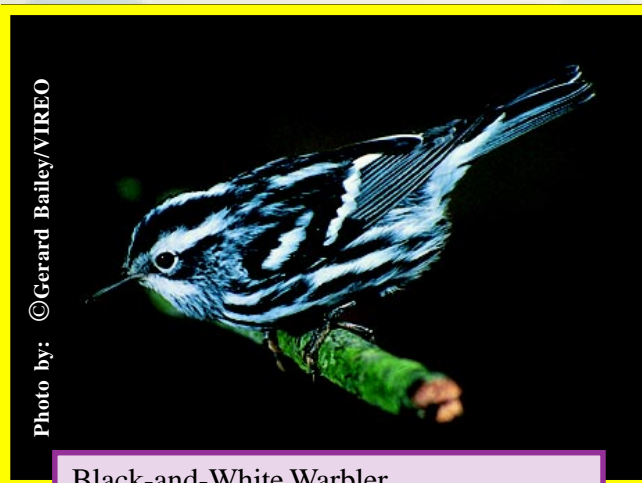
manage them so as to maintain current land cover. Longer rotation sequences in forested areas of good condition could create more areas with the potential to support excellent condition. Many of the areas in poor condition are also justified by societal requirements for agricultural and urban land uses. Community planning efforts may focus instead on those marginal landscapes in fair condition, guiding development such that they are not transformed beyond critical land-cover thresholds into areas of poor ecological condition.

The results further demonstrate that bird community composition is related to land-cover pattern at spatial scales of at least 200 acres. To mitigate the spread of poor-integrity environments, planners and managers must consider the landscape-scale consequences of localized land-cover transformations. Similarly, a landscape framework should drive restoration activities to increase the percentage of the region in good to excellent ecological condition.

BIRD COMMUNITIES

The following species belong to Mid-Atlantic bird communities shown to indicate levels of ecological condition at the landscape scale. While a full community profile is necessary to apply the bird community indicator, these examples illustrate the use of bird characteristics to determine ecological condition.

The **black-and-white warbler** is an insectivore, a neotropical migrant, a forest ground nester, and an interior forest obligate (must have interior forest to survive). If this species and other interior forest obligates, such as **ovenbirds**, **scarlet tanagers**, and **worm-eating warblers**, comprise more than 35% of the species in your bird community, it is likely an area of **excellent or good ecological condition**.



The **grasshopper sparrow** is an omnivore, a short-distance migrant, a double-brooded species, and an open-ground nester.



You may be in an area of **fair ecological condition** for the Mid-Atlantic highlands, if grassland species such as this are found in mixed communities with



forest generalists, such as the **tufted titmouse**. These areas contain fewer omnivores, nest predators, residents, and exotics; and significantly more upper-canopy foragers, single-brooded species, and forest-ground nesters than areas of low ecological condition.

The **European starling** is an omnivore, a year-round resident, a non-native (exotic) species, and a nest predator (preys on eggs or young of other birds). If this species and other nest predators such as the **American crow** or the **blue jay**, or nest parasites (lays its eggs in other birds' nests), such as the **brown-headed cowbird**, comprise more than 15% of the species in your bird community, it is likely an area of **poor ecological condition**.



(Refer to the graphic on the back cover as an example of the types of birds indicative of various ecological conditions and the types of land cover they represent.)

TABLE 1: SUMMARY OF THE LIFE HISTORY BIRD GROUPS* USED IN THE STUDY

LIFE HISTORY BIRD GROUPS*	CATEGORY	SPECIALIST	GENERALIST
Omnivore (eats both animals and plants)	Trophic (Diet)		X
Bark Prober	Insectivore Foraging Behavior	X	
Ground Gleaner	Insectivore Foraging Behavior	X	
Upper-Canopy Forager	Insectivore Foraging Behavior	X	
Lower-Canopy Forager	Insectivore Foraging Behavior	X	
Nest Predator/Brood Parasite	Population Limiting		X
Exotic (introduced species)	Origin		X
Resident	Migratory		X
Temperate Migrant	Migratory		X
Single-Brooded	Number of Broods	X	
Canopy Nester	Nest Placement	X	
Shrub Nester	Nest Placement		X
Open-Ground Nester	Nest Placement	X	
Forest-Ground Nester	Nest Placement	X	
Forest Generalist	Primary Habitat		X
Interior Forest Obligate (must have interior forest to survive)	Primary Habitat	X	

* These groups of species have similar life history traits; that is, they require similar habitat, food, or other elements for survival.

APPLICATIONS

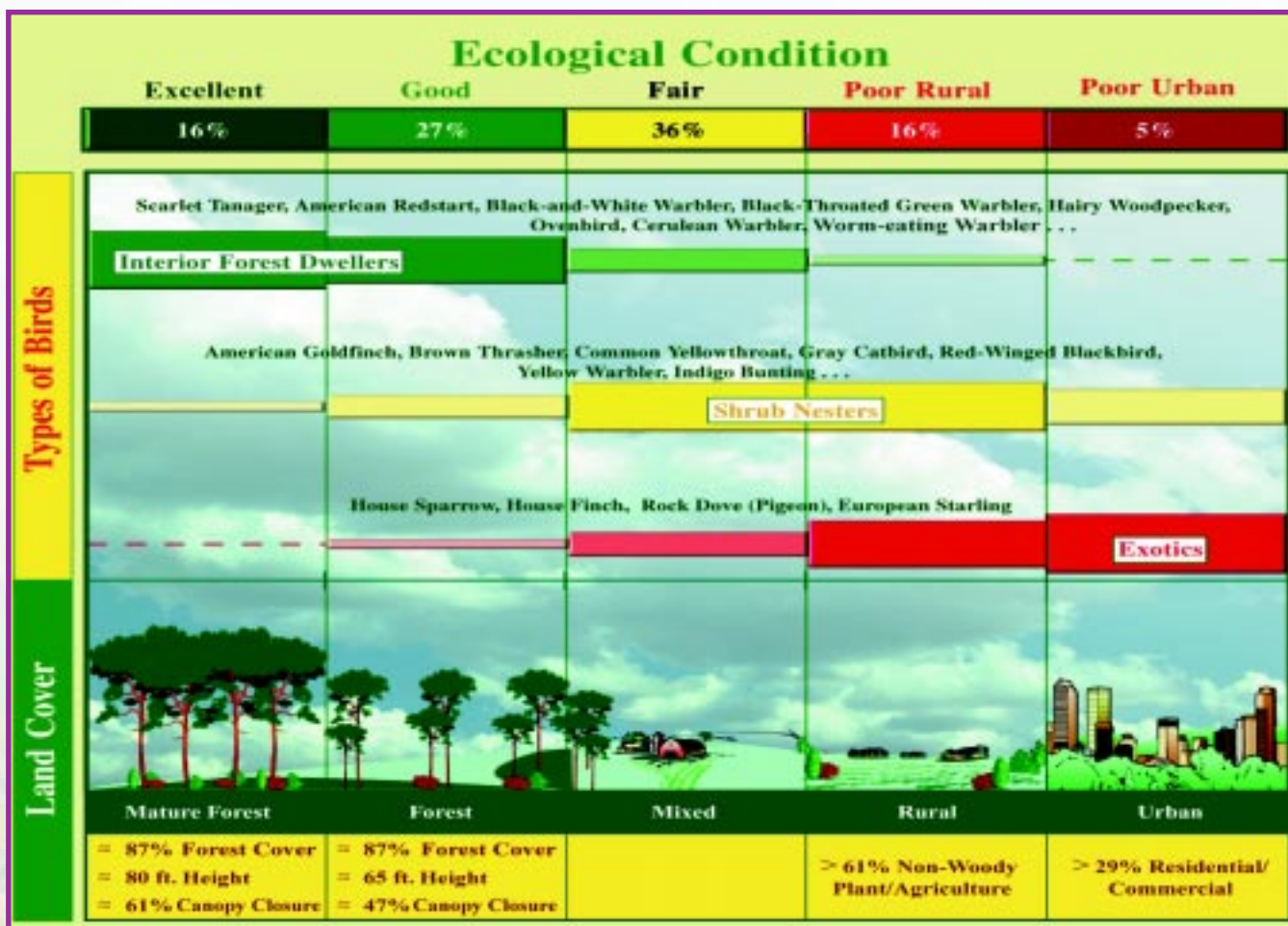
Public and private agencies, organizations, and individuals can help improve ecological conditions in the Mid-Atlantic region in the following ways:

- Protect and maintain existing forests that are in good or excellent condition.
- Restore areas in fair condition (e.g. marginally productive agricultural land).
- Guide development away from areas in good and excellent condition. Work to avoid further degradation of areas in fair condition.

- Focus development in areas that show poor ecological condition.

The land uses in the Mid-Atlantic and how they are distributed across the area affect the quality of the natural environment (see *An Ecological Assessment of the United States Mid-Atlantic Region – A Landscape Atlas*, EPA/600/R-97/130, November, 1997).

Birds in the Mid-Atlantic Highlands as Indicators of Ecological Condition



For More Information, Please Contact

Timothy O'Connell / Robert Brooks
 Pennsylvania State University
 Cooperative Wetlands Center
 University Park, PA 16802-4703
 tjo111@psu.edu / rpb2@psu.edu

Tom DeMoss
 U.S. Environmental Protection Agency
 Region 3
 Environmental Science Center
 Ft. Meade, MD 20755-5350
 demoss.tom@epa.gov

Laura Jackson
 U.S. Environmental Protection Agency
 Office of Research and Development
 Research Triangle Park, NC 27711
 jackson.laura@epa.gov

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