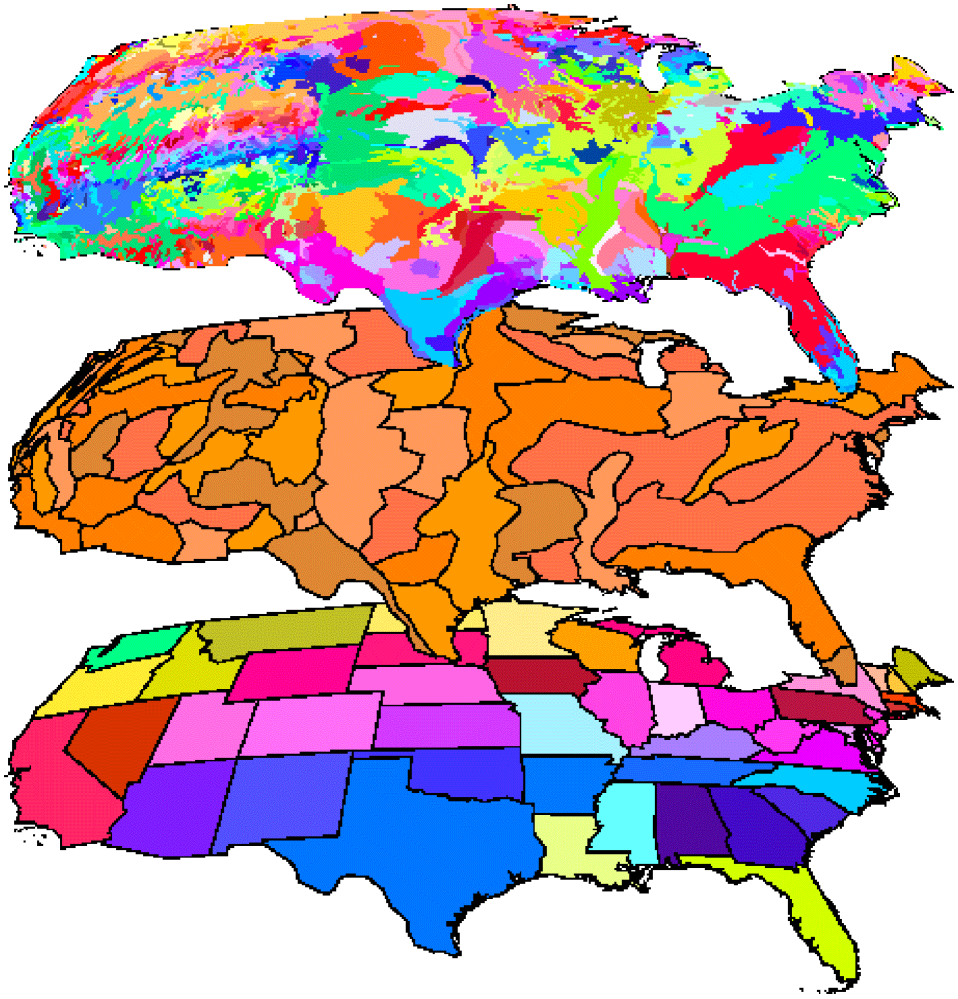
A GAP ANALYSIS OF Animal Species Distributions in MARYLAND, DELAWARE, AND NEW JERSEY

2006 Final Report



A GEOGRAPHIC APPROACH TO PLANNING FOR BIOLOGICAL DIVERSITY

U.S. Department of the Interior
U.S. Geological Survey

THE MARYLAND, DELAWARE, AND NEW JERSEY GAP ANALYSIS PROJECT

FINAL REPORT – Part 2: Vertebrate Species Distributions

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Executive Summary

Gap analysis provides an overview of the distribution and conservation status of several components of biodiversity. There are five major objectives of the national Gap Analysis Program: (1) map actual vegetation as closely as possible to the Alliance level; (2) map predicted distributions of animals for which adequate distributional records, habitat associations, and mapped habitat variables are available; (3) document occurrence of vegetation types that are inadequately represented (gaps) in special management areas; (4) document occurrence of animal species that are inadequately represented (gaps) in special management areas; and (5) make all information available to resource managers and land stewards in a readily accessible format.

To meet national objectives, gap analysis is conducted at the state level while maintaining consistency with national standards. The Maryland-Delaware-New Jersey Gap Analysis Project (MDN-GAP) involved the efforts of researchers from various government natural resource agencies and universities in all three states, with the bulk of the work and project administration being carried out by the U.S. Fish & Wildlife Service, Maryland Department of Natural Resources, University of Maryland Eastern Shore Cooperative Fish & Wildlife Research Unit, and New Jersey Department of Environmental Protection. The three-state project area includes a complex mixture of habitats, ranging from coastal beaches and estuarine tidal marshes to montane forests and bogs, and human-dominated urban and agricultural landscapes. Despite the high degree of human land use pressure and habitat fragmentation in many parts of the project area, there remain many exceptional examples of regionally and globally significant natural features and wildlife populations.

This report pertains only to the mapping and assessment of animal species distributions, and is a supplement to an earlier report describing the development and assessment of the vegetation and land stewardship components of this project. Animal species habitat modeling and distribution mapping involved the development of three primary data sets: (1) breeding ranges for all animal species; (2) a species-habitat association database with tables that identify relationships between animal species and various habitat variables; and (3) geographic information system (GIS) thematic layers representing the habitat variables for which habitat relationships have been recorded in the database tables.

The ranges or distributional limits of animal species were developed primarily through the Biodiversity Research Consortium (BRC), now administered by Nature Serve. The BRC uses the hexagons utilized by EPA's Environmental Monitoring and Assessment Program. Within the Maryland-Delaware-New Jersey project area, these hexagons range in size from about 648 to 651 square kilometers per hexagon. Each hexagon was assigned a code reflecting the level of certainty associated with the species occurrence data. In general, hexagons with "confirmed" or "probable" occurrence records were included in a species' range. For rare, threatened, or endangered species in Maryland and Delaware, 7.5-minute quadrangles, which are significantly smaller than hexagons, were

used to map ranges in order to avoid over-estimating the distributions of these rare species. Rare species data were not available for most of New Jersey, but Breeding Bird Atlas data were used to populate quad records for rare bird species in this state.

Development of the wildlife habitat relationships database began with a review of the literature and compilation of habitat requirements information into an individual summary document for each species. This document was then used as a reference in filling out a standard data form where habitat types and other variables (e.g., elevation) were assigned suitability rankings and relative weightings (i.e., relative influence on species preferred habitat and geographic distribution). These habitat suitability rankings and habitat variable weightings were then entered into tables in the wildlife habitat relationships database. The list of habitats was developed through a review of several other efforts to define wildlife habitats, and by identifying the particular habitat types that are commonly mentioned in the literature.

The habitat type map was developed from three primary data sources: (1) MDN-GAP Land Cover data; (2) National Wetlands Inventory data; and (3) National Land Cover Data. Other habitat variables used in modeling animal species' distributions included proximity to wetlands (14 wetland types; 4 buffer distances), forest interior, forest patch isolation, riparian forest width, grassland area, edge habitat, elevation, slope, aspect, juxtaposition to forest, juxtaposition to roads, and proximity to a special habitat feature (e.g., island, cave, outcrop, cliff, bridge).

Predictive habitat models and distribution maps were developed for 363 animal species (206 bird species, 69 mammal species, 47 reptile species, 41 amphibian species). Bird habitat models and distribution maps were limited to those species that regularly nest within the project area. Although there are regionally and globally significant migratory bird staging areas in Maryland, Delaware and New Jersey, project resource limitations prevented inclusion of species that use the area during migration but do not nest here. Also, there are currently many complementary efforts that are focused on addressing the needs of these migratory bird concentrations. In addition to mapping predicted distributions of individual species, analyses were conducted in order to identify and map species-rich areas or "hotspots." These analyses resulted in the identification of bird species hotspots, mammal hotspots, reptile hotspots, and amphibian hotspots. In addition, rare species hotspots were identified for each of these groups, and for all groups combined.

An accuracy assessment was undertaken, comparing predicted animal distributions with documented occurrences in managed areas (e.g., National Wildlife Refuges). The goal of GAP is to produce maps that predict animal species distributions with an accuracy of 80% or higher. A total of 12 managed areas had species checklists to which predicted distributions were compared. Of the 363 species modeled, 280 (77.1%) were included on at least one of the checklists. For birds, matches between checklists and modeled distributions exceeded 80% in only 5 of 12 areas, but exceeded 79% in 9 of these areas. Many of the non-matches were actually caused by errors in checklists. For example,

disagreements between Breeding Bird Atlas data and checklists often corresponded with recorded "errors." For mammals, matches exceeded 80% in only 1 of 3 areas for which mammal checklists existed. For reptiles, matches exceeded 80% in 3 of 4 areas, with the lowest rate of agreement being 78.8%. For amphibians, matches exceeded 80% in only 1 of 4 areas, but significant errors were found in the checklist for at least one of the management areas included in this comparison. Also, some checklists indicated a lack of certainty regarding the presence of certain secretive species, and many checklists indicated that the species included were known to occur on or "near" the management area. A more thorough accuracy assessment, including additional expert review, is needed to better determine the level of accuracy of animal species habitat models and distribution maps.

The final step of gap analysis involves intersecting the distributions of elements of biological diversity (i.e., land cover types and animal species) with the land stewardship and management status map, in order to identify "gaps" in protection. The land stewardship data set includes land ownership boundaries and land stewardship status rankings that reflect the degree to which each area is managed for biodiversity, with status 1 lands affording the highest level of protection and status 4 lands providing the least amount of protection. The predicted distributions of all 363 animal species were intersected with the land stewardship map to produce summaries of protection for each species. Birds and reptiles appear to have the best representation within status 1 and 2 lands, with over 15% of bird species and over 10% of reptile species having more than 10% of their potential habitat receiving these higher levels of protection. Amphibians appear to have received the least amount of protection, with over 95% of amphibian species having less than 10% of their potential habitat occurring within status 1 and 2 lands. When considering native species only, nearly 97% of mammal species and over 88% of all species have less than 10% of their predicted distributions occurring within status 1 or 2 lands. Overall, it appears that all groups are poorly represented within GAP status 1 and 2 lands.

In general, the habitats supporting the species of greatest conservation concern (i.e., those that are rare to extremely rare within the project area and are underrepresented in status 1 and 2 lands) include early successional habitats, unpolluted mountain streams, vernal pools (non-tidal, isolated, seasonally flooded wetlands) with substantial upland forest buffers, forested wetlands and freshwater marshes, forest interior, broad riparian and floodplain forests, and beach and dune habitats.

The most prominent rare species hotspots (i.e., areas with high rare species richness) that are unprotected include the Youghiogheny River corridor and other riparian forests in western Maryland, and some of the riparian and headwater forests of the New Jersey Highlands and Kittatinny Mountain; forest-swamp ecotones in parts of the New Jersey Pine Barrens; the large concentration of coastal plain ponds (i.e., vernal pools) and surrounding hardwood forests in the Blackbird-Millington Corridor of Delaware and Maryland; Potomac River and C&O Canal tributaries northwest of Washinton, D.C.; and

wetlands associated with headwaters and tributaries of several rivers in the southern Pine Barrens and Highlands of New Jersey.

The results of this effort identify many species of conservation concern and habitats that are in need of additional protection. These results should be incorporated into conservation planning efforts and used to guide additional field investigations. Such investigations and expert review of the results may also lead to a better understanding of data limitations and ways of refining and improving the data.

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Chapter 1: Introduction

1.1 How This Report is Organized

This report is a summation of a scientific project. While we endeavor to make it understandable for as general an audience as practicable, it reflects the complexity of the project it describes. A glossary of terms is provided to aid the reader in its understanding, and for those seeking a detailed understanding of the subjects, the cited literature should be helpful. The organization of this report follows the general chronology of project development, beginning with the production of the individual data layers and concluding with analysis of the data. It diverges from standard scientific reporting by embedding results and discussion sections within individual chapters. This was done to allow the individual data products to stand on their own as testable hypotheses and provide data users with a concise and complete report for each data and analysis product.

This is a supplement to a previously published final report describing the land cover and land stewardship mapping components of the project. The animal species distribution mapping was not completed in time for inclusion in that report, and is instead presented here. We begin this report with an overview of the Gap Analysis Program mission, concept, and limitations. We then present a synopsis of how the current biodiversity condition of the project area came to be, followed by animal species distribution prediction and species richness analyses. Data development leads to the Analysis section, which reports on the status of the elements of biodiversity (animal species) for Maryland, Delaware and New Jersey. Finally, we describe the management implications of the analysis results and provide information on how to acquire and use the data.

1.2 The Gap Analysis Program Mission

The mission of the Gap Analysis Program is to prevent conservation crises by providing conservation assessments of biotic elements (plant communities and native animal species) and to facilitate the application of this information to land management activities. This is accomplished through the following five objectives:

1) map actual land cover as closely as possible to the alliance level (FGDC 1997).
2) map the predicted distribution of those terrestrial vertebrates and selected other taxa that spend any important part of their life history in the project area and for which adequate distributional habitats, associations, and mapped habitat variables are available.
3) document the representation of natural vegetation communities and animal species in areas managed for the long-term maintenance of biodiversity.
4) make all GAP project information available to the public and those charged with land use research, policy, planning, and management.
5) build institutional cooperation in the application of this information to state and regional management activities.

To meet these objectives, it is necessary that GAP be operated at the state or regional level but maintain consistency with national standards. Within the state, participation by a wide variety of cooperators is necessary and desirable to ensure understanding and acceptance of the data and forge relationships that will lead to cooperative conservation planning.

1.3 The Gap Analysis Concept

The Gap Analysis Program (GAP) brings together the problem-solving capabilities of federal, state, and private scientists to tackle the difficult issues of land cover mapping, animal habitat characterization, and biodiversity conservation assessment at the state, regional, and national levels. The program seeks to facilitate cooperative development and use of information. Throughout this report we use the terms "GAP" to describe the national program, "GAP Project" to refer to an individual state or regional project, and "gap analysis" to refer to the gap analysis process or methodology.

Much of the following discussion was taken verbatim from Edwards et al. 1995, Scott et al. 1993, and Davis et al. 1995. The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. It uses the distribution of actual vegetation and predicted distribution of terrestrial vertebrates and, when available, invertebrate taxa. Digital map overlays in a GIS are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or underrepresented in existing management areas. It functions as a preliminary step to the more detailed studies needed to establish actual boundaries for planning and management of biological resources on the ground. These data and results are then made available to the public so that institutions as well as individual landowners and managers may become more effective stewards through more complete knowledge of the management status of these elements of biodiversity. GAP, by focusing on higher levels of biological organization, is likely to be both cheaper and more likely to succeed than conservation programs focused on single species or populations (Scott et al.1993).

Biodiversity inventories can be visualized as "filters" designed to capture elements of biodiversity at various levels of organization. The filter concept has been applied by The Nature Conservancy, which established Natural Heritage Programs in all 50 states. The Nature Conservancy employs a fine filter of rare species inventory and protection and a coarse filter of community inventory and protection (Jenkins 1985, Noss 1987). It is postulated that 85-90% of species can be protected by the coarse filter without having to inventory or plan reserves for those species individually. A fine filter is then applied to the remaining 15-10% of species to ensure their protection. Gap analysis is a coarse-filter method because it can be used to quickly and cheaply assess the other 85-90% of species. GAP is not designed to identify and aid protection of elements that are rare or of very restricted distribution; rather it is designed to help "keep common species common" by identifying risk far in advance of actual population decline. These concepts are further developed below.

The intuitively appealing idea of conserving most biodiversity by maintaining examples of all natural community types has never been applied, although numerous approaches to the spatial identification of biodiversity have been described (Kirkpatrick 1983, Margules and Nicholls 1988, Pressey and Nicholls 1989, Nicholls and Margules 1993). Furthermore, the spatial scale at which organisms use the environment differs tremendously among species and depends on body size, food habits, mobility, and other factors. Hence, no coarse filter will be a complete assessment of biodiversity protection status and needs. However, species that fall through the pores of the coarse filter, such as narrow endemics and wide-ranging mammals, can be captured by the safety net of the fine filter. Community-level (coarse-filter) protection is a complement to, not a substitute for, protection of individual rare species.

Gap analysis is essentially an expanded coarse-filter approach (Noss 1987) to biodiversity protection. The land cover types mapped in GAP serve directly as a coarse filter, the goal being to assure adequate representation of all native vegetation community types in biodiversity management areas. Landscapes with great vegetation diversity often are those with high edaphic variety or topographic relief. When elevational diversity is very great, a nearly complete spectrum of vegetation types known from a biological region may occur within a relatively small area. Such areas provide habitat for many species, including those that depend on multiple habitat types to meet life history needs (Diamond 1986, Noss 1987). By using landscape-sized samples (Forman and Godron 1986) as an expanded coarse filter, gap analysis searches for and identifies biological regions where unprotected or underrepresented vegetation types and animal species occur.

More detailed analyses were not part of this project, but are areas of research that GAP as a national program is pursuing. For example, a second filter could combine species distribution information to identify a set of areas in which all, or nearly all, mapped species are represented. There is a major difference between identifying the richest areas in a region (many of which are likely to be neighbors and share essentially the same list of species) and identifying areas in which all species are represented. The latter task is most efficiently accomplished by selecting areas whose species lists are most different or complementary. Areas with different environments tend to also have the most different species lists for a variety of taxa. As a result, a set of areas with complementary sets of species for one higher taxon (e.g., mammals) often will also do a good job representing most species of other higher taxa (e.g., trees, butterflies). Species with large home ranges, such as large carnivores, or species with very local distributions may require individual attention. Additional data layers can be used for a more holistic conservation evaluation. These include indicators of stress or risk (e.g., human population growth, road density, rate of habitat fragmentation, distribution of pollutants) and the locations of habitat corridors between wildlands that allow for natural movement of wide-ranging animals and the migration of species in response to climate change.

1.4 General Limitations

Limitations must be recognized so that additional studies can be implemented to supplement GAP. The following are general project limitations; specific limitations for the data are described in the respective sections:

1. GAP data are derived from remote sensing and modeling to make general assessments about conservation status. Any decisions based on the data must be supported by ground-truthing and more detailed analyses.

2. GAP is not a substitute for threatened and endangered species listing and recovery efforts. A primary argument in favor of gap analysis is that it is proactive: it seeks to recognize and manage sites of high biodiversity value for the long-term maintenance of populations of native species and communities before they become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered. Those species that are already greatly imperiled, however, still require individual efforts to assure their recovery.

3. GAP data products and assessments represent a snapshot in time generally representing the date of the satellite imagery. Updates are planned on a 5-10 year cycle, but users of the data must be aware of the static nature of the products.

4. GAP is not a substitute for a thorough national biological inventory. As a response to rapid habitat loss, gap analysis provides a quick assessment of the distribution of vegetation and associated species before they are lost, and provides focus and direction for local, regional, and national efforts to maintain biodiversity. The process of improving knowledge in systematics, taxonomy, and species distributions is lengthy and expensive. That process must be continued and expedited, however, in order to provide the detailed information needed for a comprehensive assessment of our nation's biodiversity. Vegetation and species distribution maps developed for GAP can be used to make such surveys more cost-effective by stratifying sampling areas according to expected variation in biological attributes.

1.5 The Study Area

The Maryland-Delaware-New Jersey Gap Analysis Project (MDN-GAP) study area includes the states of Maryland, Delaware and New Jersey (Figure 1.1). Other authors (Robbins and Blom 1996, Hess et al. 2000, Walsh et al. 1999) have described these states in detail. In general, this three-state area includes habitats ranging from coastal beaches, dunes, broad estuarine tidal marshes and bald cypress swamps on the coastal plain to upland forests and boreal bogs in the Appalachian Mountains. The area includes the southernmost extent of the ranges of many northern species, the northernmost extent of many southern species, and contains internationally significant migratory bird staging and concentration areas. This area also includes the cities of Baltimore, Maryland; Wilmington, Delaware; and Trenton, New Jersey; and is influenced by Washington, D.C.; New York City; and Philadelphia, Pennsylvania. The region is heavily impacted by urban

development and suburban sprawl, and includes a large portion of the Delmarva Peninsula which is significantly dominated by agricultural activities.

There is a diversity of topographic features from middle elevation mountains with a maximum elevation of 1035 m (3395 ft) to sea-level barrier islands. There are 6 broad physiographic provinces (Figure 1.2) of the 20 that occur in North America, each with a mix of natural diversity and ecologically significant features. The mixed forests of the Appalachian Plateau, Ridge and Valley, and Blue Ridge Plateau Provinces contain some of the most diverse, ancient broadleaf forests on earth (Olson et al. 1998). The Cranesville Sub-Arctic Swamp, a cool, "frost-pocket" bog, occurs along the western boundary of Maryland's panhandle, on the Allegheny Plateau.

New Jersey's Piedmont Province is heavily developed, but still contains the remains of several glacial lakes along with extensive freshwater wetlands. Approximately 25% of the state is the protected Pinelands, a largely uninhabited area which includes Pine Barrens (Walsh et al. 1999). Maryland's Piedmont Province contains 769 ha (1900 ac) of serpentine barrens in the Soldier's Delight Natural Environment Area. Ninety-five percent of Delaware lies in the Coastal Plain, with the Great Cypress Swamp occurring along its southern boundary. Sixty-five percent of Delaware's wetlands are inland palustrine, freshwater and nontidal (Hess et al. 2000). All three states harbor numerous examples of vernal pools throughout the Coastal Plain Province. These seasonally wet depressions are environmentally sensitive habitats for a number of rare plants and animals. One of the Coastal Plain's great features is the Chesapeake Bay, the country's largest estuary which has a longer tidal shoreline than the State of California (Robbins and Blom 1996). The Delaware Bay, an ancient, drowned river bed, separates Delaware and New Jersey and facilitates traffic into Philadelphia, Pennsylvania which is one of the busiest ports in the United States (Hess et al. 2000, Walsh et al. 1999).

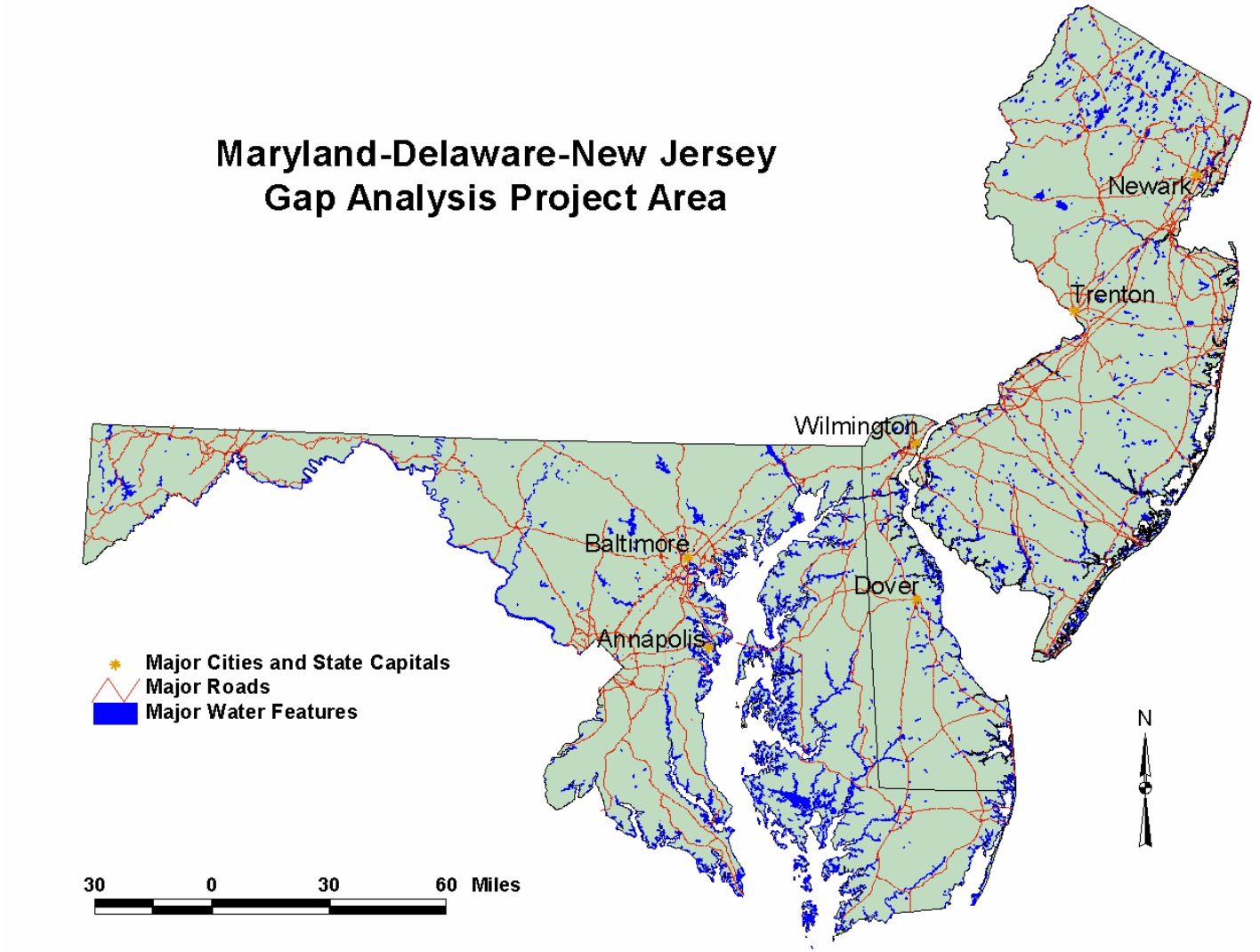

Figure 1.1. Maryland-Delaware-New Jersey Gap Analysis Project study area

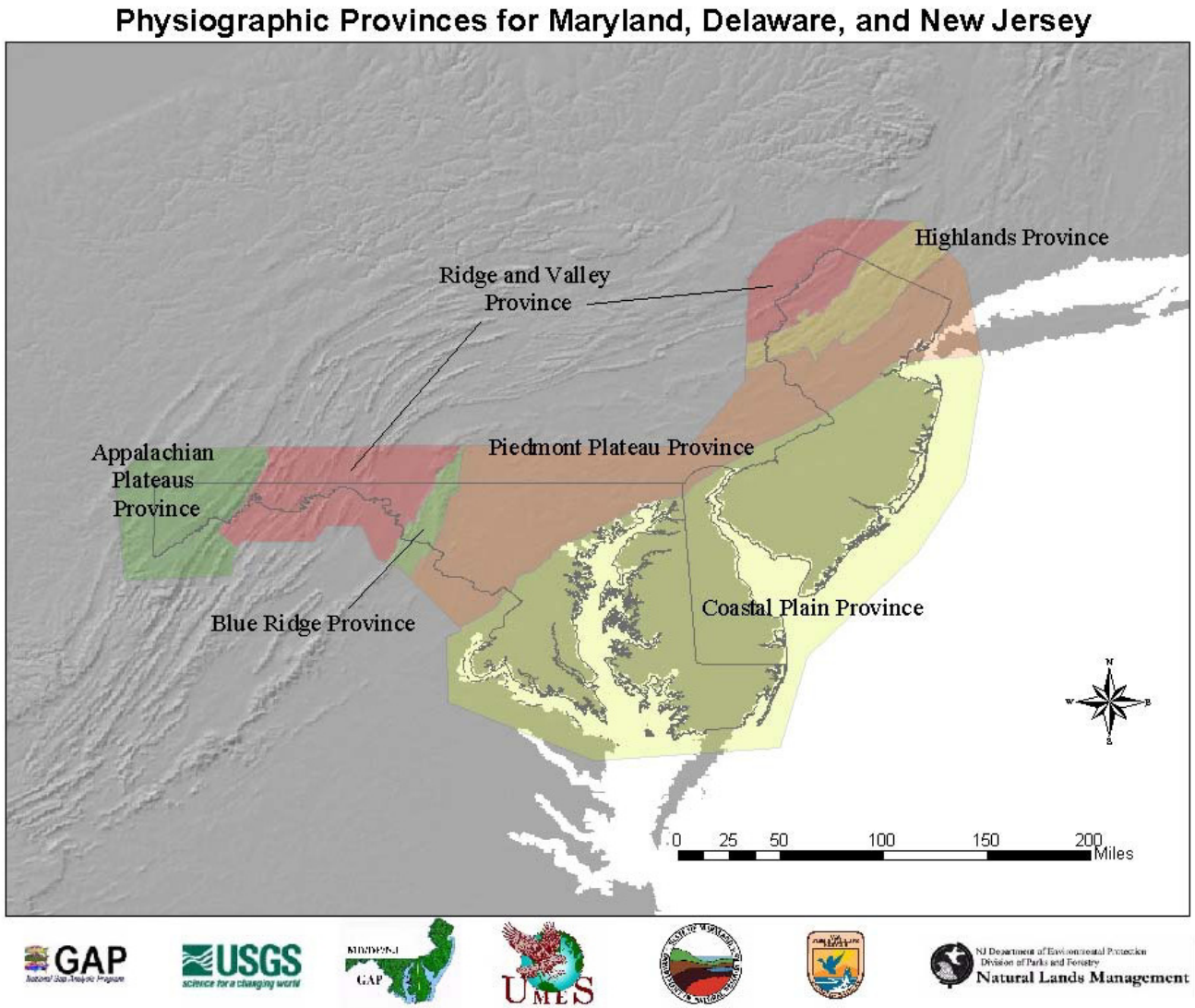

Figure 1.2. Physiographic Provinces of the Maryland-Delaware-New Jersey Gap Analysis Project study area

Chapter 2: Predicted Animal Species Distributions and Species Richness

2.1 Introduction

All species range maps are predictions about the occurrence of those species within a particular area (Csuti 1994). Traditionally, the predicted occurrences of most species begin with samples from collections made at individual point locations. Most species range maps are small-scale (e.g., 1:10,000,000) and derived primarily from point data to construct field guides which are suitable, at best, for approximating distribution at the regional level or counties for example. The purpose of the GAP vertebrate species maps is to provide more precise information about the current predicted distribution of individual native species according to actual habitat characteristics within their general ranges and to allow calculation of predicted area of distributions and associations to specific habitat characteristics.

GAP maps are produced at a nominal scale of 1:100,000 or better and are intended for applications at the landscape or "gamma" scale (heterogeneous areas generally covering 1,000 to 1,000,000 hectares and made up of more than one kind of natural community). Applications of these data to site- or stand-level analyses (site--a microhabitat, generally 10 to 100 square meters; stand--a single habitat type, generally 0.1 to 1,000 ha; Whittaker 1977, see also Stoms and Estes 1993) will likely reveal the limitations of this process to incorporate differences in habitat quality (e.g., understory condition) or necessary microhabitat features such as standing dead trees.

Gap analysis uses the predicted distributions of animal species to evaluate their conservation status relative to existing land management (Scott et al. 1993). However, the maps of species distributions may be used to answer a wide variety of management, planning, and research questions relating to individual species or groups of species. In addition to the maps, great utility may be found in the consolidated specimen collection records and literature that are assembled into databases used to produce the maps. Perhaps most importantly, as a first effort in developing such detailed distributions, they should be viewed as testable hypotheses to be confirmed or refuted in the field. We encourage biologists and naturalists to conduct such tests and report their findings in the appropriate literature and to the Gap Analysis Program such that new data may improve future iterations.

Previous to this effort there were no maps available, digital or otherwise, showing the likely present-day distribution of species by habitat type across their ranges. Because of this, ordinary species (i.e., those not threatened with extinction or not managed as game animals) are generally not given sufficient consideration in land-use decisions in the context of large geographic regions or in relation to their actual habitats. Their decline, because of incremental habitat loss can, and does, result in one threatened or endangered species "surprise" after another. Frequently, the records that do exist for an ordinary

species are truncated by state boundaries. Simply creating a consistent spatial framework for storing, retrieving, manipulating, analyzing, and updating the totality of our knowledge about the status of each animal species is one of the most necessary and basic elements for preventing further erosion of biological resources.

There are three major data sets used in GAP to predict the distribution of vertebrate species: 1) breeding ranges for all animal species; 2) a species-habitat association database with tables that identify relationships between animal species and various habitat variables; and 3) geographic information system (GIS) map overlays representing the habitat variables for which species habitat relationships have been recorded in the database tables.

2.2 Methods

The predicted animal species distribution mapping for Maryland, Delaware and New Jersey began with the mapping of species' ranges or distributional limits. Range maps for most common species were based on confirmed or probable presence within the 650 square-kilometer hexagon units used by the Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP). For most rare species, the much smaller 7.5-minute quadrangle was used, primarily because this is one method utilized by Natural Heritage Programs for tracking the distributions of rare species and, therefore, data for these species were generally available at this scale. Although information about the locations of some rare species is considered sensitive (e.g., for collectible species such as the bog turtle), the use of smaller range units was preferred because of the greater potential to overestimate distributions of rare species, many of which are habitat specialists.

The habitat modeling component, which results in more precise mapping of predicted animal species distributions within the range units, started with the compilation of habitat relationships information from the literature. Using this information as a reference, a list of commonly-described habitats (e.g., oak-hickory forest, salt marsh) was developed, and other modeling variables (e.g., slope, aspect, elevation, distance from edge, proximity to water) were identified. Raster-based modeling grids (i.e., map overlays) representing these habitat variables were then developed and the habitat relationship information gleaned from the literature was entered into an associated database of modeling tables.

2.2.1 Mapping Standards and Data Sources

All GIS modeling of species distributions was conducted in ArcView 3.2, controlled by customized Avenue scripts, within a Windows 2000 operating system environment. Many of the GIS map overlays used in the modeling were created in ARC/INFO version 7.1.2 on a Sun Workstation. All GIS overlays were developed as, or converted to, raster grids with a 30-meter cell resolution, in the Universal Transverse Mercator projection (zone 18, datum NAD83). The minimum mapping unit varied depending on the particular grid or original data sources used to create grids. The GIS overlays (i.e., grids) used in the

modeling are listed in table 2.1, and more details about the development of individual modeling grids are presented in the sections that follow the table.

Table 2.1: Grids Used in Habitat Modeling

MODELING GRID	SOURCE	DESCRIPTION
Range Extent or Distributional Limits by Hexagon	Biodiversity Research Consortium, museum records, other sources	Confirmed or Probable species presence within 650 square-kilometer hexagon range units
Range Extent or Distributional Limits by 7.5-minute quadrangle	Natural Heritage Programs, Breeding Bird Atlas projects, other sources	Confirmed or Probable species presence within 7.5-minute quadrangle range units
Habitat Types	GAP Land Cover, National Land Cover Data, National Wetlands Inventory, other sources	Source data sets were combined (see section 2.2.3.1)
Wetland Buffer (100 m, 250 m, 500 m, 1000 m)	National Wetlands Inventory; USGS 1:100,000 DLG (streams)	NWI and DLG data were aggregated into 14 wetland classes and buffered (see section 2.2.3.2)
Forest Fragmentation Metrics (Area, Patch Isolation, Riparian Forest Width)	National Land Cover Data (NLCD)	ZONALTHICKNESS applied in GRID to create Forest Area and Riparian Forest Width grids; FOCALMEAN applied to create patch isolation grid, expressed as % forest cover within 2 km (see section 2.2.3.3)
Open (Edge, Grassland Area)	Habitat Type grid (see above)	EUCDISTANCE applied in GRID to calculate distance from forest/non-forest edge; ZONALTHICKNESS used to create Grassland Area grid (see sections 2.2.3.4 and 2.2.3.5)
Land Form (Elevation, Slope, Aspect)	National Elevation Data (30-m NED)	Elevation Z units are in meters; Slope expressed as percent rise; developed in Arc/Info GRID (see section 2.2.3.6)
Juxtaposition (Roads, Forest)	USGS 1:100,000 DLGs used for Road Juxtaposition; Habitat Type (see above) used to develop Forest Juxtaposition grid	Roads converted to raster grid and EUCDISTANCE applied; FOCALMEAN, with 250-m neighborhood, applied to create Forest Juxtaposition grid (see sections 2.2.3.7 and 2.2.3.8)
Special Habitat Feature (island, cave, outcrop, cliff, dam/bridge)	Various (see section 2.2.3.9)	Each feature was buffered by 100 meters, 2 kilometers, 7 kilometers, and 15 kilometers

2.2.2 Mapping Range Extent

Existing range data sources for the MDN-GAP project included state Natural Heritage Programs (NHP), museum records, study skin collections, and Breeding Bird Atlas (BBA) projects. At the time that the range mapping was initiated, the Maryland BBA project (Robbins and Blom 1996) was just being completed, and the Delaware and New Jersey BBA projects were in the process of being completed (Hess et al. 2000, Walsh et al. 1999). Data from these projects became available at different times and there were associated delays in completing the range mapping. The data from these various sources were used to develop the Biodiversity Research Consortium (BRC) data set, which is based on the Environmental Protection Agency's hexagons used in their Environmental Monitoring and Assessment Program. Within the Maryland-Delaware-New Jersey project area, these hexagons ranged in size from about 648 to 651 square kilometers per hexagon. Because hexagons have a constant shape and size and are easily aggregated or tessellated, they overcome many problems associated with delineating species ranges using county boundaries (Boone 1996). The BRC effort was overseen by NatureServe, with staffs from the NHPs, Maryland Department of Natural Resources (MDDNR), and U.S. Fish & Wildlife Service (USFWS) involved in data gathering and development.

Although the Maryland and Delaware BRC projects were completed in draft form in 1997, there were erroneous records along the Virginia-Maryland border which were not corrected until the BRC project was finalized in July of 2002. The New Jersey BRC project was initiated much later, and was initially intended to cover only half of the state, but with assistance from the USFWS, this project was extended to cover the entire state. The New Jersey BRC data were made available in July of 2002, when the data sets for the other states were finalized. The BRC dataset formed the basis for the range-mapping component of the MDN-GAP.

The species records associated with each hexagon include a code indicating the level of certainty of breeding occurrence for the species, as shown in Table 2.2. In general, only those records with "probable" or "confident" levels of certainty were used. However, there were cases where a hexagon with a "possible" level of certainty was surrounded by hexagons with higher levels of certainty, and was therefore included in the modeling. There were also cases where new information or personal knowledge provided justification for inclusion of additional hexagons in a species range limits within the project area. The BRC data were used for most common species, and for some rare species, including three of the four modeled taxa (mammals, reptiles, amphibians) in New Jersey, where availability of NHP data was limited. An example of a hexagon-based range map is shown in Figure 2.1.

Table 2.2: Codes Indicating Level of Certainty of Species Breeding Occurrence in Hexagon (Hernandez 2002)

LEVEL OF CERTAINTY	EXPLANATION IN NUMERICAL TERMS	BASIS FOR LEVEL OF CERTAINTY OR EXAMPLES
Confident / Certain	>95% certainty that the species occurs in the hexagon -- species is confidently assumed or known to occur in the hexagon	recent, field-verified element occurrence record in the heritage database, museum record, or a verified observation; the species' habitat is believed still present in the hexagon; and the species is not a vagrant nor is it known to have undergone any local decline that would lead one to expect that it was not still currently present
Predicted / Probable	>= 80% certainty that the species occurs in the hexagon -- species is predicted to occur in the hexagon based on the fact pattern (e.g., presence of suitable habitat or conditions and historical record and/or presence in adjacent hexagon(s))	hexagon is well within the range of the species and suitable habitat is believed to be present but its occurrence in the hexagon was not known to be confirmed by the developer of this data file
Possible	10%-80% estimated likelihood of occurrence in the hexagon -- species possibly or potentially occurs in the hexagon	hexagon occurs at the edge of the species range, or the species is quite rare and sporadically distributed such that there is less than an 80% probability that it is present in the hexagon

For most rare, threatened, or endangered species, a separate range database was created, with most records coming from the Natural Heritage Programs, and the smaller 7.5-minute quadrangle unit was used. Natural Heritage Program data covering all of New Jersey could not be obtained, so BRC data were used for all species in this state, with the exception of rare, threatened, or endangered birds, for which BBA data were used to populate quad-level records. Rules regarding levels of certainty of occurrence were essentially the same in the Natural Heritage Program data and the BBA data. An example of a quad-based range map is shown in Figure 2.2. Investigators for this project had originally intended to run models at both the quad level and the hexagon level for all species, in order to compare the results of the two approaches, but available resources for this three-state project were inadequate to allow this extra level of effort. There was also an interest in running bird models using the BBA blocks, each of which is one-sixth of a 7.5-minute quadrangle, but this extra initiative was also foregone due to inadequate project resources.

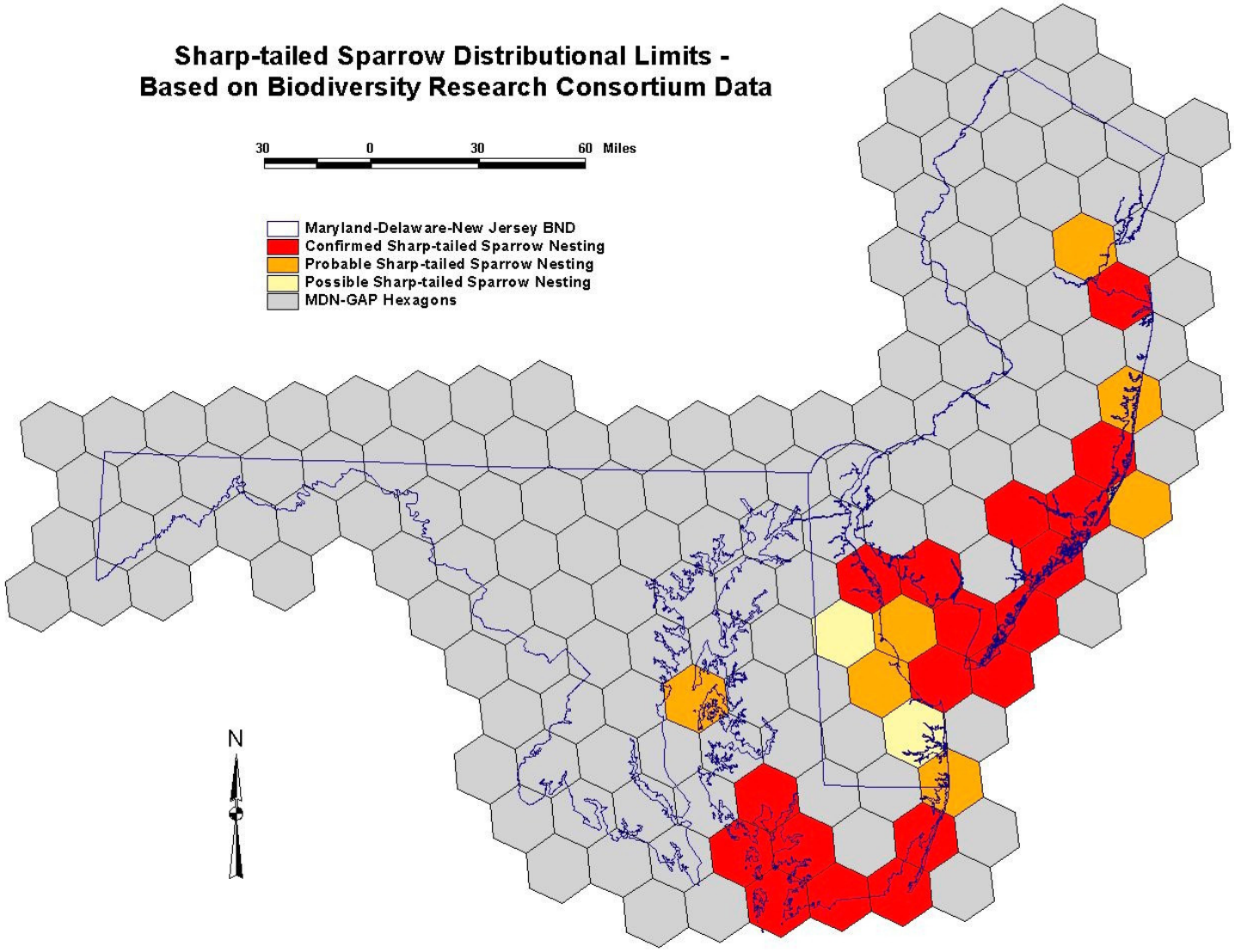

Figure 2.1: Example of a Species' Range by Hexagon

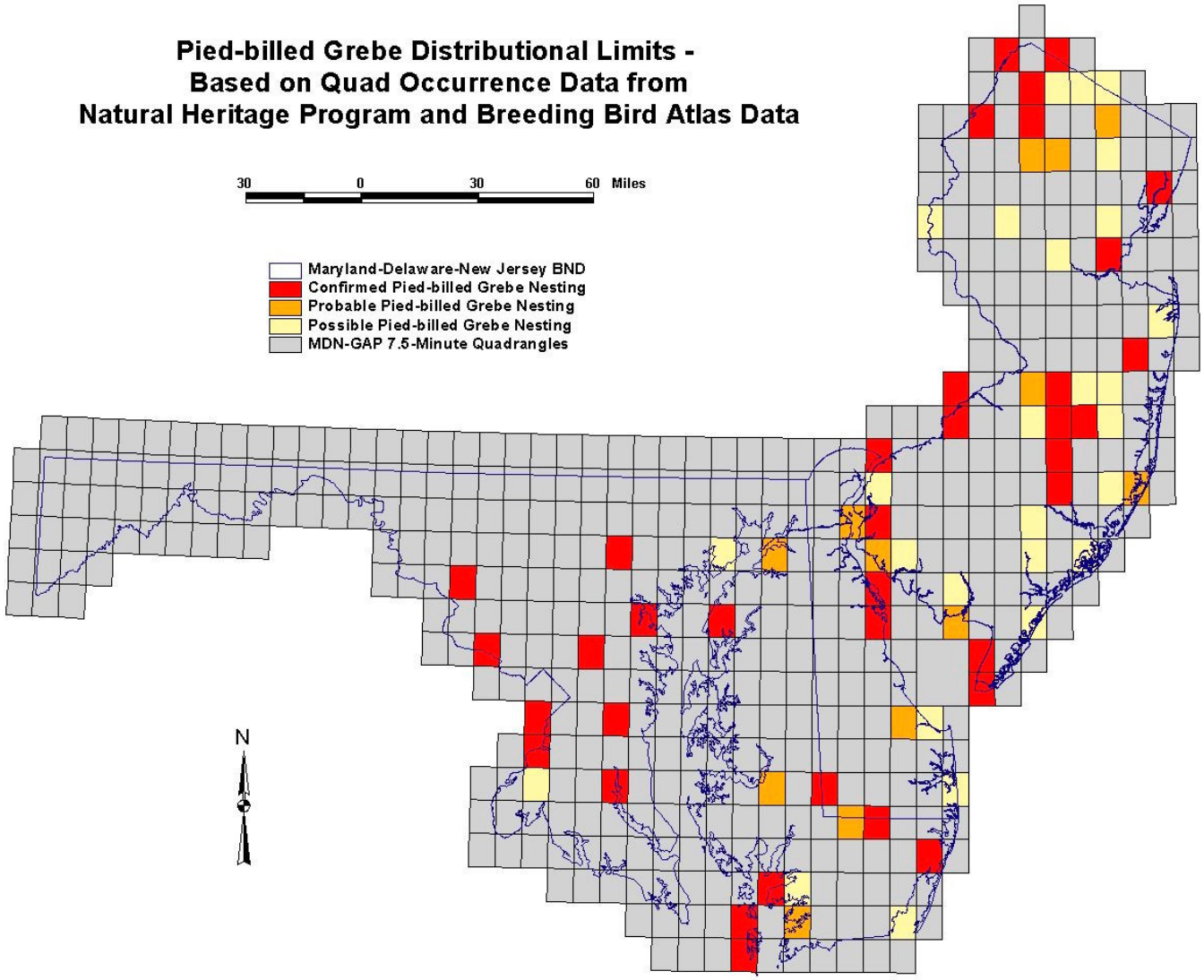

Figure 2.2: Example of a Species' Range by 7.5-Minute Quadrangle

Due to the delays in completing the BRC projects for Maryland, Delaware and New Jersey, some of the final revisions to the BRC data set were not incorporated into the range data tables used in the modeling. However, all species ranges were reviewed internally, and most, if not all, of the errors were discovered and corrected. In addition, there are still some known problems with the final BRC data set that were addressed in the modeling (e.g., range data for the red squirrel in the Coastal Plain of Maryland and Delaware are considered erroneous). This internal review also led to the development of "estimated" ranges for some, mostly common, species. Estimated ranges generally included "possible" hexagon occurrences that were surrounded by hexagons with higher levels of certainty of occurrence. However, in a few cases, hexagons were added based on new information.

There were also examples of subspecies with differing habitat requirements which necessitated separate models and then a merging of model results. For example, there are two subspecies of the deer mouse, *Peromyscus maniculatus,* within the project area. One subspecies, the woodland deer mouse, *P. m. maniculatus,* is generally restricted to woodland habitats, while the other subspecies, the prairie deer mouse, *P. m. bairdii*, is generally restricted to open, herbaceous habitats. Both subspecies occur within the project area, but their ranges are not completely overlapping. Therefore, separate range (hexagon) data were developed at the subspecies level, the two subspecies were modeled separately, and the results were merged into a final species-level model. Similar issues were addressed in much the same way for two subspecies of copperhead, *Agkistrodon contortrix,* which has a northern subspecies that uses rocky habitats, and a southern subspecies or intergrade that is found in swamps. There are also two subspecies of the eastern earth snake, *Virginia valeriae*, one of which is a rare subspecies found only in the mountains, and two subspecies of swamp sparrow, *Melospiza georgiana*, one of which is found primarily in and around tidal marshes, while the other is found primarily around inland, non-tidal marshes. Because the latter two subspecies have separate breeding ranges within the project area, species-level modeling would have resulted in many errors of commission. Although the National GAP standards and the BRC range data do not support subspecies-level modeling, this extra level of effort was deemed necessary in a few cases in order to achieve accurate model results.

2.2.3 Habitat Modeling Grids

2.2.3.1 Habitat Types

The primary species habitat modeling layer, one that was included in the modeling equations of all species, was the Habitat Types grid, which was based on the GAP Land Cover, National Land Cover Data (NLCD), and National Wetlands Inventory (NWI) data. Authors who have identified and described wildlife habitat types in the eastern United States include DeGraaf and Rudis (1986), Benyus (1989), DeGraaf et al. (1991), Hamel (1992), and Robbins and Blom (1996). Many additional efforts have been made to classify plant communities without regard for the vertebrates occupying the community. These include Harshberger (1970), Brush (1975), Brush et al. (1980), the Society of

American Foresters (Eyre 1980), TNC in conjunction with state Natural Heritage Programs (Sneddon et al. 1994; Sneddon and Berdine 1995; Clancy 1996; Clancy 1998; Sneddon 1999), and the Federal Geographic Data Committee (FGDC) (1997). Additional efforts have been focused on classifying natural communities, with consideration given to both plant and animal communities (Kricher 1988, Breden 1989, Berdine 1998, Sneddon 1998). Cowardin et al. (1979) provide a classification of wetland and aquatic communities based on plant species composition, hydrology, and other factors. Finally, Anderson et al. (1976) have provided a classification of land use/cover types, including urban and agricultural areas.

A key step in vertebrate distribution modeling is to provide a cross-walk from habitat associations in the literature to land cover types generated in the land cover mapping phase. We were constrained on several levels with regards to this objective. First, land cover mapping was conducted concurrently with the vertebrate distribution modeling, and land cover types were unavailable until late in the vertebrate modeling phase. Second, very little of the available literature on species-habitat associations was specifically focused on the mid-Atlantic region, and some sources that were focused on the mid-Atlantic were not available until late in the vertebrate modeling phase (e.g., Walsh et al. 1999, Hess et al. 2000, Hulse et al. 2001,White and White 2002). Finally, many of the sources did not consider the full range of potential habitat types available, but were limited in their scope (forests and wetlands exclusively, for example).

As a consequence of these limitations, we chose to develop a standard list of wildlife habitats (termed 'Habitat Types') for the project. They represent distinctions likely to have unique assemblages of terrestrial and amphibious vertebrates, or a unique combination of occupancy and utilization by terrestrial or amphibious vertebrates (i.e. foraging, nesting, denning, overwintering, aestivation, etc.). Species' responses to environmental parameters in habitat selection vary from species to species, but key parameters influencing distribution often include geographic context (latitude/longitude, elevation, etc.), microclimate, plant community composition, vegetative structure, ground conditions (leaf duff, soil type) and wetness (xeric, mesic, wetland hydrology). Additional parameters might include wetland salinity, special habitat features (e.g., rock outcroppings), and the degree of human disturbance. The habitat types were developed with primary consideration given to these parameters and their effects on species distributions. The steps taken in developing the final list of Habitat Types and their descriptions were as follows:

1. A literature review was conducted of key sources representing authors who had classified habitats or community types for the eastern U.S. based on either animal communities (DeGraaf and Rudis 1986, Benyus1989, DeGraaf et al. 1991, Hamel 1992) or plant and animal communities in combination (Kricher 1988). The classifications they derived, including primary plant species composition, were summarized in a document (Appendix B).

2. A spreadsheet of primary classifications from these sources was compiled. From this, new categories were derived which captured similar classifications from multiple authors. These 'habitat types' were named identically or with similar naming conventions to source classification names. The spreadsheet is included in Appendix C.

3. Aquatic habitat descriptions were developed based on modifications of Cowardin et al. 1979) and additional information from Tiner (1985), and urban and agricultural habitats were modified from Anderson et al. (1976), based on known vertebrate use of these areas.

4. Finally, the list was refined based on consultation with numerous other community classification schemes, including Harshberger (1970), Brush (1975), Brush et al. (1980), Eyre (1980), Breden (1989), Sneddon et al. (1994), Sneddon and Berdine (1995), Clancy (1996), Robbins and Blom (1996), FGDC (1997), Berdine (1998), Sneddon (1998), and Sneddon (1999). In addition, a partial crosswalk was developed from the Habitat Types to TNC's Alliances (Sneddon 1999), with reference to Gleason (1963). While consulting these sources, numerous habitat types were added in cases where identified plant communities had no previous representation in the Habitat Types classification, but were very likely to support distinct animal communities. The final list of 103 Habitat Types is included in Appendix D**,** and definitions are provided in Appendix E. Crosswalks between many of the Habitat Types and Alliances are available in Gorham and McCorkle (2006).

Once the list of habitat types was finalized, a table was built for use in cross-walking GAP Land Cover classes or aggregations of classes into the Habitat Types. In reviewing the draft GAP Land Cover as a part of this process, the decision was made to integrate National Wetlands Inventory (NWI) data and National Land Cover Data (NLCD) into the final habitat grid. This decision was based on several findings related to the GAP Land Cover, among those being: 1) it included only two water classes, which would be problematic for modeling certain species' or animal groups' distributions (e.g., amphibians), 2) there were forest classes that included both upland and wetland forests, 3) many wetland classes appeared to be under-mapped, compared with NWI, 4) many areas known to be relatively pure hardwood forests were mapped as mixed forests, 5) Atlantic white cedar swamps were found to be under-mapped in New Jersey, 6) bald cypress swamps were mapped in New Jersey, where this swamp association does not naturally occur, 7) water features larger than the stated minimum mapping unit were missing from the Land Cover in some geographic areas, but were included in both the NWI and NLCD, 8) steep slopes and cliffs along rivers were mapped as water in some areas, 9) there was only one urban developed land use class, 10) certain special wetland types that might potentially be derived from NWI, and that are very important to particular animal communities, were not included (e.g., vernal pools), and 11) coastal plain alliances or associations were mistakenly mapped in the mountains and montane alliances or associations were mistakenly mapped on the coastal plain.

Because the draft land cover layer did not line up well with NWI, NLCD, or USGS 1:100,000 scale roads and hydrography, a third-order polynomial rubber sheet transformation was applied using the WARP command in ARC/INFO GRID, using these other data sets for control point links. NWI data were then aggregated into 32 wetland classes corresponding with habitat types defined for this habitat layer. Extra steps were needed for some wetland habitats, such as vernal pools which required selection of only those wetlands that were isolated and had hydrology modifiers indicating at least seasonal inundation, and, from this subset, further selection based on wetland size (area < 2 ha) and shape (Patton Circularity Shape Index of <= 1.6). In addition, tidal wetlands with the oligohaline modifier were lumped with freshwater tidal wetlands (also including riverine tidal classes), and deciduous needle-leaved forest classes were assumed to be bald cypress swamps on Delmarva and tamarack swamps in northern New Jersey. Finally, near-shore estuarine and marine open water classes were defined as being within 300 m of shore, with offshore classes being more than 300 m from shore. Once all wetland polygons were reclassified to the habitat classes, the coverage was converted to a grid.

The NWI habitat grid had two-digit values and was multiplied by 1,000 to produce five-digit values ending with three zeros. The NLCD grid also had two-digit values, and was multiplied by 100,000 to produce seven-digit values ending in five zeros. The GAP Land Cover grid had three-digit values, and was added to each of the above grids, producing a grid having seven-digit values with the first two digits indicating the NLCD class, the next two digits indicating the NWI class, and the final three digits indicating the GAP Land Cover class. A cross-walk table was created and used for reclassifying the various combinations of NWI, NLCD and GAP Land Cover. In general, the resulting habitat class was determined by agreement between at least two of the input grids, but in cases where there was no agreement, the default was generally the GAP Land Cover classification. The primary objectives of this approach were to: 1) improve wetlands mapping in the habitat grid, especially with regards to those wetlands that were excluded from the GAP Land Cover as a result of the minimum mapping unit (e.g., vernal pools); 2) improve agreement between the resulting habitat grid and the wetland "buffer" (i.e., proximity) layers produced for the modeling (see section 2.2.3.2); 3) improve agreement between the habitat grid and the forest fragmentation grids which were based on the NLCD; 4) create distinct water habitat classes, since the GAP Land Cover had only two water classes, and wildlife species respond differently to several different aquatic habitats (e.g., pond, lake, lower perennial river, upper perennial river, tidal river, bay, ocean); 5) make a distinction between upland and wetland classes sharing similar vegetation that were lumped into one class in the GAP Land Cover; 6) better define wetland classes based on the NWI hydrology modifiers (e.g., saturated versus inundated); and 7) create additional distinctions in anthropogenic land uses. The cross-walk table referred to above is too large to be included in the appendices of this report, but will be provided either as a supplement to the final habitat modeling layer or may be obtained from the contact listed in its metadata.

After the cross-walk-driven reclassification was completed, additional refinements were required. For example, a physiographic province grid was used to create masks for

reclassifying GAP Land Cover classes which were inappropriately classified relative to physiographic province (e.g., montane classes within the Coastal Plain). In addition, aspect was used to reclassify various habitats. For example, on the coastal plain and piedmont where the northern mixed forest habitat (containing hemlock) is rare except on north-facing slopes (e.g., steep, north-facing slopes along the shores of the Chesapeake Bay), any northern mixed forest habitat cell with an aspect between 45 and 315 degrees (i.e., not north-facing) was reclassified to a different forest type – often mid-Atlantic oak-pine.

Aspect was also used to a limited extent to separate two other forest types: northern oak and oak-hickory, with the former generally occurring on north- or east-facing slopes in cooler, often more mesic conditions on deep soils, and the latter generally occurring on south- or west-facing slopes in warmer, drier conditions on thinner soils. However, this distinction was only deemed necessary for two GAP Land Cover classes that lumped both forest types together: 1) "Red Oak-White Oak" which is described as being mesic to dry and includes dry, acidic oak-hickory forests as well as northern aspect, mesic forests, and 2) "Mixed Oak-Sugar Maple" which is described as including stunted oak-hickory woodlands on talus slopes with thin, dry, acidic soils, and oak-sugar maple forests on deep, moist to well-drained loams and silt loams on north and east mid-slopes and coves. Because these lumpings create problems from a wildlife habitat perspective, it seemed appropriate to use aspect to separate them. Cells from these two Land Cover classes were reclassified to the oak-hickory habitat type if they had an aspect between 135 and 260 degrees. If their aspect was between 280 and 360 degrees, or between 0 and 100 degrees, they were reclassified to northern oak.

An elevation mask was also used to separate various habitats: Northern hardwood generally occurs above 1000 meters in the mid-Atlantic; the mixed mesophytic forest habitat generally occurs between 300 and 1000 meters; and the low-elevation mesic hardwood habitat was defined as occurring below 300 m. A slope mask was used for the high-elevation and mid-elevation woodland classes, which are defined as xeric woodlands on steep, usually south-facing, slopes. Woodlands occurring on southern aspects (135 to 260 degrees), on slopes greater than 100 percent, at elevations above 500 meters, were classified as high-elevation woodlands. Woodlands occurring within the same slope and aspect ranges, but occurring at or below 500 meters, were classified as mid-elevation woodlands.

Unclassified, isolated patches of water cells (i.e., that did not correspond with NWI and were not contiguous with a classified aquatic habitat) were assigned unique values by zone (i.e., contiguous patch of water cells) using REGIONGROUP, and were then classified by size to either "lake" or "pond," based on the Cowardin (NWI) definitions for these water classes. In general, an isolated patch of water greater than 8 hectares in size was classified as a lake, and a patch less than 8 hectares was classified as a pond. Unclassified water cells that were contiguous with classified aquatic habitats were dealt with using a nearest-neighbor reclassification.

While oligohaline tidal marshes were lumped with freshwater tidal habitats, based on the NWI oligohaline modifier, another approach was needed to separate salt marshes from brackish marshes. Salinity maps for the Chesapeake and Delaware Bays were found in Funderburk et al. (1991) and in Sutton et al. (1996), respectively. These maps were used as a reference in creating salinity masks to separate salt and brackish marshes, with brackish marshes ranging between 5 and 18 parts per thousand salinity, and salt marshes ranging between 18 and 30 parts per thousand. Oligohaline marshes range between 0.5 and 5 ppt salinity.

A hemlock data set, created by the New Jersey Department of Environmental Protection (NJDEP), was converted to a grid in the appropriate projection and used to select corresponding forest. Where one or more of the three primary data sources (GAP Land Cover, NLCD, NWI) indicated a conifer-dominated or mixed forest, the habitat was classified as either Northern Conifer or Northern Mixed Hardwood - Conifer, both of which are defined to include hemlock where the habitat occurs on a north-facing aspect or in other cool, shaded situations (e.g., ravines). If the majority of the three primary data sets indicated a hardwood-dominated forest, then the habitat was usually classified as Low Elevation Mesic Hardwood, which is also defined to sometimes include hemlock, as long as the elevation criterion was met.

Feedback from a New Jersey GAP research associate indicated that Atlantic white cedar swamps were under-mapped in the GAP Land Cover. An Atlantic white cedar swamp data set, also created by the NJDEP, was converted to a grid in the appropriate projection and used to select corresponding forest. Where one or more of the three primary data sources (GAP Land Cover, NLCD, NWI) indicated a conifer-dominated or mixed forested wetland, the habitat was classified as Atlantic White-Cedar Swamp.

There was also a slope-related issue which was discovered in the western Maryland GAP Land Cover. Cliff shadows along the Potomac River were classified as water, and NWI was used to more accurately define the river's extent in this area. The remaining cells were reclassified to the "cliff" habitat type, except where the NLCD provided vegetated classes which were classified to various steep-slope vegetated habitat types.

Prior to finalizing the Habitat Types grid, unresolved cells were reselected and any contiguous clusters of 5 or more cells (0.45 ha) were identified using REGIONGROUP. These clusters were reevaluated and classified to the most appropriate habitat type. Once these clusters were classified, a nearest neighbor classification was applied to the remaining, unclassified cells. A map of the Habitat Types in New Jersey is shown in Figure 2.3.

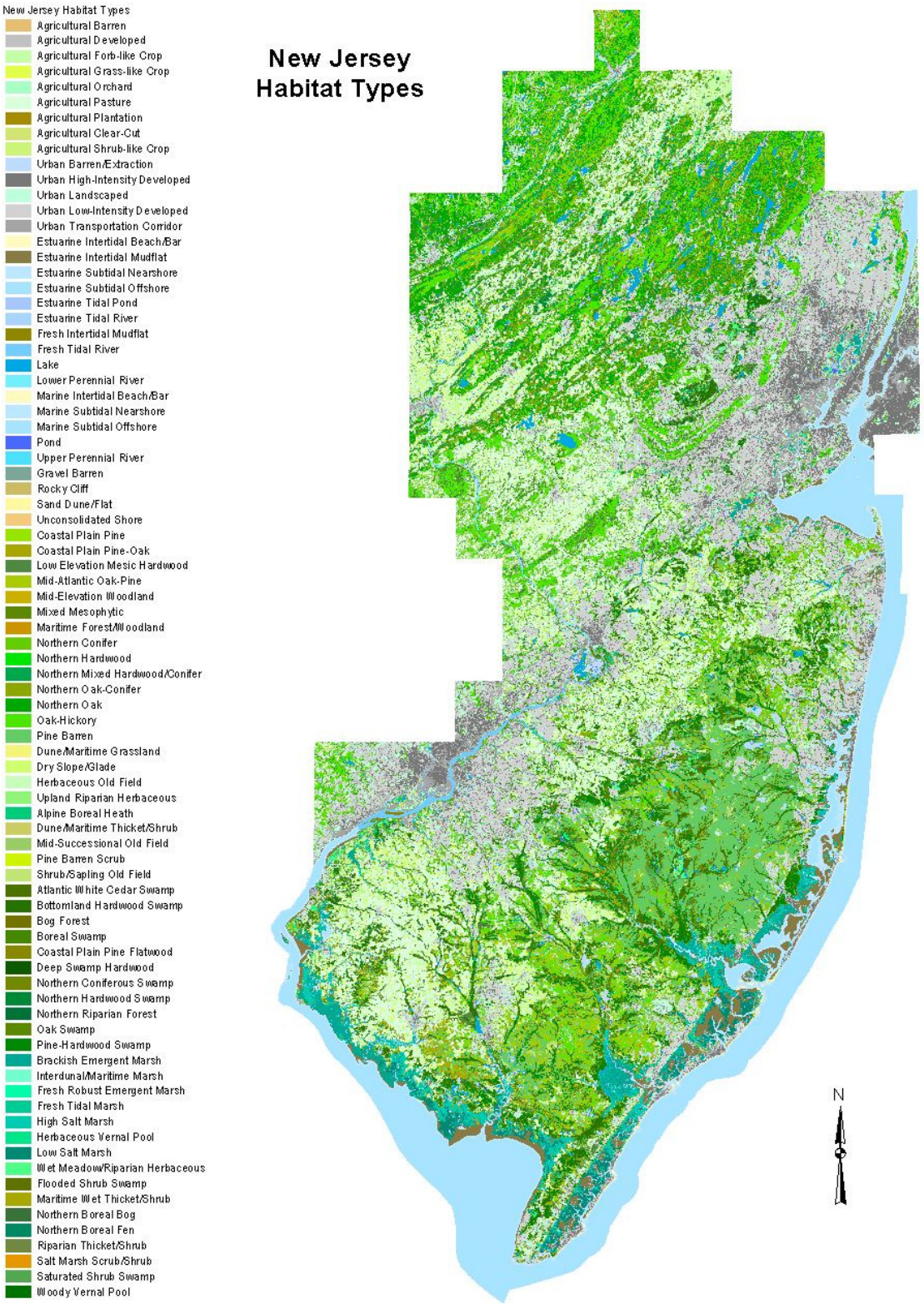

Figure 2.3: Habitat Types in New Jersey

Of the 103 habitat types which were defined for this project, several were not mapped for various reasons. For example, sparsely vegetated habitats such as "outcrop" and "gravel barren" were generally not mapped because these classes were not captured in the GAP Land Cover. Cliff data became available after this habitat grid was finalized. There are many cells which should be mapped as the cliff habitat type, but are mapped as other types. Although the "seep" habitat type is thought to be important for several amphibian species, this was not mapped because it generally occurs as a very small feature on the landscape and it could not be derived from the GAP Land Cover or other ancillary data. Some habitat types were not defined but, in retrospect, should have been defined and mapped (e.g., impoundments, aquatic beds). With regards to minimum mapping unit, this data set is relatively good in terms of completeness. NWI data were used to capture vernal pools and farm ponds as small as 0.09 hectare (0.22 acre; one 30-m cell), which were otherwise smaller than the minimum mapping unit of the GAP Land Cover. A possible drawback to this is the earlier vintage of the NWI (generally 1980s), which may have led to some errors of commission where such features have been lost through development or conversion to agriculture, but such errors were generally avoided where both the GAP Land Cover and the NLCD indicated an anthropogenic land use class.

A very important habitat which could not be included in the habitat layer was the "stream" habitat type, since most streams are much narrower than a 30-m cell. If NWI and USGS mapped a water feature as a polygon, then it was included in the habitat layer, but if the water feature was captured only as a linear (non-polygonal) feature in both of these data sets, then it could not be included in the habitat layer. This necessary omission was compensated for by a separate wetland/water feature buffer (proximity) modeling layer which is described below. Finally, the NLCD developed by EPA was used to add small woody habitats (i.e., smaller than the 2-ha minimum mapping unit of the GAP Land Cover) to the habitat layer, since these habitats are important to edge species. These cells were generally classified as Mid-Successional Old Field since they were mostly disturbed, edge habitats.

2.2.3.2 Wetland Buffers

To some degree, many animal species are associated with wetlands. Some species are almost always found near wetlands, and studies of certain species groups indicate predictable numerical relationships. For example, adult salamanders (n = 265) of six species (*Ambystoma jeffersonianum, A. maculatum, A. opacum, A. talpoideum, A. texanum, A. tigrinum*) were found an average of 125.3 m from the edge of aquatic habitats during the non-breeding portions of their life-cycles, and a wetland buffer zone of 164.3 m (534 ft) could be expected to encompass the majority of the population of these salamanders during their entire life cycle (Semlitsch 1998). The spotted turtle (*Clemmys guttata*) is generally found within 500 m of a wetland (Whitlock 1994). Gardner (1982) stated that the Virginia opossum (*Didelphis virginiana*) requires considerable amounts of water to avoid dessication, and accessibility of surface water may be critical to suitable opossum habitat. Sandridge (1953) found that the greatest distance between any opossum den and a source of drinking water was approximately 366 m (1,200 ft) [In Gardner 1982]. In a study of the habitat requirements of the osprey (*Pandion haliaetus*), Ewins

(1997) found that 93% of 179 tree nests were within 500 m of water, and the median distance to water for tree nests was 10 m (vs. 4 m for nests on artificial platforms) [In Poole et al. 2002].

In some cases, numerical data are not provided, but authors state that a species is generally found "close to streams," "along stream margins," "along swamp margins," or "in floodplains." In these cases, knowledge of the species' home range size was used in assigning the species to one of four wetland buffer distances. The four "buffer" distances chosen for inclusion in modeling the habitat requirements of species that most commonly occur near wetlands were 100, 250, 500, and 1000 m. In addition, fourteen general wetland types were identified as being important to one or more species: 1) stream, 2) river (both tidal fresh and non-tidal), 3) lake, 4) pond, 5) swamp (forested), 6) shrub swamp, 7) saturated/temporary, 8) vernal pool, 9) fresh marsh (non-tidal), 10) fresh tidal marsh, 11) salt/brackish marsh complex, 12) estuarine river/stream/pond, 13) salt bay, and 14) ocean. A table of species-wetland buffer relationships was created for each of the four taxa (birds, mammals, reptiles, amphibians), and four "hypergrids" were created, one for each buffer distance, by combining the buffers of the 14 wetland types according to the following methods:

NWI served as the primary data source for developing this modeling layer. Wetlands were aggregated into most of the types listed above based on NWI codes (see Cowardin et al. 1979) which indicate wetland SYSTEM (e.g., estuarine), SUBSYSTEM (e.g., intertidal), CLASS (e.g., emergent), and, in some cases, SPECIAL MODIFIERS (e.g., oligohaline). In addition, the Patton Circularity Shape Index was calculated for certain palustrine wetlands in order to develop a subset of wetlands meeting one of the identified criteria for vernal pools. Other criteria for vernal pools included size (area < 2 ha), and hydrology (NWI hydrologic modifiers indicating at least seasonal inundation). All of the wetland buffer types listed above were derived from NWI, with the exception of the "stream" wetland type, which was created from USGS DLGs (see below). The resulting wetland coverage was converted to 13 separate grids, one for each wetland type. The EUCDISTANCE command was then applied to each GRID, to buffer the wetlands to each of the four buffer distances (100 m, 250 m, 500 m, 1 km), creating four separate grids for each of the 13 wetland types. This approach is cleaner than buffering polygons in a vector format.

The USGS 1:100,000 Hydrography data were used to develop the stream component of the wetland buffer grids. Using NWI, a "salt mask" was created, which was essentially a polygon that included all estuarine tidal wetland areas, but excluded those with the oligohaline modifier. This polygon was intersected with the preliminary stream coverage, and all stream segments occurring within that area were deleted, leaving just those stream segments outside of the saltwater tidal areas. The final stream coverage was buffered to the four buffer distances, and these coverages were converted to grids. The stream segments that fell within the salt mask were also buffered and converted to grids, as were NWI line features falling within this zone, and the resulting grids were merged with the Estuarine River/Stream/Pond wetland buffer grids created in the previous step.

The final Wetland Buffer modeling layers were created by combining the individual component grids (stream, river, lake, pond, swamp, shrub swamp, saturated wetland, vernal pool, fresh marsh, fresh tidal marsh, salt/brackish marsh, estuarine river/stream/pond, salt bay, and ocean), each buffered to four distances (100 m, 250 m, 500 m, 1 km) for a total of 56 separate buffer grids, into 4 binary-coded "hypergrids," one for each buffer distance, such that the placement of the character in the binary code denotes the wetland type. An AML, written by Jason Karl (Idaho Cooperative Fish and Wildlife Research Unit) for use in combining final species models into multiple-species hypergrids, was used to combine the different wetland buffers into the hypergrids.

It should be noted that, for all modeling variables, a control table determined whether or not a particular modeling variable was "required." If a variable was required (e.g., species is restricted to habitats that are within 100 meters of a particular wetland type), then the final mapped species distribution was "clipped" by that variable. Conversely, if the control table indicated that a particular variable was not required by the species, then portions of the species' distribution influenced by that variable might receive a higher overall suitability ranking in the final results, but the species' distribution would not be excluded from areas outside of the influence of that variable.

2.2.3.3 Forest Fragmentation Variables

The conservation of birds requires an understanding of their nesting requirements, including area as well as structural characteristics of the habitat (Robbins et al. 1989). Several studies have shown that many bird species seem to depend on extensive forested areas to support viable breeding populations. (Robbins et al. 1989, Keller et al. 1993, Kilgo et al. 1998, Whitcomb et al. 1981, Lynch and Whigham 1982, Anderson and Robbins 1981, Robbins 1979), and forest area requirements have been summarized by various authors (Hamel 1992, bushman and Therres 1988, Rosenberg et al. 1999). Species that appear to be sensitive to forest fragmentation are sometimes referred to as forest interior-dwelling (FID) species or forest area-dependent (FAD) species. There are some species that are sensitive to forest patch isolation, requiring a large amount of overall forest cover, but which do not necessarily require forest interior. Therefore, the latter of the two terms is more applicable to this aspect of the modeling.

FAD species were defined as species showing a significant ($p < .05$) negative response to forest fragmentation in one of any number of published studies conducted in the eastern United States. The typical research approach and analysis in studies of this nature involves breeding season point counts or transects, detailed measurement of vegetation and other environmental variables, including fragmentation metrics, at point count locations, and analysis including stepwise multiple regression to identify which environmental variables are significant predictors of nesting occurrence.

Modeling FAD species distributions required the development of three forest fragmentation data layers, based on metrics identified as significant in published studies. These were forest patch size measured by zonal thickness, riparian forest width, and the

percent of forest within 2 km as a measure of forest patch isolation. These metrics are illustrated in Figure 2.4.

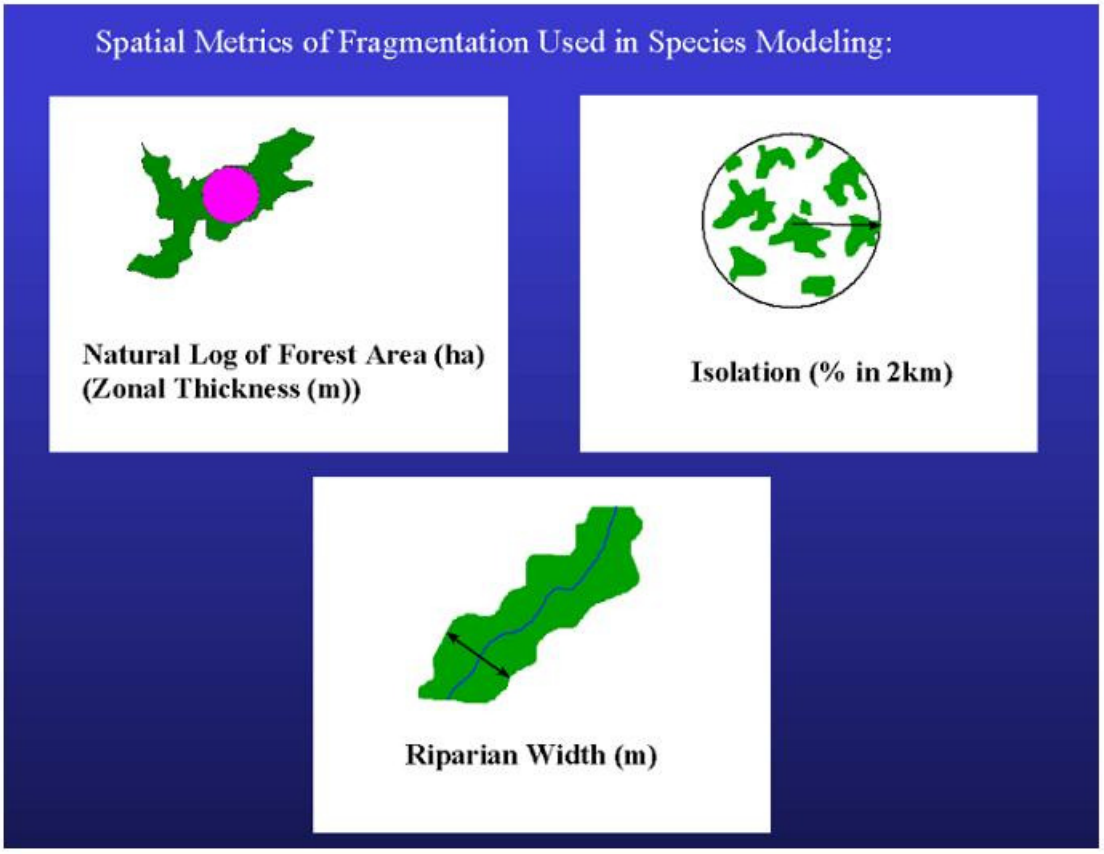

Figure 2.4: Forest Fragmentation Metrics used in Habitat Modeling.

Suitability of values in the fragmentation layers for each species was determined on a species by species basis from probability curves output from logistic regression analysis (see Figure 2.5). Data from two primary studies, Robbins et al. (1989) and Keller et al. (1993), were used for this process. The latter study was used for riparian dependent species, and the former for other species. Probability curves are species specific, with the x axis on these curves representing the fragmentation metric, and the y axis representing the probability of occurrence for that species. Fragmentation metric values corresponding with 80% of the maximum occurrence of a species were considered optimal, values corresponding with 50% of the maximum were considered suitable, and values corresponding with 20% were considered marginal. Values less that 20% of the maximum were not considered habitat. Table 2.3 provides a summary of the fragmentation metrics and the suitability thresholds used on a species by species basis.

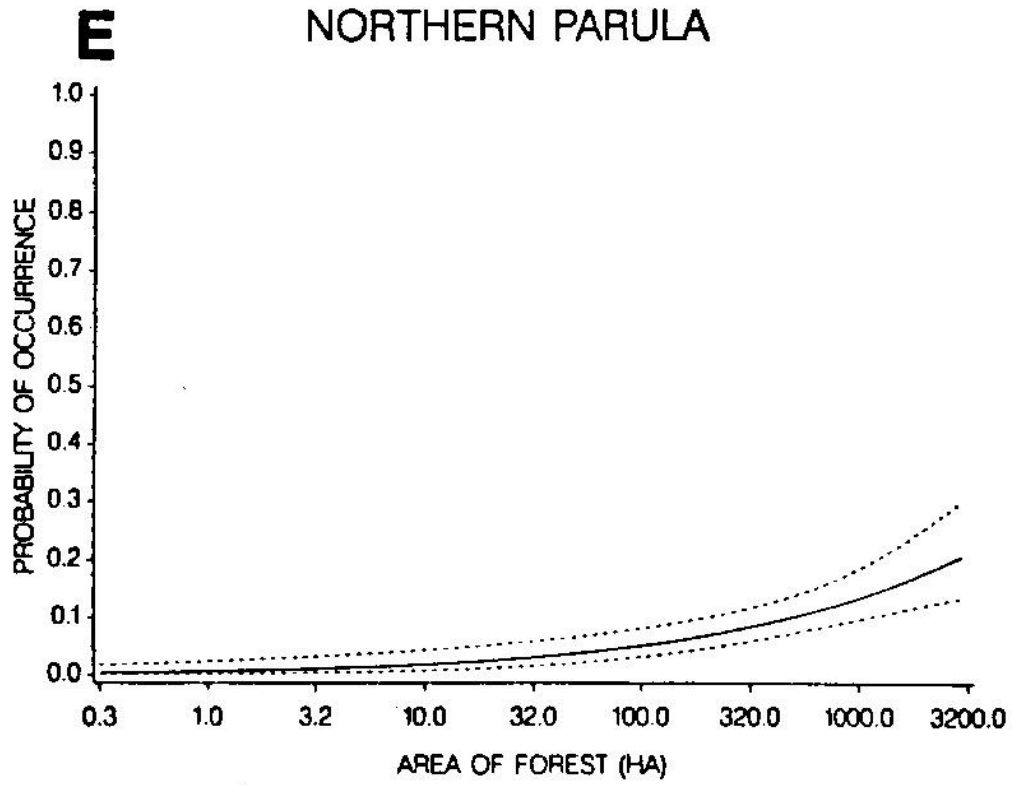

Figure 2.5: Example of Probability Curve (Robbins et al. 1989).

ZONALTHICKNESS is an ARC/INFO GRID function which measures the radius of the largest circle that will fit within a zone, in this case a forest patch. This was used as a surrogate for forest patch size because it provided an automated way to reduce the forest interior value of irregularly shaped patches or long linear forests; these forest patches were manually eliminated in the published studies we evaluated. A calibration of zonal thickness to the forest patch size as determined in the field studies was conducted from records of the original point locations (Figure 2.6).

Table 2.3: Modeling Parameters and Suitability Thresholds for Area Sensitive Species

	Significant	Modeling parameters			
	(P<.05)	variable	minimum	mid range	high range
SPECIES	(any study)	used	(>marginal)	(>suitable)	(>optimal)
Red-shouldered hawk	yes	IS2	37.2	71.1	90.1
Barred owl		RIP	188.3	580.8	1159.9
Pileated woodpecker	yes	LAR	11.6	164.9	974.5

	Significant	Modeling parameters			
	(P<.05)	variable	minimum	mid range	high range
SPECIES	(any study)	used	(>marginal)	(>suitable)	(>optimal)
Hairy woodpecker	yes	LAR	1.4	6.5	367.1
Acadian flycatcher	yes	LAR	0.2	14.7	389.8
Yellow-throated vireo	yes	IS2	36.6	69.9	89.5
Red-eyed vireo	yes	LAR	0.3	2.3	16.2
White-breasted nuthatch	yes	LAR	0.5	1.5	193.9
Brown creeper	yes	IS2	58.4	81.5	93.9
Blue-gray gnatcatcher	yes	LAR	0.8	13.7	452.7
Veery	yes	LAR	4.1	49.6	712.3
Wood thrush	yes	LAR	0.2	0.2	26
Northern parula	yes	LAR	65	528.3	1674.6
Black-throated blue warbler	yes	LAR	523.3	1079.3	1630.7
Cerulean warbler	yes	LAR	115.8	713.9	1872.9
Black-and-white warbler	yes	LAR	12.2	224.8	1219.4
American redstart	yes	IS2	15.8	61.9	87.2
Prothonotary warbler	yes	RIP	121.8	261.7	562.6
Worm-eating warbler	yes	LAR	5.8	153.2	1055.4
Swainson's warbler	yes	RIP			
Ovenbird	yes	LAR	0.8	9.1	232.9
Northern waterthrush	yes	LAR	16.7	190	855.8
Louisiana waterthrush	yes	RIP	121.3	262	580.8
Kentucky warbler	yes	RIP	5.3	47.3	716.5
Hooded warbler	yes	IS2	14.6	58.9	85.4
Canada warbler	yes	LAR	56.2	369.8	1116.2
Summer tanager	yes	LAR	0.8	47.4	736.1
Scarlet tanager	yes	LAR	0.9	12	128.8
Rose-breasted grosbeak	yes	LAR	1.1	1.1	88

LAR - area of forest stand (ha) as modeled by Robbins et al. (1989)
IS2 - forest isolation measured as % forest within 2 km radius as modeled by Robbins et al. (1989)
RIP - riparian forest width as modeled by Keller et al. (1993)

minimum: area/percent/width where modeled frequency of detection = 20% of maximum (marginal 20-49%)
mid range: area/percent/width where modeled frequency of detection = 50% of max. (suitable 50-79%)
high range: area/percent/width where modeled frequency of detection = 80% of max. (optimal 80-100%)

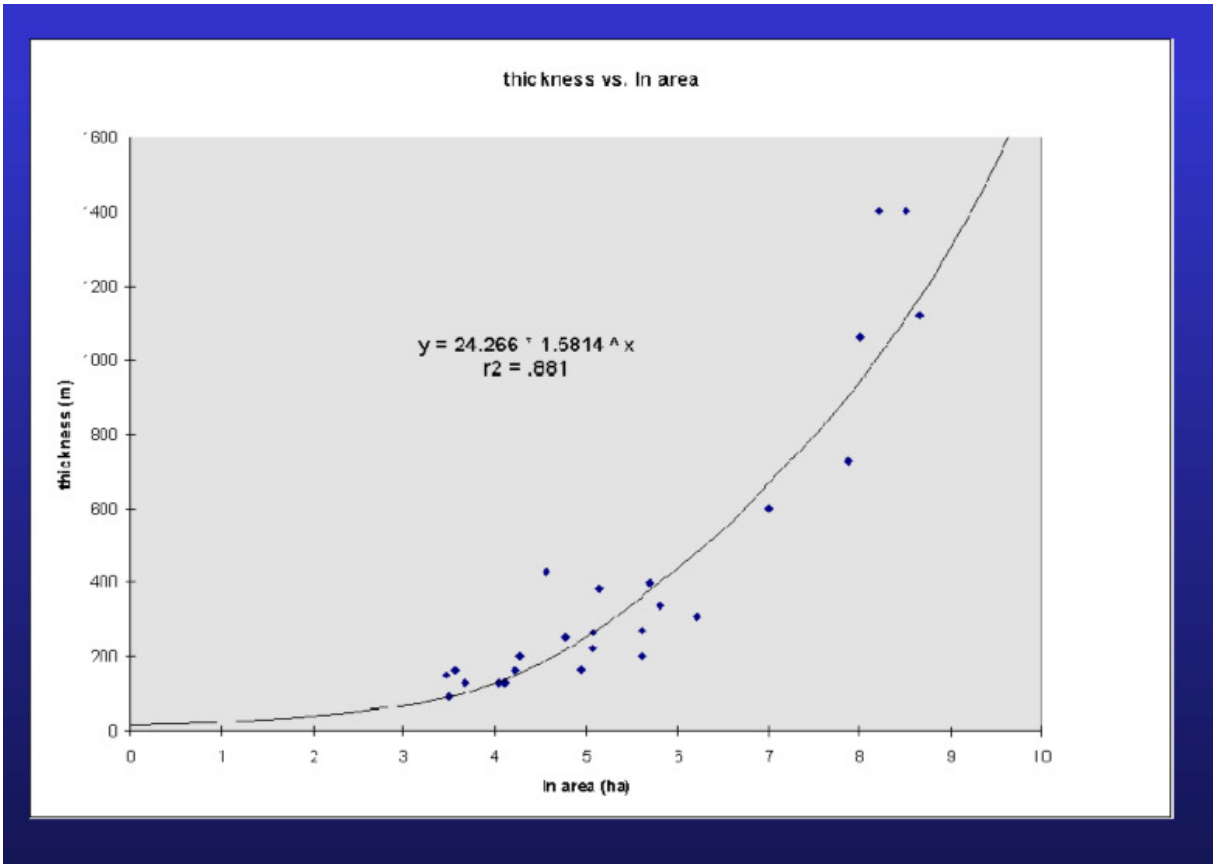

Figure 2.6: Correlation of Zonal Thickness and Natural Log of Forest Area as determined in Robbins et al. (1989).

The first step in developing the forest area modeling grid was to select forest classes and other woody classes from the NLCD, and apply various processes and filters to the data in order to: 1) eliminate small forest openings (< 1ha) not considered substantial enough to affect FAD species occurrence, and 2) separate forest patches tenuously connected so they would be considered separately in zonal thickness analysis. USGS class 1 and 2 (major) roads data were also used to separate tenuously connected forests. The selected line coverage for major roads was converted to a grid, merged with the forest grid, and then set to NODATA to create this separation. Secondary and other minor roads were assumed to be insignificant in terms of breaking the continuity of a forest patch. Although the distinction between major and minor roads is somewhat arbitrary and subjective, it was driven by a preliminary evaluation of the forest patch grid in which forest patches that appeared to be separate and distinct, and were bisected by major highways, were nevertheless tenuously connected in the NLCD. By comparing bird populations in forests on both sides of power-line and road corridors of different widths,

Robbins et al. (1989) determined that gaps of 100 m or more produced isolation characteristics in the small fragments created.

After applying the major roads grid to achieve some separation of forest patches, the SHRINK command was used in GRID to create further separation between patches. Next, two filters (majority filter and focal majority) were applied to eliminate small (e.g., single-cell) openings in the canopy, essentially smoothing the forest patch grid in order to obtain more accurate zonal thickness (i.e., forest patch depth) measurements. These processes are described in greater detail in the metadata that accompanies this modeling grid. Once the filters were applied, the EXPAND command was applied to expand the forest patches back to their original sizes.

After the forest data were smoothed and tenuously-connected patches were separated, REGIONGROUP was used to assign each spatially distinct forest patch a unique value. This allows the final processing step, measurement of zonal thickness, to evaluate each distinct patch separately. Prior to this final step, a mask was applied to eliminate distinct patches having a count of less than or equal to 10 (i.e., less than 1 ha), including forest canopy openings below this threshold. Such openings would generally be less than 100 m wide, regardless of shape. The ZONALTHICKNESS measurement was then used to measure the maximum depth into a forest patch. A map depicting forest area as measured by ZONALTHICKNESS is shown in Figure 2.7.

The width of riparian forests was also determined from zonal thickness analysis, which was applied to all forests adjacent to wetland or water features. In this case, the radius of the largest circle becomes a direct measure of one-half the width of the riparian forest.

For the forest patch isolation modeling layer, the chosen metric was based on the approach used by Robbins et al. (1989), where patch isolation is related to percentage of forest cover within 2 kilometers of the site being evaluated. After reclassifying NLCD to forest (value = 100) and non-forest (value = 0), a FOCALMEAN process was run in GRID in order to develop this modeling layer. This process measured the percentage of forest cover within a 2-kilometer radius of each grid cell. A map depicting forest patch isolation in Delaware is shown in Figure 2.8.

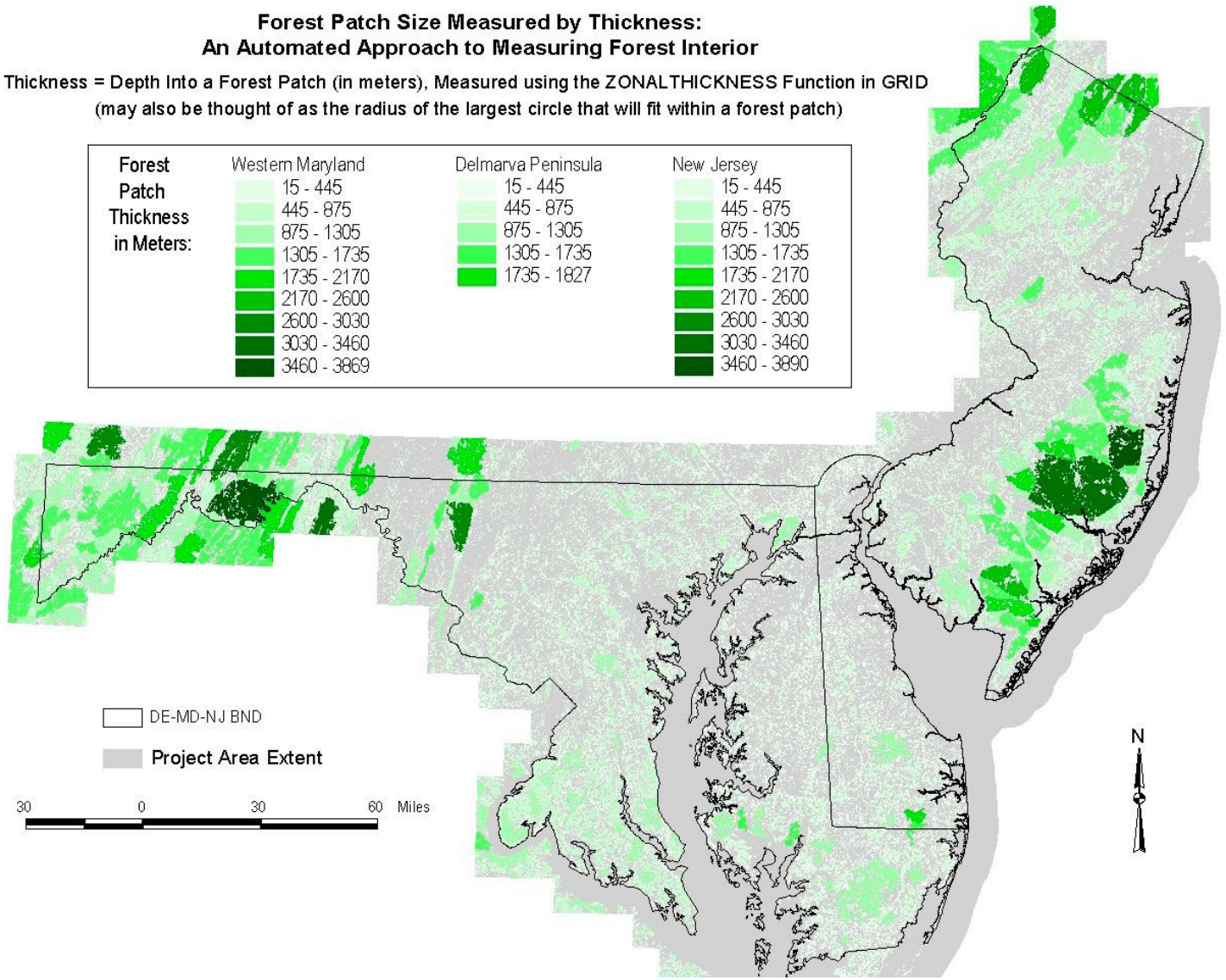

Figure 2.7: Map Depicting Forest Area Metric

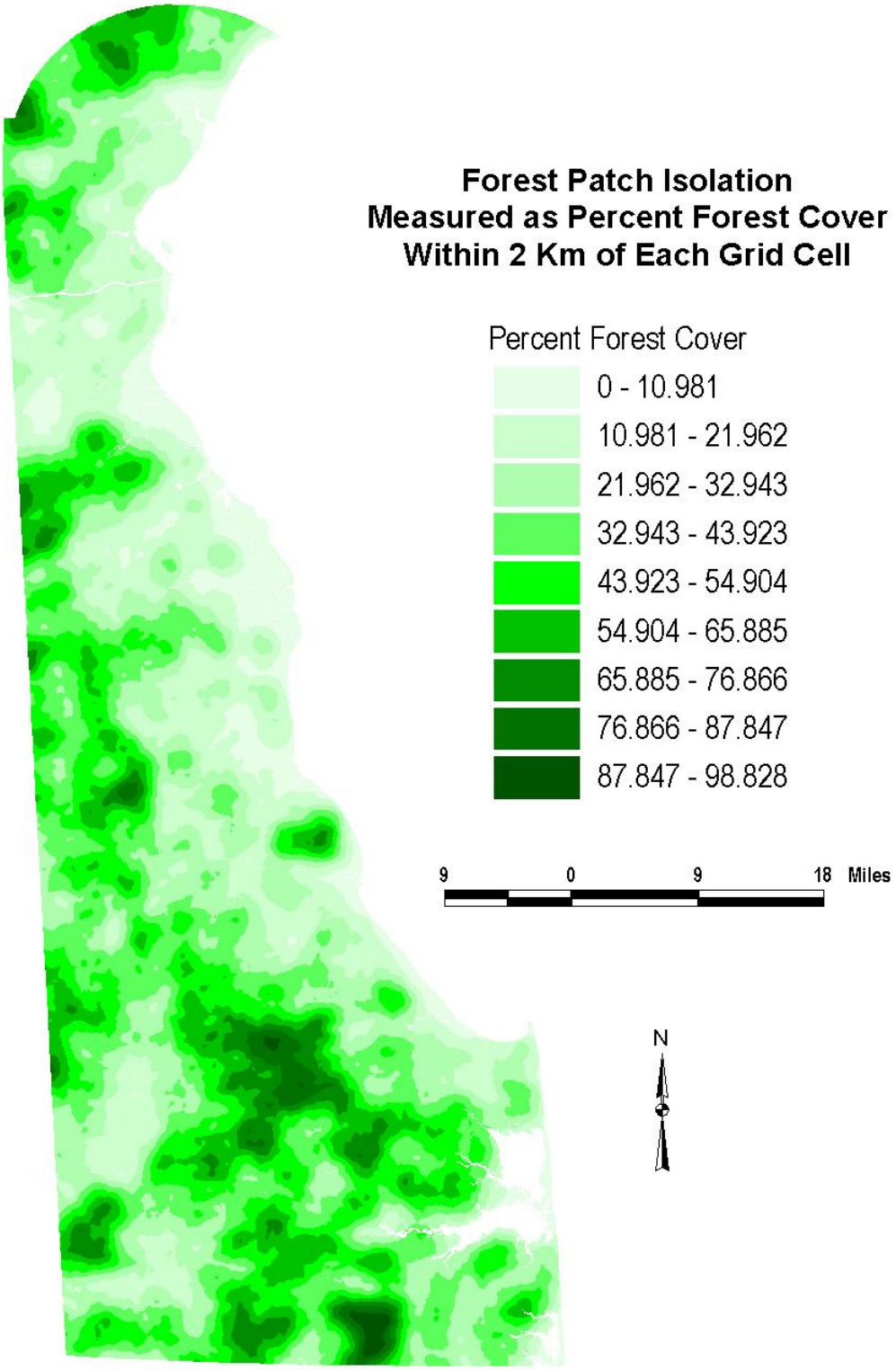

Figure 2.8: Forest Patch Isolation in Delaware

2.2.3.4 Open - Grassland Area

Just as many forest-dependent birds are area-sensitive, many grassland birds also require large, contiguous habitat patches to maintain viable breeding populations. Habitat area requirements for grassland birds were taken from several studies (Jones and Vickery unpubl., Swanson 1996, Samson 1980, Smith 1992, Smith 1991, Herkert 1994b, Herkert 1991) and minimum suitability thresholds were defined for each species. The process by which the grassland area modeling grid was created was essentially the same as that used to create the forest area grid. The herbaceous habitats evaluated included herbaceous old field, upland riparian herbaceous, maritime grassland, wet meadow, fresh marsh, herbaceous vernal pool, fresh tidal marsh, brackish marsh, low salt marsh, high salt marsh, maritime marsh, forb-like crop, grass-like crop, pasture, clear-cut, and agricultural barren / fallow. Note that, although many of these habitats are not generally used by grassland species, they would not constitute "breaks" in grassland area where they are contiguous with appropriate grassland habitat, and unsuitable habitats would be eliminated as a result of the "habitat type" selection part of the modeling. The northern harrier is known to be area-sensitive and prefers high marsh habitats.

2.2.3.5 Open - Edge Habitat

While some species require large, contiguous patches of habitat, far away from edges, other species prefer edges. For these species, an Edge habitat grid was created. This involved first reclassifying all woody habitats into one class and all non-woody habitats into another class. A EUCDISTANCE process was then applied to each, separate class, with a specified maximum distance of 300 meters. This upper threshold was based on a study that found that nest parasitism by brown-headed cowbirds decreased with distance away from forest edge, but extended >= 300 meters into the forest (Brittingham and Temple 1983). Based on this and other information, it was decided that a distance of 300 m, extending in both directions away from an edge, should encompass most of the activities and habitat needs of "edge" species. Once Euclidean distance was applied to both grids (woody and non-woody habitats), the two results were merged.

2.2.3.6 Land Form (Elevation, Slope, and Aspect)

Elevation, Slope and Aspect are also important variables for determining the distributions and preferred habitats of some species. These modeling grids were derived from the National Elevation Data (NED) set. Elevation is expressed in meters. Because the NED has a 30-m cell resolution, elevations were averaged over a 900 square-meter area for each cell. Therefore, slope is based on the relationships among cells with averaged elevation values, and this data set is only accurate for coarse-scale analyses (e.g., 1:100,000-scale or greater). The DEMGRID command was used in ARC/INFO GRID, to create the elevation grid. The SLOPE command was used in GRID, with the PERCENTRISE option, to create the slope grid, and the ASPECT command was used to create the aspect grid, which has values ranging from 0 to 359 degrees.

2.2.3.7 Road Juxtaposition

For a small number of species, studies have indicated a negative response to roads and a positive correlation with distance from roads (Clark et al. 1993, Gibbs 1998). A road

juxtaposition grid was developed for use in modeling these species' distributions. USGS 1:100,000-scale roads were appended into a seamless coverage for the project area, all road classes except for class 5 (trails) were selected and converted to a 30-m grid, and the EUCDISTANCE command was used in GRID to create a grid depicting road proximity. The value for each cell in this grid represents the distance of the cell from the nearest hard-surfaced road.

2.2.3.8 Forest Juxtaposition

There are many animal species that can be found in open, non-forested habitats during some part of their life cycle or while meeting some life history requirement, but are generally found in close proximity to forest and depend on forest habitats for meeting some of their needs. For these species, a forest juxtaposition modeling grid was created. This grid was initially created with mole salamanders in mind. These salamanders, belonging to the genus *Ambystoma*, require upland forest habitat during the non-breeding portions of their life cycles, when they spend most of their time in underground burrows, under logs, and in moist leaf duff. They generally require relatively closed canopy conditions, high ground-level moisture, and the presence of leaf duff and coarse woody debris in various stages of decomposition.

Because different forest associations exhibit these characteristics to different degrees (e.g., northern oak vs. coastal plain pine), the first step in developing this modeling layer involved creating a system for ranking different forest types for their ability to satisfy the requirements of these salamanders. A table was developed for ranking all woody habitats based on four characteristics: 1) canopy closure, 2) coarse woody debris, 3) leaf duff, 4) moisture (see Table 2.4). These rankings were subjective, but considered necessary since some woody habitats meet the non-breeding habitat requirements of these species better than others. Woody habitats received scores between 0 and 100, with 100 representing optimal forest conditions. Non-woody habitats were assigned a value of 0. The Habitat grid was then reclassified, according to this ranking system. Because a broad range of conditions may be aggregated into a particular habitat type, none of the woody habitats received an optimal ranking, although this aspect of the modeling may need revisiting.

Table 2.4: System for Ranking Salamander Non-Breeding Habitat

Note that all herbaceous and anthropogenic habitats (with the exception of PLANTATION and CLEARCUT) were assumed to have no value as non-breeding habitat for the subset of species for which this habitat modeling variable was developed (i.e., mole salamanders, other forest-dependent amphibians). Although this is a very subjective ranking process, based on habitat descriptions, it is still preferable to treating all woody habitats as equally good, in terms of meeting the non-breeding habitat needs of these species. Some summer draw-down and/or microtopographic diversity in wetlands is assumed, and ranking considers a range of conditions lumped into each habitat type.

HT_CODE	HABITAT TYPE	CWD	DUFF	MOIST	CANOPY	AVG
UF.BOCO	BOREAL CONIFER	50	25	50	50	44
UF.BOHA	BOREAL HARDWOOD	75	75	50	50	63
UF.BOMI	BOREAL MIXED HARDWOOD-CONIFER	75	50	50	75	63
UF.NOCO	NORTHERN CONIFER	50	25	50	75	50
UF.NOOK	NORTHERN OAK	100	75	50	100	81
UF.NOOC	NORTHERN OAK-CONIFER	100	50	50	100	75

HT_CODE	HABITAT TYPE	CWD	DUFF	MOIST	CANOPY	AVG
UF.NOHA	NORTHERN HARDWOOD	100	75	50	100	81
UF.NOMX	NORTHERN MIXED HARDWOOD-CONIFER	75	50	75	100	75
UF.MIME	MIXED MESOPHYTIC	100	75	75	100	88
UF.APCO	APPALACHIAN COVE HARDWOOD	100	75	75	100	88
UF.PIBA	PINE BARREN	50	25	25	50	38
UF.OKHK	OAK-HICKORY	100	75	50	100	81
UF.MAOP	MID-ATLANTIC OAK-PINE	75	50	50	75	63
UF.LEMH	LOW ELEVATION MESIC HARDWOOD	100	100	75	100	94
UF.CPPI	COASTAL PLAIN PINE	50	25	50	75	50
UF.CPPO	COASTAL PLAIN PINE-OAK	75	50	75	100	75
UF.HEWL	HIGH-ELEVATION WOODLAND	50	25	0	50	31
UF.MEWL	MID-TO LOW-ELEVATION WOODLAND	50	50	25	50	44
UF.MTFW	MARITIME FOREST/WOODLAND	25	25	25	50	31
WF.BOFO	BOG FOREST	25	25	75	50	44
WF.BOSP	BOREAL SWAMP	50	25	75	50	50
WF.NCSP	NORTHERN CONIFEROUS SWAMP	50	25	75	50	50
WF.NHSP	NORTHERN HARDWOOD SWAMP	75	25	75	75	63
WF.AWCS	ATLANTIC WHITE-CEDAR SWAMP	50	25	75	50	50
WF.CYSP	BALDCYPRESS SWAMP	75	25	50	50	50
WF.BHSP	BOTTOMLAND HARDWOOD SWAMP	75	25	75	75	63
WF.DSPH	DEEP SWAMP HARDWOOD	75	25	50	50	50
WF.CPPF	COASTAL PLAIN PINE FLATWOOD	50	25	75	50	50
WF.OKSP	MIXED OAK SWAMP	75	25	75	75	63
WF.PHSP	COASTAL PLAIN PINE-HARDWOOD SWAMP	50	25	75	75	56
WF.NORI	NORTHERN RIPARIAN	75	25	75	75	63
US.ABHT	ALPINE/BOREAL HEATH	0	25	25	25	19
US.KRUM	KRUMMHOLZ	25	25	25	25	25
US.MHTB	MONTANE HEATH THICKET/BALD	0	25	25	25	19
US.SSOF	SHRUB/SAPLING OLD FIELD	25	25	25	25	25
US.MSOF	MID-SUCCESSIONAL OLD FIELD	50	50	25	50	44
US.PBSC	PINE BARREN SCRUB	25	25	0	25	19
US.DMTS	DUNE / MARITIME THICKET / SHRUB	0	0	0	25	6
WS.NBBO	NORTHERN/BOREAL BOG	25	25	50	25	31
WS.NBFE	NORTHERN/BOREAL FEN	25	25	50	25	31
WS.SMSS	SALT MARSH SCRUB	25	0	25	25	19
WS.MWTS	MARITIME WET THICKET/SHRUB	25	25	50	25	31
WS.WVPO	WOODY VERNAL POOL	50	50	75	50	56
WS.SSSP	SATURATED SHRUB SWAMP	25	25	75	25	38
WS.FSSP	FLOODED SHRUB SWAMP	50	25	50	25	38
WS.RITS	RIPARIAN THICKET/SHRUB	25	25	75	25	38
AN.APLA	AGRICULTURAL PLANTATION	25	0	25	50	25
AN.ARCL	AGR. REGENERATING CLEARCUT	50	50	25	25	38

CWD = RELATIVE AMOUNT OF COARSE WOODY DEBRIS IN HABITAT
DUFF = RELATIVE AMOUNT OF DECIDUOUS LEAF DUFF ACCUMULATION
MOIST = RELATIVE MOISTURE AT GROUND LEVEL (MOIST, BUT NOT WET, OPTIMAL)
CANOPY = RELATIVE AMOUNT OF CANOPY / SHADE
AVG = AVERAGE RATING (CWD + DUFF + MOIST + CANOPY) / 4

A FOCALMEAN process was then applied to the reclassified Habitat grid. This process assigned to each cell a value representing the average value for all cells within a 240-meter (8-cell), circular neighborhood. This radius was a compromise between the terrestrial life zone (zone surrounding amphibian breeding habitat such as a vernal pool) requirement recommended by Semlitsch (1998) and the often-cited, more generous upland forest buffer requirement of 250 meters. Note that the Semlitsch recommendation of a 164-meter buffer zone is expected to encompass 95% of vernal pool-breeding amphibians, but was thought to be an underestimate for some species (e.g., eastern newt, *Notophthalmus viridescens*). In the modeling, this forest juxtaposition grid causes a vernal pool in the middle of a farm field to get a lower suitability ranking than that of a vernal pool in the middle of a hardwood forest.

Although this grid was developed primarily for use in modeling the habitats and distributions of vernal pool-breeding salamanders, it was included in the models of several other species that use non-forested habitats but are generally found in close proximity to forests. For these species, the bias toward certain forest types was taken into consideration, and this modeling variable was appropriately weighted in the modeling equation such that this bias would not have an inappropriate influence on the final results.

2.2.3.9 Special Habitat Features

In addition to demonstrating an affinity for certain plant communities, land form characteristics that influence these communities, and juxtaposition of habitats, there are also special habitat features that many animal species use or require. Some of these features cannot be included in landscape-scale mapping (e.g., nest cavities or boxes), while others can be mapped at such scales if data are available. Of the many special habitat features identified, only five were included in the final modeling: 1) island, 2) cave, 3) outcrop, 4) cliff, and 5) dam/bridge. There were other special habitat features that were considered important and mappable, including shale barrens and vertical stream banks (for bank swallow colonies), but data could not be obtained in time for inclusion in the modeling. Four buffer distances, 100 m, 2 km, 7 km, and 15 km, were chosen to cover the range of distances found in the literature for species that use these features.

2.2.3.9.1 Island

The Island special habitat feature is important for colonial-nesting herons, egrets, gulls and terns, which often nest most successfully on islands where human disturbance and predation are minimized. An Island data set was created by the Maryland Department of Natural Resources (MDDNR), but it covered only the Maryland portion of the three-state project area. This data set was created from National Wetlands Inventory data and personal knowledge. Vegetated wetland and upland polygons surrounded by water were selected to create this data set. Additional islands were similarly selected for Delaware and New Jersey.

2.2.3.9.2 Cave

A Caves (and mines) point coverage was provided by MDDNR, Wildlife and Heritage Division, along with criteria for evaluating the suitability of each cave for meeting the

habitat requirements of bat species that depend on these special features. MDDNR also obtained New Jersey cave data, and added these points to the data set. Not all caves in the point coverage were considered suitable habitat for species that use caves. The database associated with the point coverage included comment fields and other fields that evaluated caves in terms of elevation, mineral type (e.g., limestone, marble, sandstone, dolomite, shale, etc.), access (i.e., does the cave have an opening to allow wildlife access), length (e.g., cave length is positively correlated with bat use), air flow (indicates two or more entrances, complexity, chimney effects, and generally required for bat use), and known bat use. Cave suitability variables were based on Raesly and Gates (1987) and Navo (1994).

The variables and the scores given for each variable are shown in table 2.5. The scores were tallied for each cave to select a final subset of caves to be buffered and used in the habitat modeling for bats and other cave-dependent species. The highest possible score was 10, and the score was divided by 10 to obtain an index.

Table 2.5: Variables used in evaluating suitability of caves for bat use

VARIABLE		SCORE
Passage Length	< 100’	1
	100-700’	2
	700-1100’	3
	1100-2400’	4
	> 2400’	5
Mineral Type	Soft Rock	1
	Hard Rock	2
Air Flow	Yes	1
	No	0
Known Bat Use	Yes	2
	No	0

The final subset of caves included in the Special Habitat Features layer included only those caves with a suitability index of >= 0.5, with one exception -- a cave having a score of 0.4 that has water, supports a salamander population, and is rich in invertebrate fauna (note that the cave buffer component of the Special Habitat Features layer was also used in modeling the habitats of a few salamander species that are associated with caves).

2.2.3.9.3 Outcrop

Outcrop data were not available, so all caves and mines, including those that did not meet the cave criteria, are included in this coverage, even though some may not have corresponding outcrops. Most of the species associated with outcrops are responding more to the presence of subterranean habitats associated with these outcrops than they are to the surface of the outcrop. The assumption is that where there are caves or mines,

there are also likely to be rock outcrop formations. However, it is recognized that the caves data set is a poor substitute for an accurate accounting of outcrops and that this surrogate includes only a subset of outcrops found in the project area.

2.2.3.9.4 Cliff

Initially, no cliff data were available, so an analysis was undertaken to compare known cliff locations with slope data. It was determined that all known cliffs (e.g., those named on topographic maps) were associated with slopes >= 110% in the NED-derived slope data. Grid cells associated with slopes < 110% were reclassified to nodata, and the remaining grid cells were reclassified to zero, to create a preliminary cliff layer, which became the final cliff layer for New Jersey. A comparison of this final data set with known cliff locations along the Hudson River and upper Delaware River indicates a reasonably accurate result. Cliff data for western Maryland became available later in the project, through the Ecological Land Unit (ELU) data set created by The Nature Conservancy. ELUs are unique combinations of three primary factors (elevation, lithology, landform), that are important to the distribution and abundance of ecological communities in an ecoregion. A 90-m Digital Elevation Model was used in combination with a bedrock lithology coverage to derive the elevation zone, landforms, and geology classes used to model ELUs. The final cliff layer for western Maryland was derived from the Central Appalachian ELU data set.

2.2.3.9.5 Dam/Bridge

This component of the Special Habitat Features layer was originally intended to include both dams and bridges, but ultimately included only bridges. It was created by intersecting roads with streams and open water (DLGs and NWI). Although, in many instances, bridges are not present at stream crossings (i.e., instead there may only be a small culvert, if the stream is small), this was the only approach available at the time to create a bridge feature layer for modeling the habitats of bird species that are known to nest under or on bridge structures, over streams or open water (e.g., peregrine falcon, cliff swallow, barn swallow). Overpasses and underpasses were also extracted from the 1:100,000-scale Digital Line Graph transportation data set, using minor codes identifying these features, but these data, which may have improved modeling for certain avian species (e.g., rock dove), were excluded from the final Dam/Bridge data set. Because of the problems with this component of the SHF modeling layer, it was not used much in the modeling.

The first step in developing this component of the SHF modeling layer was to intersect 1:100,000-scale transportation DLG data with 1:100,000-scale hydrography DLG data and National Wetlands Inventory open water polygons. The intersecting road segments were then “reselected” into a new line coverage.

2.2.3.9.6 Combining Special Habitat Features

Once all of the individual Special Habitat Feature grids were created, they were either buffered and converted to grids (e.g., point and line coverages), or they were first converted to grids and EUCDISTANCE was run in GRID, the results being four separate

grids for each feature type, each having a buffer distance (100 m, 2 km, 7 km, 15 km) considered relevant to a particular species or group of species. The final SHF modeling layers were created by combining the individual component grids into four binary-coded "hypergrids," one for each buffer distance, such that the placement of the character in the binary code denotes the feature type.

Although there are intermediate buffer distances that would be more appropriate for certain species, an attempt was made to limit the number of grids for simplicity's sake. Another option that was considered would have involved creating separate modeling grids for each feature type, and then running EUCDISTANCE just once for each feature type without specifying an upper limit on distance, allowing for the selection of any buffer distance based on individual species' requirements. However, because the original concept for this SHF layer involved a large number of different feature types, this would have meant a much larger number of modeling grids to deal with, compared to the final set of four hypergrids.

2.2.4 Wildlife Habitat Relationships

2.2.4.1 MDN-GAP Species List

The list of species for which wildlife habitat relationships models were developed includes only those species that regularly breed within the project area. The Delaware Bay hosts one of the largest concentrations of migrating shorebirds in the Western Hemisphere (Senner and Howe 1984, Myers et al. 1987), and the wetlands associated with this bay and the Chesapeake Bay host large concentrations of migrating waterfowl. Many songbirds and raptors also pass through this region during migration. Various efforts are currently aimed at conserving the staging areas that support these large concentrations of migratory birds (e.g., Focus Areas under the Atlantic Coast Joint Venture of the North American Waterfowl Management Plan, Mid-Winter Waterfowl Survey, Partners In Flight, Twin Capes program for fall migrations, Western Hemisphere Shorebird Reserve Network designation of Delaware Bay as a Hemispheric Reserve, Ramsar designation of Delaware Bay wetlands as Wetlands of International Importance for migratory birds, National Audubon Society's designation of the Delaware Bay shoreline as an Important Bird Area, Shorebird Technical Committee under the Atlantic States Marine Fisheries Commission, The Nature Conservancy's Delaware Bayshore Project, and long-term shorebird population monitoring efforts in both Delaware and New Jersey). Unfortunately, although MDN-GAP investigators initiated efforts to include these important staging areas in the Gap Analysis, inadequate project resources prevented the completion of this component of the project. Therefore, users of the final MDN-GAP data sets should be aware of this omission, and should consider the results of this project as complementary to these other efforts when assessing biodiversity conservation priorities.

Within the three-state project area, there are 41 amphibian species, 47 reptile species, 69 mammal species, and 206 regularly-nesting bird species. These taxonomic groups combine for a total of 363 animal species for which wildlife habitat relationships models

and distribution maps were developed. Regularly-occurring non-native species were included in this total.

2.2.4.2 Development of Wildlife Habitat Relationships Models

Development of the Wildlife Habitat Relationships Models (WHRM) began with a compilation of habitat requirements information from available literature. A list of the most frequently referenced sources is provided in Appendix F. In addition to these sources, many species-specific studies were also utilized. A summary document of habitat requirements was created for each species, and that document was then referred to in filling out a standard form which was used for ranking each of the 103 habitats, in terms of suitability (unsuitable, marginal, suitable, highly suitable, optimal) for the particular species, as well as for providing numerical summaries of relationships with other modeling variables (e.g., relationship to wetlands, elevation, slope, aspect, special habitat features, etc.). A sample of one of the forms developed for the compilation of habitat requirements, the one used for birds, is shown in Appendix G. Separate forms were developed for each taxonomic group (birds, mammals, reptiles, amphibians).

Habitats were given suitability rankings from 1 to 4, with marginal habitats being assigned a value of 1, suitable habitats a value of 2, highly suitable (or preferred) habitats a value of 3, and optimal habitats assigned a value of 4. In determining habitat suitability based on associations described in the literature, terms such as “uses” or “is found in” were interpreted as indicating that a habitat is “suitable” (value = 2). Terms such as “favors” or “prefers” were interpreted as indicating that a habitat is “highly suitable” (value = 3). Terms such as “occasionally uses” were interpreted as indicating “marginal” habitat (value = 1). The value of 4 was reserved for rare cases where a habitat was considered “optimal.” In many cases, a suitability ranking may have been based more on the number of times that a habitat association was mentioned in the literature. If a particular habitat was not specifically mentioned or inferred through habitat descriptions, the suitability of that habitat was determined based on the shared characteristics of habitats that were described.

Once the habitat summary form was filled out, the numerical rankings and weightings were entered into the wildlife habitat relationships tables. These tables, and the range data tables, were stored in a Structured Query Language (SQL) relational database. For each taxonomic group (birds, mammals, reptiles, amphibians), a separate table was created for each of the modeling variables described in section 2.2.3. A modeling control table was also created for each group. This table controlled which modeling variables were used for each species, and the relative weight of each variable. The database was initially developed in Oracle v. 8.03, and was subsequently exported to Microsoft Access. It is currently maintained in MS Access 2002. The database tables which were used in the species habitat and distribution modeling are listed in Table 2.6.

Table 2.6. Database Tables Used in Modeling Species Habitat Relationships and Distritbutions

RANGE TABLES	**DESCRIPTION**
RAN_CONT	Controls which of three range mapping approaches is used: 1) BRC data, 2) EST (estimated) range, with added hexagons, 3) QUAD data (primarily for Rare, Threatened, or Endangered species)
AM_HEX, AV_HEX, MA_HEX, RE_HEX	For each taxonomic group, this table controls which hexagons are included in species' ranges, based on the Biodiversity Research Consortium (BRC) data set
AM_RAN, AV_RAN, MA_RAN, RE_RAN	Table controlling which hexagons are included in species' estimated (EST) ranges (BRC hexagons plus other hexagons added based on expert review)
AM_QUAD, AV_QUAD, MA_QUAD, RE_QUAD	Table controlling which 7.5-minute quadrangles are included in species' ranges (primarily for Rare, Threatened, or Endangered species)
HABITAT RELATIONSHIPS TABLES	**DESCRIPTION**
AM_CONT, AV_CONT, MA_CONT, RE_CONT	Table controlling which modeling variables (e.g., habitat type, wetland buffer, aspect) are included in each species' model, and also includes relative weightings for each variable
AM_EQ, AV_EQ, MA_EQ, RE_EQ	For each taxonomic group, this table stores the modeling equation for each species; modeling equations are similar to those used in Habitat Suitability Index (HSI) modeling
AM_HT, AV_HT, MA_HT, RE_HT	Table containing species-Habitat Type (e.g., Oak-Hickory Forest, Brackish Tidal Marsh) relationships data (i.e., suitability rankings)
AM_WB, AV_WB, MA_WB, RE_WB	Table containing species-Wetland Buffer (i.e., proximity) relationships data for each taxon
AM_FAD, AV_FAD, MA_FAD, RE_FAD	Table containing forest fragmentation metric (Area, Patch Isolation, Riparian Forest Width) relationship data for Forest Area Dependent (FAD) species (note that currently there are no data for reptiles)
AM_OPN, AV_OPN, MA_OPN, RE_OPN	Table containing species-Open habitat (i.e., Edge, Grassland Area) relationships data for each taxon
AM_LF, AV_LF, MA_LF, RE_LF	Table containing species-Land Form (i.e., Elevation, Slope, Aspect) relationships data for each taxon
AM_JUX, AV_JUX, MA_JUX, RE_JUX	Table containing species-habitat Juxtaposition (i.e., to roads, to forest) relationships data for each taxon
AM_SHF, AV_SHF, MA_SHF, RE_SHF	Table containing species-Special Habitat Features (e.g., island, cliff, cave) relationships data for each taxon

2.2.5 Distribution Modeling

SQL scripts which access the database were embedded in ArcView (v. 3.2) Avenue scripts, in a customized ArcView project herein referred to as the Species Conservation and Modeling (SCM) software (Gorham 1999). Open Database Connectivity drivers provide the link between ArcView and the database.

The SCM software allows a user to run models one at a time or in batches, and the user can also specify which range-mapping approach to use, as well as which modeling variables to include in the modeling equation. Otherwise, the SCM software defaults to the range approach and modeling variables specified in the control tables. There is also an option to extend a species distribution beyond range boundaries within suitable habitat patches. This is facilitated by the REGIONGROUP command which assigns a unique value to each suitable habitat patch. All suitable habitat patches that have at least one cell within the range unit boundaries are selected in their entirety and copied to the final grid representing the species' predicted distribution. This option provides a more natural-looking distribution, but was used conservatively to avoid overestimating species' distributions. In addition, this option resulted in greatly increased processing time for some species' models, in some cases taking longer than a week for a single model.

The basic modeling process involved the following steps, controlled by Avenue scripts within the SCM software:

1) control tables queried for specified range approach (BRC, EST, QUAD), and appropriate habitat variables and associated weightings
2) query results written to a habitat suitability index modeling equation which includes relative weightings, from control table, for each variable
3) modeling equation drives query of tables corresponding with selected variables for habitat suitability rankings assigned to different classes or ranges for each variable
4) query results drive selection of raster cells from associated modeling variable grids, and reclassification of those cells based on suitability rankings
5) reclassified raster grid cells from the selected grids (appropriate variables) are multiplied by weightings (variable's relative importance to species), taken from the control table, and added together (driven by model equation) to produce a final grid with cell values being the product of weight x suitability ranking

Below is the modeling equation for the black bear, *Ursus americanus*:

((0 * RANGE) + (1 * HABITAT) + (1 * (WETBUFF_1K) / 1) + (1 * (LANDFORM_ASP + LANDFORM_SLP) / 2) + (2 * (FADCOVERS_LAR) / 1) + (1 * (JUXTAPOSITION_RDS))) / 11
EXTEND RANGE

The resulting grid has a range of values falling between 0 and 100. The final step involves running an ARC/INFO AML which selects cells with values above a standard suitability threshold (generally above 50), which are then reclassified to 1,

with all other cells (below threshold) reclassified to 0. For some species, custom thresholds were set based on expert review.

2.3 Results

2.3.1 Birds

The degree of sophistication and accuracy in the bird habitat modeling varied greatly, depending on the species and the habitat variables that influence the species' habitat. For some species, GIS coverages representing important habitat variables were not available. For example, a stream-bank coverage would have greatly improved the modeling for the bank swallow (*Riparia riparia*). Because such a coverage was not available, the model for this species is considered to be of relatively poor quality. The same can be said for the purple martin (*Progne subis*) which relies more on human-provided nest-gourds or houses than on natural cavities which were historically important. Habitat structure appears to be very important for many bird species, including those that are most commonly associated with mature or old-growth forest, or those that require an open canopy with a well-developed shrub layer. Although a small pilot project was undertaken in the project area to map structure along transects using Light Detection and Ranging (LIDAR) technology, a comprehensive data set was not available for the project area.

For herons and egrets, island features were buffered based on known foraging distances from rookeries. However, there is often a directional component to these forays and, as such, distributions were overestimated for some of these species. Results were much better for other groups of species. For example, a great deal of information is available regarding forest patch size and isolation requirements of fragmentation-sensitive species like the cerulean warbler (*Dendroica cerulea*). GIS layers representing a few of these metrics were created and incorporated into modeling for these species, greatly improving model accuracy. Likewise, area requirements information was available for a group of grassland-nesting birds, allowing for the inclusion of area metrics in modeling for these species as well. Availability of National Wetlands Inventory data for the entire project area greatly improved model accuracy for many wetland-dependent species. Elevation thresholds were found in the literature for several bird species, and the use of elevation data in these models greatly improved results for these species.

Habitat models and distribution maps were developed for a total of 206 bird species, including a few exotic species. These included only those species that nest regularly within the project area. Earlier objectives included mapping of important over-wintering and migratory staging areas, but resource limitations precluded this. An example of a bird species distribution map is shown in Figure 2.9. The yellow hexagons represent the species' range or distributional limits, and the magenta represents suitable habitats within the range.

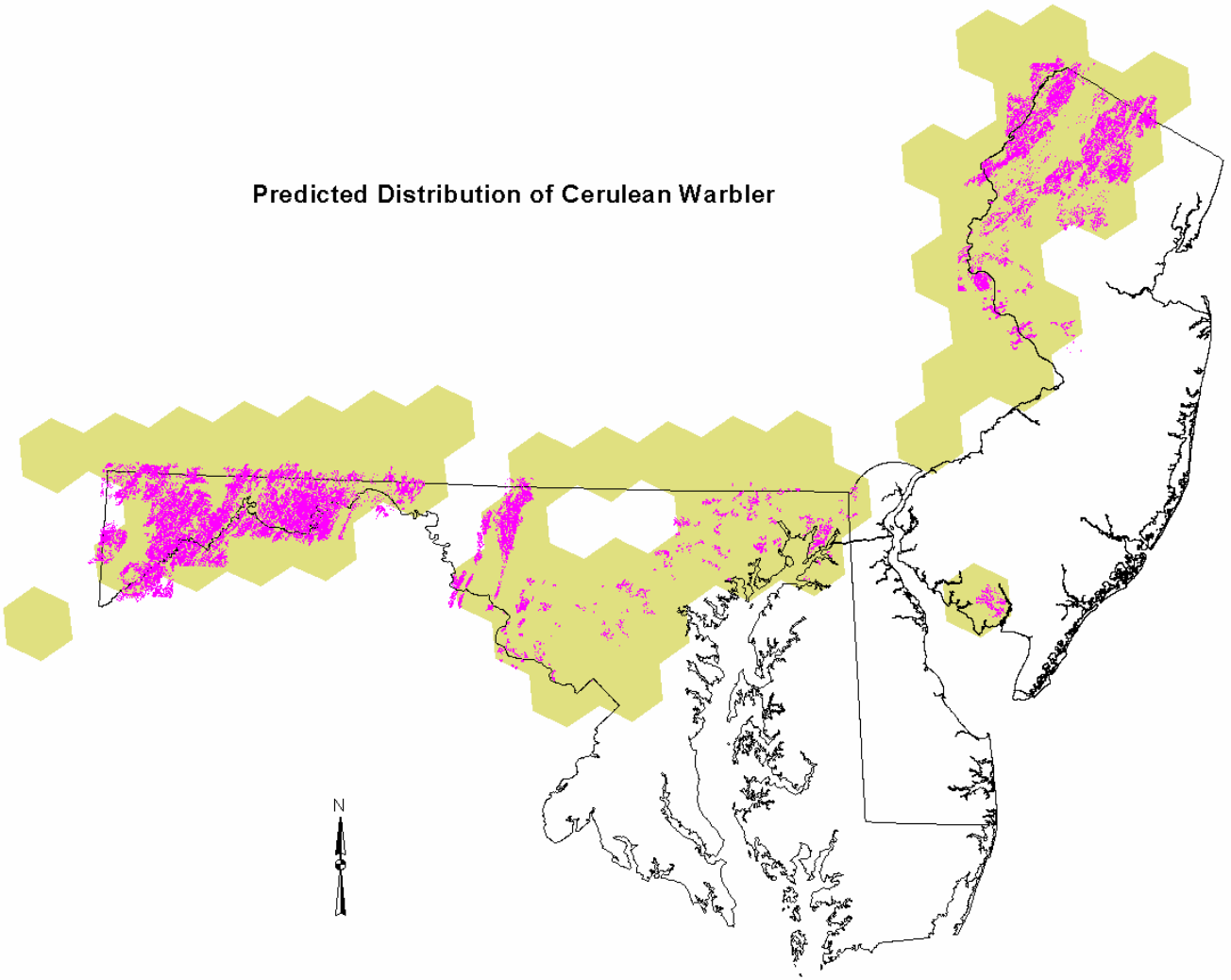

Figure 2.9: Example of a Bird Species Distribution Map

2.3.2 Mammals

Detailed soils mapping might have improved modeling for several mammal species. The State Soil Geographic Data Base (STATSGO) and associated GIS coverage was available, but this level of soils mapping proved to be too generalized. Several small mammal species (e.g., moles, shrews) are known to have soil type preferences, and their distributions might have been more accurately modeled had detailed soils data been available. There are also some small mammal species which exhibit strong preferences for certain geologic formations (e.g., rock vole, *Microtus chrotorrhinus*), and their modeling might have been improved by the inclusion of a geologic formation map overlay. Rock outcroppings, for example, appear to be important to several species. A caves data set was available, and this coverage was used as a surrogate for rock outcrops, but it was likely a poor substitute for a more comprehensive outcrops overlay. A subset of these caves was selected based on criteria that are important to bats, and use of this data layer likely improved model results for cave-dwelling bat species. In general, model accuracy is good for those species that are most often associated with wetlands or riparian areas. In addition, forest fragmentation and forest juxtaposition layers were incorporated into several models (e.g., fisher, *Martes pennanti*; black bear, *Ursus americanus*; American beaver, *Castor canadensis*; bobcat, *Lynx rufus*; woodland vole, *Microtus pinetorum*; woodland jumping mouse, *Napaeozapus insignis*; New England cottontail, *Sylvilagus transitionalis*; forest bats; shrews; squirrels), improving model accuracy for many of these species.

Habitat models and distribution maps were developed for a total of 69 mammal species, including a handful of exotic species. An example of a mammal species distribution map is shown in Figure 2.10.

2.3.3 Reptiles

With the exception of wetland-dependent species, reptiles as a group seemed to be the least specialized in their habitat requirements, and therefore possibly the most difficult group for which to develop accurate models. Adding to this difficulty is the use by many species of microhabitat features that are not easily mapped, such as cover objects, debris piles, and basking sites. However, many in this group are considered “edge” species, and the creation and use of an Edge layer greatly improved model results for these species and many in other taxonomic groups.

Habitat models and distribution maps were developed for a total of 47 reptile species. An example of a reptile species distribution map is shown in Figure 2.11.

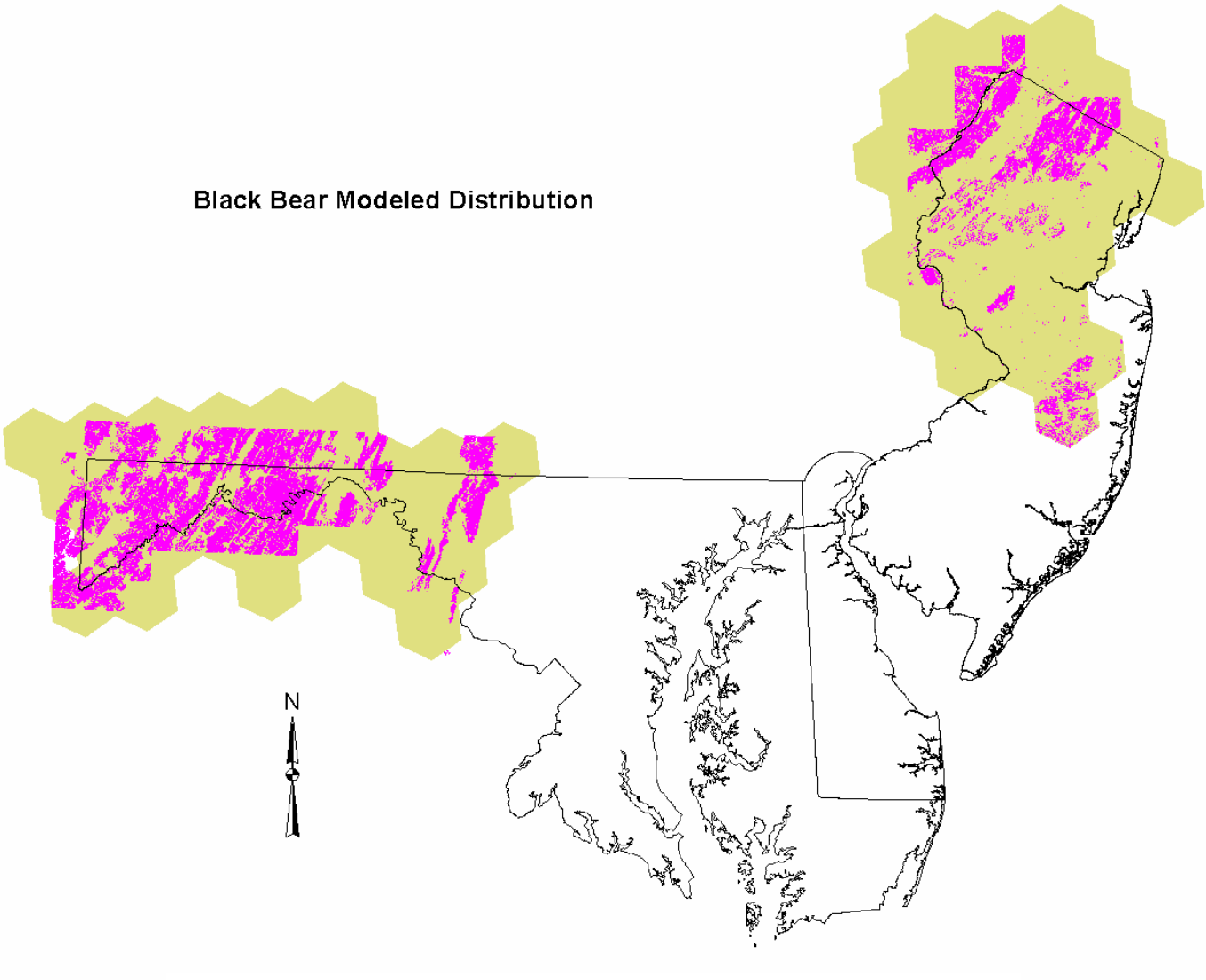

Figure 2.10: Example of a Mammal Species Distribution Map

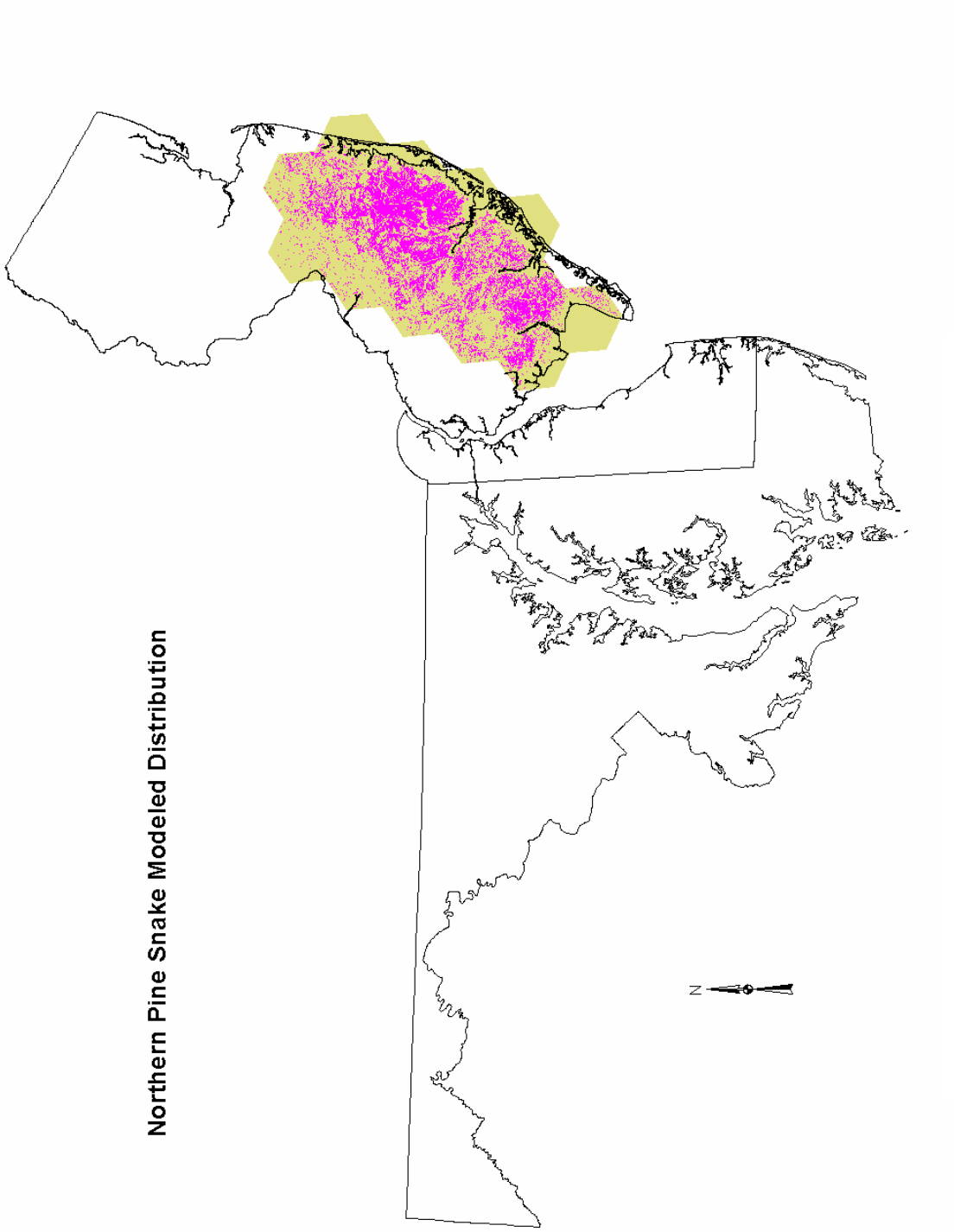

Figure 2.11: Example of a Reptile Species Distribution Map

2.3.4 Amphibians

As with some mammal species, detailed soils mapping would have improved model results for certain amphibian species (e.g., toads). Geology is also important to some amphibian species. For example, shale banks were mentioned for a small number of salamander species, including slimy salamander (*Plethodon glutinosus*) and longtail salamander (*Eurycea longicauda*). A geology data set, with above-ground features identified, was not available for inclusion in modeling. A forest juxtaposition layer was developed for species which breed in wetlands and require adjacent upland forest habitat for the remainder of their life cycle. The inclusion of this variable in the modeling greatly improved results for vernal pool-breeding amphibians.

Habitat models and distribution maps were developed for a total of 41 amphibian species. An example of an amphibian species distribution map is shown in Figure 2.12.

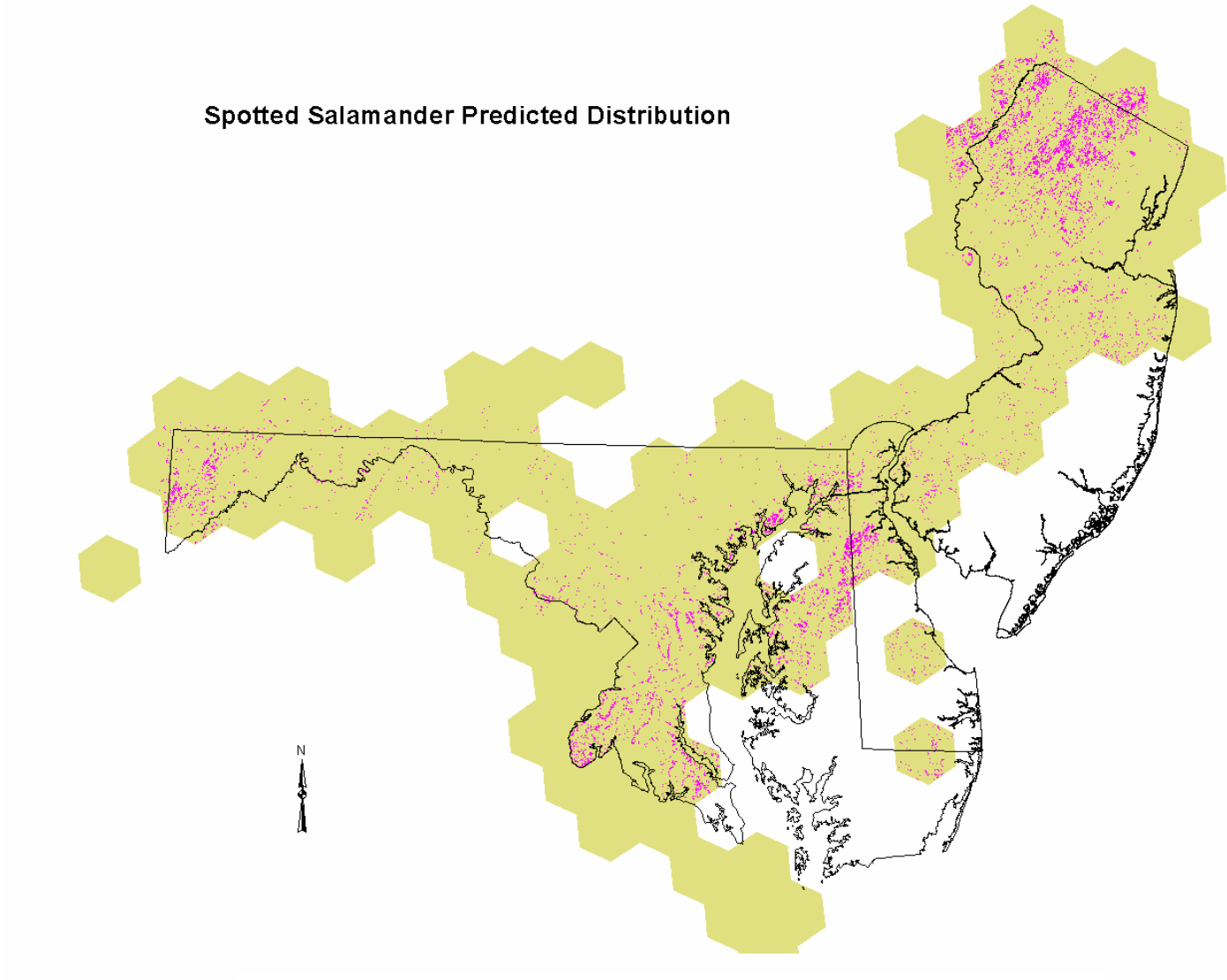

Figure 2.12: Example of an Amphibian Species Distribution Map

2.4 Species Richness

GAP has often been associated with the mapping of species-rich areas or "hotspots." Richness maps identify where species co-occur in the same geographic locations (in the case of our data, where numbers of animal species are mapped for the same grid cells.) These are color coded or shaded in intensity from the highest numbers of co-occurrence (richness), to the lowest. While we continue to perform this useful pattern analysis, it is only one of many that may be conducted using the data. Richest areas may or may not indicate best conservation opportunities. They may occur in already protected areas or may represent mostly already protected species or those not at risk. Still, they are often a useful starting point to examine conservation opportunities in combination with other analyses described in this report's Introduction and in the Analysis section. We also feel they may be useful for other rewarding applications such as identifying places of interest for wildlife observation and study.

2.4.1 Bird Species Richness

No particular area stands out significantly in terms of bird species richness, but the areas of highest richness for this taxonomic group appear to correspond with heavily forested regions (Figure 2.13).

2.4.2 Rare Bird Species Richness

Although one of the stated objectives of the Gap Analysis Program is to prevent common species from becoming rare, the mid-Atlantic region already has a long history of human impacts, and wildlife species that are considered common, most of them associated with edge habitats, are likely to remain common. Of greater interest in the mid-Atlantic are the many rare and declining species that are associated with its relatively few remaining natural areas. Therefore, in addition to looking at total species richness and richness by taxonomic group, it seems appropriate to identify areas that are hotspots for rare species. Tables listing these species by taxonomic group are presented in Appendix H. Many areas within Maryland, Delaware and New Jersey stand out in terms of richness of rare bird species (Figure 2.14). Forested areas in the mountains of western Maryland, especially those of Savage River State Forest and the riparian forests along the Youghiogheny River near the West Virginia border (Figure 2.15), appear to be important for rare bird species. South of Washington, D.C., the riparian corridors of Mattawoman Creek and Zekiah Swamp Run are relatively high in rare bird species richness, and to the northeast of Washington, the riparian forests of the Patuxent River are important. Looking farther east, toward Annapolis, Maryland, the riparian forests along the North River, Bacon Ridge Branch and Broad Creek tributaries of the South River appear to be hotspots. There also appear to be some important riparian forests along tributaries of the Susquehanna River, including Conowingo Creek. To the south of this river, forested hotspots also occur along Grays Run and the headwaters of Romney Creek within the Aberdeen Proving Ground Military Reservation.

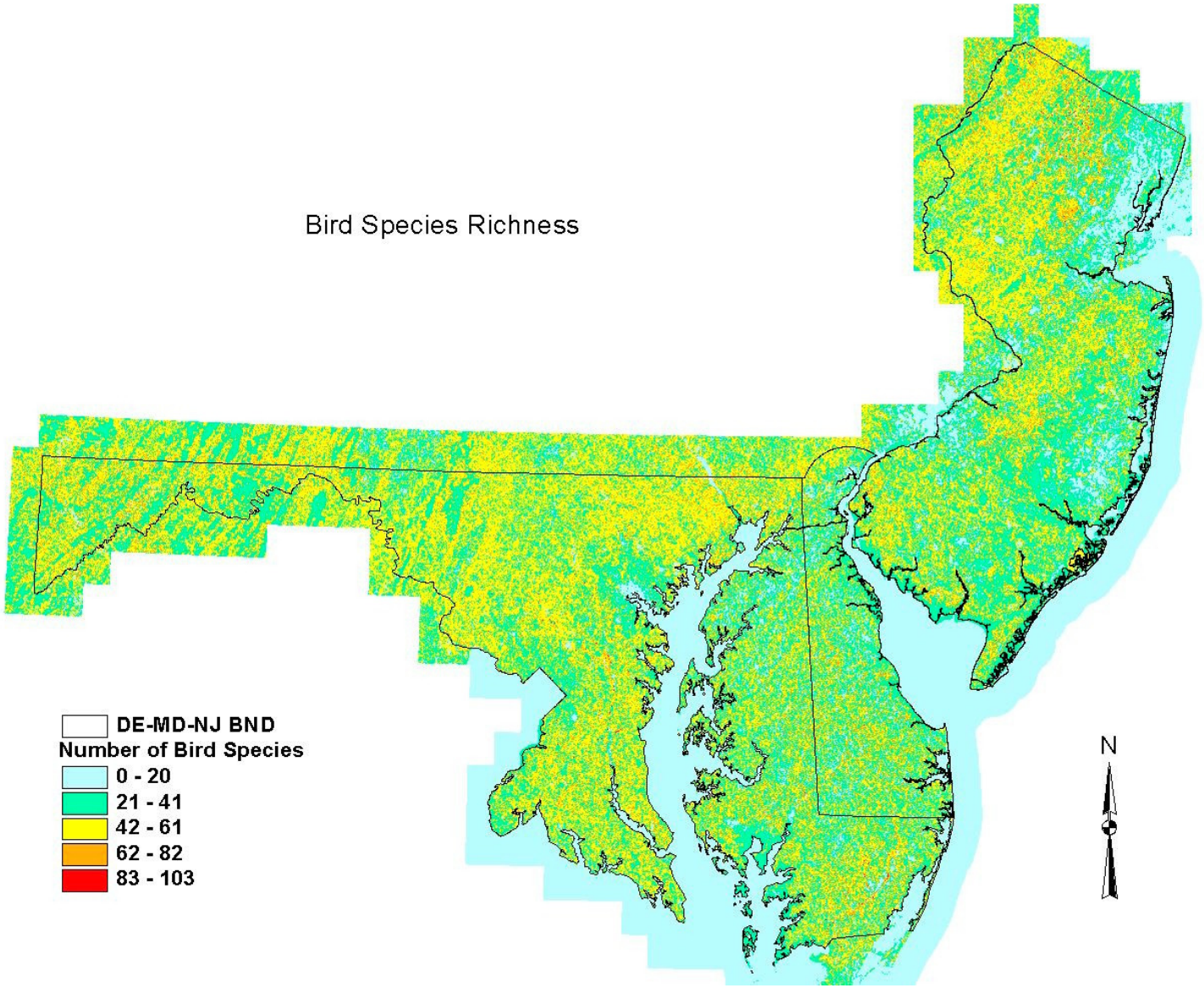

Figure 2.13: Predicted Bird Species Richness for the MDN-GAP Study Area

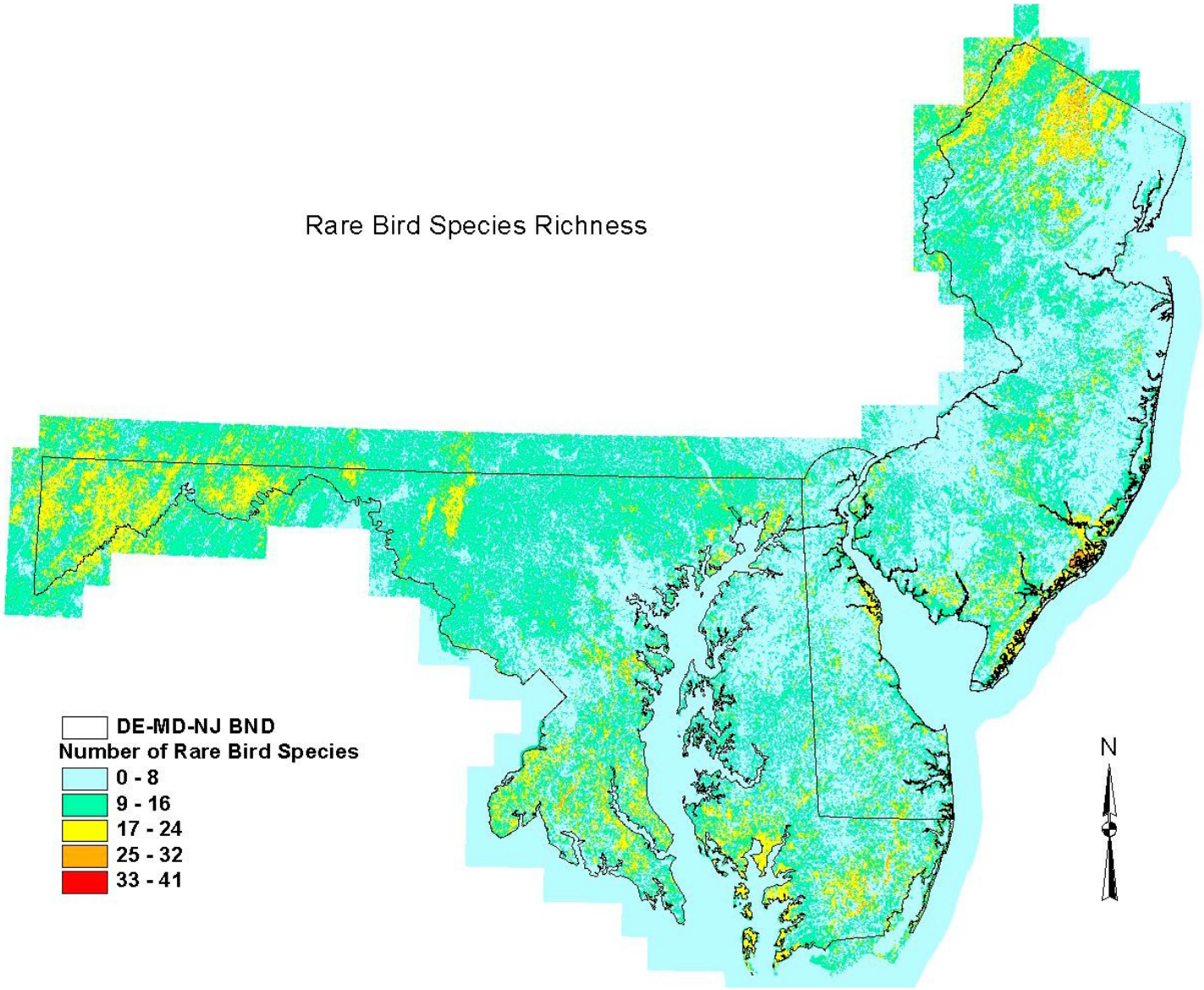

Figure 2.14: Predicted Rare Bird Species Richness for the MDN-GAP Study Area

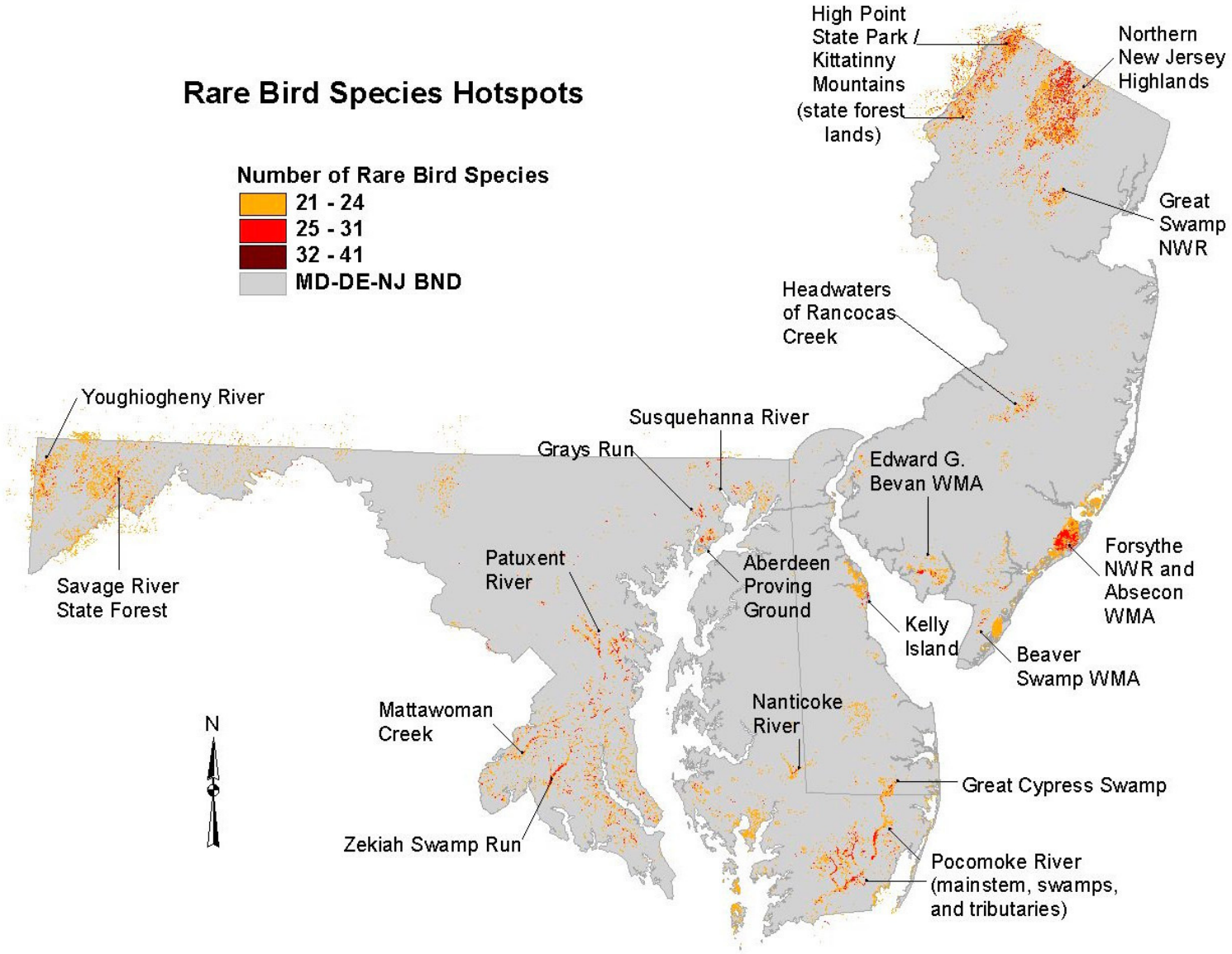

Figure 2.15: Predicted Rare Bird Species Hotspots in the MDN-GAP Study Area

On the Eastern Shore of Maryland, the forested swamps of the Pocomoke River and its tributaries also appear to be important, as does the Nanticoke River corridor near the Delaware border. While there don't appear to be many significant hotspots for rare bird species in Delaware, the Great Cypress Swamp is important, and the brackish marshes of Kelly Island appear to be important. In New Jersey, hotspots for rare bird species appear to include swamps and mesic forests just south of the Edward G. Bevan Wildlife Management Area (WMA), and similar habitats in the Beaver Swamp WMA and along the headwater areas of the Rancocas Creek. Tidal mudflats within the Forsythe National Wildlife Refuge and Absecon WMA provide important foraging habitat to a large number of rare bird species. By far, the most significant hotspots for rare bird species within the project area are found in the Kittatinny Mountains and Highlands of northern New Jersey. These forested hotspots not only cover large areas, but they also support the largest numbers of rare bird species within the project area. To the south of these hotspots, the Great Swamp NWR is also important. Although many obvious hotspots are mentioned above, there are several others that are not mentioned. For the most part, habitats supporting the largest numbers of rare bird species include expansive hardwood and mixed riparian and palustrine forests.

2.4.3 Mammal Species Richness

The Piedmont and mountainous areas of the project area appear to support the largest numbers of mammal species, particularly along streams and rivers, and especially in the forested riparian corridors of the western Maryland panhandle (Figure 2.16).

2.4.4 Rare Mammal Species Richness

No part of the project area stands out as conspicuously as the afore-mentioned forested riparian areas of the western Maryland panhandle which, by far, appear to support the greatest number of rare mammal species. Most of the obvious riparian forest hotspots are associated with the main-stems and tributaries of the Youghiogheny, North Branch Potomac, and Savage Rivers (Figure 2.17). Within the Savage River State Forest, there are also hotspots associated with the Casselman River and its tributaries. To a lesser extent, the Highlands and Kittatinny Mountain Provinces of northern New Jersey also appear to be important.

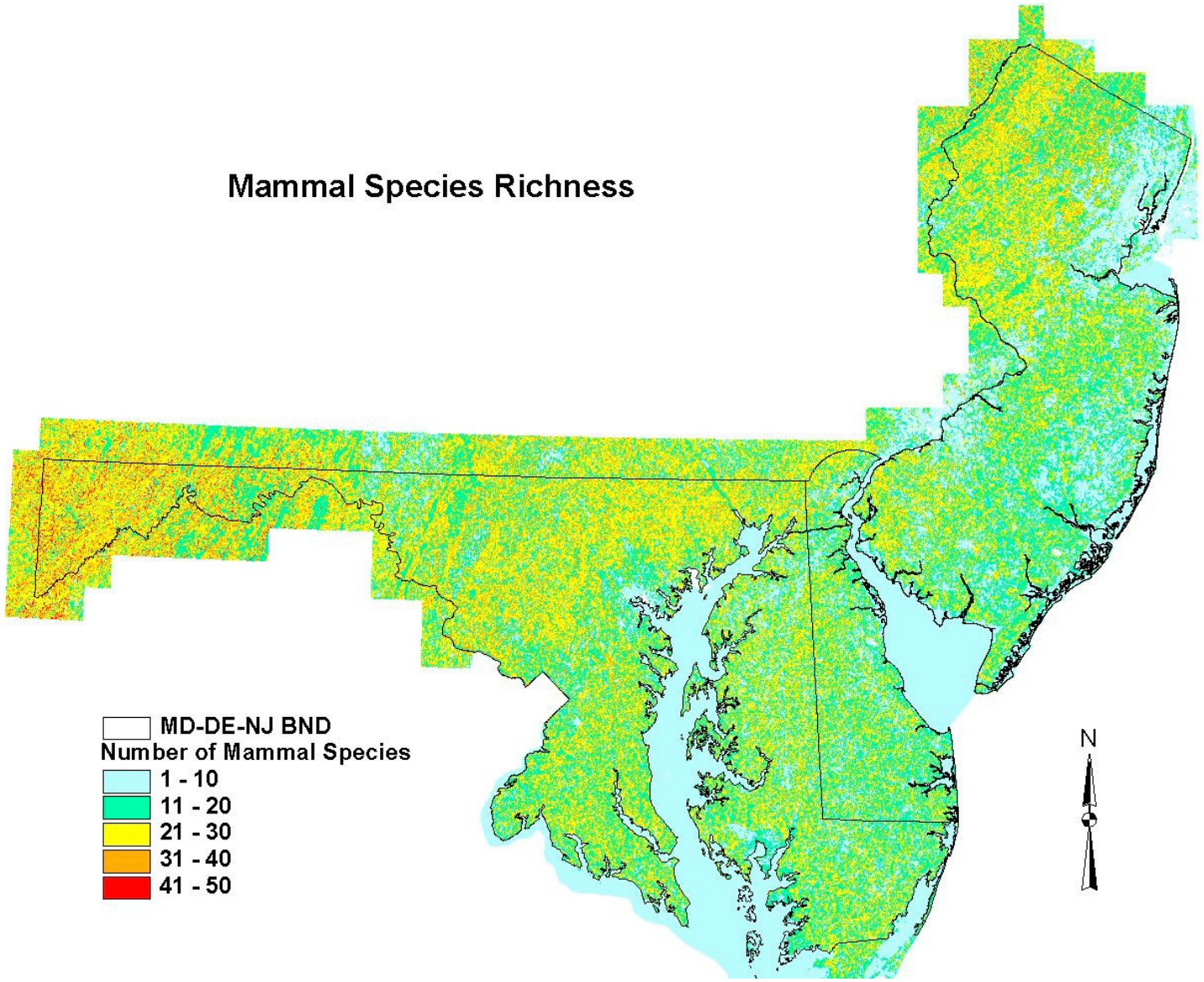

Figure 2.16: Predicted Mammal Species Richness for the MDN-GAP Study Area

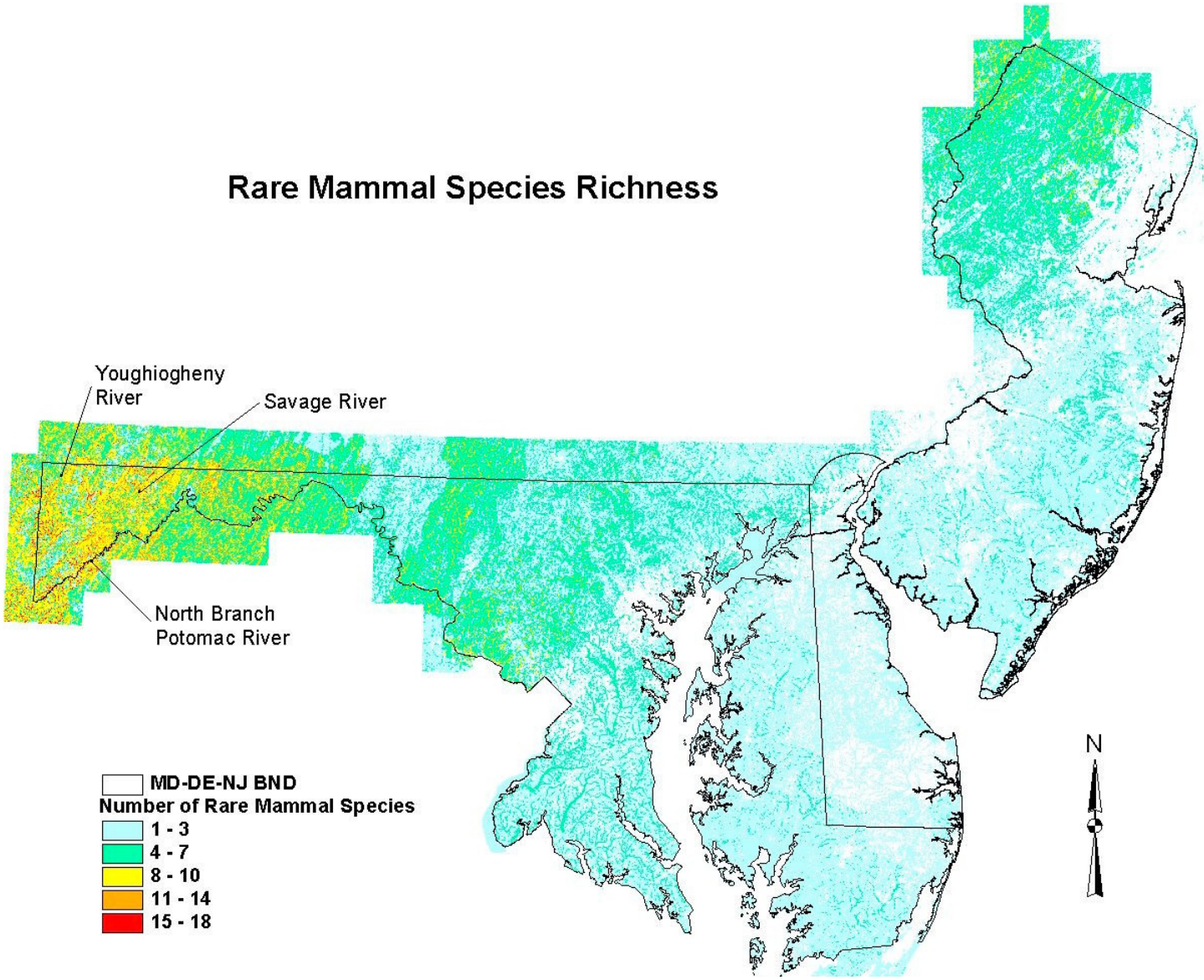

Figure 2.17: Predicted Rare Mammal Species Richness for the MDN-GAP Study Area

2.4.5 Reptile Species Richness

Among the areas of apparent reptile species richness, portions of the Potomac River corridor in western Maryland look important, as do other areas along this river northwest of Washington, D.C. (Figure 2.18). In general, many Potomac River tributaries in the vicinity of Washington appear to be important, including the headwaters of Mattawoman and Piscataway Creeks, and Zekiah Swamp Run, to the south of the city. Farther south, St. Marys County as a whole appears to be relatively important. To the northeast of Washington, headwaters and tributaries of several rivers, including the Patuxent, Severn, South and Patapsco, appear to be high in reptile species richness. On the Eastern Shore of Maryland, areas high in reptile species richness include tributaries of the Nanticoke River, headwaters of the Wicomico River, and the swamps of the Pocomoke River and its tributaries. To a lesser extent, in New Jersey, the Pine Barrens also appear to be important to reptiles.

2.4.6 Rare Reptile Species Richness

Most of the areas listed above stand out even moreso (Figure 2.19), in terms of richness of rare reptile species, with the New Jersey Pine Barrens, in particular, appearing to be a very significant hotspot.

2.4.7 Amphibian Species Richness

Riparian areas of western Maryland appear to support large numbers of amphibian species, as do parts of the Potomac River corridor and its tributaries near Washington, D.C. (Figure 2.20). Among these tributaries are the previously-mentioned Mattawoman and Piscataway Creeks, and Zekiah Swamp Run. All of these stream corridors are heavily-forested with swamp inclusions. Another such hotspot, also previously mentioned, is the upper Patuxent River Corridor. The Aberdeen Proving Ground Military Reservation, which includes forested and swampy headwaters of Romney Creek, is very prominent as a potential hotspot. Also quite conspicuous is an area spanning the Maryland-Delaware border, the focus of recent conservation efforts, known as the Blackbird-Millington Corridor, which hosts the largest concentration of Coastal Plain Ponds (AKA vernal pools) in the project area. The Pocomoke River area in southern Maryland, with its extensive swamp lands, also appears to be significant, but to a lesser extent. In New Jersey, many areas stand out, including headwater areas of the western Pine Barrens, an area known as Mannington Meadow along the Salem River and, most conspicuous, the riparian forests and wetlands of the Kittatinny and Highland Provinces. Also prominent is the Great Swamp National Wildlife Refuge of the north-central Piedmont.

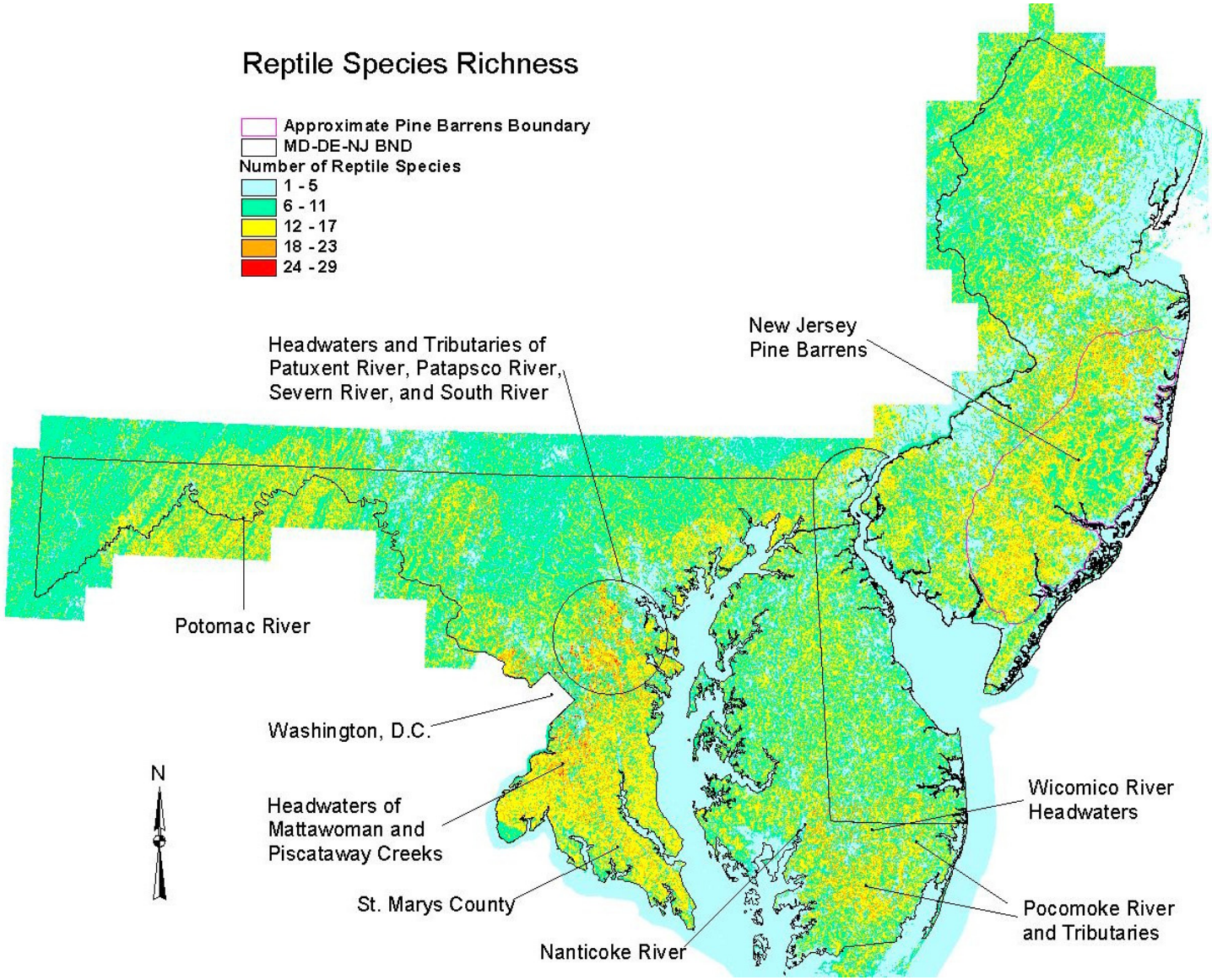

Figure 2.18: Predicted Reptile Species Richness for the MDN-GAP Study Area

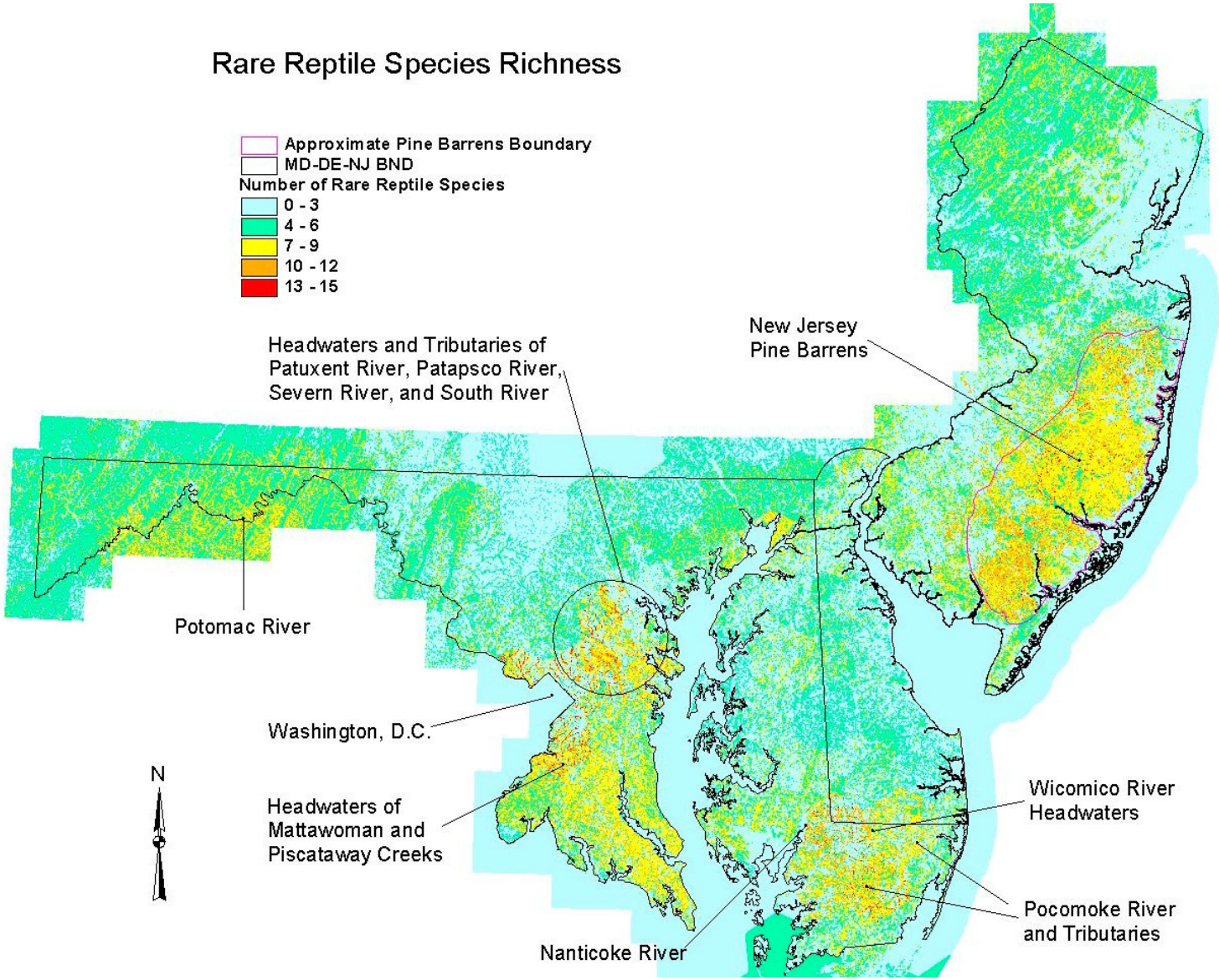

Figure 2.19: Predicted Rare Reptile Species Richness for the MDN-GAP Study Area

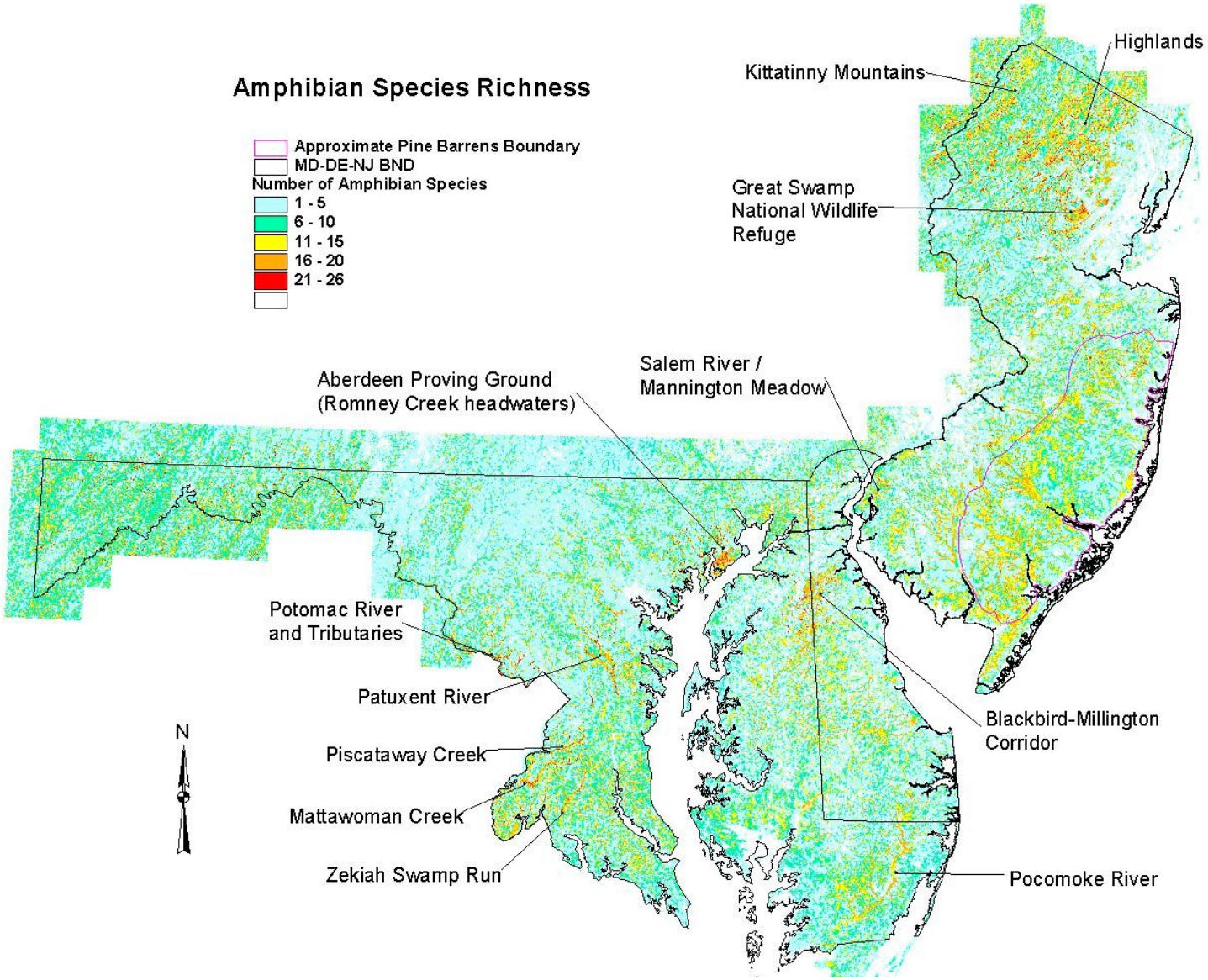

Figure 2.20: Predicted Amphibian Species Richness for the MDN-GAP Study Area

2.4.8 Rare Amphibian Species Richness

No area is more conspicuous for its apparent concentration of rare amphibian species than the Blackbird-Millington corridor along the Maryland-Delaware border, with its high concentration of Coastal Plain Ponds (Figure 2.21). A less significant-looking hotspot on Delmarva is the Nassawango Creek corridor which connects with the Pocomoke River corridor. In western Maryland, the Youghiogheny River appears to support a large number of rare amphibian species, and to a lesser extent, other important areas include some of the previously-mentioned riparian corridors, such as those of the Patuxent River and Mattawoman Creek. The Aberdeen Proving Ground also appears to support a significant number of rare amphibian species. In New Jersey, predicted rare amphibian hotspots include the Tuckahoe Wildlife Management Area (AKA Griscom Swamp), the headwaters of some Dennis Creek tributaries, the Beaver Swamp Wildlife Management Area in northern Cape May County, swampy areas along the upper Maurice River, and riparian forests and wetlands of northern New Jersey.

2.4.9 Vertebrate Species Richness – All Taxonomic Groups

Forested riparian corridors stand out the most in terms of species richness when considering all taxonomic groups together (Figure 2.22). For example, the riparian forests in the mountains of western Maryland and northern New Jersey include many obvious hotspots. Other obvious hotspots include the forests along the Patuxent River to the east of Washington, D.C., and the Great Swamp National Wildlife Refuge in north-central New Jersey. Otherwise, it's difficult to identify particular areas that are exceptioinally high in overall vertebrate species richness. In general, overall richness appears to correspond with forested areas, especially along headwater streams and in other riparian situations.

2.4.10 Rare Vertebrate Species Richness

Among the apparent hotspots for rare vertebrate species of all taxonomic groups, are the forests of western Maryland, especially along the Youghiogheny River (Figure 2.23). Other hotspots in this part of the project area include Savage River State Forest, forested tributaries of the North Branch Potomac River, and the riparian corridor along Georges Creek. Within the Ridge and Valley and Blue Ridge provinces, additional hotspots in Maryland include Green Ridge State Forest, Indian Springs Wildlife Management Area, South Mountain through which the Appalachian Trail passes, and Catoctin Mountain. For the most part, hotspots in the Coastal Plain and Piedmont Provinces pale in comparison to those of the Appalachian Plateau, Ridge and Valley, and Highlands physiographic provinces of the project area.

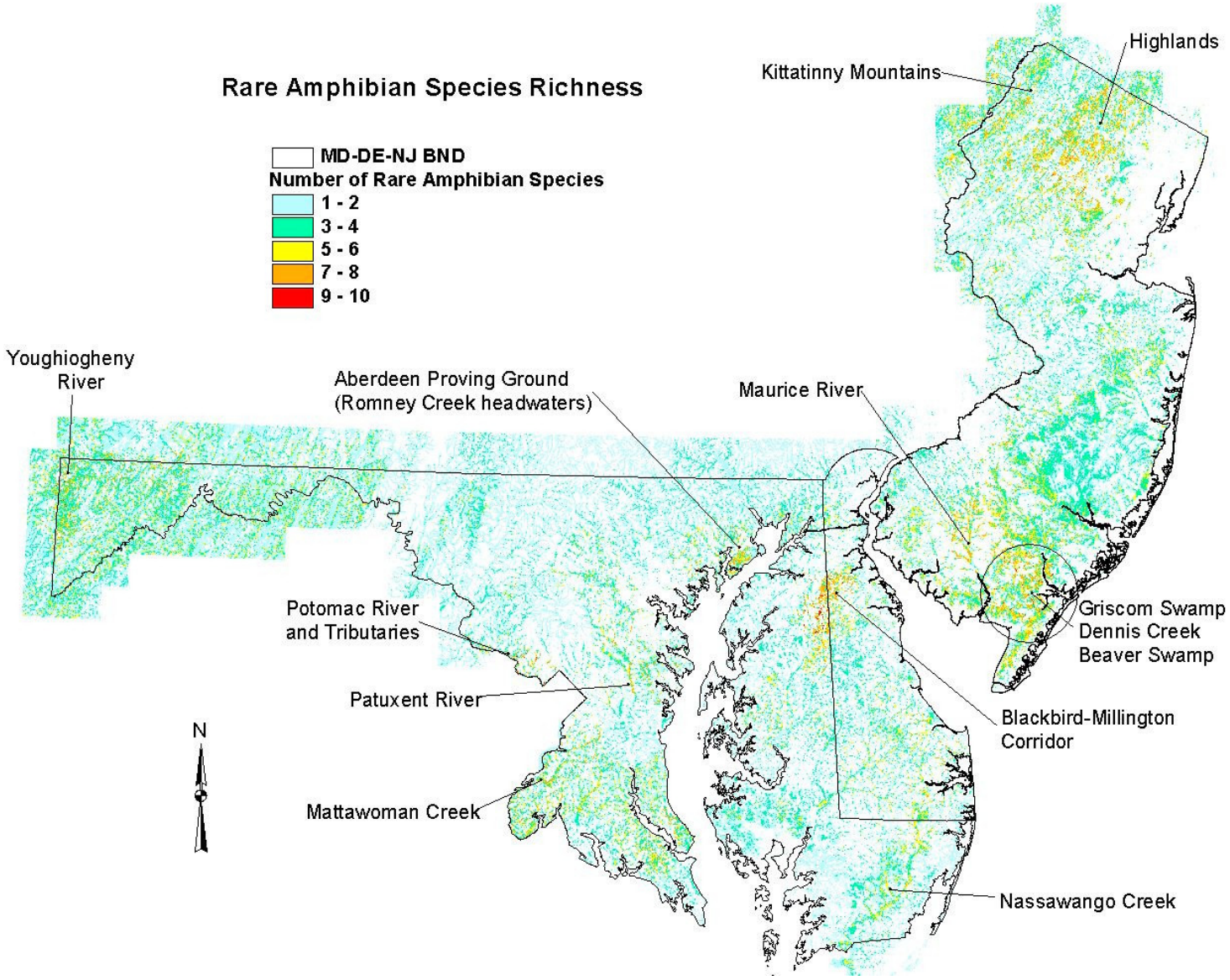

Figure 2.21: Predicted Rare Amphibian Species Richness for the MDN-GAP Study Area

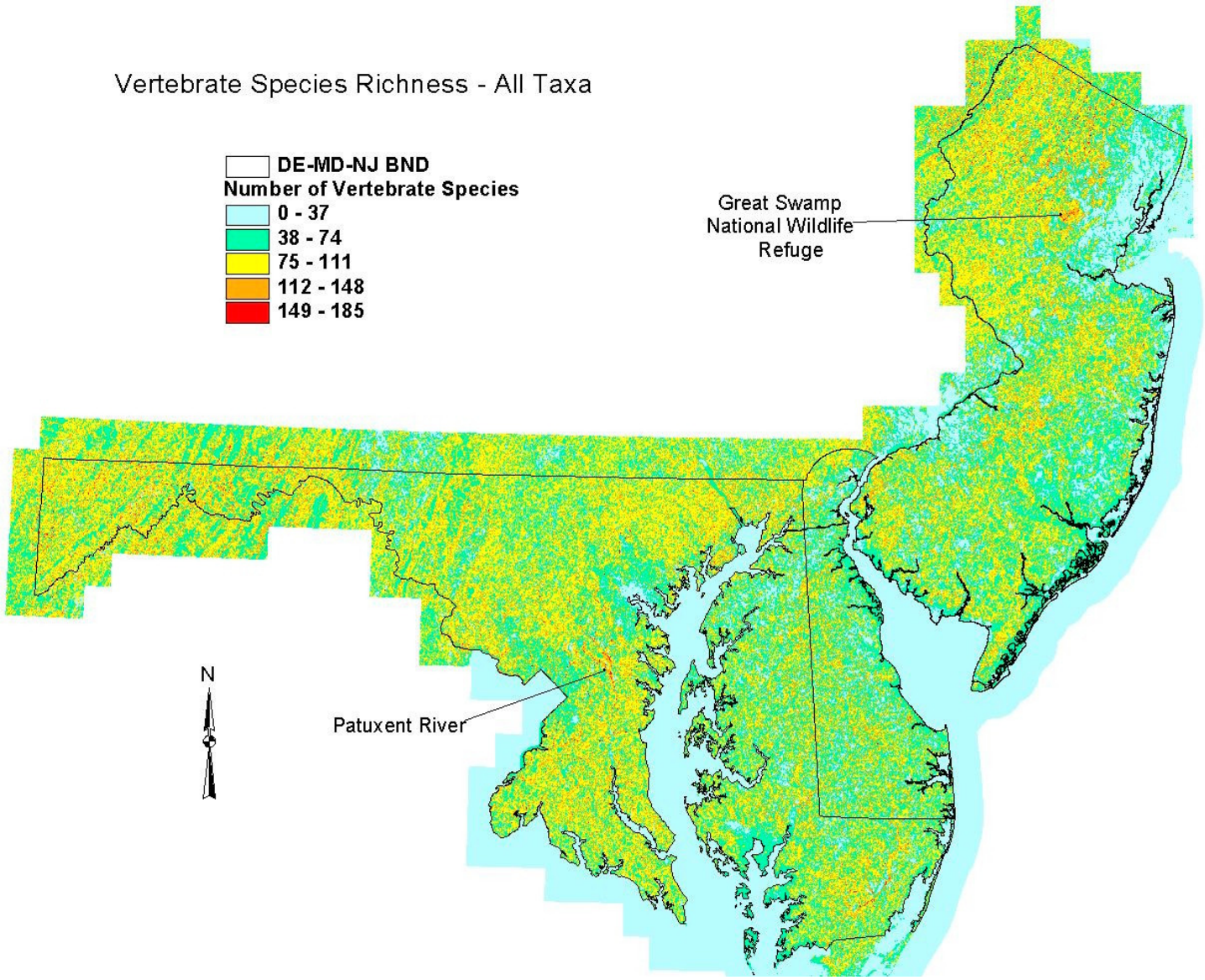

Figure 2.22: Predicted Vertebrate Species Richness for the MDN-GAP Study Area

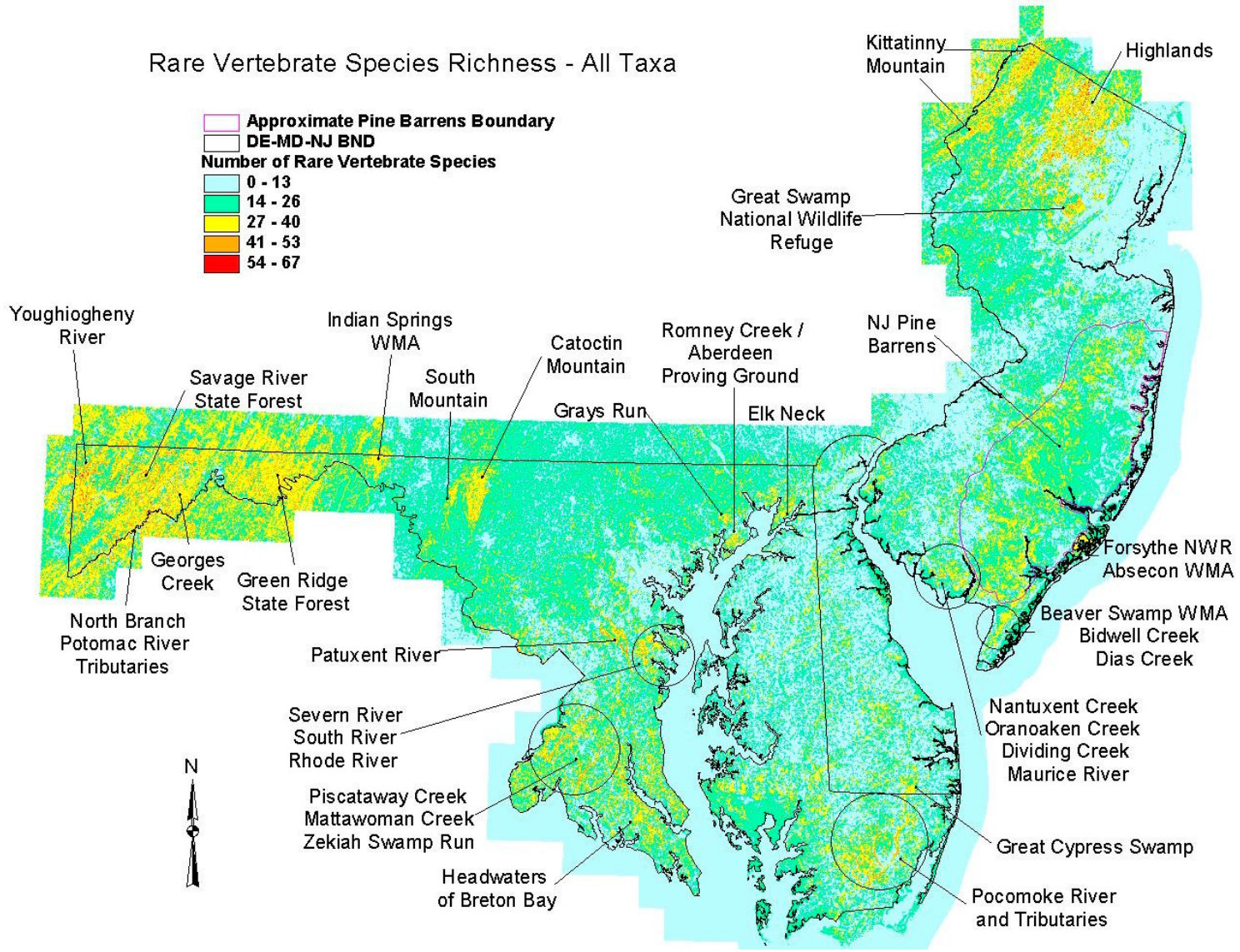

Figure 2.23: Predicted Rare Vertebrate Species Richness for the MDN-GAP Study Area

Within the Piedmont and Coastal Plain of the Western Shore of Maryland, other obvious hotspots include the Grays Run riparian corridor, headwaters of Romney Creek within the Aberdeen Proving Ground Military Reservation, the forests of Elk Neck, the Patuxent River corridor, headwaters and tributaries of the Severn, South and Rhode Rivers, the forested riparian corridors of Piscataway and Mattawoman Creeks, Zekiah Swamp Run, and the headwaters of Breton Bay. On the Delmarva Peninsula, hotspots include the forests and swamps surrounding Blackwater National Wildlife Refuge, portions of the Nanticoke River corridor, Great Cypress Swamp, and, most prominent on Delmarva, the forests and swamps along the Pocomoke River and its tributaries.

In New Jersey, the Kittatinny Mountain and Highlands Provinces are the most obvious hotspots for rare vertebrate species. Also important are the Great Swamp National Wildlife Refuge, forested headwaters of Rancocas Creek, Mullica River, Great Egg Harbor River and other riparian forests of the Pine Barrens, the tidal wetlands of the Brigantine Division of Forsythe National Wildlife Refuge and Absecon Wildlife Management Area, forested swampland tributaries of Nantuxent Creek, Oranoaken Creek, Dividing Creek and the Maurice River, Beaver Swamp WMA, and palustrine forests of Bidwell and Dias Creeks.

There are other potential hotspots, many of them too small to show up on small-scale maps. For example, in the Piedmont Physiographic Province of extreme northern Delaware, the riparian forests of the Red Clay and White Clay Creeks appear to be hotspots for rare vertebrate species. While this species richness assessment may be very useful for identifying conservation priorities, especially when the assessment focuses on rare species, it should be reiterated that there may be species that are not captured by this type of assessment. For example, there are many rare beach-nesting species that are not captured in this assessment because their preferred nesting and foraging habitats support a relatively low diversity of vertebrate species in general. A few GAP projects have undertaken a complementarity analysis which determines the minimum number of sites needed to conserve all species, although it does not take into account how much of an individual species' range or habitat is included within the selected sites. This type of assessment is generally thought to be beyond the computing capabilities of most research facilities. In the absence of this approach, the species-richness assessment is a good complement to the actual gap analysis which assesses how well individual elements of biodiversity are captured and managed for by the existing network of protected areas.

2.5 Accuracy Assessment

Assessing the accuracy of the predicted vertebrate distributions is subject to many of the same problems as assessing land cover maps, as well as a host of more serious challenges related to both the behavioral aspects of species and the logistics of detecting them. These are described further in the Background section of the GAP Handbook on the national GAP home page. It is, however, necessary to provide some measure of confidence in the results of the gap analysis for species collectively, if not individually or by taxonomic group (comparison to stewardship and management status), and to allow users to judge the suitability of the distribution maps for their own uses. We, therefore, feel it is important to provide users with a statement about the accuracy of GAP-predicted vertebrate distributions within the limitations of available resources and practicalities of such an endeavor. We acknowledge that distribution maps are never finished products but are continually updated as new information is gathered. This reflects not only an improvement over the modeling process, but also the opportunity to map true changes in species distributions over time. However, we feel that assessing the accuracy of the current maps provides useful information about their reliability to potential users.

Our goal was to produce maps that predict distribution of terrestrial vertebrates and from that, total species richness and species content with an accuracy of 80% or higher. Failure to achieve this accuracy indicates the need to refine the data sets and models used for predicting distribution. There is a conscious effort in the GAP process, however, to err on the side of commission. In other words, to attribute species as possibly present when they are not. There are two primary reasons for doing so: first, few species have systematic, unbiased known ranges and we believe science is best served by identifying a greater potential for sampling and investigation than a conservative approach that may miss such opportunities; second, in conducting the analysis of conservation representation (see the Analysis section), we believe it most appropriate to identify a species that may need additional conservation attention that is then refuted by further investigation rather than identifying a species as sufficiently protected that is discovered not to be by its subsequent loss.

The methods for validating and assessing the accuracy of the vertebrate distribution maps are presented below along with the results.

2.5.1 Methods

Due to project resource limitations, outside expert review was put on hold and, as of the writing of this report, accuracy assessment has been limited to the minimum standards which require a comparison between modeled species distributions and existing checklists from managed areas. This assessment involved intersecting managed area boundaries with predicted species distributions, recording which species were predicted to occur within those areas, and then comparing these records with species checklists for the corresponding managed areas. Bird checklists were obtained for eight national wildlife refuges and four state parks. These checklists indicated seasonal occurrence and whether or not a species was actually nesting within the refuge or park. Reptile and

amphibian species checklists were obtained for four national wildlife refuges, and mammal checklists were available for three of these refuges. The results of this comparison, shown in Table 2.7, include: 1) Matches, meaning the predicted distribution is supported by the checklist data, 2) Errors of Commission, where a species is predicted to occur in an area based on the modeling but is not included in the corresponding checklist, and 3) Errors of Omission, where the species is not predicted to occur within the area but is included in the checklist. The accuracy assessment results for each individual species are shown in Appendix I.

2.5.2 Results

A total of 12 areas (Figure 2.24) were assessed for accuracy, with birds being listed in 12, mammals in only 3, amphibians in 4, and reptiles in 4. Of the 363 species modeled, 280 (77.1%) were included on at least one of the checklists. These included 178 birds (86.4%), 44 mammals (63.8%), 33 reptiles (70.2%), and 25 amphibians (61.0%). As mentioned in the discussion below, no checklists exist for the mountainous region of western Maryland. This information gap accounts for many of the species that are not included on any of the available checklists.

For birds, matches between checklists and modeled distributions exceeded 80% in only 5 of 12 areas, but exceeded 79% in 9 of the areas. Although this level of accuracy falls short of the above-stated goal, a significant percentage of errors were questionable when compared with Breeding Bird Atlas and Natural Heritage Program data sets. For mammals, matches exceeded 80% in only 1 of 3 areas for which checklists exist, and although some errors were questionable, this poor level of accuracy may reflect some of the identified weaknesses in the mammal modeling (see section 2.3.2). For reptiles, matches exceeded 80% in 3 of 4 areas, with the lowest rate being 78.8%.

For amphibians, matches exceeded 80% in only 1 of 4 areas, and the lowest rate of matches for any taxonomic group was recorded for amphibians within the Blackwater National Wildlife Refuge. However, a number of the recorded errors are questionable. For example, the gray treefrog (*Hyla versicolor*) was included on the checklist for this refuge, but Cope's gray treefrog (*Hyla chrysoscelis*) was not included. These two species are nearly indistinguishable and are often lumped together under *H. versicolor*. White and White (2002) state that *H. versicolor* appears to be most common in the northern portion of the Coastal Plain [of Delmarva], possibly not occurring in the southern third of the Peninsula, and *H. chrysoscelis* has a more southern distribution on the Delmarva Peninsula. Although the authors further state that more field study is required to better define the Delmarva ranges of these 2 species, the Biodiversity Research Consortium hexagon occurrence data used to model ranges did not include any "confirmed" or "probable" records for *H. versicolor* in the area of this refuge, but did include a "confirmed" record and a "probable" record for *H. chrysoscelis.* Therefore, *H. chrysoscelis* is the more likely of the two species to occur within this refuge.

Table 2.7. Accuracy Assessment by Management Area

Taxonomic Group	Management Area	Number Assessed for Area	Number Matches	% Matches	Number Commission Errors	% Commission Errors	Number Omission Errors	% Omission Errors
Birds	Blackwater NWR	140 / 206	117	83.57	13	9.29	10	7.14
Birds	Bombay Hook NWR	122 / 206	102	83.61	13	10.66	7	5.74
Birds	Prime Hook NWR	137 / 206	113	82.48	16	11.68	8	5.84
Birds	Great Swamp NWR	133 / 206	106	79.70	24	18.05	3	2.26
Birds	Forsythe NWR	147 / 206	104	70.75	38	25.85	5	3.40
Birds	Eastern Neck NWR	122 / 206	97	79.51	14	11.48	11	9.02
Birds	Wallkill River NWR	146 / 206	118	80.82	24	16.44	4	2.74
Birds	Patuxent Res. Refuge	123 / 206	102	82.93	19	15.45	2	1.63
Birds	Brandywine Creek SP	112 / 206	89	79.46	22	19.64	1	0.89
Birds	Cape Henlopen SP	122 / 206	84	68.85	37	30.33	1	0.82
Birds	Trap Pond SP	112 / 206	89	79.46	23	20.54	0	0.00
Birds	Del. Seashore SP	123 / 206	91	73.98	32	26.02	0	0.00
Mammals	Blackwater NWR	42 / 69	31	73.81	11	26.19	0	0.00
Mammals	Bombay Hook NWR	39 / 69	34	87.18	5	12.82	0	0.00
Mammals	Great Swamp NWR	44 / 69	30	68.18	12	27.27	2	4.55
Amphibians	Blackwater NWR	23 / 41	14	60.87	5	21.74	4	17.39
Amphibians	Bombay Hook NWR	19 / 41	14	73.68	5	26.32	0	0.00
Amphibians	Great Swamp NWR	24 / 41	17	70.83	7	29.17	0	0.00
Amphibians	Patuxent Res. Refuge	23 / 41	21	91.30	2	8.70	0	0.00
Reptiles	Blackwater NWR	31 / 47	25	80.65	4	12.90	2	6.45
Reptiles	Bombay Hook NWR	24 / 47	21	87.50	3	12.50	0	0.00
Reptiles	Great Swamp NWR	24 / 47	20	83.33	3	12.50	1	4.17
Reptiles	Patuxent Res. Refuge	33 / 47	26	78.79	6	18.18	1	3.03

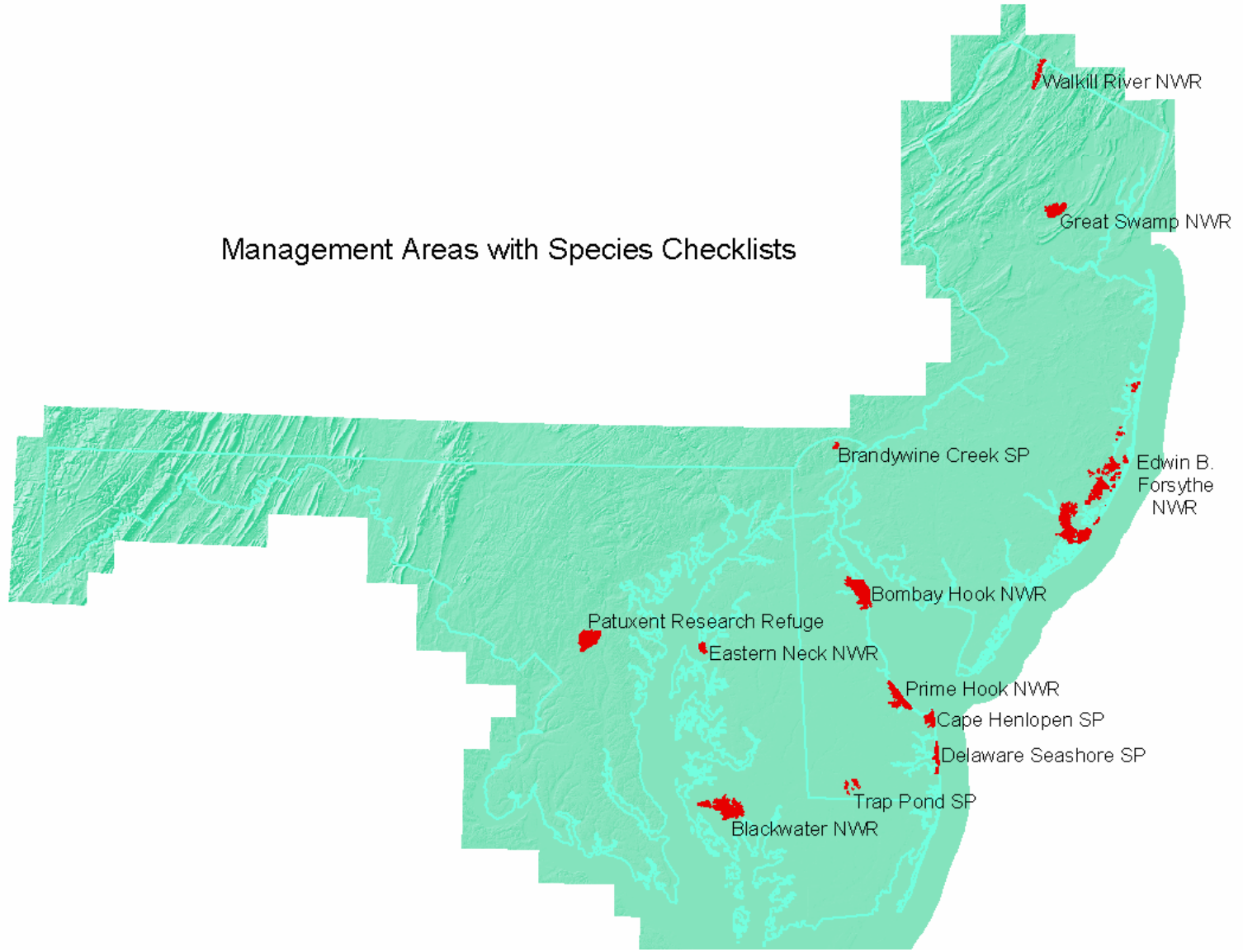

Figure 2.24: Management Areas Included in MDN-GAP Vertebrate Model Accuracy Assessment

Assuming this is the case, two of the errors for this area are false. These were not the only questionable errors. Nevertheless, there appears to be significant room for improvement in the modeling for amphibians.

2.6 Limitations and Discussion

Wildlife habitat modeling is an imperfect science, and is largely dependent upon the accuracy of model inputs. The model results presented here should be viewed as testable hypotheses, and while MDN-GAP investigators attempted to produce data sets and models that would be useful in assisting local-level conservation decisions, the results of this effort are most reliable at landscape or regional levels of conservation planning (e.g., 1:100,000 scale). It should also be noted that, due to insufficient project resources and associated delays in completing the various components, the final results of this effort are significantly dated. Recent land use and land cover changes within the project area (e.g., new residential developments), and habitat conservation efforts that have led to changes in land ownership and stewardship status in some areas, may not be reflected in the final results.

2.6.1 Species Richness

The identification of habitats or sites on the landscape that are high in species richness can be a valuable tool in conservation planning but, as others have pointed out (e.g., Scott et al. 2002), there may be many shortcomings inherent in this approach. For example, measures of species richness do not account for species composition, and areas high in species richness may not capture all species. Habitat edges or ecotones between habitats may be high in species richness but, in the highly fragmented mid-Atlantic, most of the species in these situations may be quite common and not in need of conservation. In addition, species richness hotspots may not capture all of the required habitats of the individual species found in those locations.

The confidence level associated with a species' presence within a hexagon or 7.5-minute quadrangle is high, since the records for these range units are based on reliable field data. However, the confidence level associated with a species' presence within a particular habitat patch within the range unit is not as high, especially for rare species or habitat specialists. Therefore, it is important to keep in mind that some of the identified hotspots may be exaggerated by errors of commission. Modeling accuracy at the stand level depends on how well a species' habitat requirements are known, how well those requirements are captured in the modeling, and the accuracy of the model inputs representing those requirements (see section 2.6.2 below).

Many species richness analyses fail to consider the conservation status (i.e., rarity) of individual species. The MDN-GAP effort mostly avoided this shortcoming by running separate richness analyses for rare species tracked by the state Natural Heritage Programs. Still, distinctions were not made as to the degree of species rarity or population trends. We also recognize that there are species of conservation concern that do not occur in species-rich areas. For example, there are several rare beach-nesting species that occur in

areas of relatively low species richness. One of the highest conservation priorities within this project area, the Pea Patch Island heron rookery which supports 9 wading bird species and is the largest rookery north of Florida, did not show up as a hotspot in the species richness analyses.

Because this is a three-state project, some of the species included in the rare species-richness analyses may be rare in only one or two of the three states, and the distribution of hotspots may be skewed toward portions of the project area where certain "rare" species are not so rare. For example, many forest fragmentation-sensitive bird species (hairy woodpecker, *Picoides villosus;* pileated woodpecker, *Dryocopus pileatus;* white-breasted nuthatch, *Sitta carolinensis;* brown creeper, *Certhia americana;* yellow-throated vireo, *Vireo falvifrons;* black-and-white warbler, *Mniotilta varia;* American redstart, *Setophaga ruticilla;* worm-eating warbler, *Helmitheros vermivorus;* Louisiana waterthrush, *Seiurus motacilla;* Kentucky warbler, *Oporornis formosus;* hooded warbler, *Wilsonia citrina;* and summer tanager, *Piranga rubra*) are rare to extremely rare in Delaware, where forest fragmentation is severe, but are not considered rare in Maryland or New Jersey where large blocks of unfragmented forest remain. As a result, hotspots for rare bird species in the mountains of western Maryland and northern New Jersey may be unduly influenced by the presence of these species, and in terms of regional conservation priorities, these areas may not be as important as they appear (i.e., there may be more important hotspots, supporting more intrinsically rare species, which should be the focus of conservation efforts). On the other hand, one of the primary goals of GAP is to keep common species common, and Delaware provides for Maryland and New Jersey a good example of how common species may become rare due to unchecked human impacts on the landscape.

Most GAP projects have had a single-state focus, which enables investigators to identify state-level conservation priorities. Because this particular project covers a three-state area, conservation priorities that may emerge from the results are more representative of regional biodiversity conditions than they are state-level conditions. From an individual state perspective, biodiversity conservation priorities in Delaware may have been diluted by the influences of biodiversity conditions in Maryland and New Jersey. Except for its importance to rare amphibians, Delaware appears to be under-represented in terms of species richness hotspots. This is partly attributable to the relatively narrow breadth of habitat types found in Delaware when compared to Maryland and New Jersey. There are only two physiographic provinces represented in Delaware. Maryland hosts montane habitats, not found in Delaware, within its Allegheny Plateau and Ridge and Valley Provinces, and New Jersey includes similar habitats in its Ridge and Valley and Highlands Provinces. Therefore, the results of this project are best viewed from a regional perspective, and these results can assist state land managers in understanding how their local management actions might influence regional biodiversity.

In determining the reliability of species richness analysis, it is also important to keep in mind the limitations of the habitat models and the data sets that went into them. Though not always stated in the above presentation of results, these are "predicted" hotspots based on habitat modeling. While the presence of each species within 7.5-

minute quadrangles or 650 square-kilometer hexagons is based on reliable range data, the presence of a species in a particular cell or habitat patch is less certain and depends on the accuracy of the habitat model and the model inputs.

2.6.2 Vertebrate Species Distribution Model Accuracy

Of the many potential sources of error in modeling wildlife species distributions, some of which have been pointed out by other GAP projects (e.g., Scott et al. 2002), the following were identified as limitations for the MDN-GAP project:

1) Poorly-defined habitat preferences due to insufficient information in the scientific literature;
2) Inaccuracies in range data;
3) Inaccuracies in GIS layer model inputs (e.g., land cover);
4) Model limitations related to scale and exclusion of important micro-habitat features (e.g., vertical stream banks for swallows, snags for cavity-nesters);
5) GIS layers representing important habitat variables not available for parts or all of project area (e.g., habitat structure, surficial geology, large-scale wetlands mapping, large-scale soils mapping);
6) Oversimplification of models or modeling layers due to computer processing limitations.

Because of the limitations mentioned above, accuracy at the stand level, especially for certain habitat specialists, may be poor. For example, the bog turtle (*Clemmys muhlenbergii*) prefers a very specific type of wetland that is difficult, if not impossible, to map from satellite imagery. Also, sites occupied by this species tend to be small and, given the scope of this project these sites were probably poorly mapped. An extra effort was made to capture small vernal pools, but a methodology for teasing the preferred habitat of the bog turtle out of the dated NWI data were not available. Therefore, there may be many errors of both commission and omission for this species and other habitat specialists.

Accuracy may also be poor for species that rely on a mixture of habitats that are of sufficient size and are juxtaposed to one another. For example, the wood duck (*Aix sponsa*) not only requires nest cavities, but also requires different habitats for different life history requirements (e.g., brood habitat). Although there were forest juxtaposition, wetland proximity, and forest area components to the modeling, methodology for modeling the unique combination of habitats required by this species was not developed. As a result, this species' final distribution map includes some small woody wetlands in coastal areas that are unlikely to suitable.

In retrospect, given the final Special Habitat Feature grids include only 5 SHF types, it would have made more sense, and improved model accuracy for some species, to have created a separate grid for each SHF type, with buffer distances customized for each species, as opposed to combining SHF types into four hypergrids with each grid

representing a fixed distance. With regards to the forest juxtaposition modeling layer, more liberal rankings for some of the forest types were probably warranted, and this aspect of the modeling should be revisited. Some potentially important habitats were excluded from the Habitat Type modeling layer, including aquatic beds and impoundments, and surficial geology features might have been included if the GAP Land Cover had mapped them (e.g., shale barrens, rock outcroppings, cliffs). The distinction in the Habitat grid between low salt marsh and brackish marsh was based on some very generalized maps depicting salinities in major estuarine water bodies, and did not account for the influence of smaller streams and groundwater seeps on salinity. Therefore, there are, no doubt, inaccuracies in this distinction in the Habitat layer, and separating these marsh classes continues to be a challenge for landscape-level mapping efforts. In developing a separate Habitat Type modeling layer (i.e., separate from the GAP Land Cover), many of the problems identified in the land cover were fixed, but this modeling overlay was not assessed for accuracy. It was essentially based on the GAP Land Cover (which itself was subjected to an accuracy assessment), with some of the habitat classification being informed by the NLCD (also assessed for accuracy) and NWI (assessed for accuracy in some geographic areas). Nevertheless, many of the errors in predicted species distributions may be traced back to inaccuracies in the Habitat Type grid, and many areas for improvement have been identified.

There may also be inaccuracies introduced by the range data where hexagons span states that are separated by large bodies of water. For example, there were cases where a hexagon spanned the Delaware Bay and covered portions of Delaware and New Jersey on opposite sides of the bay, but a species was present only within the Delaware portion of the hexagon. In such cases, because the range-mapping was not done at the state level, the species was erroneously committed to the New Jersey portion of the hexagon. As a result of this problem, there may be errors of commission and exaggerated species richness hotspots along some of the project area's large water bodies (e.g., Delaware Bay, Chesapeake Bay, Susquehanna River, Potomac River).

2.6.3 Accuracy Assessment of Predicted Vertebrate Species Distributions

Due to project resource constraints, the accuracy assessment of predicted vertebrate species distributions was limited to comparison with species checklists from National Wildlife Refuges and state parks. All of these lists were based on actual inventories, but some lists were somewhat outdated. An unfortunate limitation of the accuracy assessment for this project was the complete absence of any reliable checklists for the mountainous regions of western Maryland which host several rare species that are found nowhere else in the project area. A bird checklist for the entire western-most county does exist, but since this county is larger than the standard hexagon range unit, use of this checklist was deemed inappropriate.

The checklists for birds indicate whether or not a species is known to nest within the managed area, and because modeling focused only on breeding distributions, the accuracy assessment compared only those species that were listed as nesters to the modeled

distributions, with a few exceptions. These exceptions included widely-foraging species such as colonial-nesting herons and egrets that are known to travel many kilometers from their rookeries to foraging habitats during the breeding season. Gulls, terns and swallows are also known to travel considerable distances from nesting sites while foraging. If a checklist indicated that one of these species was "common" or "abundant" during the nesting season, then the managed area was assumed to include foraging habitat important to the reproductive success of the species and was therefore considered part of the species' local breeding range, even if the species was not known to nest within the boundaries of the managed area.

In a very small number of cases, a checklist was determined to be in error based on new, reliable field data indicating the breeding occurrence of a species which was not included in the checklist, and the predicted distribution of the species within that managed area was recorded as a "match" in the accuracy assessment. This rule was not applied to sporadic nesters. There were also mistakes, confirmed by land managers, which had nothing to do with checklist vintage. Other potential problems were associated with bird checklists which state that listed nesters are known to nest "on or near the refuge." This fuzziness may have caused false errors of omission in cases where a species' modeled distribution fell just outside of a refuge. There were also cases where sporadic breeders were included as nesters on a checklist. In addition, there were many cases where a breeding bird atlas or NHP element occurrence records indicated that a species was nesting within a particular park, refuge or management area, often specifically mentioning the area by name as a known nesting location, but the species was not included as a nester on the checklist. In some cases, a checklist indicated that the species had recently been extirpated. There were also some instances where a species was listed as a nester on a checklist, but there were no corresponding "probable" or "confirmed" nesting records in the breeding bird atlas.

One reptile and amphibian checklist stated that "the occurrence of the more rare and secretive skinks, salamanders, frogs, and toads has not been fully substantiated." For this particular refuge, an error of omission was recorded for a very rare skink. This was also a problem for some rare or secretive mammals. Conversely, there were often errors of commission recorded for secretive species that were predicted to occur in an area but were not included in the corresponding checklist. This was also the case for some bat species. Errors of commission were recorded for sea turtle species that were predicted to occur in nearshore areas, but were not included in checklists.

There are obviously many potential problems associated with this approach to accuracy assessment, including differences in vintage of checklists and source data sets used in range mapping. It also appears that more coordination between checklist compilers and other efforts (e.g., NHP inventories, BBA surveys) is needed. Ultimately, a more thorough accuracy assessment, including outside expert review, is needed to better assess the accuracy of MDN-GAP predicted animal distributions.

Chapter 3: Analysis Based On Stewardship and Management Status

3.1 Introduction

This chapter describes the methods and results of the gap analysis as used by the Gap Analysis Program. As described in the general introduction to this report, the primary objective of GAP is to provide information on the distribution and status of several elements of biological diversity. Although GAP "seeks to identify habitat types and species not adequately represented in the current network of biodiversity management areas" (GAP Handbook, Preface, Version 1, p. I), it is unrealistic to create a standard definition of "adequate representation" for either land cover types or individual species (Noss et al. 1995). A practical solution to this problem is to report both percentages and absolute area of each element in biodiversity management areas and allow the user to determine which types or species are adequately represented in natural areas. There are many other factors that should be considered in such determinations such as:

- historic loss or gain in distribution,
- nature of the spatial distribution,
- immediate versus long term risk, and
- degree of local adaptation among populations of the biotic elements that are worthy of individual conservation consideration.

Such analyses are beyond the scope of this project, but we encourage their application coupled with field confirmation of the mapped distributions.

Currently, land cover types and terrestrial vertebrates are the primary focus of GAP's mapping efforts, but other components of biodiversity, such as aquatic organisms or selected groups of invertebrates may be incorporated into GAP distributional data sets. Where appropriate, GAP data may also be analyzed to identify the location of a set of areas in which most or all land cover types or species are predicted to be represented. The use of "complementarity" analysis, that is, an approach that additively identifies a selection of locations that may represent biodiversity rather than "hot spots of species richness" may prove most effective for guiding biodiversity maintenance efforts. Several quantitative techniques have been developed recently that facilitate this process (see Pressey et al. 1993, Williams et al. 1996, Csuti et al. 1997, for details). These areas become candidates for field validation and may be incorporated into a system of areas managed for the long-term maintenance of biological diversity.

The network of Conservation Data Centers (CDCs) and Natural Heritage Programs (NHPs) established cooperatively by The Nature Conservancy and various state agencies maintain detailed databases on the locations of rare elements of biodiversity. GAP cooperatively uses these data to develop predicted distributions of potentially suitable habitat for these elements, which may be valuable for identifying research needs and preliminary considerations for restoration or reintroduction. Conservation of such elements, however, is best accomplished through the fine-filter approach of the above

organizations as described in the introduction. It is not the role of GAP to duplicate or disseminate Heritage Program or CDC Element Occurrence Records. Users interested in more specific information about the location, status, and ecology of populations of such species are directed to their state Heritage Program or CDC.

3.2 Methods

The gap analysis is accomplished by first producing maps of 1) land cover, 2) predicted distributions for selected animal species, and 3) land stewardship and management status. Once these tasks are accomplished, the land stewardship and management layer is intersected with the land cover and animal species distribution layers, and the results are presented in tables which summarize the area and percent of total mapped distribution of each element in different land stewardship and management categories. The results presented here pertain only to the land stewardship and management status of animal species for which models were developed. For results pertaining to the stewardship and management status of different land cover classes, see Rasberry et al. (2003).

The characteristics used to determine stewardship and management status are as follows:

- Permanence of protection from conversion of natural land cover to unnatural (anthropogenic habitats, human induced barren, exotic-dominated, arrested succession)

- Relative amount of the tract managed for natural cover

- Inclusiveness of the management, i.e., a single feature or species versus all biota that would be expected to occur in the absence of human impacts

- Type of management and degree to which it is mandated through legal and institutional arrangements

The four status categories can generally be defined as follows (after Scott et al. 1993, Edwards et al. 1995, Crist et al. 1995):

Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management.

Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities.

Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type

or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area.

Status 4: Lack of irrevocable easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Intensive use throughout the tract is allowed. Also those tracts for which the existence of such restrictions or sufficient information to establish a higher status is unknown are included.

For more background information regarding the land stewardship overlay used in this analysis, see Rasberry et al. (2003).

The methods for conducting the analysis involved first converting the land stewardship and management GIS vector coverage into a raster grid, with cell values of 1 through 4, representing the four stewardship and management categories. Individual species distribution grids were then reclassified to 0 and nodata, with the value of zero indicating the species' presence and nodata indicating its absence. Each reclassified species grid was then added to the land stewardship and management grid, thus intersecting the grids and assigning values of 1 through 4 to cells where the species is present. Four new fields were then added to the Value Attribute Table (VAT) of each resulting grid, one for each of the stewardship categories, and calculations were run to populate each field with a number representing the area, in hectares, under each stewardship category. The VAT for each of these grids was then "unloaded" to a text file and imported into a table which presents the results of this analysis (Appendix J).

3.3 Results

The data are provided in a format that allows users to carry out inquires about the representation of each element in different land stewardship and management categories as appropriate to their own management objectives. This forms the basis of Gap's mission to provide land owners and managers with the information necessary to conduct informed policy development, planning, and management for biodiversity maintenance.

As a coarse indicator of the status of the elements, we provide a breakdown along five levels of representation (0-<1%, 1-<10%, 10-<20%, 20-<50%, and >=50%). The <1% level indicates those elements with essentially none of their distribution in a protected status while levels of 10%, 20%, and 50% have been recommended in the literature as meaningful amounts of conservation (Noss and Cooperrider 1994; Noss 1991; Odum and Odum 1972; Specht et al. 1974; Ride 1975; Miller 1994).

The complete analysis table found in Appendix J provides the area, in hectares, of each species' mapped distribution by management status, and the percent of the species' total distribution in each category. For example, the entry for Jefferson Salamander (*Ambystoma jeffersonianum*) indicates that this species has 10,446 ha of potential habitat in lands that are ranked Status 2, which represents 10.5% of that species' total predicted distribution.

A total of 363 species were cross-tabulated with the stewardship map to produce summaries of protection for each species. Although only about 8% of all species have ≤ 1% of their predicted distributions within status 1 and 2 lands (Table 3.1), over 80% have only 1-10% of their predicted distributions within status 1 and 2 lands.

Table 3.1. Proportion of each taxonomic group with 0-1%, 1-10%, 10-20%, 20-50%, and > 50% of their predicted distributions in GAP status 1 and 2 lands

Taxonomic Group	Total Species	0-1%	1-10%	10-20%	20-50%	> 50%
Amphibians	41	1 (2.4%)	38 (92.7%)	2 (4.9%)	0 (0.0%)	0 (0.0%)
Birds	206	24 (11.7%)	150 (72.8%)	27 (13.1%)	3 (1.5%)	2 (0.9%)
Mammals	69	2 (2.9%)	63 (91.3%)	2 (2.9%)	1 (1.4%)	1 (1.4%)
Reptiles	47	1 (2.1%)	41 (87.2%)	2 (4.3%)	2 (4.3%)	1 (2.1%)
Total	363	28 (7.7%)	292 (80.4%)	33 (9.1%)	6 (1.7%)	4 (1.1%)

Birds and reptiles appear to be the taxa that are best represented in status 1 and 2 lands, with over 15% of the bird species and over 10% of the reptile species having more than 10% of their potential habitat falling within status 1 and 2 lands. Looking at species with at least 20% of their potential habitat occurring within status 1 and 2 lands, reptiles appear to be the taxonomic group that is best represented, with 6.4% of the reptile species having at least 20% of their potential habitat occurring within status 1 or 2 lands. Overall, however, it appears that all taxa are poorly represented within GAP status 1 and 2 lands. Amphibians appear to be in the worst shape, with over 95% of amphibian species having less than 10% of their potential habitat occurring within status 1 and 2 lands. When considering native species only, over 88% of all species (307 of 348) have less than 10% of their predicted distributions occurring within status 1 or 2 lands.

3.3.1. Species with Less than 1% of Predicted Distribution in Status 1 or 2

3.3.1.1 Amphibians

One amphibian species, the green salamander (*Aneides aeneus*), has less than 1% of its predicted distribution occurring within status 1 or 2 lands. Given that this species is considered very rare within the project area, this represents a high conservation priority.

3.3.1.2 Birds

There are 24 bird species with less than 1% of their predicted distributions occurring within status 1 or 2 lands. Some of these species are on the edges of their breeding range (e.g., green-winged teal, *Anas crecca*), while others are human-adapted, occurring mostly in disturbed or urban areas (e.g., rock dove, *Columba livia*). The exotic ring-necked pheasant (*Phasianus colchicus*) has been introduced as a game bird to some areas, but has a very limited distribution within the project area. Species of conservation concern include the American kestrel (*Falco sparverius*), short-eared owl (*Asio flammeus*) which is an extremely rare breeder, royal tern (*Sterna* maxima), which is an endangered species in Maryland, common nighthawk (*Chordeiles minor*), and mourning warbler (*Oporornis philadelphia*).

In addition, there are several grassland bird species with less than 1% of their potential habitat falling within status 1 or 2 lands. These species, all of which are rare to extremely rare nesters within one or more of the project area's states, include the upland sandpiper (*Bartramia longicauda*), grasshopper sparrow (*Ammodramus* savannarum), vesper sparrow (*Pooecetes gramineus*), savannah sparrow (*Passerculus sandwichensis*), Henslow's sparrow (*Ammodramus henslowii*), dickcissel (*Spiza americana*), bobolink (*Dolichonyx oryzivorus*), and eastern meadowlark (*Sturnella magna*). Some of these grassland birds require large, contiguous patches of grassland or prairie habitat, a condition which did not naturally occur within this project area until many of its forests were cleared for agriculture. This forest-clearing trend has had a very negative impact on forest-dependent species, especially those which require large, contiguous tracts containing forest interior habitat. Therefore, although many of these grassland birds are species of management concern and are poorly represented on GAP status 1 and 2 lands, any management actions taken on their behalf should not be at the expense of forest interior habitat.

3.3.1.3 Mammals

Two mammal species, Townsend's big-eared bat (*Corynorhinus townsendii*) and black rat (*Rattus rattus*), have less than 1% of their predicted distributions occurring within status 1 and 2 lands. The former has an extremely limited range which barely extends into the project area, while the latter is an exotic species commonly associated with urban areas and is therefore unlikely to occur within the undeveloped habitats of status 1 or 2 lands.

3.3.1.4 Reptiles

Only one reptile species has less than 1% of its predicted distribution occurring within status 1 or 2 lands, and that species, the slider (*Trachemys scripta*), was introduced to the project area, most likely through the pet trade.

3.3.2 Species with Less than 10% of Predicted Distribution in Status 1 or 2

3.3.2.1 Amphibians

There are far too many species with less than 10% of their predicted distributions in status 1 or 2 lands to list them all here. However, when considering species rarity in combination with representation within status 1 or 2 lands, there are many species worth noting. The mudpuppy (*Necturus maculosus*), hellbender (*Cryptobranchus alleganiensis*), and barking treefrog (*Hyla gratiosa*) are all considered extremely rare within the project area and have less than 5% of their predicted distributions occurring within status 1 or 2 lands. The mountain chorus frog (*Pseudacris brachyphona*), Cope's gray treefrog (*Hyla chrysoscelis*), Eastern narrowmouth toad (*Gastrophryne carolinensis*) and carpenter frog (*Rana virgatipes*) are all considered extremely rare to very rare within the project area, and also have less than 5% of their predicted distributions occurring within status 1 or 2 lands. There are also a few rare to extremely rare mole salamander

species with less than 10% of their potential habitat within status 1 and 2 lands. These species are included as part of an important species assemblage described below.

3.3.2.2 Birds

Nearly 73% of nesting bird species in this project area have between 1 and 10% of their predicted distributions occurring within GAP status 1 or 2 lands. Among these are many species of management concern, including wetland-dependent species such as the pied-billed grebe (*Podilymbus podiceps*), American bittern (*Botaurus lentiginosus*), least bittern (*Ixobrychus exilis*), black rail (*Laterallus jamaicensis*), king rail (*Rallus elegans*), sora (*Porzana carolina*), common moorhen (*Gallinula chloropus*), American coot (*Fulica Americana*), black-necked stilt (*Himantopus mexicanus*), sedge wren (*Cistothorus platensis*) and the swamp sparrow (*Melospiza Georgiana*), which includes a coastal plain subspecies (*M. g. nigrescens*) of management concern. Also included are the blue-winged warbler (*Vermivora pinus*) and chestnut-sided warbler (*Dendroica pensylvanica*), both of which are associated with brushy second-growth, and the alder flycatcher (*Empidonax alnorum*) and Nashville warbler (*Vermivora ruficapilla*), species that are associated with both wetlands and brushy second growth habitats.

Other species, such as the red-shouldered hawk (*Buteo lineatus*), barred owl (*Strix varia*), brown creeper (*Certhia americana*), veery (*Catharus fuscescens*), northern parula (*Parula americana*), American redstart (*Setophaga ruticilla*), Swainson's warbler (*Limnothlypis swainsonii*) and hooded warbler (*Wilsonia citrina*) have been found to be sensitive to forest fragmentation, and are mostly restricted to unbroken forests. The brown-headed nuthatch (*Sitta pusilla*) is at the extreme northern end of its range, preferring the pines of the southernmost portions of the project area. Also associated with pines but equally at home in mature riparian or floodplain forests is the yellow-throated warbler (*Dendroica dominica*). Another species of management concern that is underrepresented within status 1 and 2 lands and often associated with mature riparian woodlands is the warbling vireo (*Vireo gilvus*).

Three species that are near the southern extremes of their breeding ranges and are likewise underrepresented in status 1 and 2 lands are the winter wren (*Troglodytes troglodytes*), blackburnian warbler (*Dendroica fusca*) and dark-eyed junco (*Junco* hyemalis), all of which are often associated with more northern or boreal habitats, and generally nest only within the mountainous portions of the project area. Other species of management concern that have less than10% of their predicted distributions occurring within GAP status 1 or 2 lands include the bald eagle (*Haliaeetus leucocephalis*), northern harrier (*Circus cyaneus*), sharp-shinned hawk (*Accipiter striatus*), broad-winged hawk (*Buteo platypterus*), least tern (*Sterna antillarum*), black-billed cuckoo (*Coccyzus erythropthalmus*), red-headed woodpecker (*Melanerpes erythrocephalus*), cliff swallow (*Hirundo pyrrhonota*), common raven (*Corvus corax*), Bewick's wren (*Thryomanes bewickii*), and loggerhead shrike (*Lanius ludovicianus*). All of these species are considered very rare or extremely rare in at least one of the three states.

3.3.2.3 Mammals

Over 91% of the mammal species in this project area have less than10% of their potential habitat occurring within GAP status 1 or 2 lands. Of these, three are at the extremes of their ranges. The common porcupine (*Erethizon dorsatum*), which is considered very rare to extremely rare in Maryland, is at the extreme southern end of its range in the north-central part of this state. The ermine, *Mustela erminea,* also appears to be at the southern end of its range where it occurs in north-central Maryland and northern New Jersey. The eastern spotted skunk, *Spilogale putorius*, is at the extreme northern end of its range in western Maryland, where it is considered extremely rare. There is also an extremely rare subspecies, the southern rock vole (*Microtus chrotorrhinus carolinensis*), whose southern distribution appears to reach its northern terminus in western Maryland.

Among the other very rare or extremely rare species with less than10% of their predicted distributions in status 1 or 2 lands are the water shrew (*Sorex palustris*), smoky shrew (*Sorex fumeus*), long-tailed shrew (*Sorex dispar*), two subspecies of the pygmy shrew (*Sorex hoyi*), social myotis (*Myotis sodalis*), eastern small-footed myotis (*Myotis leibii*), eastern fox squirrel (*Sciurus niger*) which includes the federally endangered Delmarva subspecies (*S. n. cinereus*), Allegheny woodrat (*Neotoma magister*), southern bog lemming (*Synaptomys cooperi*), and least weasel (*Mustela nivalis*). Also included among these species are the New England cottontail (*Sylvilagus transitionallis*) and the Appalachian cottontail (*Sylvilagus obscurus*) which, until recently, were thought to be members of the same species but were treated as separate species in this project. The former appears to occur in northern New Jersey, though its status is currently undetermined, while the latter occurs in extreme western Maryland where it is extremely rare. One other noteworthy species whose status may be uncertain within the project area is the fisher, *Martes pennanti*. Once extirpated over most of its eastern range, it has been reintroduced in the northeast and, in 1969, twenty-three animals from New Hampshire were released in West Virginia, near the Virginia and Maryland state lines, apparently with some success (Whitaker and Hamilton 1998).

3.3.2.4 Reptiles

Over 87% of reptile species in this project area have less than 10% of their predicted distributions occurring within status 1 and 2 lands. Among these are many species of management concern, including the federally threatened bog turtle (*Clemmys muhlenbergii*), which is found in a small number of isolated bogs and spring-fed wet meadows within the project area. Also included are three southern species, scarlet snake (*Cemophora coccinea*), rainbow snake (*Farancia erythrogramma*) and plainbelly watersnake (*Nerodia erythrogaster*), which are at the northern extremes of their ranges within the project area. The common map turtle (*Graptemys geographica*) and spiny softshell (*Apalone spinifera*) are both associated with aquatic habitats, as is the queen snake (*Regina septemvittata*) which requires relatively unpolluted streams and is declining due to continuing habitat degradation. The remaining species, broadhead skink (*Eumeces laticeps*), ground skink (*Scincella lateralis*), coal skink (*Eumeces anthracinus*), redbelly snake (*Storeria occipitomaculata*), corn snake (*Elaphe guttata*), smooth earth

snake (*Virginia valeriae*), copperhead (*Agkistrodon contortrix*) and timber rattlesnake (*Crotalus horridus*), are all primarily associated with forests.

3.3.3 Species with Less than 20% of Predicted Distribution in Status 1 or 2

3.3.3.1 Amphibians

Only two amphibian species, Jefferson salamander (*Ambystoma jeffersonianum*) and blue-spotted salamander (*Ambystoma laterale*), have between 10 and 20% of their distributions in status 1 or 2 lands. The former is considered rare in both Maryland and New Jersey, while the latter is absent from most of the project area, occurring only in northern New Jersey where it is considered extremely rare. All other amphibian species have less than 10% of their predicted distributions occurring within status 1 or 2 lands.

3.3.3.2 Birds

Just over 13% of bird species have between 10 and 20% of their predicted distributions occurring within status 1 or 2 lands. In addition to three wading bird species included in an important project-wide species assemblage (described below), other species of management concern include several beach-nesting species such as American oystercatcher (*Haematopus palliatus*), great black-backed gull (*Larus marinus*), common tern (*Sterna hirundo*), Forster's tern (*Sterna forsteri*) and black skimmer (*Rynchops niger*). Other rare species associated with coastal habitats include double-crested cormorant (*Phalacrocorax auritus*), gadwall (*Anas strepera*), and the peregrine falcon (*Falco peregrinus*) which often hunts along bay beaches. This group also includes the hooded merganser (*Lophodytes cucullatus*), which requires tree cavities and is generally associated with inland, non-tidal wetlands.

Species in this group that are rare because they're associated with more northern or boreal habitats for nesting, and reach their southern limits within the project area, include the northern goshawk (*Accipiter gentilis*), northern saw-whet owl (*Aegolius acadicus*), red-breasted nuthatch (*Sitta Canadensis*), golden-crowned kinglet (*Regulus satrapa*), and yellow-bellied sapsucker (*Sphyrapicus varius*). A species that is extremely sensitive to forest fragmentation, and has less than 20% of its potential habitat within GAP status 1 and 2 lands, is the cerulean warbler (*Dendroica cerulea*), which is a species of management concern in the northeast.

3.3.3.3 Mammals

Only two mammal species, the nutria (*Myocastor coypus*) and black bear (*Ursus americanus*), have between 10 and 20% of their predicted distributions occurring within status 1 or 2 lands. The nutria is an exotic nuisance species that is responsible for the conversion of large areas of tidal marsh to open water in the Blackwater National Wildlife Refuge in Maryland. A trapping program has greatly reduced its numbers, but it is still a management problem and has expanded into other parts of the project area, including some areas of Delaware. The black bear is listed as a rare species in Maryland and New Jersey where it is a source of controversy due to increasing conflicts with humans.

3.3.3.4 Reptiles

Two reptile species, the leatherback seaturtle (*Dermochelys coriacea*) and diamondback terrapin (*Malaclemys terrapin*), have between 10 and 20% of their distributions occurring within status 1 and 2 lands. In actuality, none of the leatherback seaturtle's potential habitat is protected within the project area, as this species does not nest here but is found in nearshore waters along the coast and in the bays. Habitat mapping for this species included estuarine open water habitats which sometimes included small lagoons that occur within the boundaries of status 1 or 2 lands (probable errors of commission). The diamondback terrapin also uses nearshore waters along ocean and bay beaches where it nests, but as a juvenile, it spends most of its time in tidal creeks and marshes.

3.3.4 Species with Less than 50% of Predicted Distribution in Status 1 or 2

3.3.4.1 Amphibians

All amphibian species have less than 20% of their predicted distributions occurring within status 1 or 2 lands.

3.3.4.2 Birds

Bird species with between 20 and 50% of their predicted distributions occurring within status 1 or 2 lands include the piping plover (*Charadrius melodus*), a federally threatened beach-nester, gull-billed tern (*Sterna nilotica*), also an extremely rare beach-nester, and pine siskin (*Carduelis pinus*). The two beach nesters have extremely limited distributions within the project area, and significant portions of their nesting habitat are protected. The pine siskin is an extremely rare breeder in both New Jersey and Maryland. Breeding records for this species in Maryland are from state and federal lands.

3.3.4.3 Mammals

One mammal species, the northern flying squirrel (*Glaucomys sabrinus*), has 20 to 50% of its potential habitat within status 1 or 2 lands. This is mostly a northern species, occurring only in the highlands of northwestern New Jersey and in the mountains near the southernmost portion of the Maryland-West Virginia border. Its status is currently undetermined within the project area.

3.3.4.4 Reptiles

The two reptile species with 20 to 50% of their predicted distributions occurring within status 1 or 2 lands are federally threatened sea turtles. Only one of the two species, the loggerhead seaturtle (*Caretta caretta*), uses terrestrial habitats within the project area. This turtle is a confirmed nester on Assateague Island, on the Atlantic coast at the southern extreme of the project area. In addition, both the Chesapeake Bay and Delaware Bay host large numbers of juvenile loggerheads each summer, where they feed primarily on horseshoe crabs. The Delaware Bay hosts the world's largest population of spawning horseshoe crabs. The Atlantic green turtle (*Chelonia mydas*) does not nest within the project area, but juveniles of this species are observed foraging among submerged aquatic vegetation in shallow marine and estuarine waters of the project area.

3.3.5 Species with More than 50% of Predicted Distribution in Status 1 or 2

3.3.5.1 Amphibians

No amphibian species have more than 20% of their predicted distributions occurring within status 1 or 2 lands.

3.3.5.2 Birds

Two bird species, the brown pelican (*Pelecanus occidentalis*) and white-throated sparrow (*Zonotrichia albicollis*), have more than 50% of their predicted distributions occurring within status 1 or 2 lands. Each species has an extremely limited breeding distribution within the project area but, in each case, this distribution largely coincides with state- and federally-owned protected areas. The white-throated sparrow nests primarily in hemlock-northern hardwood forests of the New Jersey Highlands. The brown pelican is somewhat of a newcomer to the project area, with the first nesting confirmation occurring in 1987 on a dredge spoil island in Chincoteague Bay.

3.3.5.3 Mammals

Only one mammal species, the feral horse or "Assateague pony" (*Equus caballus*), has more than 50% of its predicted distribution occurring within Gap status 1 or 2 lands. Most of this species potential habitat occurs within the Assateague Island National Seashore.

3.3.5.4 Reptiles

The only reptile species with more than 50% of its potential habitat falling within status 1 or 2 lands is the Atlantic ridley seaturtle (*Lepidochelys kemppii*). This federally-listed endangered species does not nest within the project area, but is found in relatively high numbers in the Chesapeake Bay and along the Atlantic coast of the project area during the summer, often in or near eelgrass meadows. Very little if any of this seaturtle's potential habitat is actually protected within the project area. Habitat mapping for this species included estuarine open water habitats which sometimes included small lagoons that occur within the boundaries of status 1 or 2 lands (probable errors of commission).

3.3.6 Analysis of Important Statewide Species Assemblages

3.3.6.1 Vernal pool-breeding amphibians

In terms of rarity and vulnerability to human impacts, vernal pool-breeding amphibians represent an important species assemblage. Several species that occur within an area known as the Blackbird-Millington corridor are of particular conservation concern. Among these species are the spotted salamander (*Ambystoma maculatum*), marbled salamander (*Ambystoma opacum*), tiger salamander (*Ambystoma tigrinum*) and barking treefrog, all of which are considered rare to extremely rare, and all of which depend upon forests and seasonal wetlands for their survival. The Blackbird-Millington Corridor, which spans the boundary between Maryland and Delaware, is also an area of very high amphibian species richness (see Figure 2.15), and because it occurs on the coastal plain

where topography is very flat, its forests and seasonal wetlands are especially vulnerable to development. Despite the fact that significant portions of this corridor occur on state-owned forest land and wildlife management area land, all of the species mentioned above have less than 10% of their predicted distributions occurring within status 1 or 2 lands.

3.3.6.2 Wading birds of Pea Patch Island

Another important species assemblage includes nine wading bird species, all of which are considered rare to extremely rare within the project area, and all of which can be found nesting on Pea Patch Island in the upper Delaware Bay. This island rookery, which is protected by the State of Delaware, represents the largest heron rookery north of Florida. While some of the nine species may be found nesting in other, smaller rookeries throughout the project area, Pea Patch Island is the only site known to support all of these species. Six of these species have less than 10% of their predicted distributions occurring within status 1 and 2 lands. These species include the great blue heron (*Ardea herodias*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), little blue heron (*Egretta caerulea*), cattle egret (*Bubulcus ibis*) and black-crowned night-heron (*Nycticorax nycticorax*). The remaining three species have 10 to 20% of their predicted distributions occurring within status 1 and 2 lands. These include the tricolored heron (*Egretta tricolor*), yellow-crowned night-heron (*Nyctanassa violaceus*) and glossy ibis (*Plegadis falcinellus*). Two of these three species, the tricolored heron and yellow-crowned night-heron, have slightly more potential habitat falling within GAP status 1 and 2 lands because they do not travel far from their rookery to find suitable foraging habitat. The glossy ibis, on the other hand, may travel many kilometers from the rookery to forage, as will the other six species, most of which are relatively abundant but appear to be less protected due to their wide-ranging foraging habits.

3.3.7 Analysis of State Endemics

Although there are no endemic terrestrial vertebrate species in any of the project area's three states, there are some notable subspecies. Possibly most important among these is the federally-listed endangered Delmarva fox squirrel (*Sciurus niger cinereus*). Although this subspecies is not endemic to any of the three states, it is endemic to the Delmarva Peninsula, which includes Delaware and the Eastern Shore (i.e., of the Chesapeake Bay) portions of Maryland and Virginia. Within Maryland and Delaware, only 2.34% of this subspecies' predicted distribution falls within status 1 or 2 lands. A geographically-isolated subspecies of vole, known as Rhoad's southern red-backed vole (*Clethrionomys gapperi rhoadsi*), occurs in the cedar swamps and sphagnum bogs of southern New Jersey. The protection status of this subspecies was not determined but, at the species level, only 3.88% of this vole's predicted distribution falls within status 1 or 2 lands across the project area.

3.4 Limitations and Discussion

When applying the results of our analyses, it is critical that the following limitations are considered: 1) the limitations described for each of the component parts (animal species mapping, stewardship mapping) of the analyses, 2) the spatial and thematic map accuracy

of the components, and 3) the suitability of the results for the intended application (see Appropriate and Inappropriate Use below).

It should be noted that flaws in the land stewardship and management GIS coverage were discovered during the accuracy assessment of vertebrate distributions. In New Jersey alone, over 11,000 hectares of National Wildlife Refuge land were not included in this GIS coverage, and at least 3,900 hectares of National Wildlife Refuge land in Maryland were not included in the mapping. In addition, 8,261 hectares of state Wildlife Area land in Delaware were mis-labeled as "private." Although most or all of these lands are unlikely to meet the status 1 criteria, they are likely to be status 2 or 3, but were mapped as status 4 lands. Therefore, the analysis of management status of land cover in these states was flawed, and this problem was discovered after the analysis had already been conducted for the predicted vertebrate distributions. These errors were corrected for the accuracy assessment of the vertebrate distributions, so the comparison of predicted species distributions to species checklists from these areas is considered valid. Unfortunately, there will be cases where certain land cover types and wildlife species appear to be more under-represented in managed areas that afford some level of biodiversity protection than they truly are and, thus the results may include some false "gaps" in biodiversity conservation. However, the 23,161 total hectares known to be excluded from stewardship areas represents less than one-half of one percent (0.46%) of the total project area, and therefore probably would not significantly increase a species' protection status.

It should also be noted that the only GAP status 1 lands are the salt marshes of South Marsh Island and Cedar Island Wildlife Management Areas, which are both surrounded by waters of the Chesapeake Bay in southern Maryland. Because the mesohaline to polyhaline habitats of these areas are inhospitable to amphibians, no species of this taxonomic group is afforded the highest biodiversity conservation status anywhere within the Maryland-Delaware-New Jersey project area.

Although we have indicated that many of the species that are underrepresented in status 1 and 2 lands are near the extremes of their ranges, it is important to keep in mind that the analyses presented here do not take into account the distribution or protection status of species in other parts of their ranges. Many of the species that have very limited ranges in the MDN-GAP project area range widely in adjacent states. To consider fully the conservation status of these species, a comprehensive, rangewide assessment would need to be completed (Scott et al. 2002).

It is apparent that many species of conservation concern are poorly represented within lands that are managed for biodiversity. A very large percentage of the project area is privately owned, which creates considerable challenges to biodiversity conservation. However, there are also significant portions of the project area in status 3 protection (e.g., state forests), and these areas offer great potential for incorporating biodiversity conservation priorities into their management plans.

Chapter 4: Stewardship Status of Predicted Rare Species Richness Hotspots

4.1 Introduction

As previously stated, the primary objective of GAP is to provide information on the distribution and conservation status of elements of biological diversity. Currently, land cover types and terrestrial vertebrates are the primary focus of GAP's mapping efforts. This report focuses on modeling and mapping the distributions of 363 terrestrial vertebrate species (breeding birds, mammals, reptiles, and amphibians), and determining their conservation status in Maryland, Delaware and New Jersey. It is a supplement to a previous report by Rasberry et al. (2003) which focused on mapping and determining the conservation status of natural land cover types for this three-state area. The results of the analysis of the stewardship and management status of terrestrial vertebrates are presented in Chapter 3 and Appendix J. These results report the percentage and absolute area of each species' predicted distribution falling within each of the four stewardship and management categories.

A secondary objective of GAP is to identify areas that are high in species richness and may be considered potential biodiversity "hotspots." However, as discussed in chapter 2, there are many shortcomings to this secondary analysis (e.g., hotspots may not capture all species of concern), and the results of the species richness analysis are more subjective (e.g., how many species constitute a hotspot?). For these and other reasons, GAP places primary emphasis on the more objective and quantitative results which identify how well each species, or landcover type, is represented within lands that are managed in a way that will ensure its continued existence. Nevertheless, identifying hotspots, particularly rare species hotspots that appear to be inadequately protected, may be a valuable approach to habitat conservation planning, as long as its limitations are acknowledged and it is viewed as complementary to other conservation planning tools.

4.2 Methods

Tables listing rare vertebrate species tracked by the Natural Heritage Programs in Maryland, Delaware and New Jersey are presented in Appendix H. Species richness analyses were conducted by taxonomic group (birds, mammals, reptiles, amphibians), for all species in the four taxonomic groups combined, for rare species of each taxonomic group, and for rare species in all taxonomic groups combined. Species richness grids for rare birds, rare mammals, rare reptiles, rare amphibians, and all rare vertebrates combined, were intersected with GAP stewardship status 4 lands (i.e., no protection) and status 3 and 4 lands combined (i.e., potential management gaps or no protection at all).

4.3 Results

4.3.1 Predicted Gaps in Protection of Rare Bird Species Hotspots

Predicted hotspots for rare bird species that are potential management gaps (status 3) or lacking protection altogether (status 4) are too numerous to name, but some of the more obvious potential gaps are shown in Figure 4.1. This figure depicts predicted hotspots occurring within status 4 lands only. Among the most prominent are riparian forests within the Youghiogheny River corridor on the Allegheny Plateau in western Maryland, and the riparian and headwater forests of the New Jersey Highlands and Kittatinny Mountain where the largest numbers of rare bird species are found.

Other unprotected hotspots in Maryland include riparian forests along the Conowingo Creek and Grays Run in the Piedmont Province, riparian forests along the Patuxent River and tributaries of the Severn and South Rivers (e.g., North River, Bacon Ridge Branch, Flat Creek, western shore tributaries of Little Round Bay), and forested swampland along Zekiah Swamp Run and in the Pocomoke River corridor within Maryland's Coastal Plain. In New Jersey, additional hotspots which appear to be unprotected include the swampy headwaters of Oranoaken Creek (Bear Swamp west) on the Coastal Plain, tidal marshes in the vicinity of Atlantic City, and the forested headwaters of Rancocas Creek at the western edge of the New Jersey Pine Barrens. Additional predicted hotspots that are unprotected or represent potential management gaps are listed in Appendix K.

4.3.2 Predicted Gaps in Protection of Rare Mammal Species Hotspots

By far, the most prominent, unprotected hotspots for rare mammal species are in western Maryland on the Allegheny Plateau and, to a lesser extent, in the Ridge and Valley Province of Maryland (Figure 4.2). The forests of theYoughiogheny River corridor again appear to be important and are mostly unprotected. Other predicted hotspots that are not adequately protected include forests along the Casselman River and some of its tributaries, riparian forests of the North Branch Potomac River and tributaries, forests of the Georges Creek corridor, and hardwood and mixed forests on Piney Mountain. Within the Ridge and Valley Province of western Maryland, uprotected hotspots for rare mammals include the hardwood, mixed and riparian forests of Collier Mountain and Collier Run, and forests along Sideling Creek.

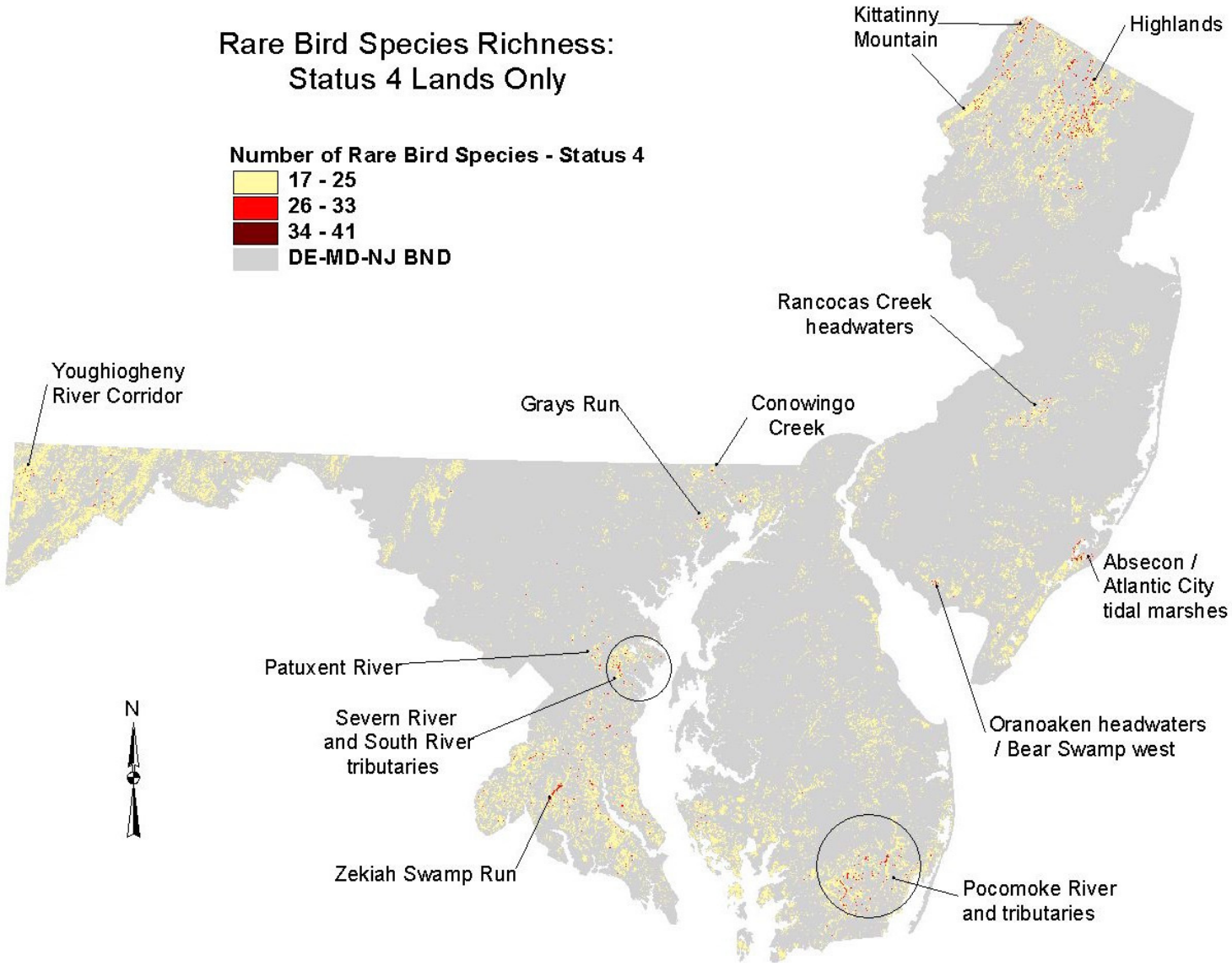

Figure 4.1: Predicted Rare Bird Species Hotspots on Status 4 Lands

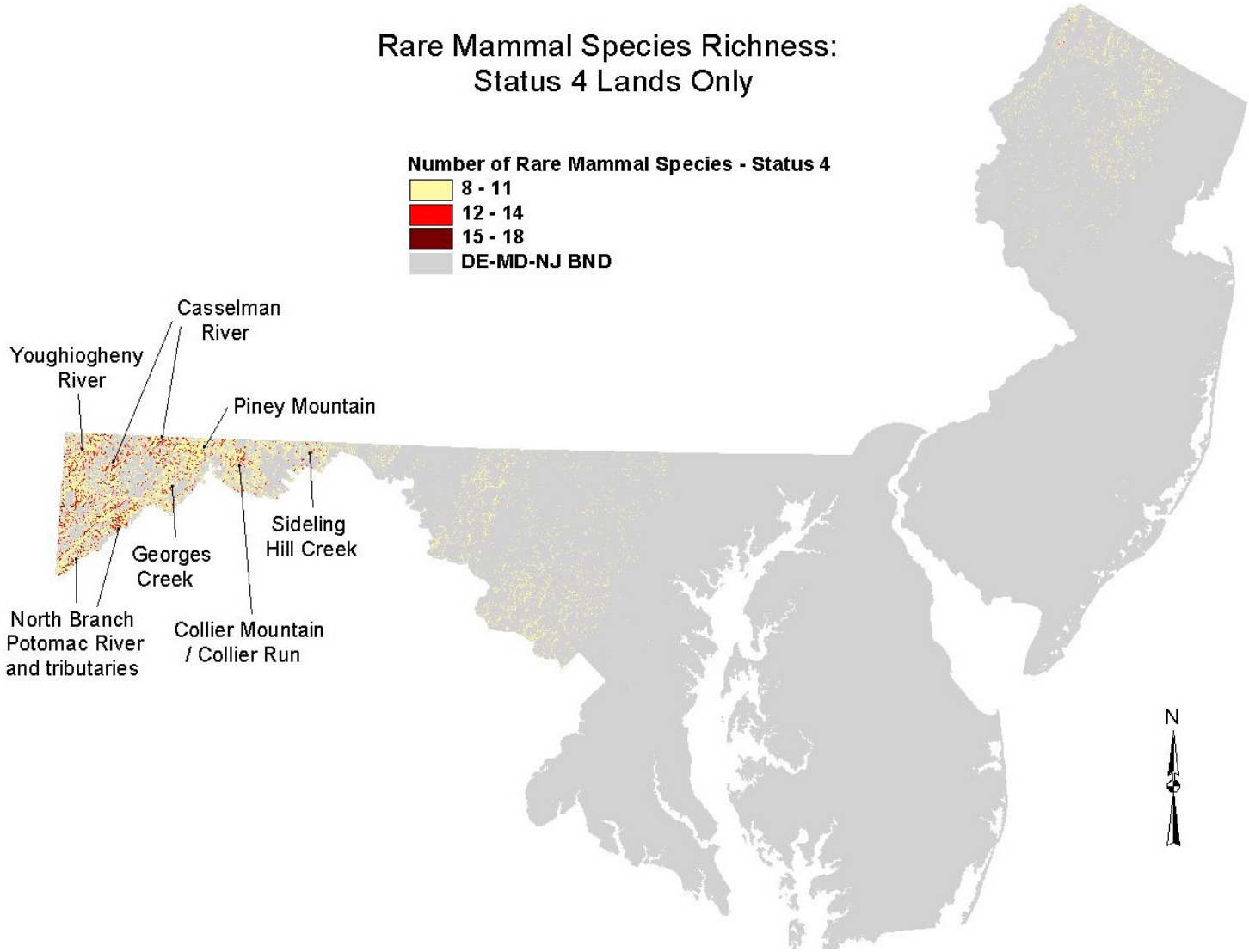

Figure 4.2: Predicted Rare Mammal Species Hotspots on Status 4 Lands

4.3.3 Predicted Gaps in Protection of Rare Reptile Species Hotspots

Predicted hotspots for rare reptile species that are not adequately protected generally include riparian corridors where there is a mix of woody and herbaceous habitat types, and edges or ecotones between these habitats, juxtaposed with nearby wetland or aquatic habitats. In the New Jersey Pine Barrens, unprotected hotspots also appear to include ecotones between open, pine-dominated woodlands and forested swamps (Figure 4.3). In the Ridge and Valley Province of western Maryland, there appear to be significant, unprotected hotspots along the Potomac River and tributaries, and the Chesapeake and Ohio Canal which runs parallel to the Potomac.

Other predicted hotspots that are lacking protection include several Potomac River and C&O Canal tributaries just northwest of Washington, D.C. (Sandy Branch, Greenbrier Branch, Watts Branch, Cabin John Creek and others), and headwaters and tributaries of the Patuxent River, Severn River, South River and Anacostia River north and east of Washington. To the south of Washington, unprotected hotspots include the upper Mattawoman Creek, and tributaries of Piscataway Creek. Within the Maryland portion of the Delmarva Peninsula, there appear to be many unprotected hotspots along headwaters and tributaries of the Nanticoke, Wicomico and Pocomoke Rivers. These hotspots appear to consist of edge-dominated riparian forests and forest-swamp ecotones, with many of the upland forests including a strong pine component, similar to hotspots in the New Jersey Pine Barrens.

4.3.4 Predicted Gaps in Protection of Rare Amphibian Species Hotspots

Of the many unprotected hotspots for rare amphibians, those that appear to be highest in species richness include the Youghiogheny River corridor, Potomac River and C&O Canal tributaries northwest of Washington, D.C., the Blackbird-Millington Corridor in Maryland and Delaware, and wetlands associated with headwaters and tributaries of several rivers in the southern Pine Barrens and Highlands of New Jersey (Figure 4.4). Within the Youghiogheny River corridor, unprotected hotspots appear to include vernal pools, shrub swamps, and wet meadows in heavily forested riparian areas. Some upper perennial river and stream reaches in this area also appear to be hotspots, possibly because these reaches fall within the limited ranges of the hellbender (*Cryptobranchus alleganiensis*) and mudpuppy (*Necturus maculosus*). The forested riparian areas of the Potomac River and C&O Canal tributaries include vernal pools, shrub swamps, forested swamps, ponds and stream habitats.

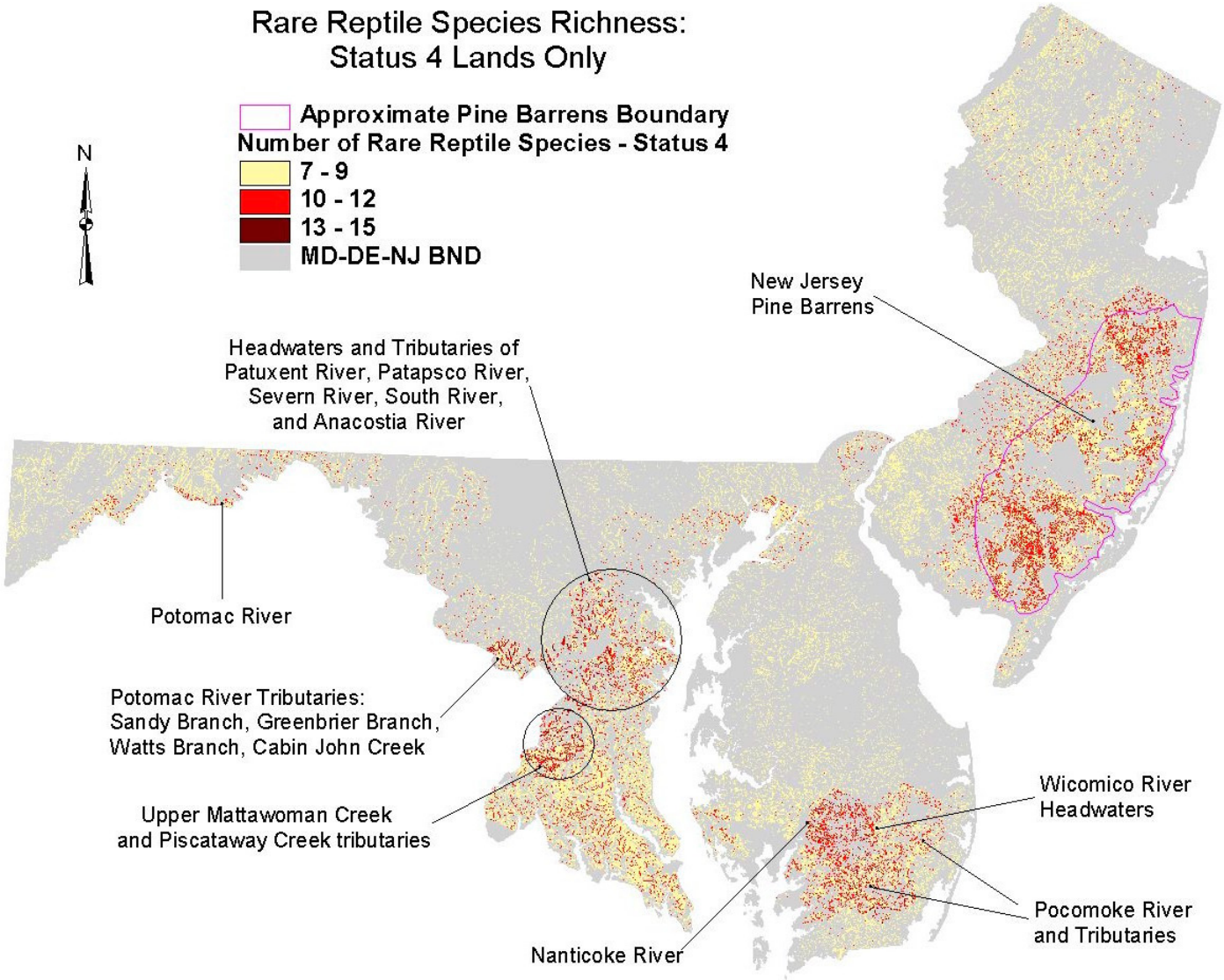

Figure 4.3: Predicted Rare Reptile Species Hotspots on Status 4 Lands

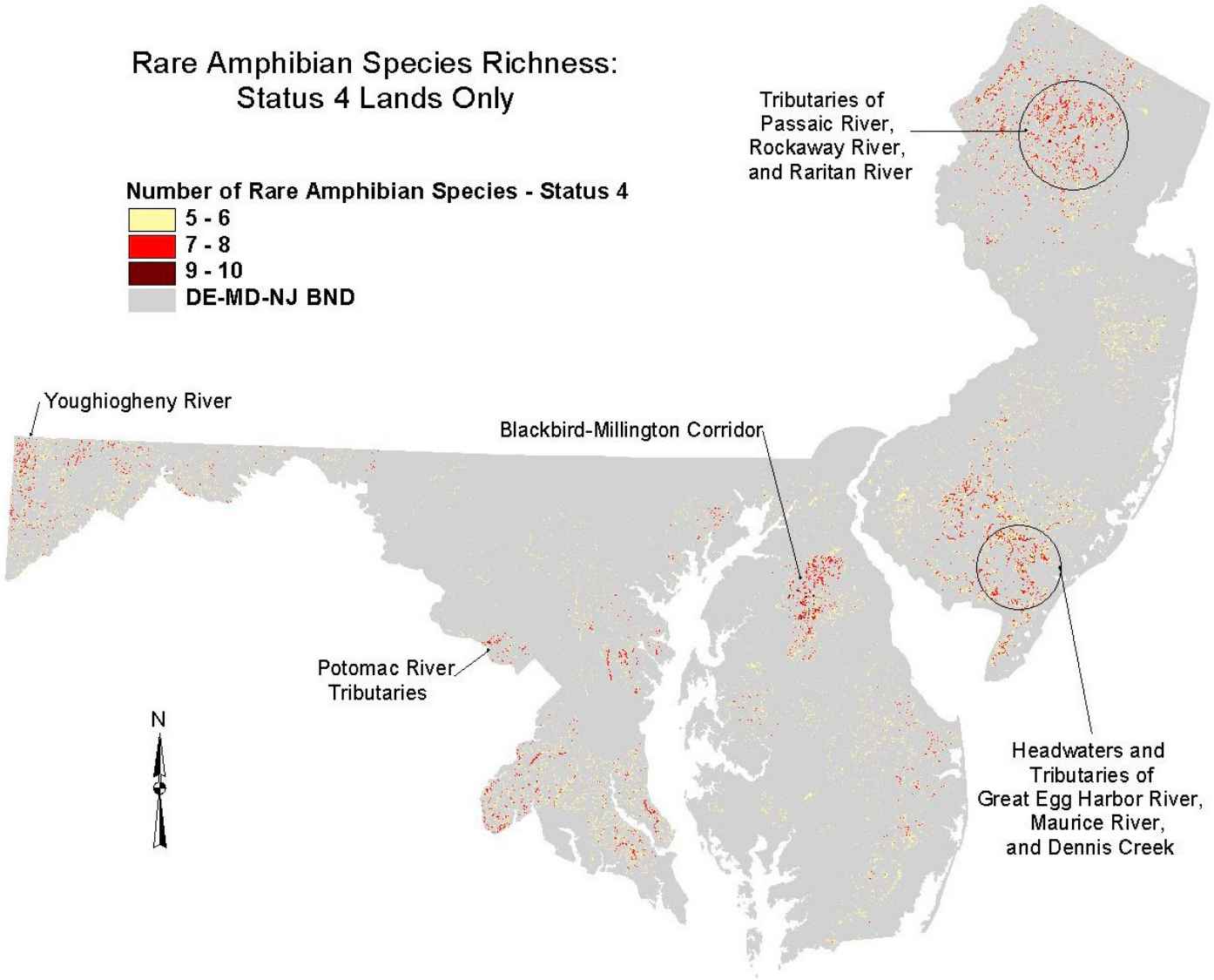

Figure 4.4: Predicted Rare Amphibian Species Hotspots on Status 4 Lands

The Blackbird-Millington area on the northern Coastal Plain of Maryland and Delaware includes the largest concentration of Coastal Plain Ponds (vernal pools) in the project area. These seasonal wetlands and the surrounding matrix of hardwood forest appear to represent the most significant rare amphibian species hotspot in the MDN-GAP project area, and much of the area remains unprotected. In the southern New Jersey Pine Barrens, the most significant unprotected hotspots correspond mostly with shrub swamps and bottomland hardwood swamps along heavily forested headwater streams and tributaries of the Great Egg Harbor River, Maurice River and Dennis Creek. In the Highlands and upper Piedmont of northern New Jersey, the unprotected habitats that are highest in rare amphibian species richness include hardwood swamps associated with tributaries of the Passaic, Rockaway and Raritan Rivers.

4.3.5 Predicted Gaps in Protection of Rare Vertebrate Species Hotspots

The most significant unprotected hotspots for rare vertebrate species in general are found in the mountainous regions of the project area (Figure 4.5). In western Maryland, these include the Youghiogheny River corridor, and portions of the Casselman River, North Branch Potomac River and Georges Creek corridors. In New Jersey, unprotected areas that are high in rare vertebrate species richness include riparian areas at middle and lower elevations of the Kittatinny Ridge, and similar situations within the Highlands Province. Within these areas, the habitats corresponding with high species richness generally appear to include mesic hardwood and mixed forests, often on north-facing slopes or in cool ravines, or broad riparian and floodplain forests. These hotspots tend to be adjacent to streams, rivers, ponds, lakes, marshes or wet meadows, or in swampy headwaters.

Other unprotected hotspots that are worth mentioning include riparian forests and hardwood swamps along tributaries of the Potomac River near Washington, D.C., and similar habitats along the Patuxent River and tributaries of the Severn and South Rivers. The upper Mattawoman Creek and Zekiah Swamp Run are both somewhat less significant in terms of species richness, but are relatively wide riparian forest corridors that are lacking protection. Headwater streams of Breton Bay and many tributaries along the lower Patuxent River are also unprotected and appear to be representative of relatively species-rich habitats in St. Marys County where the forests and swamps include more pines. On the Delmarva Peninsula, a very prominent hotspot is the Pocomoke River corridor. Significant portions of this corridor remain unprotected. Species-rich habitats along the Pocomoke and its tributaries include mostly bottomland hardwood and mixed pine-hardwood swamps, some of which include bald cypress as a co-dominant.

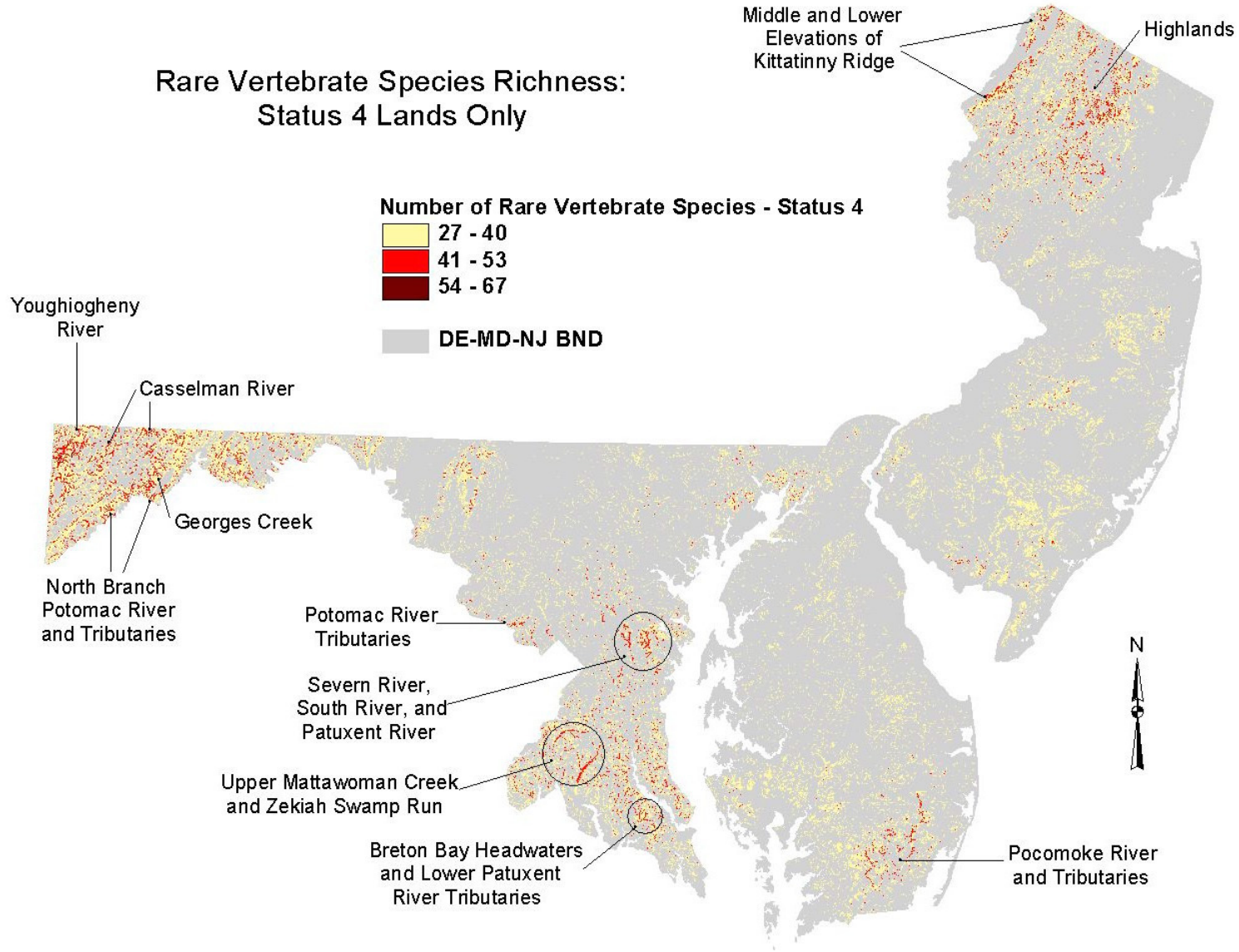

Figure 4.5: Predicted Rare Vertebrate Species Hotspots on Status 4 Lands

4.4 Limitations and Discussion

Limitations of the species richness analysis and the land stewardship data are presented in sections 2.6.1 and 3.4, respectively. The identification of gaps in the protection of rare species hotspots goes beyond the typical GAP project, and should be viewed with caution due to its subjective nature. The typical "analysis" includes only an assessment of the conservation status of individual species. Although such an analysis is based on predicted distributions, it is less subjective than an analysis which requires one to make a judgement as to what constitutes a "hotspot." In assessing species richness alone, there are gradations in numbers of species, and while some areas stand out more than others, we are not necessarily jumping to conclusions about which of the areas that appear to be highest in species richness are most important. In attempting to identify gaps in protection of hotspots by intersecting rare species richness with status 3 and 4 lands, it is necessary to make some subjective conclusions as to what constitutes a hotspot. Nevertheless, we've attempted to identify these potentially important gaps because there do appear to be many areas that are high in rare species richness that do not fall within status 1 or 2 lands, and we felt there would be some added value in pointing them out.

Because GAP data sets for this project are somewhat outdated, some of the identified "hotspots" may no longer support large numbers of rare species. Development is occurring at a rapid pace in some portions of the project area and may have significantly impacted some of these areas. Changes in land ownership and management have also, undoubtedly, occurred, and some of the identified gaps may now be protected. Nevertheless, many of the identified gaps in protection of rare species hotspots are still likely to be valid conservation targets, and should be further investigated and considered in biodiversity protection planning efforts.

Chapter 5: Conclusions and Management Implications

Over 88% (307 of 348) of all native vertebrate species for which models were developed have less than 10% of their predicted distributions occurring within lands managed for long-term maintenance of biodiversity (i.e., GAP status 1 or 2 lands). Nearly 97% of native mammal species have less than 10% of their predicted distributions occurring within status 1 and 2 lands. Among these are seven species which are associated primarily with forests, and are considered extremely rare in at least one of the three states. Over 95% of all amphibian species have less than 10% of their predicted distributions occurring within status 1 or 2 lands. Many of the rare to extremely rare species within this taxon are associated with seasonal wetlands with extensive forest buffers, and a few species are associated with unpolluted streams in heavily forested regions. Over 89% of native reptile species are similarly underrepresented in status 1 and 2 lands. Species of management concern include the federally threatened bog turtle (*Clemmys muhlenbergii*), and the queen snake (*Regina septemvittata*) which requires relatively unpolluted streams.

Nearly 84% of native breeding bird species have less than 10 % of their predicted distributions occurring within status 1 or 2 lands. Among those that are rare to extremely rare are several wetland-dependent species and several species associated with early successional habitats. There are also several species of management concern that are sensitive to forest fragmentation. The objectives of conserving large forests and early successional habitats may seem to be in conflict in some situations, but there are many opportunities (e.g., through Farm Bill programs) to build early successional habitats from the ground up, and young reforestation sites will serve the latter objective over the short term. Within the mid-Atlantic region, the establishment of grasslands may be desirable in agricultural areas where reforestation is not possible, but forest restoration should be targeted in areas where it will knit together forest fragments or in riparian areas where it will also benefit water quality and aquatic biota. From a regional perspective, intensive land management that is aimed at maximizing diversity at the local level may negatively impact regional diversity.

Other species of manangement concern that are underrepresented in status 1 and 2 lands include a few that are associated with beach and dune habitats. Others are associated with freshwater tidal wetlands, bogs, or seeps. Management gaps may exist for other species that are associated with old growth forest, or for those that require snags (i.e., for nest cavities) or coarse woody debris. It should also be recognized that some "protected" habitats may be threatened by factors that are difficult to manage for, such as sea level rise and salt-water intrusion.

One of the project area's most important species assemblages is found on Pea Patch Island in the upper Delaware Bay, where nine wading bird species nest in the largest rookery north of Florida. Although this rookery has status 2 protection, most of these

species travel far from the rookery to forage, and six of them have less than 10% of their predicted distributions occurring within status 1 or 2 lands. Another important assemblage includes several vernal pool-breeding amphibians in the Blackbird-Millington Corridor on the upper Coastal Plain of Maryland and Delaware. These species depend on the extensive hardwood forests surrounding their breeding pools, and much of this area, which also appears to be the most important hotspot in the project area for rare amphibians, remains unprotected or in status 3 ownership.

Areas of highest rare bird species richness appear to correspond with the heavily forested regions of the project area, especially where there are large blocks of unbroken forest and expansive riparian and palustrine forests. Many of these hotspots remain unprotected. Riparian forests in western Maryland appear to support the largest numbers of rare mammal species, and hotspots for rare reptiles also tend to be associated mostly with riparian areas. When considering all taxonomic groups combined, areas of highest species richness tend to correspond mostly with forested areas, especially along headwater streams and in other riparian situations.

The results of this coarse-scale analysis offer a regional perspective on gaps in the protection of biodiversity. Because this was a three-state project, there may be significant state-level habitat conservation needs that were overshadowed by the regional-level priorities that were identified. For example, there are some significant rare species hotspots in Delaware that are relatively small compared to some of the hotspots in Maryland and New Jersey. Also, only two of the six physiographic provinces found in the project area are represented in Delaware. As a result, there are some rare species assemblages that are found in Maryland and New Jersey (e.g., in the mountains) that are not found in Delaware. At a minimum, the results of this project should be useful in identifying regional-level conservation priorities and geographic areas in need of further investigation. State-level conservation planning efforts may also benefit from the results of this analysis, but the data are not intended for use in applications which require a high level of precision, such as efforts to establish legally-defined boundaries of new nature preserves.

It is also important to note that there are many rare plant communities which require a level of conservation assessment that is beyond the scope of this project, and there are other animal groups (e.g., insects, aquatic species) which were excluded from this analysis. Important migratory bird staging areas were also excluded from the analysis. Biodiversity conservation planning efforts should consider GAP data as complementary to data sets that identify important migratory bird staging areas and habitats, and additional efforts should be directed toward identifying gaps in the protection of rare plant communities, insects and aquatic species.

Vertebrate species models and predicted distributions were subjected to the minimum required accuracy assessment. Overall model accuracy was very close to meeting the minimum standard (>= 80%), but model accuracy for some species fell short of this standard. A process for outside expert review was set up, but resource constraints

prevented its implementation. Additional accuracy assessments, including outside expert review, may lead to a better understanding of model limitations and appropriate uses, and facilitate improvements and refinements in models. There were many delays in completing this project and, as a result, all of the data sets are out-of-date. Ideally, the landcover should be updated from recent satellite imagery, and vertebrate models should be rerun using updated modeling layers. Many sources of error and solutions for refining and improving the accuracy of the landcover have been identified, and these improvements will lead to more accurate vertebrate distribution maps.

Updates and refinements in species ranges should also be considered. For example, Breeding Bird Atlas data are available for all three states at a much finer resolution than was used in this project. The BBA block unit is one-sixth the size of the 7.5-minute quadrangle used for rare species modeling, and is approximately one-twenty-fifth the size of the hexagon used for modeling most common species. Reptile and amphibian atlas efforts are also underway in at least two of the three states. The addition of a detailed soils overlay would improve model accuracy for several species, as would overlays depicting vegetative structure and surficial geology. However, completing these updates and improvements in a timely manner will require substantial resources.

Many changes in land ownership have likely occurred since the land stewardship layer was completed. An accurate update of the analysis of the conservation status of land cover classes and vertebrate species will require that these land ownership changes be incorporated into the stewardship layer.

Many useful data sets were developed through this effort. Where the gaps in biodiversity protection identified through this effort agree with the priorities of other conservation planning efforts, this layer of information may provide added justification for conservation actions. Some of these other efforts include Maryland's Green Infrastructure Assessment, New Jersey's Landscape Project, and Delaware's Wildlife Action Plan. Where identified gaps do not agree with conservation targets of other efforts, these gaps should be further investigated. In addition to identifying species that are lacking adequate protection or management to ensure their continued existence within the project area, potential species richness hotspots which aren't currently protected have been identified and should receive attention in conservation efforts or field investigations. MDN-GAP data sets will be made available to federal and state natural resource agencies, and private conservation organizations for use in identifying habitat conservation priorities. These data sets include the Wildlife Habitat Relationships database and habitat summary documents for all species, several GIS layers used in the habitat modeling (e.g., habitat, wetland buffer, forest fragmentation metrics), species' ranges by hexagon and/or 7.5-minute quadrangle (rare species), predicted species distributions (i.e., maps, raster grids) by habitat, and species richness grids.

Chapter 6: Product Use and Availability

6.1 How to Obtain the Products

It is the goal of the Gap Analysis Program and the USGS Biological Resources Division (BRD) to make the data and associated information as widely available as possible. Use of the data requires specialized software called geographic information systems (GIS) and substantial computing power. Additional information on how to use the data or obtain GIS services is provided below and on the GAP home page (URL below). While a CD-ROM of the data will be the most convenient way to obtain the data, it may also be downloaded via the Internet from the national GAP home page at:

http://gapanalysis.nbii.gov/

The home page will also provide, over the long term, the status of our state's project, future updates, data availability, and contacts. Within a few months of this project's completion, CD-ROMs of the final report and data should be available at a nominal cost--the above home page will provide ordering information. To find information on this state GAP project's status and data, follow the links to "Current Projects" and then to the particular state of interest.

Additional options for obtaining MDN-GAP products may be available in the near future. For current information, please contact:

Rick McCorkle
U.S. Fish & Wildlife Service
2610 Whitehall Neck Road
Smyrna, DE 19977
302-653-9152, ext. 117
302-653-9421 (fax)
richard_mccorkle@fws.gov

6.1.1 Minimum GIS Required for Data Use

The MDN-GAP animal species distribution data sets have been successfully used on Intel Pentium-class machines running Windows NT/2000/XP with ArcMAP 8.1 and ArcView 3.2x.

These large data layers will require several gigabytes of hard disk space, but can be successfully used on machines that meet the minimum hardware requirements for ESRI software.

6.2 Disclaimer

Following is the official Biological Resources Division (BRD) disclaimer as of 29 January 1996, followed by additional disclaimers from GAP. Prior to using the data, you

should consult the GAP home page (see How to Obtain the Data, above) for the current disclaimer.

Although these data have been processed successfully on a computer system at the BRD, no warranty expressed or implied is made regarding the accuracy or utility of the data on any other system or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. This disclaimer applies both to individual use of the data and aggregate use with other data. It is strongly recommended that these data are directly acquired from a BRD server [see above for approved data providers] and not indirectly through other sources which may have changed the data in some way. It is also strongly recommended that careful attention be paid to the content of the metadata file associated with these data. The Biological Resources Division shall not be held liable for improper or incorrect use of the data described and/or contained herein.

These data were compiled with regard to the following standards. Please be aware of the limitations of the data. These data are meant to be used at a scale of 1:100,000 or smaller (such as 1:250,000 or 1:500,000) for the purpose of assessing the conservation status of animals and vegetation types over large geographic regions. The data may or may not have been assessed for statistical accuracy. Data evaluation and improvement may be ongoing. The Biological Resources Division makes no claim as to the data's suitability for other purposes. This is writable data which may have been altered from the original product if not obtained from a designated data distributor identified above.

6.3 Metadata

Proper documentation of information sources and processes used to assemble GAP data layers is central to the successful application of GAP data.

Metadata is a description of the content, quality, lineage, contact, condition, and other characteristics of data. It is a valuable tool that preserves the usefulness of data over time by detailing methods for data collection and data set creation. It greatly minimizes duplication of effort in the collection of expensive digital data and fosters sharing of digital data resources. Metadata supports local data asset management such as local inventory and data catalogs, and external user communities such as Clearinghouses and websites. It provides adequate guidance for end-use application of data such as detailed lineage and context. Metadata makes it possible for data users to search, retrieve, and evaluate data set information by providing standardized descriptions of geospatial and biological data.

The Federal Geographic Data Committee approved the Content Standard for Digital Geospatial Metadata (FGDC-STD-001-1998) in June 1998 and NBII (<http://www.nbii.gov>) developed the Biological Data Profile (approved in 1999) that adds fields for biological information such as taxonomy, analytical tools, and methodology to the FGDC standard core set of elements. <http://www.nbii.gov/datainfo/metadata/standards/> Executive Order 12906 requires that

any spatial data sets generated with federal dollars will have FGDC-compliant metadata.

Each spatial data layer submitted must be accompanied by its metadata (*.xml or .sgml file) in the same directory. You must also include an additional directory (called "meta_master') which will include each metadata file in four forms (*.txt, *.xml, *.html, and *.sgml).

There are many tools available for metadata creation. For some examples, see <http://www.nbii.gov/datainfo/metadata/tools/> Please note that some tools are free, and some are not. The redundancy in output format is to provide one file for error checking (*.txt), one for presentation on the Internet (*.html), and two for indexing elements for the spatial data clearinghouse (*xml, *.sgml). Remember, metadata describes the development of the spatial data set being documented. If there are companion files to the GIS data, use metadata to reference (reports, spreadsheet, another GIS layer).

USGS (NBII and FGDC) personnel conduct metadata training to meet FGDC standards and to include biological data. The metadata workshop provides an introduction to the metadata standard with hands-on practice producing documentation for a sample data set using appropriate software: Intergraph's "Spatial Metadata Management System (SMMS)" and USDA Forest Service North Central Research Station's "Metavist" are commonly used. The focus of the workshop is an understanding of the metadata standard, but other topics will include the metadata clearinghouse, metadata development tools, and strategies for metadata production. See <http://www.nbii.gov/datainfo/metadata/training/> for more information and access to the training calendar.

6.4 Appropriate and Inappropriate Uses of the Data

All information is created with a specific end use or uses in mind. This is especially true for GIS data, which is expensive to produce and must be directed to meet the immediate program needs. For GAP, minimum standards were set (see A Handbook for Gap Analysis, Scott et al. 1993) to meet program objectives. These standards include: scale or resolution (1:100,000 or 100 hectare minimum mapping unit), accuracy (80% accurate at 95% confidence), and format (ARC/INFO coverage/grid).

Recognizing, however, that GAP would be the first, and for many years likely the only, source of statewide biological GIS maps, the data were created with the expectation that they would be used for other applications. Therefore, we list below both appropriate and inappropriate uses. This list is in no way exhaustive but should serve as a guide to assess whether a proposed use can or cannot be supported by GAP data. For most uses, it is unlikely that GAP will provide the only data needed, and for uses with a regulatory outcome, field surveys should verify the result. In the end, it will be the responsibility of each data user to determine if GAP data can answer the question being asked, and if they are the best tool to answer that question.

Scale: First we must address the issue of appropriate scale to which these data may be applied. The data were produced with an intended application at the ecoregion level, that is, geographic areas from several hundred thousand to millions of hectares in size. The data provide a coarse-filter approach to analysis, meaning that not every occurrence of every plant community or animal species habitat is mapped, only larger, more generalized distributions. The data are also based on the USGS 1:100,000 scale of mapping in both detail and precision. When determining whether to apply GAP data to a particular use, there are two primary questions: do you want to use the data as a map for the particular geographic area, or do you wish to use the data to provide context for a particular area? The distinction can be made with the following example: You could use GAP land cover to determine the approximate amount of oak woodland occurring in a county, or you could map oak woodland with aerial photography to determine the exact amount. You then could use GAP data to determine the approximate percentage of all oak woodland in the region or state that occurs in the county, and thus gain a sense of how important the county's distribution is to maintaining that plant community.

Appropriate Uses: The above example illustrates two appropriate uses of the data: as a coarse map for a large area such as a county, and to provide context for finer-level maps. The following is a general list of applications:

- Statewide biodiversity planning
- Regional (Councils of Government) planning
- Regional habitat conservation planning
- County comprehensive planning
- Large-area resource management planning
- Coarse-filter evaluation of potential impacts or benefits of major projects or plan initiatives on biodiversity, such as utility or transportation corridors, wilderness proposals, regional open space and recreation proposals, etc.
- Determining relative amounts of management responsibility for specific biological resources among land stewards to facilitate cooperative management and planning.
- Basic research on regional distributions of plants and animals and to help target both specific species and geographic areas for needed research.
- Environmental impact assessment for large projects or military activities.
- Estimation of potential economic impacts from loss of biological resource-based activities.
- Education at all levels and for both students and citizens.

Inappropriate Uses: It is far easier to identify appropriate uses than inappropriate ones, however, there is a "fuzzy line" that is eventually crossed when the differences in resolution of the data, size of geographic area being analyzed, and precision of the answer required for the question are no longer compatible. Examples include:

- Using the data to map small areas (less than thousands of hectares), typically requiring mapping resolution at 1:24,000 scale and using aerial photographs or ground surveys.
- Combining GAP data with other data finer than 1:100,000 scale to produce new hybrid maps or answer queries.

- Generating specific areal measurements from the data finer than the nearest thousand hectares (minimum mapping unit size and accuracy affect this precision).
- Establishing exact boundaries for regulation or acquisition.
- Establishing definite occurrence or non-occurrence of any feature for an exact geographic area (for land cover, the percent accuracy will provide a measure of probability).
- Determining abundance, health, or condition of any feature.
- Establishing a measure of accuracy of any other data by comparison with GAP data.
- Altering the data in any way and redistributing them as a GAP data product.
- Using the data without acquiring and reviewing the metadata and this report.

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Glossary of Terms

alliance level - a land unit made up of an "alliance" of natural communities that have the same dominant or co-dominant plant species or, in the absence of vegetation, by the dominant land cover typically described according to the Anderson land cover classification (see "Natural Community Alliance" in Grossman et al. 1995)

anthropogenic - caused by man

assemblages - a group of ecologically interrelated plant and animal species

biodiversity - generally, the variety of life and its interrelated processes

biological diversity - see biodiversity

cell - the smallest spatial unit in a GRID-format raster data structure

classify - to assign objects, features, or areas on an image to spectral classes based upon their appearance as opposed to “classification” referring to a scheme for describing the hierarchies of vegetation or animal species for an area

coarse filter - the general conservation activities that conserve the common elements of the landscape matrix, as opposed to the "fine filter" conservation activities that are aimed at special cases such as rare elements (see Jenkins 1985)

community - a group of interacting plants and animals

cover type - a non-technical higher-level floristic and structural description of vegetation cover

cross-walking - matching equivalent land cover categories between two or more classification systems

datum – A set of parameters and control points used to accurately define the three-dimensional shape of the earth (e.g., as a spheroid). The corresponding datum is the basis for a planar coordinate system. For example, the North American datum for 1983 (NAD83) is the datum for map projections and coordinates within the United States and throughout North America.

ecoregion - a large region, usually spanning several million hectares, characterized by having similar biota, climate, and physiography (topography, hydrology, etc).

ecosystem - a biological community (ranging in scale from a single cave to millions of hectares), its physical environment, and the processes through which matter and energy are transferred among the components

element - a plant community or animal species mapped by GAP. May also be referred to as "element of biodiversity".

error of commission - the occurrence of a species (or other map category) is erroneously predicted in an area where it is in fact absent

error of omission - when a model fails to predict the occurrence of a species that is actually present in an area

extinction - disappearance of a species throughout its entire range

extirpation - disappearance of a species from part of its range

fine filter - see "coarse filter"

floristic - pertaining to the plant species that make up the vegetation of a given area.

gamma diversity - the species diversity of a landscape, generally covering 1,000 to 1,000,000 hectares, made up of more than one kind of natural community (see Whittaker 1977)

gap analysis - a comparison of the distribution of elements of biodiversity with that of areas managed for their long-term viability to identify elements with inadequate representation

geographic information systems - computer hardware and software for storing, retrieving, manipulating, and analyzing spatial data

habitat - the physical structure, vegetational composition, and physiognomy of an area, the characteristics of which determine its suitability for particular animal or plant species

hectare - a metric unit of area of 10,000 square meters and equal to 2.47 acres

hex/hexagon - typically refers to the EPA EMAP hexagonal grid of 650 square kilometer units

metadata - information about data, e.g., their source, lineage, content, structure, and availability

minimum mapping unit - the smallest area that is depicted on a map

physiographic province - a region having a pattern of relief features or land forms that differ significantly from that of adjacent regions

pixel - the smallest spatial unit in a raster data structure

polygon - an area enclosed by lines in a vector-based Geographic Information System data layer or a region of contiguous homogeneous pixels in a raster system

range - the geographic limit of the species

range unit - a spatial, geographic unit to record and display species geographic range.

reach - a stream or river segment between inflowing tributaries

remote sensing - deriving information about the earth's surface from images acquired at a distance, usually relying on measurement of electromagnetic radiation reflected or emitted from the feature of interest

resolution - the ability of a remote sensing system to record and display fine detail in a distinguishable manner or: the smallest feature that can be distinguished or resolved on a map or image, such as a TM pixel

scale, map - the ratio of distance on a map to distance in the real word, expressed as a fraction; the smaller the denominator, the larger the scale, e.g. 1:24,000 is larger than 1:100,000

species richness - the number of species of a particular interest group found in a given area

tessellation - the division of a map into areas of equal and uniform shape such as the EPA- EMAP hexagon

transect - a transversely cut line along which physical and biological observations are made

Universal Transverse Mercator - one of several map projections or systems of transformations that enables locations on the spherical earth to be represented systematically on a flat map

vector format - a data structure that uses polygons, arcs (lines), and points as fundamental units for analysis and manipulation in a Geographic Information System

wildlife habitat relationship model - a method of linking patterns of known habitat use by animal species with maps of existing vegetation, thereby identifying the spatial extent of important habitat features for use in conservation and management.

Glossary Of Acronyms

AML ARC/INFO Macro Language
BBA Breeding Bird Atlas
BRC Biodiversity Research Consortium
BRD Biological Resources Division
CDC Conservation Data Center
DEM Digital Elevation Model
DLG Digital Line Graph
DNR Department of Natural Resources
ELU Ecological Land Unit
EMAP Environmental Monitoring & Assessment Program
EPA Environmental Protection Agency
ESRI Environmental Systems Research Institute
FAD Forest Area Dependent
FGDC Federal Geographic Data Committee
FID Forest Interior Dwelling
GAP Gap Analysis Program
GIS Geographic Information System
HSI Habitat Suitability Index
MDN-GAP Maryland-Delaware-New Jersey Gap Analysis Project
MDDNR Maryland Department of Natural Resources
MMU Minimum mapping unit
NBII National Biological Information Infrastructure
NBS National Biological Service
NED National Elevation Data
NHP Natural Heritage Program
NJDEP New Jersey Department of Environmental Protection
NLCD National Land Cover Data
NWI National Wetlands Inventory (USFWS)
NWR National Wildlife Refuge
SCM Species Conservation and Modeling software
SF State Forest
SHF Special Habitat Feature
SP State Park
STATSGO State Soil Geographic Database
TNC The Nature Conservancy
URL Universal Resource Locator
USFWS US Fish & Wildlife Service
USGS United States Geological Survey
UTM Universal Transverse Mercator
VAT Value Attribute Table
WHRM Wildlife habitat relationship model
WMA Wildlife Management Area

Appendices

Appendix A: Example GAP Applications

Businesses and Non-government Organizations:
The following are some examples of applications of GAP data by the private sector:

- The Wyoming Natural Heritage Program (a private non-government organization) transformed the endangered and sensitive species database into a spatially referenced digital geographic information system using the GAP digital base map and other GAP spatial data.
- Hughes Corp. is experimenting with the Utah and Nevada GAP digital base maps, simulating images to aid the development of new space-based remote sensing devices.
- The Nature Conservancy used the Wyoming GAP data to develop a map of ecoregions of Wyoming.
- Weyerhaeuser Corp. is using the Arkansas GAP data in managing their lands in Arkansas.
- IBM Corp. is funding a project at the University of California-Santa Barbara that, in part, uses GAP data in the development of visualization software.
- NM-GAP vegetation data is being used for an environmental assessment of a proposed spaceport, a state/private venture.

County and City Planning:
Some other examples of the use of GAP by local governments are:

- CA-GAP biological data were combined with the Southern California Association of Governments (SCAG) land ownership data to show which ownerships and jurisdictions were needed for joint conservation planning and management of a particular natural community or species, maximizing efficiency and minimizing the potential for yet another conservation crisis.
- In California, county and city planners of several jurisdictions, wildlife agencies, developers of the 4S Ranch property, and the state Natural Communities Conservation Planning program used the GAP regional data, as well as more detailed information, to conserve 1,640 acres of habitat within a 2,900-acre planned development.
- Day-to-day county planning operations in Piute, Grande, and Washington counties, Utah.
- County planners in Piute County, Utah, used GAP data to optimize the siting of a proposed sawmill for aspen with respect to the distribution of aspen stands.
- Missoula County, Montana, used the GAP land cover map of the area as a base map for its comprehensive long-range plan.
- Snohomish County, Washington, used the GAP land cover map in meeting state requirements for a growth management plan.
- The City of Bainbridge Island, Washington, used GAP data to assist them in development of a watershed planning project.

State Uses:

The following are some examples of uses of GAP data by state agencies.

- The GAP database of species habitats was used by the Tennessee Wildlife Resources Agency (TWRA) to update its book "Species in Need of Management."
- Images of land cover derived from GAP TM data are used by TWRA for locating particular habitat types. Information on the locations of these habitat types is provided by TWRA to the public for a wide variety of public service functions, from education to cooperative resource management.
- Early GAP data developed by TWRA were used to help identify an extremely important area of the state with high biodiversity that was subsequently purchased by the state for conservation.
- Preliminary findings from GAP were used by TWRA to develop three resource management initiatives.
- The Tennessee GAP project, which is being carried out primarily by TWRA, is the foundation of a multi-agency, long-term biodiversity program for Tennessee.
- GAP data have been used by the Tennessee Forestry Stewardship Program to help develop a district program for nine conservation planning districts, outlining Best Management Practices (BMPs) for biological conservation on private lands.
- GAP data are being used extensively by TWRA in the preparation of project proposals to the North American Waterfowl Conservation Program. These proposals require that biodiversity issues are addressed in specific detail. The use of GAP data on occurrence of land cover types and terrestrial vertebrates has made this possible.
- The Wyoming Department of Fish and Game used GAP data to assist them in transforming the Wildlife Observation System database into a spatially referenced geographic information system.
- The Utah Division of Wildlife Resources and the Bear River Water Conservancy District used the Utah GAP land cover map in a resource management assessment for mitigating conflicts between a proposed groundwater withdrawal project and the maintenance of an elk calving area in the Uinta Mountains.
- The Utah Division of Wildlife Resources, the Rocky Mountain Elk Foundation, and Sheik Safari International used the Utah GAP land cover map to identify critical elk habitat. The environmental profile of these areas was then used to identify other similar areas for elk habitat enhancement.
- The Utah Division of Wildlife Resources used the Utah GAP land cover map for a rapid ecological assessment of the Echo Henefer Wildlife Management Area.
- The Washington Department of Fish and Wildlife used GAP data to develop a breeding bird atlas and an atlas of mammals of Washington State.
- The Washington Department of Fish and Wildlife uses GAP data to operate an integrated landscape management program.
- The Washington Department of Fish and Wildlife uses GAP data from Eastern Washington to assist with an innovative program that brings the forest products industry, state agency biologists, non-government organizations, and tribal biologists together in the field to jointly determine the appropriate management practices for any particular site of concern (Timber, Fish & Wildlife Program).

- The Idaho Department of Fish and Game used GAP data to evaluate the impact from expanded military training activities on public lands in Southern Idaho.
- The Idaho Department of Fish and Game uses GAP data for regional planning efforts on a regular basis.

Statewide Planning:
Biodiversity planning programs or projects are now under way in Arizona, California, Colorado, Maine, Missouri, Nevada, Oregon, and Tennessee. It is likely that similar efforts will develop in other states. These activities were the subject of the State Biodiversity Programs meeting discussed on page _ in this report. In some cases, these efforts grew out of the state GAP project, however, in most cases, the GAP data are being used to meet a previously defined need. In all cases, GAP data are central to their development and operations. The goals of each of these programs or projects are presented briefly below.

Federal Agency Applications:
Some examples of applications of GAP data by federal agencies follow:
- GAP data are being supplied to all military installations in the Great Basin ecoregion for integrated management of the natural resources. These installations constitute a very large amount of land area. Much of it is of high value for native species.
- The Ouachita National Forest used the Arkansas GAP data to help them develop an ecosystem management plan.
- The Wyoming GAP data were used by NASA to calibrate a model that predicts vegetation types based on climate and soil variables.
- The potential contributions to biodiversity conservation of four different options proposed for new wilderness designation in Idaho were quantified by the Idaho Cooperative Fish and Wildlife Research Unit in cooperation with the Park Studies Unit.
- The potential contributions to biodiversity conservation of four different options proposed for new national park designation in Idaho were quantified by the Idaho Cooperative Park Studies Unit.
- The U.S. Forest Service in Booneville, Arkansas, used the Arkansas GAP data land cover maps in a 3-dimensional presentation to provide the public with a visual representation of the region and to enhance the public's involvement with the National Forest planning process.
- The U.S. Fish and Wildlife Service regularly uses the GAP data for Southern California for habitat evaluation and management.
- The U.S. Forest Service, Bureau of Land Management, and National Park Service are using the GAP data for a wide variety of natural resource management operations in Utah. For example, the entire Utah GAP database is directly linked with existing National Park Service databases for use by National Parks.
- The Bureau of Land Management uses the Wyoming GAP data for managing the Buffalo Resource Area.
- The U.S. Forest Service used the Utah GAP data to help assist them in evaluating human-induced impacts to forested lands surrounding ski resorts in central Utah.

- The U.S. Fish and Wildlife Service in Delaware used GAP data to help identify potential habitat for the federally endangered Delmarva fox squirrel. These maps were displayed and served as a catalyst for bringing together people with a stake in the issue.
- The U.S. Fish and Wildlife Service used the Indiana GAP data as part of a biological assessment for the base closure of the Jefferson Proving Grounds and its conversion to a National Wildlife Refuge. This 58,000-acre installation has restricted human access due to unexploded ordinance and contains some of the highest-quality natural habitat in Indiana.
- The U.S. Fish and Wildlife Service in Louisiana used GAP data to avoid conflict over the designation of critical habitat of the federally endangered Louisiana black bear.
- The NOAA Coastal Marine Sanctuary in Washington State uses GAP data for an educational display.
- In Washington and New Mexico, digital land cover maps have been distributed to all National Forests.
- The U.S. Natural Resources Conservation Service (NRCS) in New Mexico is using a GAP clustered imagery as a base for their land cover mapping activities.
- The Department of Defense is funding the development of an electronic environmental information system for the Mojave ecoregion, which would use GAP data as a foundation or base layer of information. The system will link 29 DoD installations to a common source of environmental information.

APPENDIX B: HABITAT TYPES OF THE EASTERN UNITED STATES:

Eastern Forests - Kricher (1988):

Eastern Forest Communities:

Boreal Forest: white spruce, black spruce, balsam fir, paper birch, aspen, balsam poplar, tamarack, e. hemlock, w. pine, r. pine, j. pine, red spruce, Fraser fir

Boreal Bog: black spruce, tamarack, n. white-cedar, older bogs w/ balsam fir, paper birch, balsam poplar, black ash

Jack Pine Forest: jack pine, red pine, red maple, aspens, paper birch, black spruce

Northern Hardwood Forest: yellow birch, sugar maple, American beech, e. hemlock, w. pine, r. pine, n. red oak, gray birch, paper birch, pin cherry, balsam poplar, American mountain-ash, mountain maple, red spruce

New England Alpine Community: stunted balsam fir, black spruce, mountain birch

Beech-Maple Forest: American beech, sugar maple, Ohio buckeye, white ash, tuliptree, white oak, e. hemlock, flowering dogwood, witch hazel

Maple-Basswood Forest: sugar maple, American basswood, n. red oak, American elm, slippery elm, butternut, flowering dogwood

Oak-Hickory Forest: n. red oak, s. red oak, black oak, scarlet oak, white oak, chestnut oak, other oaks, pignut hickory, mockernut hickory, bitternut hickory, American chestnut, flowering dogwood, sassafras, hophornbeam, hackberry, green hawthorn (mesic- tuliptree, A. elm, sweetgum, shagbark hickory; disturbed- black locust, gray birch, e. red cedar, aspen, pitch pine, w. pine, bear oak)

Northern Riverine (Floodplain) Forest: eastern cottonwood, black willow, American elm, slippery elm, e. sycamore, speckled alder, green ash, black ash, red maple, silver maple, shagbark hickory, boxelder, river birch, basswood, swamp white oak, pin oak, balsam poplar

Northern Swamp Forest: red maple (abundant), Atlantic white-cedar, n. white-cedar, black tupelo, sweetgum, speckled alder, black ash, swamp white oak, cherrybark oak, willow oak, A. elm, A. holly, e. hemlock, balsam fir

Northern Pine-Oak Forest: pitch pine, Virginia pine, bear oak, blackjack oak, chinkapin oak, scarlet oak, post oak, black oak, e. red cedar

Southern Mixed Pine-Oak Forest: longleaf pine, loblolly pine, shortleaf pine, slash pine, Virginia live oak, turkey oak, post oak, myrtle oak, laurel oak, s. red oak, common persimmon, s. catalpa, hickories, hawthorns, s. bayberry, Carolina holly

White-cedar Swamp Forest: A. white-cedar (abundant se/coastal plain), n. white (abundant interior states, boreal region), red maple, tamarack, (boreal- black spruce, balsam fir, balsam poplar)

Appalachian Cove Forest: white basswood, Carolina silverbell, tuliptree, yellow buckeye, sugar maple, red maple, yellow birch, beech, white ash, bigleaf magnolia, allegheny chinkapin, bitternut hickory, e. hemlock, etc.(high diversity)

Appalachian Heath Balds: catawba rhododendron, rosebay rhododendron, flame azalea

Southern Hardwood Forest: s. magnolia, magnolia sp., Virginia live oak, common persimmon, pecan, w. oak, laurel oak, redbay, pawpaw, A. beech, black tupelo, sweetgum, hackberry, sourwood, hickory sp.

Southern Riverine Forest: baldcypress, pondcypress, redbay, swamp tupelo, water tupelo, black willow, swamp cottonwood, A. white-cedar, A. elm, water hickory, common persimmon, red maple, Carolina ash, green ash, box-elder, e. sycamore

Southern Mixed Hardwood Swamp Forest: black tupelo, water tupelo, sweetgum, red maple, swamp hickory, water hickory, e. sycamore, swamp chestnut oak, overcup oak, cherrybark oak, water oak, willow oak, pawpaw, sweetbay, sourwood, deciduous holly

Other Communities Mentioned:

Rocky Outcrops
Beaches and Dunes
Northern Old Fields
Southern Old Fields

Eastern U.S. - DeGraaf et al. (1991):

Eastern Forest Types:

White-Red-Jack Pine: e. white pine (northeast, Appalachians), red pine (Lake States, Canada), jack pine (Lake States)

Spruce-Fir: red spruce, balsam fir, paper birch, aspen, red maple, eastern white pine, n. white cedar

Longleaf-Slash Pine: longleaf pine, slash pine, hardwoods

Loblolly-Shortleaf Pine: loblolly, shortleaf, upland oaks

Oak-Pine: upland oaks, loblolly pine, shortleaf pine, Virginia pine, pitch pine

Oak-Hickory: upland oaks, hickories, pines

Oak-Gum-Cypress: tupelo, blackgum, sweetgum, oak, bald cypress, a few pines

Elm-Ash-Cottonwood: elm sp., ash sp., cottonwood, red maple, sycamore, willow, red maple, American beech

Maple-Beech-Birch: sugar maple, red maple, American beech, yellow birch, balsam fir, red spruce, aspen, n. red oak, white ash, e. white pine, paper birch, e. hemlock

Aspen-Birch: quaking aspen, bigtooth aspen, paper birch

Eastern Non-forest Types:

Field, Glade, Orchard
Pasture, Wet, or Sedge Meadow
Fresh Marsh, Pond
Wooded Swamp, Bog, Shrub Swamp
Lake, Stream, River
Sand Pine, Scrub Oak
Pocosins
Alpine Tundra, Krummholz

New England - DeGraaf and Rudis (1986):

Forest Types/Subtypes:

Aspen-Birch

Aspen: quaking aspen, bigtooth aspen, paper birch, pin cherry

Birch: paper birch, quaking aspen, bigtooth aspen, balsam fir, red spruce, white pine, yellow birch, hemlock

Northern Hardwoods: sugar maple, beech, yellow birch; grades in southern N.E. to mixed with basswood, red maple, hemlock, white ash, white pine, balsam fir, black cherry, paper birch, sweet birch, red spruce

Sugar Maple/Ash: sugar maple, white ash, yellow birch subtype on good soils

Beech/Birch/Maple: sugar maple, beech, yellow birch; typical subtype on drained soils

Beech/Red Maple: beech, red maple, northern red oak, some softwoods (spruce, hemlock, white pine)

Swamp Hardwoods

Red Maple: red maple, yellow birch, balsam fir, sugar maple, black gum, sycamore, red spruce, silver maple

Spruce-Fir

Balsam Fir: balsam fir, paper birch, aspen, red spruce, n. white-cedar, hemlock, red maple

Red Spruce: red spruce, balsam fir, paper birch, yellow birch, sugar maple, red maple, mountain ash, eastern white pine, eastern hemlock

Red Spruce-Balsam Fir: red spruce, balsam fir, red maple, paper birch, yellow birch, aspens, white pine, hemlock, black spruce, tamarack, n. white-cedar

Eastern Hemlock: e. hemlock, beech, sugar maple, yellow birch, red maple, black cherry, white pine, n. red oak, white oak, sweet birch, paper birch, balsam fir, red spruce

Oak-Pine Types

Oak-Pine: n. red oak, w. pine, black oak, white oak, chestnut oak, red maple, aspen, gray birch

Pitch Pine: pitch pine, aspen, gray birch, red maple, white pine, black oak, white oak, bear oak

Mixed Oak-Hardwood: n. red oak, maple sp., oak sp., birch sp., ash, hickory sp.

Old-field Pine: white pine, red cedar

White Pine-Northern Red Oak-Red Maple: n. red oak, e. white pine, red maple, white ash, paper birch, yelllow birch, sweet birch, sugar maple, beech, hemlock, black cherry

Northern Red Oak: n. red oak, black oak, scarlet oak, chestnut oak, hickories, red maple, black cherry, sugar maple, white ash, American beech

Eastern White Pine: w. pine, red pine, hemlock, pitch pine, gray birch, aspen, red maple, white oak, birch sp., white ash, black cherry, n. red oak, sugar maple, hemlock, red spruce, n. white cedar

Upland Nonforested Habitats:

Cultivated Fields
Forb Openings
Grass Openings
Shrub/Old Fields Openings
Pasture
Savanna
Orchards
Krummholz
Alpine

Wetland Nonforested Habitats:
Palustrine-
Sedge Meadows
Shallow Marshes
Deep Marshes
Shrub Swamps: shrub buttonbush, alder, dogwood, red maple, white ash
Bogs: peat
Ponds
Deepwater-
Lakes
Riverine-
Streams
Rivers
Riparian
Special Features:
Stable Banks
Cliffs, Ledge, Talus, Outcrops
Caves
Structures

Southeastern U.S. - Hamel (1992):

Pine Savanna: longleaf pine, slash pine, Florida slash pine
Southern Scrub Oak: scrub oaks
Sand Pine-Southern Scrub Oak: sand pine, srub oaks
Longleaf Pine-Scrub Oak: longleaf pine, scrub oaks
Sandhills Longleaf Pine: longleaf pine, some hardwoods
Southern Mixed Mesic Hardwoods: beech, southern magnolia, Georgia, Florida
Bay Swamp-Pocosin: blackgum, swamp tupelo, red bay, sweet bay, loblolly bay
Pond Pine Pocosin: pond pine, A. white-cedar
Longleaf Pine-Slash Pine: longleaf pine, slash pine
Oak-Gum-Cypress: water tupelo, blackgum, sweetgum, oak sp., baldcypress, intermediate between bay swamp-pocosin and elm-ash-cottonwood
Live Oak Maritime: live oak (*Q. virginiana*)
Elm-Ash-Cottonwood: elm sp., cottonwood, ash sp.
Loblolly Pine-Shorleaf Pine: loblolly pine, shortleaf pine, eastern redcedar
Virginia Pine-Pitch Pine: Virginia pine, pitch pine
Mixed Pine-Hardwood: loblolly pine, shortleaf pine, oak sp., Virginia pine
Oak-Hickory: upland oaks, hickory sp.
White Pine-Hemlock: white pine, hemlock
Cove Hardwoods: tuliptree, basswood, sugar maple, buckeye, white oak, diverse
Maple-Beech-Birch: sugar maple, beech, yellow birch
Spruce-Fir: red spruce, Fraser fir

Eastern U.S. - Benyus (1989):

Sandy Beach and Dune
Salt Marsh
Mangrove Forest
Lake and Pond
River and Stream
Cattail Marsh
Everglades
Sedge Meadow
Shrub Swamp
Bog and Bog Forest: balsam fir, birch sp., black ash, black spruce, e. hemlock, red maple, tamarack, A. white-cedar, n. white-cedar, shrubs
Northern Floodplain Forest: American elm, ash sp., red maple, silver maple, river birch, yellow-poplar, willow sp., sycamore, sweetgum, speckled alder, n. pin oak, swamp white oak, water oak, hickory sp., American holly
Southern Floodplain Forest: Carolina ash, green ash, baldcypress, willow sp., water tupelo, elm sp., cottonwood, sycamore, sweetgum, redbay, red maple, silver maple, hickory sp., cherrybark oak, n. pin oak, overcup oak, post oak, Shumard oak, swamp oak, chestnut oak, water oak, willow oak
Grassy Field
Shrub-Sapling Opening/Edge
Aspen-Birch Forest: bigtooth aspen, quaking aspen, balsam fir, paper birch, alder sp.
Transition Forest: American basswood, red maple, sugar maple, yellow birch, white ash, n. red oak, e. white pine, e. hemlock, American beech, black cherry
Appalachian Cove Forest: American beech, Carolina silverbell, birches, blackgum, e. hemlock, e. white pine, tulip tree, white basswood, white ash, black oak, northern red oak, white oak, red maple, sugar maple, magnolia sp., hickory sp.
Oak-Hickory Forest: American basswood, bur oak, n. pin oak, shingle oak, blackjack oak, chestnut oak, scarlet oak, chinkapin oak, post oak, Shumard oak, s. red oak, bitternut hickory, mockernut hickory, pignut hickory, shagbark hickory, e. white pine, pitch pine, shortleaf pine, Virginia pine, sweetgum, tulip tree, blackgum, red maple, sugar maple
Northern Needleleaf Forest:
Spruce-Fir: balsam fir, black spurce, Fraser fir, red spruce, tamarack, white spruce, aspens, poplar, birch sp., e. hemlock, n. white-cedar, red maple
Pine: e. white pine, jack pine, red pine, black oak, n. pin oak, n. red oak, scarlet oak, white oak, aspens, poplar, birch sp., e. hemlock, n. white-cedar, red maple
Southern Needleleaf Forest: loblolly pine, shortleaf pine (loblolly-shortleaf forest); longleaf pine, slash pine, saw-palmetto (longleaf-slash forest); blackgum, hickory sp., sweetbay, red maple, sweetgum, blackjack oak, laurel oak, post oak, southern red oak, water oak, white oak, willow oak (both)

APPENDIX C – Table summarizing habitats defined by other authors and proposed habitats for MDN-GAP

TYPE:	PROPOSED (Gorham 1998)	Kricher (1988)	DeGraaf et al. (1991)	Degraaf and Rudis (1986)	Hamel (1992)	Benyus (1989)
Uplands-Forests	Boreal Conifer	Boreal Forest	Spruce-Fir	Spruce-Fir	Spruce-Fir	Northern Needleleaf Forest, Spruce-Fir
	Boreal Hardwood		Aspen-Birch	Aspen-Birch		Aspen-Birch Forest
	Boreal Mixed					
		Jack Pine Forest				
			White-Red-Jack Pine			
	Northern Conifers			Eastern Hemlock		Northern Needleleaf Forest, Pine
					White Pine-Hemlock	
	Northern Oak-Conifer			White Pine, Northern Red Oak		
	Northern Oak					
	Northern Mixed Hardwoods / Conifer					
		Northern Hardwood Forest				Transition Forest
	Northern Hardwoods	Beech-Maple Forest	Maple-Beech-Birch	Northern Hardwoods - Beech / Birch / Maple	Maple-Beech-Birch	
				Northern Hardwoods -Sugar Maple/Ash		
	Mixed Mesophytic	Maple-Basswood				
	Appalachian Cove	Appalachian Cove			Cove Hardwoods	Appalachian Cove Forest
	Oak-Hickory	Oak-Hickory Forest		Mixed Oak-Hardwood	Oak-Hickory	Oak-Hickory Forest
	Oak-Hickory-Pine					
	Mixed Oak / Deciduous					

TYPE:	PROPOSED (Gorham 1998)	Kricher (1988)	DeGraaf et al. (1991)	Degraaf and Rudis (1986)	Hamel (1992)	Benyus (1989)
				Oak-Pine		
	Mid-Atlantic Oak-Pine	Northern Pine-Oak Forest			Virginia Pine-Pitch Pine	
			Oak-Pine	Oldfield Pine	Mixed Pine-Hardwood	
	Pine Barrens			Pitch Pine (in part)		
	Outcrop / Talus Mixed Woodland					
	Outcrop / Talus Deciduous Woodland					
	Southern / Coastal Pine-Oak		Loblolly-Shortleaf Pine		Loblolly Pine-Shortleaf Pine	Southern Needleleaf Forest, Loblolly / Shortleaf Pine
		Southern Mixed Pine-Oak Forest				
			Longleaf-Slash Pine		Longleaf Pine-Slash Pine	Southern Needleleaf Forest, Longleaf / Slash Pine
	Maritime Hardwood Forest / Woodlands				Live Oak Maritime	
	Maritime Mixed Forest / Woodlands					
	Southern Pines				Pine Savanna	
					Sandhills Longleaf Pine	
			Sand Pine, Scrub Oak		Sand Pine-Southern Scrub Oak	
					Longleaf Pine-Scrub Oak	
					Southern Scrub Oak	
	Southern Hardwoods	Southern Hardwood Forest			Southern Mixed Mesic Hardwoods	

TYPE:	PROPOSED (Gorham 1998)	Kricher (1988)	DeGraaf et al. (1991)	Degraaf and Rudis (1986)	Hamel (1992)	Benyus (1989)
Wetlands-Woody	Boreal Bogs	Boreal Bog	Bog	Bogs		Bog and Bog Forest
	Boreal Swamps					
	Bog Forests					
	White-cedar Swamps	White-cedar Swamp Forest				
	Pond Pine Pocosin		Pocosin (in part)		Pond Pine Pocosin	
	Shrub Swamps		Shrub Swamp	Shrub Swamps		Shrub Swamp
	Red Maple Swamp	Northern Swamp Forest	Wooded Swamp	Swamp Hardwoods - Red Maple		
	Red Maple-Hemlock Swamps					
	Pine-Hardwood Swamps					
	Mixed Oak Swamps					
	Northern Riparian	Northern Riverine Forest	Elm-Ash-Cotton-wood	Riparian?	Elm-Ash-Cotton-wood	Northern Floodplain Forest
	Riparian Thicket/Shrub					
	Southern / Coastal Floodplains	Southern Riverine Forest				Southern Floodplain Forest
	Baldcypress Swamps	Baldcypress Swamp Forest	Oak-Gum-Cypress		Oak-Gum-Cypress	
		Southern Mixed Hardwood Swamp Forest				
			Pocosin (in part)		Bay Swamp Pocosin	
	Maritime Wet Thicket/Shrub					
Wetlands-Herbaceous				Shallow Marsh		
	Fresh Emergent Marsh		Fresh Marsh			Cattail Marsh

TYPE:	PROPOSED (Gorham 1998)	Kricher (1988)	DeGraaf et al. (1991)	Degraaf and Rudis (1986)	Hamel (1992)	Benyus (1989)
	Marsh/Open Water Complex			Deep Marsh		
	Brackish Emergent Marsh					
	Low Salt Marsh					Salt Marsh-Low
	High Salt Marsh					Salt Marsh-High
	Salt Marsh Pannes					Salt Marsh-Pannes
						Salt Marsh-Pools
	Salt Marsh Scrub					Salt Marsh-Edge
	Wet Meadows		Sedge Meadow	Sedge Meadows		Sedge Meadow
			Wet Meadow (seasonal)			
	Vernal Pools					
	Seeps					
Upland Scrub or Herbaceous	Alpine Meadow		Alpine Tundra	Alpine		
	Alpine/Boreal Heath	New England Alpine Community				
	Krummholz		Krumm-holz	Krummholz		
	Balds	Appalachian Heath Balds	Glade			
	Glade					
				Savanna		
	Shrub / Sapling Oldfields	Northern Old Fields		Shrub/Old Fields Openings		Shrub-Sapling Opening/Edge
		Southern Old Fields				
	Herbaceous Oldfields			Forb Openings		
	Annual Grassland	Grassy Field	Field			
	Perennial Grassland (tall, intermediate, short)			Grass Openings		
	Pasture		Pasture	Pasture		

TYPE:	PROPOSED (Gorham 1998)	Kricher (1988)	DeGraaf et al. (1991)	Degraaf and Rudis (1986)	Hamel (1992)	Benyus (1989)
	Cropped			Cultivated Field		
	Orchard			Orchards		
		Beaches and Dunes				Sandy Beach and Dune
	Beaches					SBD- Upper Beach
	Dune Grassland					SBD- Foredune
	Interdunal Marsh					SBD- Dune Hollows (interdunal)
	Dune / Maritime Thickets					SBD- Backdune
Aquatic	Ponds		Pond	Ponds		Lake and Pond
	Lakes		Lake	Lakes		
	Streams		Stream	Streams		River and Stream
	Rivers		River	Rivers		
	Mudflats					
Other	Rocky Cliffs and Outcrops	Rocky Outcrops		Cliff, Ledges, Talus, Outcrops		
	Special Habitat Feature			Stable Banks		
	Subterranean			Caves		
	Special Habitat Feature			Structures		

APPENDIX D: LIST OF HABITAT TYPES: MDN-GAP PROJECT

ID	HT_CODE	HT_GROUP	HABITAT TYPE
1	UF.BOCO	UPLAND FORESTS / WOODLANDS	BOREAL CONIFER
2	UF.BOHA		BOREAL HARDWOOD
3	UF.BOMI		BOREAL MIXED HARDWOOD - CONIFER
4	UF.NOCO		NORTHERN CONIFER
5	UF.NOOK		NORTHERN OAK
6	UF.NOOC		NORTHERN OAK - CONIFER
7	UF.NOHA		NORTHERN HARDWOOD
8	UF.NOMX		NORTHERN MIXED HARDWOOD - CONIFER
9	UF.MIME		MIXED MESOPHYTIC
10	UF.APCO		APPALACHIAN COVE HARDWOOD
11	UF.PIBA		PINE BARREN
12	UF.OKHK		OAK - HICKORY
13	UF.MAOP		MID-ATLANTIC OAK - PINE
14	UF.LEMH		LOW ELEVATION MESIC HARDWOOD
15	UF.CPPI		COASTAL PLAIN PINE
16	UF.CPPO		COASTAL PLAIN PINE - OAK
17	UF.SOPI		SOUTHERN PINE
18	UF.HEWL		HIGH-ELEVATION WOODLAND
19	UF.MEWL		MID- TO LOW-ELEVATION WOODLAND
20	UF.MTFW		MARITIME FOREST / WOODLAND
21	WF.BOFO	WETLAND FORESTS / WOODLANDS	BOG FOREST
22	WF.BOSP		BOREAL SWAMP
23	WF.NCSP		NORTHERN CONIFEROUS SWAMP
24	WF.NHSP		NORTHERN HARDWOOD SWAMP
25	WF.AWCS		ATLANTIC WHITE-CEDAR SWAMP
26	WF.CYSP		BALD CYPRESS SWAMP
27	WF.BHSP		BOTTOMLAND HARDWOOD SWAMP
28	WF.DSPH		DEEP SWAMP HARDWOOD
29	WF.CPPF		COASTAL PLAIN PINE FLATWOOD
30	WF.OKSP		MIXED OAK SWAMP
31	WF.PHSP		COASTAL PLAIN PINE - HARDWOOD SWAMP
32	WF.NORI		NORTHERN RIPARIAN
33	US.ABHT	UPLAND SHRUBS	ALPINE / BOREAL HEATH
34	US.KRUM		KRUMMHOLZ
35	US.MHTB		MONTANE HEATH THICKET / BALD
36	US.SSOF		SHRUB / SAPLING OLD FIELD
37	US.MSOF		MID-SUCCESSIONAL OLD FIELD
38	US.PBSC		PINE BARREN SCRUB
39	US.DMTS		DUNE / MARITIME THICKET / SHRUB
40	WS.NBBO	WETLAND SHRUBS	NORTHERN / BOREAL BOG
41	WS.NBFE		NORTHERN / BOREAL FEN
42	WS.SMSS		SALT MARSH SCRUB
43	WS.MWTS		MARITIME WET THICKET / SHRUB
44	WS.WVPO		WOODY VERNAL POOL
45	WS.SSSP		SATURATED SHRUB SWAMP
46	WS.FSSP		FLOODED SHRUB SWAMP
47	WS.RITS		RIPARIAN THICKET / SHRUB
48	UH.ALGM	UPLAND HERBACEOUS	ALPINE GRASSLAND / MEADOW
49	UH.DSGD		DRY SLOPE GLADE
50	UH.HEOF		HERBACEOUS OLD FIELD
51	UH.URHE		UPLAND RIPARIAN HERBACEOUS
52	UH.DMGL		DUNE / MARITIME GRASSLAND
53	WH.WMRH	WETLAND HERBACEOUS	WET MEADOW / WET RIPARIAN HERBACEOUS
54	WH.FEMS		FRESH ROBUST EMERGENT MARSH
55	WH.SEEP		SEEP AND RIVULET
56	WH.HVPO		HERBACEOUS VERNAL POOL

ID	HT_CODE	HT_GROUP	HAB_TYPE
57	WH.FTMS		FRESH TIDAL EMERGENT MARSH
58	WH.BEMS		BRACKISH EMERGENT MARSH
59	WH.LSMS		LOW SALT MARSH
60	WH.HSMS		HIGH SALT MARSH
61	WH.DMMS		INTERDUNAL / MARITIME MARSH
62	SV.ROCL	SPARSELY VEGETATED	ROCKY CLIFF
63	SV.ROTB		ROCKY OUTCROP / TALUS / BARREN
64	SV.GRBA		NATURAL GRAVEL BARREN
65	SV.ERSL		ERODING SLOPE / BANK
66	SV.UNCS		UNCONSOLIDATED RIVER / LAKE SHORE
67	SV.SDNF		SAND DUNE / FLAT
68	SV.SUBT		SUBTERRANEAN
69	AQ.POND	AQUATIC	FRESHWATER POND
70	AQ.LAKE		FRESHWATER LAKE / RESERVOIR
71	AQ.LPRI		LOWER PERENNIAL RIVER
72	AQ.LPST		LOWER PERENNIAL STREAM
73	AQ.UPRI		UPPER PERENNIAL RIVER
74	AQ.UPST		UPPER PERENNIAL STREAM
75	AQ.INSR		INTERMITTENT STREAM / RIVER
76	AQ.FTRI		FRESH TIDAL RIVER
77	AQ.FTST		FRESH TIDAL STREAM
78	AQ.FITM		FRESH INTERTIDAL MUDFLAT / SHORE
79	AQ.ESRI		ESTUARINE TIDAL RIVER
80	AQ.ESST		ESTUARINE TIDAL STREAM
81	AQ.ESPO		ESTUARINE TIDAL POND
82	AQ.ESIM		ESTUARINE INTERTIDAL MUDFLAT / SHORE
83	AQ.ESIB		ESTUARINE INTERTIDAL SANDY BEACH
84	AQ.ESNS		ESTUARINE SUBTIDAL NEARSHORE
85	AQ.ESOS		ESTUARINE SUBTIDAL OFFSHORE
86	AQ.MAIR		MARINE INTERTIDAL ROCKY
87	AQ.MAIB		MARINE INTERTIDAL SANDY BEACH
88	AQ.MANS		MARINE SUBTIDAL NEARSHORE
89	AQ.MAOS		MARINE SUBTIDAL OFFSHORE
90	AN.AFCR	ANTHROPOGENIC	AGRICULTURAL FORB-LIKE / ROW CROP
91	AN.AGCR		AGRICULTURAL GRASS-LIKE CROP
92	AN.ASCR		AGRICULTURAL SHRUB-LIKE CROP
93	AN.APAS		AGRICULTURAL PASTURE
94	AN.AORC		AGRICULTURAL ORCHARD
95	AN.APLA		AGRICULTURAL PLANTATION
96	AN.ARCL		AGRICULTURAL REGENERATING CLEARCUT
97	AN.ABAR		AGRICULTURAL BARREN - PLOWED / FALLOW
98	AN.ADEV		AGRICULTURAL DEVELOPED
99	AN.ULID		URBAN LOW-INTENSITY DEVELOPED
100	AN.UHID		URBAN HIGH-INTENSITY DEVELOPED
101	AN.UTRA		URBAN TRANSPORTATION CORRIDOR
102	AN.ULAN		URBAN LANDSCAPED
103	AN.UBAR		URBAN BARREN - VACANT / EXTRACTION

APPENDIX E: **MDN-GAP Habitat Type Descriptions**

UPLAND FORESTS/WOODLANDS:

1. Boreal Conifer (UF.BOCO): Consists of upland "spruce-fir" forests in boreal or alpine zones of northern latitudes and higher elevations. Dominant species include red spruce, black spruce, balsam fir, or Fraser fir. Hardwoods may be present, but comprise less than 25% of the canopy cover. Associate species may include yellow birch, white birch, quaking aspen, tamarack, and white pine. Soils are shallow to bedrock, acidic, nutrient-poor, and generally on till from granite or limestone. The bryophyte layer is often well-developed. In the mid-Atlantic region, it occurs in Maryland over about 3000 feet, in the mountains of West Virginia and Virginia, the higher mountains in New Jersey, and in the Alleghenies in Pennsylvania.
Dominant/Subdominant Species- *Picea rubens*, *Picea mariana*, *Abies balsamea*, *Abies fraseri*
Associative Species- *Betula allegheniensis*, *B. papyrifera*, *Pinus strobus*, *Populus tremuloides*
Shrub/Vine Species- *Acer spicatum, Sorbus americanus, Kalmia angustifolia*, *Vaccinium* spp., *Ledum groenlandicum*

2. Boreal Hardwood (UF.BOHA): A boreal or alpine habitat consisting of successional, disturbance-related forests of aspen, birch or fire cherry. Conifers if present comprise less than 25% of the canopy cover. Soils are varied from dry, rocky ledges and sandy plains to moist or well-drained loamy soils. In the mid-Atlantic states, it occurs primarily as fire cherry stands in higher elevations of Maryland, Pennsylvania, New Jersey, and Virginia and West Virginia.
Dominant/Subdominant Species- *Populus tremuloides*, *Prunus pensylvanica*
Associative Species- *Betula allegheniensis*, *B. papyrifera*, *Acer rubrum, A. saccharum*, *Quercus rubra, Populus balsamifera, P. grandidentata, Picea rubens, P. glauca, Abies balsamea*
Shrub/Vine Species- *Corylus cornuta*, *Acer pensylvanicum*, *Rubus* spp., *Viburnum alnifolium*, *Taxus canadensis*

3. Boreal Mixed (UF.BOMI): A boreal or alpine habitat with forests of spruce, aspen, birch, and fir. Boreal conifers and hardwoods each comprise greater than 25% of the canopy cover. It usually occurs on sites that are more moist than northern hardwood, and is generally found on mid-slopes with well-drained to poorly-drained soils. In the mid-Atlantic region, distribution is not well known, but probably limited to higher elevations in Maryland, West Virginia, Pennsylvania and New Jersey.
Dominant/Subdominant Species- *Abies balsamea*, *Abies fraseri*, *Betula allegheniensis*, *B. papyrifera*, *Populus tremuloides*, *Prunus pensylvanica*
Associative Species- *Acer rubrum, A. saccharum*, *Fagus grandifolia*, *Tsuga canadensis*, *Pinus strobus*
Shrub/Vine Species- *Acer spicatum, A. pensylvanicum, Viburnum alnifolium, Rubus* spp.

4. Northern Conifer (UF.NOCO): This habitat consists of northern / higher elevation forests of red pine, white pine, eastern hemlock, or Jack pine (Lake States) in mixed or pure stands with less than 25% hardwoods. In the mid-Atlantic region it is found in cool ravines and on slopes in the Appalachians, and in some drier locations at slightly lower elevations where white pine is generally dominant with other pines.
Dominant/Subdominant Species- *Tsuga canadensis*, *Pinus strobus*, *P. resinosa, Thuja occidentalis*
Associative Species- *P. rigida, Acer rubrum*, *Picea rubens, Quercus rubra, Fagus grandifolia*, *Betula allegheniensis*, *B. lenta*
Shrub/Vine Species- *Viburnum cassinoides, Vaccinium angustifolium, Amelanchier canadensis, Acer spicatum, A. pensylvanicum, Hamamelis virginiana*

5. Northern Oak (UF.NOOK): This habitat consists of northern forests dominated by northern red oak, or oak and sugar maple with less than 25% conifers. It has more oak and less beech, birch and maple than northern hardwoods. It occurs on deep, moist to well-drained loams and silt loams. Variants may occur on more xeric, thinner soils on upper slopes and ridges. It has a spotty distribution along the mountains from Pennsylvania southward and is found at elevations up to about 3500 feet in West Virginia and the mid-Atlantic region, but can occur over a range of elevations. In the mid-Atlantic region, it's found at mid to higher elevations, on cool slopes, and in coves; occasionally on drier slopes or ridges.
Dominant/Subdominant Species- *Quercus rubra*, *Q. velutina, Q. alba, Q. prinus*
Associative Species- *Acer rubrum, Acer saccharum, Quercus alba, Fraxinus americana, Fagus grandifolia, Betula lenta, Liriodendron tulipifera, Pinus* spp., *Tilia americana.*
Shrub/Vine Species- *Kalmia latifolia*, *Viburnum acerifolium, Hamamelis virginiana, Vaccinium* spp., *Acer pensylvanica, Corylus cornuta*

6. Northern Oak-Conifer (UF.NOOC): This habitat consists of northern / higher elevation forests with northern red oak, black oak and white pine generally dominating, and other common associates including chestnut oak, red maple, eastern hemlock, paper birch, and white oak. It generally occupies fertile, well-drained sites, including north slopes and coves, but may also be found on drier ridges and south- and west-facing broad slopes. Other soil descriptions include acidic, well-drained to rapidly drained sands, sandy loams, or loamy sands. It may also occur on rocky slopes. In the Appalachians south of Pennsylvania, it is found up to about 2500 ft. South of Maryland and West Virginia, northern red oak is less common, and this type is represented primarily by the chestnut oak-white pine forest type, with an occurrence generally between 1200 ft.-3600 ft. It's distribution in the mid-Atlantic states is patchy, primarily limited by the occurrence of white pine. It is found in scattered locations in the mid to higher elevations.
Dominant/Subdominant Species- *Quercus rubra, Q. velutina*, *Pinus strobus*
Associative Species- *Acer rubrum, Quercus prinus, Tsuga canadensis, Q. alba, Pinus rigida*
Shrub/Vine Species- *Gaylussacia baccata*, *Kalmia angustifolia, K. latifolia, Vaccinium* spp., *Alnus rugosa, Hamamelis virginiana*

7. Northern Hardwood (UF.NOHA): A northern / higher elevation forest with a mix of sugar maple, yellow birch and American beech. Other associates may include northern red oak, hemlock, white pine, aspens, and a number of other species. Sugar maple is almost always present and unifies this habitat type. It often occurs on moderately well-drained to moist fertile loams and sandy loams on cooler northern slopes, but can be found in varying conditions from shallow bedrock to poorly drained soils. Soils can arise from granite and schists in the glaciated region, and calcareous rocks, sandstones and shales elsewhere. Elevations range from near sea level in the northern portion of its range, to elevations over 4000 feet in the south. In the mid-Atlantic region, it generally occurs over about 2500 feet, or in cool microclimates below 2500 ft.
Dominant/Subdominant Species- *Acer saccharum*, *Fagus grandifolia*, *Betula allegheniensis*,
Associative Species- *Tsuga canadensis*, *Acer rubrum, Pinus strobus, Betula lenta, Prunus serotina, Tilia americana, Magnolia acuminata, Quercus rubra, Fraxinus americana, Picea rubens*
Shrub/Vine Species- *Viburnum acerifolium, V. alnifolium, Hamamelis virginiana, Ilex montana, Ribes glandulosum, Amelanchier* spp., *Lindera benzoin*
Herbaceous Species-*Dennstaedtia punctilobula*

8. Northern Mixed Hardwood/Conifer (UF.NOMX): This habitat has a mix similar to that of northern hardwood, but with a strong conifer component (>25%), usually consisting of eastern hemlock, white pine or red pine. Northern white cedar may also be present on some sites. In addition to the typical northern hardwood component, tulip poplar is common in the canopy in "hemlock ravines." It occurs on cool, mesic sites, and its occurrence in the southern mid-Atlantic states may be restricted to cool ravines and north facing slopes, where it may be patchily distributed.
Dominant/Subdominant Species- *Acer saccharum*, *Betula allegheniensis*, *Fagus grandifolia*, *Tsuga canadensis*, *Pinus strobus*
Associative Species- *Acer rubrum, Tilia americana, Liriodendron tulipifera, Prunus* spp., *Betula lenta, Thuja occidentalis*
Shrub/Vine Species- *Acer spicatum, A. pensylvanicum, Viburnum alnifolium, Diervella lonicera, Sambucus pubens, Taxus canadensis, Rhododendron maximum*

9. Mixed Mesophytic (UF.MIME): A northerly, mid-elevation forest characterized by high diversity and variability, this habitat includes as co-dominants some assemblage of the following: American basswood, sugar maple, white ash, tulip poplar, American beech, northern red oak, chestnut oak, eastern hemlock, and red maple. Canopy associates may include slippery elm, black walnut, yellow birch, hop-hornbeam, magnolias, hickories, and black cherry. Soils are usually deep, well-drained loams and silt loams, moderately acid to moderately alkaline, and are often derived from calcareous parent materials. This habitat is likely to be situated on mid to lower slopes or in coves and ravines, with cooler microclimates, greater moisture retention, and deeper, more fertile soils. In the mid-Atlantic states, it occurs on mid elevation slopes and in coves, up

to a maximum elevation of about 800-1000 m; it grades into the Appalachian cove hardwood habitat type in the central and southern Appalachians.
Dominant/Subdominant Species- *Acer saccharum, Tilia americana, Fraxinus americana, Liriodendron tulipifera, Fagus grandifolia, Quercus rubra, Q. prinus, Tsuga canadensis, Acer rubrum*
Associative Species- *Ulmus rubra, Juglans nigra, Betula allegheniensis, Ostrya virginiana, Magnolia virginiana, M. acuminata, Carya* spp., *Prunus serotina*
Shrub/Vine Species- *Viburnum acerifolium, Cornus alternifolia, Hamamelis virginiana, Rhododendron nudiflorum, Lonicera canadensis, Staphylea trifoliata*

10. Appalachian Cove Hardwood (UF.APCO): This habitat is similar to the mixed mesophytic habitat of the northern Appalachians, but it has a more central and southerly distribution which coincides with the northern limits of white basswood and yellow buckeye, two of the species that help to characterize this habitat type. In addition to these species, other co-dominant species may include Florida basswood, hoary basswood, Carolina silverbell, tulip poplar, sugar maple, red maple, American beech, northern red oak, black oak, white oak, and eastern hemlock. Canopy associates may include black walnut, butternut, white ash, yellow birch, magnolias, hickories, and black cherry. It has a high degree of diversity and is highly variable. Soils are usually deep, well-drained, and friable. This habitat is likely to be situated on mid to lower slopes or in coves and ravines, with cooler microclimates, greater moisture retention, and deeper, more fertile soils. In the east, it ranges from Pennsylvania south through the mid-Atlantic and into the southern Appalachians. In the mid-Atlantic region, it occurs at mid-elevations, up to about 1000 m.
Dominant/Subdominant Species- *Tilia heterophylla, T. floridana, T. neglecta, Acer saccharum, Liriodendron tulipifera, Aesculus octandra, Halesia carolina, Quercus rubra, Q. alba, Q. velutina, Fagus grandifolia, Tsuga canadensis*
Associative Species- *Juglans nigra, J. cinerea, Magnolia acuminata, M. virginiana, Carya* spp.*, Betula allegheniensis, Fraxinus americana, Prunus serotina*
Shrub/Vine Species- *Viburnum acerifolium, Lindera benzoin, Cornus alternifolia, Hamamelis virginiana, Rhododendron nudiflorum, R. calendulaceum, R. maximum*

11. Pine Barren (UF.PIBA): This habitat type includes woodland communities dominated by pitch pine in the overstory, and bear oak and/or dwarf chinquapin oak sharing dominance with ericaceous shrubs in the understory. Other associates include shortleaf pine, blackjack oak and other oaks and pines. It has a spotty distribution, and is generally restricted to dry, sandy, nutrient-poor soils, or acidic, rocky or otherwise infertile slopes and ridgetops. It is most abundant in the coastal plain sandy soils from New Jersey north, but is also found in the mountains south along the Appalachians. In the northern mountains, it is restricted to elevations below 600 m; in the south, it ranges up to 1400 m.
Dominant/Subdominant Species- *Pinus rigida, Quercus ilicifolia, Q. prinoides*
Associative Species- *Pinus virginiana, P. strobus, P. echinata, P. pungens, Carya* spp.*, Quercus coccinea, Q. prinus, Q. falcata, Q. marilandica, Q. velutina, Q. rubra, Q. stellata*, *Sassafras albidum*

Shrub/Vine Species- *Quercus ilicifolia, Q. prinoides, Comptonia asplenifolia, Gaylussacia dumosa, G. baccata, Ilex glabra, Kalmia angustifolia, Rhus glabra, Vaccinium angustifolium, V. pallidum*
Herbaceous Species- *Andropogon scoparius, Panicum depauperatum, Tephrosia virginiana, Arctostaphylos uva-ursi, Epigaea repens, Euphorbia ipecacuanhae, Gaultheria procumbens, Pyxidanthera barbulata, Cypripedium acaule, Cladonia rangiferina*

12. Oak-Hickory (UF.OKHK): Oak-dominated forests generally occurring in drier soil conditions at mid and lower elevations, as well as on ridgetops. Dominant species may include chestnut oak, black oak, white oak, northern red oak, post oak, blackjack oak, pignut hickory, shagbark hickory, mockernut hickory, bitternut hickory, white ash, and American beech. Canopy associates may include chinquapin oak, southern red oak, scarlet oak, red maple, tulip poplar, Virginia pine, eastern white pine, pitch pine, and table mountain pine. It is distinguished from the Northern Oak (UF.NOOK) Habitat Type by the lack of other mesic, cool-site species in the canopy, but sugar maple is invading many sites. Pines and other conifers generally make up less than 25% of the canopy. Soils are well-drained to xeric loams, sandy-loams, or coarse-textured soils on rocky ridges or outcrops. The aspect, especially in northern latitudes or at higher elevations, is southerly, westerly, or sometimes easterly. In the mid-Atlantic states, it has limited occurrence on the coastal plain in some drier locations, is widespread in the Piedmont and the Ridge and Valley Provinces, and is found in some lower elevations in the mountains. The chestnut oak forests contained in this habitat may extend up to 1000 m in western Maryland.
Dominant/Subdominant Species- *Quercus prinus, Q. velutina, Q. alba, Q. rubra, Q. stellata, Q. marilandica, Carya ovata, C. cordiformis, C. tomentosa, C. glabra, Fraxinus americana, Fagus grandifolia*
Associative Species- *Q. muehlenbergii, Q. falcata, Q. coccinea, Acer rubrum, A. saccharum, Liriodendron tulipifera, Pinus virginiana, P. strobus, P. rigida, P. echinata, P. pungens*
Shrub/Vine Species- *Vaccinium vacillans, V. angustifolium, Gaylussacia frondosa, G. baccata*

13. Mid-Atlantic Oak-Pine (UF.MAOP): This habitat consists of oak-pine forests of the mid-Atlantic region, occurring at mid to lower elevations on drier soils. It is similar to the Pine Barren (UF.PIBA) and Oak-Hickory (UF.OKHK) habitats, but includes at least 25% canopy coverage of tree-form oaks and at least 25% canopy coverage of pines. Oak species may include white oak, scarlet oak, chestnut oak, post oak, blackjack oak, black oak and southern red oak. Pine species may include Virginia pine, pitch pine, and shortleaf pine. Other canopy associates may include hickories, tulip poplar, black gum, red maple, loblolly pine, table mountain pine, eastern white pine, and eastern red cedar. Soils may be coarse-textured, well-drained to xeric, and often shallow and droughty; on the Coastal Plain they may be sandy, and on ridges and slopes in the Piedmont and mountains they may be rocky. This habitat occurs from southern New England, New York, Pennsylvania, and central New Jersey, south along the Piedmont and mountain

foothills, well into the southeast. It also occurs sporadically on the coastal plain of New Jersey, Delaware, Maryland, and Virginia. It rarely occurs above 900 m elevation, and is generally below 600 m.
Dominant/Subdominant Species- *Pinus virginiana, P. echinata, P. rigida, Quercus falcata, Q. coccinea, Q. prinus, Q. marilandica, Q. stellata, Q. alba, Q. velutina*
Associative Species- *Pinus taeda, P. strobus, P. pungens, Juniperus virginiana, Diospyros virginiana*
Shrub/Vine Species- *Kalmia latifolia, Vaccinium* spp.*, Gaylussacia* spp.*, Rhododendron nudiflorum, Smilax rotundifolia, Rhus* spp.*, Rubus* spp.*, Cercis canadensis*

14. Low Elevation Mesic Hardwood (UF.LEMH): This habitat occurs at mid to low elevations in the Piedmont and Coastal Plain on mesic sites with rich soils. It consists of mixed hardwoods other than oaks; typically tulip poplar, American beech, black gum, ironwood, sassafras, black cherry, hickory spp., white ash, or red maple. Oaks are often present, but make up less than 50% of the canopy cover, and often include white oak and northern red oak. Many other tree species may be present in the canopy, including sweet birch, eastern hemlock, magnolias, sweetgum, loblolly pine, and sugar maple. The shrub and herbaceous layers are generally well-developed and diverse. Soils are moderately deep to deep, moist to well-drained, with a medium to fine loose texture. Generally found at elevations below 300 m, it is typically situated on lower slopes or in coves on the Piedmont, or on gentle slopes or plains on the Coastal Plain, from New Jersey, Pennsylvania, Maryland and south.
Dominant/Subdominant Species- *Liriodendron tulipifera, Nyssa sylvatica, Carpinus caroliniana, Prunus serotina, Carya* spp., *Fraxinus americana, Sassafras albidum, Acer rubrum, Quercus alba, Q. rubra, Fagus grandifolia*
Associative Species- *Juglans nigra, J. cinerea, Robinia pseudoacacia, Acer saccharum, Liquidambar styraciflua, Quercus velutina, Q. prinus, Q. coccinea, Q. falcata, Betula lenta, Tsuga canadensis, Pinus taeda, P. echinata*, *Ilex opaca, Cornus florida*
Shrub/Vine Species- *Viburnum* spp., *Lindera benzoin, Gaylussacia frondosa, Rhododendron periclymenoides, Vaccinium vaccilans, Smilax* spp.

15. Coastal Plain Pines (UF.CPPI): This habitat on the Coastal Plain and lower Piedmont consists of loblolly pine-dominated forests, sometimes co-dominant with shortleaf pine (longleaf pine in the south), but is generally more mesic than the Mid-Atlantic Oak-Pine (UF.MAOP) Habitat Type. Hardwoods, if present, make up less than 25% of the canopy cover. Other canopy associates may include Virginia pine, southern red oak, white oak, post oak, blackjack oak, hickories, sassafras, persimmon, tulip poplar, red maple, and sweetgum. Understory species may include American holly, flowering dogwood and black cherry. This type readily invades disturbed sites, and eventually succeeds to hardwood-dominated habitats without periodic burning or other management. Loblolly pine plantations may be included in this habitat, after they mature past the sapling stage, if understory vegetation is not actively suppressed. On good sites, the understory is rich and varied. Found on the Coastal Plain from Delaware south, and sporadically on the Piedmont in southern Maryland, Virginia and further south.
Dominant/Subdominant Species- *Pinus taeda, P. echinata, P. palustris*

Associative Species- *Pinus virginiana, Quercus falcata, Q. alba, Q. stellata, Q. marilandica, Carya* spp.*, Sassafras albidum, Liriodendron tulipifera, Acer rubrum, Liquidambar styraciflua, Diospyros virginiana*, *Ilex opaca, Cornus florida, Prunus serotina*
Shrub/Vine Species- *Crataegus* spp., *Callicarpa americana, Myrica* spp., *Smilax* spp., *Clethra alnifolia*

16. Coastal Plain Pine-Oak (UF.CPPO): Includes upland mixed forests of pines and hardwoods, primarily oaks, with dominant species including loblolly pine, shortleaf pine, red maple, southern red oak, willow oak, water oak, white oak, post oak, scarlet oak, hickories, black gum, magnolias, and sweetgum. Other associates include tulip poplar, chestnut oak, Virginia pine, longleaf pine, and sassafras. Both pines and hardwoods are present with at least 25% canopy cover each. This habitat type occurs in a variety of different soil types and conditions from mesic to xeric, and is similar to the Mid-Atlantic Oak-Pine (UF.MAOP) type. However, loblolly pine is more common as the dominant pine, it has a greater affinity for the Coastal Plain, and is generally more mesic. Widespread but somewhat sporadic on the Coastal Plain from Delaware and Maryland southward. Also occurs to a limited extent on the Piedmont, but is most common on the Coastal Plain in the mid-Atlantic region.
Dominant/Subdominant Species- *Pinus taeda, P. echinata, Acer rubrum, Quercus falcata, Q. phellos, Q. nigra, Q. alba, Q. stellata, Q. coccinea, Carya* spp.*, Nyssa sylvatica, Magnolia* spp.*, Liquidambar styraciflua*
Associative Species- *Liriodendron tulipifera, Quercus prinus, Pinus virginiana, P. palustris , Sassafras albidum*
Shrub/Vine Species- *Kalmia latifolia, Rhododendron periclymenoides, Gaylussacia frondosa, Vaccinium* spp., *Myrica* spp., *Rubus* spp., *Smilax* spp., *Lonicera* spp.

17. Southern Pine (UF.SOPI): This type consists of open forests or woodlands where longleaf pine is dominant, often over an understory of turkey oak, but sometimes in open stands over an herbaceous layer. Canopy associates may include pond pine, Virginia pine, loblolly pine, blackjack oak, southern red oak, water oak, black gum, sassafras, persimmon, sweetgum and sand post oak. It is both established and maintained by fire, and occurs on poor sites with droughty, infertile, and coarse-textured soils; typically dry sands of low pH and marine origin. The herbaceous layer is often dominated by grasses. Occurs on the Coastal Plain from southern Virginia to Florida and west to eastern Texas. Also occurs on the Piedmont Plateau in Alabama and Georgia. Not known from the mid-Atlantic region.
Dominant/Subdominant Species- *Pinus palustris, Quercus laevis*
Associative Species- *Pinus serotina, P. virginiana, P. taeda, Quercus marilandica, Q. falcata, Q. nigra, Q. stellata, Nyssa sylvatica, Sassafras albidum, Liquidambar styraciflua, Diospyros virginiana*
Shrub/Vine Species- *Gaylussacia* spp., *Kalmia angustifolia, Vaccinium* spp., *Myrica* spp., *Serenoa repens*

18. High Elevation Woodland (UF.HEWL): This habitat is composed of open to sparse woodlands at higher elevations or northern latitudes on talus, rocky slopes, bedrock, dry ridges, outcrops, shale barrens, or less typically, sandy soils. Dominant trees are often stunted and may include pitch pine, red pine, table mountain pine, red spruce, northern white cedar, eastern red cedar and northern red oak. Associate species may include American mountain-ash, pignut hickory, post oak, chestnut oak, white oak, scarlet oak, balsam fir, black spruce, birch spp., and eastern white pine. Soils are characteristically shallow, sometimes only a shallow duff layer on bedrock or talus. A good herbaceous layer may be present, and lichens and mosses are often present. In the mid-Atlantic region, generally found above 500 m on slopes and mountain ridges.
Dominant/Subdominant Species- *Pinus rigida, P. resinosa, P. pungens, Picea rubens, Thuja occidentalis, Juniperus virginiana, Quercus rubra*
Associative Species- *Fraxinus americana, Carya glabra, Q. stellata, Q. prinus, Q. alba, Q. coccinea, Abies balsamea, Picea mariana, Betula* spp., *Pinus strobus*
Shrub/Vine Species- *Vaccinium* spp., *Gaylussacia baccata, Kalmia angustifolia, Ribes glandulosum, Arctostaphylos uva-ursi*

19. Mid-Low Elevation Woodland (UF.MEWL): Consists of mid to low elevation woodlands on talus slopes, rocky outcrops, shale barrens, or rocky, dry slopes with southern exposures and/or steep slopes where moisture is limiting. Some woodland alliances on sand, serpentine derived soils, or other substrates inimical to plant growth may also fit. Canopy cover is 60% or less and trees are often stunted. Dominant species may include chestnut oak, chinkapin oak, black oak, eastern red cedar, post oak, northern red oak, Virginia pine, shortleaf pine, white oak, pitch pine, American basswood, white ash, or sugar maple. Canopy associates may include white pine, scarlet oak, hop hornbeam, hickory spp., red maple, and others. This habitat can be dominated by either coniferous or deciduous trees. Soils are well-drained to xeric. In the mid-Atlantic region, ranges from the lower slopes on the Piedmont and possibly scattered sandy locations on the Coastal Plain, to the lower elevational limits of the boreal species in the mountains.
Dominant/Subdominant Species- *Quercus prinus, Q. muehlenbergii, Q. velutina, Q. alba, Q. stellata, Q. rubra, Juniperus virginiana, Pinus virginiana, P. rigida, P. echinata, Tilia americana, Fraxinus americana, Acer saccharum*
Associative Species- *Pinus strobus, Quercus coccinea, Ostrya virginianus, Carya* spp.*, Acer rubrum*
Herbaceous Species- *Schizachyrium scoparium*

20. Maritime Forest/Woodland (UF.MTFW): This habitat consists of stunted forests and woodlands on back dunes or sandy substrates in maritime areas. Conifers or hardwoods may dominate, and dominant species may include eastern red cedar, loblolly pine, Virginia pine, pitch pine, black cherry, southern red oak, black oak, scarlet oak, white oak, or post oak. Associates may include American beech, sassafras, American holly, sourwood, pignut hickory, willow oak, and water oak. It is frequent on barrier islands and is typically wind-pruned. The substrate is characteristically excessively well-rained and nutrient poor. Patches of dense shrubs and vines often characterize this habitat. Occurs widely along the Atlantic coast and barrier islands from New England to

the southeast. In the mid-Atlantic states, loblolly pine is a common component in this habitat from Delaware south.
Dominant/Subdominant Species- *Juniperus virginiana, Pinus taeda, P. virginiana, P. rigida, Prunus serotina, Quercus velutina, Q. stellata, Q. coccinea, Q. alba, Q. falcata*
Associative Species- *Fagus grandifolia, Sassafras albidum, Ilex opaca, Oxydendrun arboreum, Carya glabra, Q. phellos, Q. nigra*
Shrubs/Vines- *Smilax rotundifolia, Smilax glauca, Toxicodendron radicans, Vitis* spp.*, Parthenocissus quinquefolia, Myrica pensylvanica, Myrica cerifera, Hudsonia tomentosa, Juniperus communis, Vaccinium corymbosum*

WETLAND FORESTS/WOODLANDS:

21. Bog Forest (WF.BOFO): Includes high-elevation or northern forests of black spruce, tamarack, balsam fir, birch, red maple, eastern hemlock, and northern white-cedar associated with boreal bogs. Associate species may include red maple, black ash, aspen spp., eastern white pine, and pitch pine. Soils are typically seasonally to semi-permanently saturated, poorly to very poorly drained, and waters are acidic and nutrient poor. Trees are often stunted, and there is extensive peat accumulation. A dense ericaceous shrub layer is often present. In the mid-Atlantic region, it generally occurs above 700 m elevation in the mountainous areas, but may occur much lower in the glaciated sections of New Jersey or Pennsylvania. May also be found in the New Jersey pine barrens.
Dominant/Subdominant Species- *Picea mariana, P. rubens, Abies balsamea, Larix laricina, Tsuga canadensis, Betula* spp.*, Pinus rigida, Sphagnum* spp.
Associative Species- *Acer rubrum, Populus* spp., *Pinus strobus*
Shrub/Vine Species- *Vaccinium corymbosum, Vaccinium angustifolium, Chamaedaphne calyculata, Rhododendron canadense, Ledum groenlandicum, Gaylussacia baccata, Kalmia latifolia, Viburnum* spp., *Ilex* spp., *Nemopanthus mucronata.*

22. Boreal Swamp (WF.BOSP): Includes forested wetlands of northern latitudes or higher elevations where boreal or northern species dominate, but where peat accumulations are not well developed. Dominant species may include red spruce, black spruce, balsam fir, red maple, northern white cedar, tamarack, and black ash. Associates may include speckled alder, Atlantic white cedar, eastern hemlock, fire cherry, black gum, and birch spp.. Soils are typically saturated mucks over mineral soil. The herbaceous layer is often well developed, and *Sphagnum*, if present, is patchy or sparse. Widespread throughout southeastern Canada and New England; New York, south in some areas in Pennsylvania, New Jersey and sporadically along the mountains to the southern Appalachians. In the mid-Atlantic region, it occurs at lower elevations in Pennsylvania and New Jersey, but generally over 700 m from Maryland south.
Dominant/Subdominant Species- *Picea rubens, P. mariana, Abies balsamea, Acer rubrum, Thuja occidentalis, Larix laricina, Fraxinus nigra*
Associative Species- *Alnus rugosa, Chamaecyparis thyoides, Tsuga canadensis, Prunus pensylvanica, Nyssa sylvatica, Betula* spp.

Shrub/Vine Species- *Vaccinium corymbosum, Nemopanthus mucronata, Viburnum cassinoides, Cornus canadensis, C. sericea, Lonicera oblongifolia, Clethra alnifolia, Rhododendron viscosum, R. maximum*

23. Northern Coniferous Swamp (WF.NCSP): Woodland and forest swamps of northern latitudes and higher elevations, but below the spruce-fir zone; dominated by species such as eastern hemlock, white pine, pitch pine, and in some cases northern white cedar. Hardwoods may be present but do not make up a majority of the stocking. Associate species may include red maple, black ash, black gum, American elm, yellow birch, gray birch, and, in some areas, Atlantic white cedar. Soils are typically saturated mucks, and are often acidic, but in some cases may be neutral to alkaline and influenced by calcareous groundwater. This habitat occurs along streams and bottomlands, in poorly drained upland depressions, or in seepage areas. Occurs from New England through New York, Pennsylvania, and New Jersey; south of this it is at higher elevations in the mountains. In the mid-Atlantic region it occurs in isolated locations at low to mid elevations in the northern states, and at higher elevations (generally above 600 m) in the southern mid-Atlantic states.
Dominant/Subdominant Species- *Tsuga canadensis, Pinus strobus, P. rigida, Thuja occidentalis*
Associative Species- *Acer rubrum, Betula allegheniensis, B. lenta, Fraxinus nigra, Nyssa sylvatica*
Shrub/Vine Species- *Vaccinium corymbosum, Lindera benzoin, Ilex verticillata, Cornus* spp., *Lonicera oblongifolia, Rhododendron canadense, Kalmia angustifolia*

24. Northern Hardwood Swamp (WF.NHSP): Northern and higher elevation wetland forests and woodlands dominated by hardwoods that make up at least 50% of canopy. Dominant species may include red maple, black ash, green ash, yellow birch, gray birch, and black gum. Associates may include eastern hemlock, northern white cedar, Atlantic white cedar, American elm, slippery elm, pin oak, pitch pine, and white pine. Boreal species may also be present, but not in large numbers. Occurs in poorly drained depressions along streams, in seeps, and in floodplains and oxbows of major rivers. Soils are generally muck, seasonally to semi-permanently flooded or saturated. In the mid-Atlantic, it occurs in the northern states and at higher elevations in the lower states. From central and southern New Jersey south along the mid-Atlantic Coastal Plain, it grades into the bottomland hardwood swamp (WF.BHSP) habitat type.
Dominant/Subdominant Species- *Acer rubrum, Fraxinus nigra, F. pennsylvanica, Betula allegheniensis, B. lenta, Nyssa sylvatica*
Associative Species- *Tsuga canadensis, Thuja occidentalis, Chamaecyparis thyoides, Ulmus americana, U. rubra, Quercus palustris, Pinus rigida, P. strobus*
Shrub/Vine Species- *Lindera benzoin, Toxicodendron vernix, Rhamnus alnifolia, Vaccinium corymbosum, Clethra alnifolia, Ilex verticillata, Rhododendron viscosum*

25. Atlantic White-Cedar Swamp (WF.AWCS): Narrowly defined to contain wetland forests where Atlantic white-cedar is dominant or provides at least 25-50% of the stocking. Typical co-dominants can include red maple, green ash, sweetgum, and black

gum. Canopy associates may include American holly, loblolly pine, pitch pine, pond pine, persimmon, eastern hemlock, yellow birch, swamp tupelo, and red bay. In inland areas to the north, great Rhododendron may be a characteristic shrub associate, while further south, on the coastal plain, inkberry, winterberry, sweetbay magnolia, or seaside alder may be characteristic, along with many other shrubs. This habitat occurs mostly on acidic saturated muck, with variable peat accumulations. Cedars typically occur on mounds of organic material, surrounded by depressions filled with water (hummock and hollow microtopography). The herbaceous layer may be quite diverse, and often includes several *Sphagnum* species. In the mid-Atlantic region, it is widespread in the pine barrens of New Jersey and at some higher elevations in New Jersey; it also occurs sporadically on the Coastal Plain of Delaware and the Eastern Shore of Maryland, and along the Coastal Plain of Virginia. Situations for this habitat range from low sites between hills and ridges, along lakes and swampy valleys of meandering streams, in low sites in pine barrens, and along fresh tidal rivers or slow-moving watercourses on the Coastal Plain.
Dominant/Subdominant Species- *Chamaecyparis thyoides, Acer rubrum, Fraxinus pennsylvanica, Nyssa sylvatica, Liquidambar styraciflua, Magnolia virginiana*
Associative Species- *Ilex opaca, Pinus taeda, P. rigida, P. serotina, Tsuga canadensis, Diospyros virginiana, Betula allegheniensis, Nyssa biflora, Persea palustris*, *Sphagnum* spp.
Shrub/Vine Species- *Clethra alnifolia, Ilex verticillata, I. glabra, Rhododendron maximum, R. viscosum, Alnus maritima, A. serrulata, Smilax* spp., *Viburnum* spp., *Myrica* spp*., Vaccinium corymbosum, V. macrocarpon, Leucothoe racemosa, Gaylussacia frondosa*

26. Bald Cypress Swamp (WF.CYSP): Includes semi-permanently to permanently flooded swamps dominated by bald cypress. In some cases it may be only seasonally or temporarily flooded. Associates may include black gum, red maple, sweetgum, swamp tupelo, loblolly pine, green ash, water tupelo, sweetbay magnolia, black willow, American elm, water hickory, and overcup oak. This habitat occurs on flat alluvial floodplains or backwaters and sloughs of slow to moderate flowing streams and rivers, or in swamps and estuaries of the Coastal Plain. Sites may be tidally influenced or storm-tide influenced, but bald cypress will not tolerate prolonged salinities above 0.89 percent. Soils range from fine sand to clay, often with a layer of muck or shallow peat present; they are wet and very poorly drained. In the Mid-Atlantic, it occurs on the Coastal Plain from Delaware south.
Dominant/Subdominant Species- *Taxodium distichum, Nyssa biflora, N. aquatica, Acer rubrum*
Associative Species- *Nyssa sylvatica, Fraxinus pennsylvanica, Liquidambar styraciflua, Pinus taeda, Ulmus americana, Salix nigra, Magnolia virginiana, Quercus lyrata, Carya aquatica*
Shrub/Vine Species- *Clethra alnifolia, Viburnum dentatum, V. nudum, Rosa palustris, Leucothoe racemosa, Itea virginica, Smilax* spp*., Ilex opaca, I. verticillata, Rhododendron viscosum, Lindera benzoin, Sambucus canadensis, Toxicodendron radicans, Cornus amomum, Cephalanthus* spp.

27. Bottomland Hardwood Swamp (WF.BHSP): Includes wetland forests and woodlands dominated by hardwoods including red maple, sweetgum, green ash, black gum, or occasionally black ash. Red maple is almost always present, and frequently dominant. Canopy associates may include loblolly pine, bald cypress, American elm, pin oak, silver maple, swamp white oak, basket oak, willow oak, white oak, pond pine, and Atlantic white cedar. Coniferous species, if present, are less than 50% total canopy coverage. Oaks, if present, also comprise less than 50% of the canopy coverage. American holly, sweetbay magnolia, sassafras and other small trees may be present in the understory, and the shrub, vine, and herbaceous layers may be well-developed. Standing water is usually not present throughout the growing season, but soils are generally moist to saturated and water may be present into the early growing season. This habitat type is most common throughout the Coastal Plain from New Jersey south, and in some bottomland sites in the Piedmont. In general, the habitat distribution follows the natural distribution of sweetgum. In the mid-Atlantic region, this habitat is common on the Coastal Plain from central and southern New Jersey south; it also extends into the Piedmont along rivers and large streams.
Dominant/Subdominant Species- *Acer rubrum, Liquidambar styraciflua, Fraxinus pennsylvanica, Fraxinus nigra, Nyssa sylvatica*
Associative Species- *Pinus taeda, P. serotina, Taxodium distichum, Ulmus americana, Quercus palustris, Q. bicolor, Q. phellos, Q. alba, Q. lyrata, Q. michauxii, Nyssa sylvatica* var. *biflora, Persea palustris, Chamaecyparis thyoides, Magnolia virginiana, Acer saccharinum, Betula nigra, Populus heterophylla, Ilex opaca*
Shrub/Vine Species- *Vaccinium corymbosum, Rhododendron viscosum, Clethra alnifolia, Rosa palustris, Smilax rotundifolia, S. walteri, Toxicodendron radicans*, *Gaylussacia frondosa*

28. Deep Swamp Hardwood (WF.DSPH): This habitat consists of semi-permanently to permanently flooded wetland forests, sometimes tidally influenced, and dominated by hardwoods. Swamp tupelo and/or water tupelo (south) are often characteristic. Other common canopy associates may include water hickory, overcup oak, red maple, sweetgum, black gum, pumpkin ash, green ash, American elm, and loblolly pine. Bald cypress or Atlantic white cedar may also be present, but represent less than 25% of the canopy. Permanently flooded examples of this habitat may not be naturally occurring in the mid-Atlantic. Standing dead snags are often present, and there is often a pronounced hummock-and-hollow microtopography, with hollows generally holding some water throughout the year. It occurs in the southeastern U.S., on flat alluvial floodplains or backwaters and sloughs of slow to moderate-flowing streams and rivers, in oxbows, old beaver ponds, in headwater swamps, and along tidal rivers of the Coastal Plain. Extent within the mid-Atlantic is unknown, but some known situations include former Atlantic white cedar-bald cypress-red maple-swamp tupelo forests where all of the cypress and cedars have been harvested.
Dominant/Subdominant Species- *Nyssa biflora*, *N. aquatica*, *Fraxinus profunda, Acer rubrum trilobum, Liquidambar styraciflua*

Associative Species - *Carya aquatica, Nyssa sylvatica, Quercus lyrata, Fraxinus pennsylvanica, Ulmus americana, Quercus laurifolia, Pinus taeda, Taxodium distichum, Chamaecyparis thyoides, Magnolia virginiana, Persia palustris*, *Symplocos tinctoria*, *Sphagnum* spp.
Shrub/Vine Species- *Clethra alnifolia, Ilex verticillata, Itea virginica, Leucothoe racemosa, Vaccinium corymbosum, Rhododendron viscosum, Lindera benzoin, Viburnum dentatum, V. nudum, Cornus amomum, Rosa palustris, Cephalanthus occidentalis, Smilax* spp., *Decumaria barbara, Toxicodendron radicans*
Herbaceous Species- *Impatiens capensis, Peltandra virginica, Polygonum arifolium, P. punctatum, Saururus cernuus, Carex crinita, C. bromoides, C. stricta, Lemna* spp., *Hydrocotyle* spp.

29. Coastal Plain Pine Flatwood (WF.CPPF): This habitat is composed of pine-dominated wetland forests where hardwoods do not comprise more than 25% of the total canopy. The most common representative of this habitat consists of loblolly pine stands on the Coastal Plain often occurring adjacent to the high salt marsh or as islands within the salt marsh. Red maple, sweetgum, black gum, red bay, and willow oak are common associates. The understory is often dominated by vines, and a well-developed shrub layer is common. It occurs on saturated mucks overlying sand, and trees tend to occur on elevated hummocks, with standing water evident in hollows. In the mid-Atlantic, this habitat type typically occurs from Delaware south, but it may have limited representation in New Jersey, as well.
Dominant/Subdominant Species- *Pinus taeda*
Associative Species- *Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Persea palustris*
Shrubs/Vines- *Smilax rotundifolia*, *Myrica cerifera*, *Baccharis halimifolia, Toxicodendron radicans, Parthenocissus quinquefolia, Ilex glabra*

30. Mixed Oak Swamp (WF.OKSP): This habitat occurs in stream headwaters and on floodplains of streams and rivers, and in poorly-drained depressions isolated from streams. It includes oak-dominated swamps with less than 25% pines or other conifers. Dominant species include basket oak, willow oak, swamp white oak, pin oak, or water oak. Associates may include red maple, black gum, sweetgum, elms, loblolly pine, pitch pine, white oak, and other species. The shrub layer may be sparse or well-developed, and there is often a well-developed herbaceous layer. Sites are temporarily flooded or seasonally flooded to saturated floodplain terraces, or low depressions, generally without standing water for most of the growing season. Soils are poorly-drained muck with varying combinations of silt, loam, and sand; sometimes underlain by impervious clays. It is found in the mid-Atlantic region sporadically on the Coastal Plain from Delaware south, and possibly in some sites in the Piedmont and low mountains.
Dominant/Subdominant Species- *Quercus palustris, Q. bicolor, Q. michauxii, Q. phellos, Q. nigra*
Associative Species- *Pinus taeda, Acer rubrum, Liquidambar styraciflua, Nyssa sylvatica, Ulmus* spp.*,Pinus rigida, Pinus serotina, Q. falcata, Q. alba, Carya* spp.

Shrub/Vine Species- *Vaccinium corymbosum, Leucothoe racemosa, Clethra alnifolia, Lindera benzoin, Viburnum* spp.*, Ilex laevigatum, Ilex opaca, Rhododendron viscosum*

31. Pine - Hardwood Swamp (WF.PHSP): This habitat consists of wetland forests of floodplains on the Coastal Plain with alliances dominated by pines and hardwoods, with each component comprising at least 25% of the canopy coverage. Loblolly is the typical dominant pine, although pitch pine or pond pine may replace it in some areas. Oaks are often well represented in the hardwood component, including willow oak, pin oak, swamp chestnut oak, swamp white oak, water oak, white oak, southern red oak, and northern red oak. Other common hardwoods in this habitat are black gum, sweetgum, red maple, green ash, and elms. The shrub layer may be well developed. It is typically found on temporarily flooded sites. Occurs from central and southern New Jersey south through the Coastal Plain in the southeast. It may occur in some Piedmont sites in the southern portion of its range. In the mid-Atlantic it is well represented by loblolly dominated wetland forests on the Coastal Plain, and by pitch pine dominated wetlands in the New Jersey pine barrens.
Dominant/Subdominant Species- *Pinus taeda, P. serotina, P. rigida, Quercus phellos, Q. michauxii, Q. nigra, Q. bicolor, Q. palustris, Nyssa sylvatica, Acer rubrum, Liquidambar styraciflua, Magnolia virginiana*
Associative Species- *Chamaecyparis thyoides, Quercus alba, Q. falcata, Q. rubra, Ulmus* spp.*, Sassafras albidum, Fraxinus pennsylvanica, Ilex opaca, Oxydendrum arboreum, Nyssa biflora*
Shrub/Vine Species- *Clethra alnifolia, Ilex laevigatum, Leucothoe racemosa, Vaccinium corymbosum, Rhododendron viscosum*, *Kalmia latifolia, Gaylussacia frondosa, G. dumosa, Toxicodendron radicans, Smilax* spp.*,Gelsemium sempervirens*

32. Northern Riparian (WF.NORI): Consists of stream-side and floodplain forests and woodlands from the mid-Atlantic region north dominated by pioneer species such as eastern cottonwood, river birch, or black willow, or secondary successional floodplain species such as sycamore, American elm, slippery elm, silver maple, boxelder and green ash. More common on streams with moderate to higher gradients than those on the Coastal Plain or on larger rivers, where sufficient stream energy exists to ensure active depositional and erosional processes. It generally occurs on alluvial floodplain deposits within or immediately adjacent to the active river channel, or on older deposits or streambanks with slightly higher elevations. The shrub, vine, and herbaceous layers are often well-developed. In the mid-Atlantic region, this habitat is most frequently found along the streams and rivers in the Piedmont and lower mountains, or along larger rivers in the Coastal Plain.
Dominant/Subdominant Species- *Populus deltoides, Salix nigra, Platanus occidentalis, Ulmus americana, U. rubra, Acer negundo, Acer saccharinum, Betula nigra, Fraxinus pennsylvanica*
Associative Species- *Liquidambar styraciflua, Acer rubrum, Quercus phellos, Q. palustris, Juglans cinerea, J. nigrans, Liriodendron tulipifera*
Shrub/Vine Species- *Toxicodendron radicans, Lindera benzoin, Robinia pseudoacacia, Rosa multiflora, Vitis riparia, Smilax rotundifolia, Parthenocissus quinquefolia*

Herbaceous Species- *Urtica dioica, Laportea canadensis, Leersia virginica*

SHRUB UPLANDS:

33. Alpine/Boreal Heath (US.ABHT): Consists of high elevation or boreal upland communities dominated by heath or heath-like shrubs. They typically occur above timberline and on or in association with bedrock outcrops and ledges, bedrock tablelands, and exposed windswept summits and high ridges. Also may occur in depressions on level out-wash plains and valley floor frost pockets. Dominant species may include tundra bilberry, velvetleaf blueberry, late low blueberry, early low blueberry, and mountain laurel. Scattered, stunted boreal trees may be present, and other shrub species may include Labrador tea, rhodora azalea, black crowberry, evergreen bearberry, dwarf huckleberry, rhododendron rosebay, and bearberry dwarf willow. Soils are typically shallow accumulations of organic material on bedrock sites, or rapidly drained and nutrient poor sands on out-wash plains. In the mid-Atlantic, it is restricted to mountainous areas, from New Jersey to West Virginia.
Dominant/Subdominant Species- *Vaccinium myrtilloides, V. vacillans, V. angustifolium, V. uliginosum, Kalmia latifolia*
Associative Species- *Picea mariana, P. rubens, Abies balsamea, Betula papyrifera* var. *cordifolia, Larix laricina, Ledum groenlandicum, Rhododendron canadense, R. lapponicum, Empetrum nigra, Arctostaphylos uva-ursi, Salix uva-ursi*
Herbaceous/Bryophyte Species- *Juncus trifidus, Carex bigelowii, Potentilla tridentata, Deschampsia flexuosa, Schizachyrium scoparium, Solidago canadensis, Lycopodium* spp.

34. Krummholz (US.KRUM): High elevation scrub on rocky, exposed ridges and slopes where severe weather conditions prevail. This habitat is dominated by stunted black spruce, balsam fir, and other boreal species. Mountain paper birch is sometimes found as an associate. Soils are typically thin and rocky, and well-drained to xeric. The bryophyte layer may be well developed.
This habitat is confined to alpine areas of New England, New York, and at some elevations farther south. In the mid-Atlantic region, this habitat may be restricted to higher elevations in West Virginia; other occurrences are unknown.
Dominant/Subdominant Species- *Abies balsamea, Picea rubens, P. mariana*
Associative Species- *Betula papyrifera* var. *cordifolia*
Herbaceous/Bryophyte Species- *Sorbus americana*, *Potentilla tridentata, Pleurozium schreberi*

35. Montane Heath Thicket / Bald (US.MHTB): Consists of high-elevation shrublands occurring on steep ridges, rock outcroppings, and landslides at elevations over 1675 m. It has 25-100% shrub cover and may occur as a dense shrubland, 2-4 m tall, or as a shorter, more open shrubland with areas of exposed rock, scattered mats of prostrate vegetation, and isolated clumps of herbaceous species. It is dominated by rhododendrons and sandmyrtle, along with Fraser fir, red chokeberry, black chokeberry, southern bush-honeysuckle, largeleaf holly, minniebush, pieris, fire cherry, highbush blueberry, southern mountain cranberry, and northern wild raisin. The herbaceous layer is highly variable,

depending on density of shrub cover, and thick hummocks of lichens and mosses may occur on flatter sites. Wind-sheared spruces and firs may occur in some areas. Soils are shallow and nutrient-poor. Vegetation is influenced by seepage areas on steep cliffs and ledges in some areas. This habitat is known from the Great Smoky Mountains of eastern Tennessee, but is not known from the mid-Atlantic region.
Dominant/Subdominant Species- *Rhododendron carolinianum, R. catawbiense, Leiophyllum buxifolium*
Associative Species- *Abies fraseri, Aronia arbutifolia, Aronia melanocarpa, Diervilla sessilifolia, Ilex montana, Menziesia pilosa, Pieris floribunda, Prunus pensylvanica, Vaccinium corymbosum, V. erythrocarpum, Viburnum cassinoides*

36. Shrub / Sapling Old Field (US.SSOF): Regenerating forest openings dominated by pioneer shrubs and tree saplings, including eastern red cedar, black locust, ashes, sweetgum, red maple, cherries, aspens, birches, pines, sassafras, tulip poplar, sumacs, hawthorns, buckthorns, viburnums, dogwoods, and blackberries, as well as various vines, including poison ivy, greenbriers and grapes. In general, these fields would range between 5-25 years post disturbance, with ample shrubs and saplings present, and tree stature on average less than 5 m tall. This habitat can form in a wide range of soil conditions and landscape positions. In the mid-Atlantic region, it is represented by fire cherry and red maple stands in the mountains, by red cedar and Virginia pine stands in the Piedmont and lower mountains, and red maple and sweetgum stands on the Coastal Plain, as well as many other shrub and sapling associations throughout the region.
Dominant/Subdominant Species- *Juniperus virginiana, Acer rubrum, Robinia pseudoacacia, Myrica pennsylvanica, Cornus* spp., *Viburnum* spp., *Rhus* spp.*, Rubus* spp.*, Spirea* spp.*, Rhamnus* spp.*, Crataegus* spp.*, Rosa multiflora, Smilax* spp.*, Vitus* spp.*, Toxicodendron radicans, Populus tremuloides, P. grandidentata, Pinus strobus, Prunus pensylvanica, Betula populifolia, Liquidambar styraciflua, Pinus virginiana, P. taeda, Prunus serotina*
Associative Species- *Sassafras albidum, Fraxinus* spp.*, Ilex opaca*, *Liriodendron tulipifera*

37. Mid-Successional Old Field (US.MSOF): Consists of late stage upland old fields with well-developed woody growth of small trees and large shrubs, with the overstory vegetation on average between 5 and 12 m tall; this stage generally occurs between 15 and 35 years post-disturbance. Dominant species include eastern red cedar, black locust, ashes, sweetgum, red maple, cherries, aspens, birches, pines, sassafras, tulip poplar, sumacs, hawthorns, buckthorns, viburnums, dogwoods, and blackberries, as well as various vines, including poison ivy, greenbriers and grapes. This habitat can form in a wide range of soil conditions and landscape positions. In the mid-Atlantic region, it is represented by fire cherry and red maple stands in the mountains, by red cedar and Virginia pine stands in the Piedmont and lower mountains, and red maple and sweetgum stands on the Coastal Plain, as well as many other associations throughout the region.
Dominant/Subdominant Species- *Juniperus virginiana, Acer rubrum, Robinia pseudoacacia, Myrica pennsylvanica, Cornus* spp., *Viburnum* spp., *Rhus* spp.*, Spirea* spp.*, Crataegus* spp.*, Rhamnus* spp.*, Rosa multiflora, Smilax* spp.*, Rubus* spp.*, Vitus*

spp.*, Toxicodendron radicans, Populus tremuloides, P. grandidentata, Pinus strobus, Prunus pensylvanica, Betula populifolia, Liquidambar styraciflua, Prunus serotina, Pinus virginiana, P. taeda*
Associative Species- *Sassafras albidum, Fraxinus* spp., *Ilex opaca*, *Liriodendron tulipifera*

38. Pine Barren Scrub (US.PBSC): Floristically similar, although scrubbier in structure, to the pine barrens habitat type which consists of forest and woodland communities of pitch pine, scrub oak and other oaks found on disturbed, nutrient-poor sites. The more stunted, scrubby stature of this habitat is likely indicative of lower nutrient availability and drier conditions, but may also be disturbance related. Plant species of moister Pine Barren situations are scarce or absent, with dominant species including pitch pine, bearberry, bear oak and dwarf chinquapin oak. This habitat may include bare patches of sand with pine needle accumulations. Most abundant in the coastal plain sandy soils from New Jersey north, but also in the mountains south along the Appalachians. In the northern mountains, it is restricted to elevations below 600 m, in the south, it ranges up to 1400 m.
Dominant/Subdominant Species- *Pinus rigida, Arctostaphylos uva-ursi, Quercus prinoides, Quercus ilicifolia, Comptonia asplenifolia, Cypripedium acaule, Vaccinium pallidum*
Associative Species- *Pinus echinata, Quercus marylandica, Quercus velutina, Sassafras albidum, Gaylussacia baccata, Gaultheria procumbens*, *Epigaea repens,*
Herbaceous/Bryophyte Species- *Panicum depauperatum, Andropogon scoparius, Euphorbia ipecacuanhae, Pyxidanthera barbulata, Tephrosia virginiana, Cladonia rangiferina*

39. Dune / Maritime Thicket / Shrub (US.DMTS): This habitat is broadly composed of alliances that form upland thickets and shrublands in maritime areas, including dry seaside bluffs, back-dune ridges or coastal moraines, headlands, sandy dunes and other maritime sites. Physiognomy of this habitat varies from dense thicket or vine thicket to more sparse and open shrub communities. Dominant species may include northern bayberry, beach plum, groundsel bush, eastern red cedar, or woolly hudsonia. Associates may include highbush blueberry, winged sumac, Virginia creeper, common greenbrier, and other shrubs and vines. Other examples may include stunted oaks, black gum, pitch pine, or American holly. In slightly lower, more protected communities along backdunes in “shrunken forests” that have shrubland physiognomy, other species may include black cherry, red maple, loblolly pine, persimmon, serviceberry, red chokeberry, sassafras, and narrowleaf crabapple. This habitat may grade into a maritime woodland or wet thicket, or may replace a cleared maritime woodland. The more typical example is drier and more elevated. In the mid-Atlantic region, it occurs on coastal dunes and on the ocean side of barrier islands.
Dominant/Subdominant Species- *Myrica pensylvanica, Prunus maritima, P. serotina, Baccharis halimifolia, Amelanchier canadensis, Juniperus virginiana, Hudsonia tomentosa, H. ericoides, Smilax glauca, Toxicodendron radicans*

Associative Species- *Vaccinium corymbosum, Rhus copallinum, Parthenocissus quinquefolia, Rosa* spp.*, V. angustifolium, Gaylussacia baccata, Malus angustifolia, Aronia arbutifolia, Viburnum* spp., *Sassafras albidum, Pinus taeda, Pinus rigida, Acer rubrum, Quercus velutina, Q. stellata, Q. alba, Q. coccinea, Ilex opaca, Nyssa sylvatica, Diospyros virginiana, Smilax rotundifolia, Vitus rotundifolia*
Herbaceous/Bryophyte Species- *Schizachyrium scoparium, Solidago sempervirens, Rumex acetosella, Lechea maritima, Aster dumosus*

SHRUB WETLANDS:

40. Northern / Boreal Bogs (WS.NBBO): This habitat consists of both the herbaceous and shrubland components of ombrotrophic or weakly minerotrophic peatland communities in flat basins, kettle-holes, or shallow depressions in rock outcrops, as well as "poor fen" communities with some minerotrophic groundwater enrichment or other nutrient inflow. There is typically an extensive *Sphagnum* component. Peat development is generally extensive, but less so in poor fens. Waters are typically acid; bogs have pH < 4.2; poor fens have pH values 4.2-5.8. In addition to *Sphagnum* spp., dominant species may include bog rosemary, leatherleaf, swamp loosestrife, highbush blueberry, large cranberry, swamp azalea, black huckleberry, black crowberry, mountain-holly, or Labrador tea. In the mid-Atlantic region, this habitat occurs in the glaciated regions of New Jersey and Pennsylvania, south in the higher elevations in Maryland and West Virginia, and in the Pine Barrens of New Jersey.
Dominant/Subdominant Species- *Sphagnum* spp.*, Carex* spp.*, Chamaedaphne calyculata, Andromeda glaucophylla, Decodon verticillatus, Vaccinium corymbosum, V. macrocarpon, Gaylussacia baccata, Empetrum nigrum, Rhododendron viscosum, Nemopanthus mucronata, Ledum groenlandicum, Scirpus cespitosus*
Associative Species- *Rhododendron maximum, Pyrus melanocarpa, Rhamnus alnifolia, Myrica gale, Acer rubrum, Larix laricina, Picea rubens, P. mariana, Populus tremuloides, Pinus rigida, Tsuga canadensis*

41. Northern / Boreal Fen (WS.NBFE): Consists of both the herbaceous and shrubland components of more minerotrophic conditions than traditional bogs with some groundwater flow-through but considerable peat buildup and *Sphagnum* growth. This habitat type includes "rich fens" and "extremely rich fens" which generally have a pH > 5.8. In addition to *Sphagnum* mosses, the plant community may include ten-angled pipewort, beaked spike-rush, sundews, bladderworts, sedges, rushes, bulrushes, cinnamon fern, royal fern, showy ladyslipper, red turtlehead and St. John's-worts, with scattered trees and shrubs including red maple, black gum, sweetbay magnolia, alders, chokeberries, bristly dewberry, large cranberry, swamp rose, winterberry, poison ivy, wax myrtle, northern bayberry, groundsel tree, marsh elder, and eastern red cedar. Found at all elevations, and as far south as the Coastal Plain in Delaware. Occurrences farther south than this are probably limited by climate, with warmer yearly temperature averages increasing decomposition rates and limiting the factors that contribute to bog/fen development. Main occurrence is farther north (more frequent from the New Jersey pine barrens and farther north) or at higher elevations.

Dominant/Subdominant Species- *Sphagnum* spp.*, Eriocaulon decangulare, Eleocharis rostellata, Drosera* spp., *Utricularia* spp., *Carex* spp.*,Scirpus americanus*, *Scirpus cyperinus, Rhychospora* spp., *Rosa palustris, Aronia* spp.*, Ilex verticillata, Magnolia virginiana, Alnus* spp.
Associative Species- *Aster novi-belgii, Cladium mariscoides, Juncus* spp., *Lysimachia terrestris, Cypripedium reginae, Phragmites australis, Scirpus pungens, Toxicodendron radicans, Triadenum virginicum, Gentiana clausa, Chelone obliqua, Osmunda cinnamomea, Osmunda regalis, Hypericum densiflorum, Vaccinium macrocarpon, Myrica cerifera, Myrica pensylvanica, Baccharis halimifolia, Iva frutescens, Rubus hispidus, Acer rubrum, Nyssa sylvatica, Juniperus virginiana*

42. Salt Marsh Scrub (WS.SMSS): This habitat occurs along the borders of salt marshes, typically found between high salt marsh vegetation (*Spartina patens*) and adjacent upland vegetation. It is also found on sites of slightly higher elevation and lower salinities within the salt marsh proper, as well as on spoil mounds adjacent to ditches. Dominant species include groundsel-tree and marsh elder; associates may include northern bayberry, common wax myrtle, eastern red cedar, and swamp rose. The water table is typically at or near the surface and soils are a shallow layer of peaty muck over mottled sand. It is common in the mid-Atlantic region adjacent to salt marshes.
Dominant/Subdominant Species- *Baccharis halimifolia, Iva frutescens*
Associative Species- *Myrica cerifera, M. pennsylvanica, Rosa palustris, Juniperus virginiana, Spartina patens, Panicum virgatum, Distichlis spicata, Spartina cynosuroides, Spartina alterniflora, Phragmites australis, Hibiscus moscheutos, Toxicodendron radicans*

43. Maritime Wet Thicket / Shrub (WS.MWTS): Consists of wetland thickets found in maritime back-dune areas and along some tidal rivers. Typically dominated by common waxmyrtle, groundsel-tree, sapling red maple, highbush blueberry, large cranberry, and/or alders. Associate species may include northern bayberry, poison ivy, swamp rose, eastern red cedar, winterberry, silky dogwood, buttonbush, and American holly. Typically occurs between the high marsh herbaceous or scrub vegetation and coastal forests or woodlands, and is especially frequent on the bay-side of barrier islands, as well as protected areas behind coastal dunes and in interdunal areas where soils are wet (e.g., "cranberry swales"). Occurs in coastal areas from New Jersey south to the Carolinas. In the mid-Atlantic region, it is especially common on barrier islands.
Dominant/Subdominant Species- *Myrica cerifera, Baccharis halimifolia, Acer rubrum, Vaccinium corymbosum, Vaccinium formosum, Vaccinium macrocarpon, Alnus* spp., *Cornus amomum*
Associative Species- *Myrica pensylvanica, Rosa palustris, Toxicodendron radicans, Juniperus virginiana, Pinus taeda, Ilex verticillata, Cephalanthus occidentalis, Juncus* spp.*, Hydrocotyle* spp.*, Carex* spp.*, Eleocharis* spp., *Panicum virgatum, Andropogon virginicus, Shyzachyrium scoparium, Spartina patens, Scirpus pungens, Phragmites australis*

44. Woody Vernal Pool (WS.WVPO): Isolated depressional wetlands in forests or woodlands that are typically inundated during late fall/winter and spring, and often dry out by mid to late summer. They may be dominated by buttonbush, which may occur throughout, or may be restricted to either the central or peripheral zone. Water willow (swamp loosestrife) may be co-dominant in some communities. Smartweeds, sedges, manna grasses, panic grasses, witch grasses, and are typical herbaceous associates. Some communities may also have patches of *Sphagnum* spp. Sweet pepperbush, highbush blueberry, swamp fetterbush, swamp azalea, persimmon, sweetgum, red maple, black gum, and other trees and shrubs may be found growing along the edges or sometimes within the depression. Vernal pools may be perched on clay loams, or may be groundwater-fed wetlands in sandy loams. Overlying soils are generally wet to dry muck, with no peat buildup except for recently accumulated detritus. This habitat occurs throughout the mid-Atlantic. On the Coastal Plain of Delaware and Maryland, representatives of this habitat type include Coastal Plain Ponds, or Delmarva Bays.
Dominant/Subdominant species- *Cephalanthus occidentalis, Clethra alnifolia, Vaccinium corymbosum, Leucothoe racemosa, Decodon verticillatus, Carex striata, Glyceria pallida*, *Polygonum amphibium*, *Panicum verrucosum, Dichanthelium spretum, Rhexia virginica, Fimbristylis autumnalis*
Associative species- *Polygonum hydropiperoides, P. pensylvanicum, Cladium mariscoides, Juncus canadensis, Panicum Rigidulum, P. hemitomon, Proserpinaca pectinata, Dulichium arundinaceum, Bidens frondosa, B. discoidea, Woodwardia virginica, Scirpus cyperinus, Leersia virginica, Rhododendron viscosum, Sphagnum* spp., *Acer rubrum, Diospyros virginiana, Liquidambar styraciflua, Quercus bicolor, Nyssa sylvatica*

45. Saturated Shrub Swamp (WS.SSSP): Consists of seasonally flooded to saturated shrub swamp where standing water, if present, does not persist through the growing season. This habitat can occur in a wide range of situations, from high elevation seeps and stream headwaters to fresh tidal wetlands. Dominant species may include highbush blueberry, southern highbush blueberry, black-berried highbush blueberry, swamp azalea, silky willow, southern arrowwood, smooth alder, speckled alder, European white alder, swamp rose, poison ivy, silky dogwood, and winterberry holly. Associate species may include leatherleaf, black huckleberry, large cranberry, small cranberry, mountain-holly, red-osier dogwood, northern meadowsweet, maleberry, fetterbush, possum-haw, Walter's greenbrier, sweet pepperbush, and sapling red maple, Atlantic white-cedar, pitch pine, pond pine, northern white cedar and black ash. This habitat can occur in shallow depressions, in headwater wetlands, along freshwater portions of tidal river shores, or on other soils disturbed by regular or seasonal flooding. Soils may be saturated peats or mucks, or moist mineral soils without significant peat deposits. In the mid-Atlantic region, it includes highbush blueberry shrub swamps at seeps and in poorly drained depressions, and alder swamps on fresh tidal rivers or other Coastal Plain sites.
Dominant/Subdominant Species- *Vaccinium corymbosum, V. formosum, V. fuscatum, Rhododendron viscosum, Salix sericea, Viburnum dentatum, Alnus serrulata, A. rugosa, Alnus incana, Rosa palustris, Toxicodendron radicans, Cornus amomum, Ilex verticillata*

Associative Species- *Chamaedaphne calyculata, Gaylussacia baccata, Vaccinium macrocarpon, V. oxycoccos, Nemopanthus mucronata, Cornus sericea, Spirea alba, Lyonia* spp., *Leucothoe racemosa, Viburnum nudum, Smilax walteri, Clethra alnifolia*, *Acer rubrum, Chamaecyparis thyoides, Pinus rigida, P. palustris, Thuja occidentalis, Fraxinus nigra*
Herbaceous/Bryophyte Species- *Aster simplex, Calamagrostris canadensis, Caltha palustris, Carex lacustris, C. prairea, C. crinita, C. glaucescens, Eupatorium maculatum, Impatiens capensis, Lycopus uniflorus, Scirpus atrovirens, Symplocarpus foetidus, Thelypteris palustris, Typha* spp., *Eleocharis* spp., *Rhynchospora* spp., *Scleria* spp., *Utricularia gibba, Sphagnum* spp.

46. Flooded Shrub Swamp (WS.FSSP): Consists of permanently or semipermanently flooded shrublands. Standing water is present through most of the growing season, and may be present year-round. Buttonbush is often the single dominant, but other shrubs are common either as co-dominants or as associates. These may include water willow, swamp azalea, silky willow, common highbush blueberry, silky dogwood, red-osier dogwood, swamp rose, broadleaf spirea, southern arrowwood, and winterberry holly. Sapling red maple, swamp cottonwood, or water oak may be present on some sites. Emergent and/or floating aquatic herbaceous vegetation may also be present. Occurs along pond and lake borders, in depressions with a perched water table, in embayments or along margins of slow-moving streams, in open areas with a gentle slope and slow water flow, and in freshwater tidal wetlands along the coast. In the mid-Atlantic region, it is especially common on the Coastal Plain.
Dominant/Subdominant Species- *Cephalanthus occidentalis, Decodon verticillatus*
Associative Species- *Rhododendron viscosum, Salix sericea, Vaccinium corymbosum, Cornus amomum, C. stolonifera, Rosa palustris, Spiraea latifolia, Viburnum dentatum, Ilex verticillata, Acer rubrum, Populus heterophylla, Quercus palustris*
Herbaceous Species- *Dulichium arundinaceum, Scirpus cyperinus, Typha* spp., *Nuphar lutea, Nymphaea odorata, Lemna* spp.

47. Riparian Thicket / Shrub (WS.RITS): Consists of seasonally/temporarily flooded thicket communities of pioneer species typically occurring on alluvial depositional bars along streams and rivers. Dominant species may include river birch, black willow, alders, and sapling cottonwood or stunted sycamore. Associate species may include red-osier dogwood, willows, swamp loosestrife, and sand cherry. Soils are typically well-drained sandy, gravelly, or cobble alluvial deposits or other mineral soils. These communities are typically early colonists on point bars, mid-channel islands, or floodplains. This habitat is more common along streams with slight to moderate gradients, or larger rivers, where depositional and erosional processes are more active. In the mid-Atlantic, it is likely along streams in the Piedmont and mountains and along larger rivers throughout the region.
Dominant/Subdominant Species- *Salix nigra, Populus deltoides, Betula nigra, Alnus* spp*., Platanus occidentalis*
Associative Species- *Cornus sericea, Salix interior, Decodon verticillatus, Prunus depressa, Polygonum* spp*., Bidens* spp*., Andropogon gerardii*

UPLAND HERBACEOUS:

48. Alpine Grassland / Meadow (UH.ALGM): Alpine low grass and forb-dominated habitat; at present consists of two alliances; one dominated by Bigelow's sedge which occurs on thin, acidic soils with low moisture holding capacity, and the other dominated by wild oat grass in conjunction with several sedge species and referred to as "grass balds." Typically occurs on high elevation south- to south-west-facing domes, ridgetops and gentle slopes. Strong winds, high rainfall, frequent fog, and extremes of temperature and moisture are characteristic of grass balds. Occurs in the alpine areas of New York, New Hampshire, Vermont and Maine. Also occurs as grass balds in Tennessee and other southern mountains; reported from Virginia.
Dominant/Subdominant Species- *Danthonia compressa, Carex bigelowii*
Associative Species- *Carex brunnescens, Carex pensylvanica, Carex debilis*

49. Dry Slope Glade (UH.DSGD): Natural woodland openings or sparse woodlands generally associated with poor soils or other edaphic features restricting forest growth. This habitat is characterized by communities of serpentine bedrock, high elevation mafic glades, and diabase glades, generally occurring on south- or southwest-facing slopes. They are essentially herbaceous communities with scattered trees. Occurs on thin alfisols or mollisols derived from serpentine or similar ultra-mafic rock. Soils are nutrient poor, organic content is low, there is a low calcium to magnesium ratio, and moisture holding capacity is low. Dominant species include little bluestem, sideoats grama, bristleleaf sedge and many other grasses, sedges and forbs, with scattered eastern red cedar, chinquapin oak, Virginia pine, pitch pine, and various other trees and shrubs. Trees are generally stunted, sometimes occurring in clumps. Occurs in Maryland, Pennsylvania, New Jersey, Virginia, and North Carolina. Small occurrences known historically in Delaware are no longer extant.
Dominant/Subdominant Species- *Schizachyrium scoparium, Bouteloua curtipendula, Andropogon gerardii, Sorghastrum nutans, Carex eburnea, Anemone cylindrica, Solidago bicolor, Panicum virgatum, Carex pensylvanica, Lespedeza* spp., *Asclepias viridiflora, A. verticillata, Muhlenbergia sobolifera, Onosmodium* spp., *Packera aurea, Packera obovata, Helianthus divaricatus, Manfreda virginica, Silphium* spp., *Liatris* spp., *Rudbeckia* spp., *Sabatia angularis, Verbesina alternifolia, Juniperus virginiana, Pinus virginiana, Pinus rigida*
Associative Species- *Quercus muehlenbergii, Quercus stellata, Cornus florida, Ulmus alata, Rhus copallinum, Symphoricarpos orbiculatus, Toxicodendron radicans, Fraxinus americana, Ostrya virginiana, Celtis occidentalis, Cornus alternifolia*

50. Herbaceous Old Field (UH.HEOF): Includes regenerating old fields in the early stages prior to extensive woody invasion. Largely composed of non-native grasses and forbs especially from post-agricultural fields. These grasslands are generally 1-3 feet tall with occasional scattered shrubs. This habitat type does not include pasture and other forb or grass-like crops that are actively managed or farmed.

51. Upland Riparian Herbaceous (UH.URHE): Representatives of this habitat are dominated by tall grasses such as big bluestem, Indian grass and other prairie grasses and are referred to as "riverside prairies", "linear prairies", or "rivershore grasslands". Typically associated with dry cobble riverbanks or lake shores, but may also be found on flood-scoured acidic as well as calcareous bedrock exposures associated with major rivers or rolling outwash plains. Native prairie species are often present in abundance, as are numerous exotic species. In the mid-Atlantic, occurs primarily along upper perennial rivers in the mountains and on the Piedmont.
Dominant/Subdominant Species- *Andropogon gerardii, Sorghastrum nutans*
Associative Species- *Schizachyrium scoparium, Panicum virgatum*

52. Dune / Maritime Grassland (UH.DMGL): This habitat consists of coastal dune grasslands dominated by American beach grass, bitter panicgrass and, in overwash situations, saltmeadow hay and common threesquare. Seaside goldenrod is a common associate and is diagnostic of communities in this habitat type. Other common associates include northern sea-rocket and beach pea, along with numerous other species. Vines and scattered, stunted or seedling-form shrubs may be present, including northern bayberry, poison ivy, and groundsel bush. This habitat generally occurs on sandy, unstable, droughty soils where there is active sand deposition and erosion. It may occur on foredunes that are subject to storm-tide overwash, or on dunes that receive the force of wind and salt spray but are beyond the influence of most storm tides. In more sheltered areas, associates may include prickly pear, seaside pinweed, broomsedge, and little bluestem. Litter accumulation from plant debris is nearly absent. Occurs along the Atlantic Coastline on beaches and barrier islands. It is common in the Mid-Atlantic.
Dominant/Subdominant Species- *Ammophila breviligulata, Panicum amarum, Spartina patens, Schoenoplectus pungens*
Associative Species- *Solidago sempervirens, Cakile edentula, Lathyrus japonicus, Triplasis purpurea, Cenchrus tribuloides, Chamaesyce polygonifolia, Cyperus grayi, C. lupulinus, Polygonella articulata, Strophostyles helvula, Setaria parviflora, Distichlis spicata, Sabatia stellaris, Suaeda linearis, S. maritima, Spergularia salina, Atriplex prostrata, A. patula, Euphorbia polygonifolia, Fimbristylis castanea, Oenothera humifusa, Diodia teres, Nuttallanthus canadensis, Salsola kali, Carex silicea, Artemisia stelleriana, Xanthium strumarium, Paspalum distichum, Bassia hirsuta, Polygonum glaucum, Salicornia bigelovii, S. Virginica, Opuntia humifusa, Lechea maritima, Andropogon virginicus, Schizachyrium scoparium, Myrica pensylvanica, Toxicodendron radicans, Lythrum lineare, Kosteletzkya virginica, Baccharis halimifolia*

WETLAND HERBACEOUS:

53. Wet Meadow / Wet Riparian Herbaceous (WH.WTMD): Encompasses a broad range of herbaceous wetlands including prairie-like floodplain communities occurring along rivershores and floodplains that are seasonally flooded and often semi-permanently saturated, shallow ground-water basins not classified as vernal pools, swales in somewhat poorly to poorly drained soils, streamside (alluvial) peaty or mucky marshes dominated by tussock forming sedges, sand and gravel bars in valleys and gorges and rocky river

shoals. This habitat type also develops in old lake beds and is reported from pond and lake shores. It has been described as "sedge meadow," "sedge swale" and "inland graminoid marsh." It is commonly dominated by sedges, rushes, reed canary grass, blue-joint, and other narrow-leaved graminaceous species. Found throughout the mid-Atlantic region generally outside of the Coastal Plain, associated with lakes, ponds, or riparian areas.
Dominant/Subdominant Species- *Carex torta, Phalaris arundinacea, Calamovifla brevipilis, Juncus balticus, Juncus effusus, Rhynchospora careyana/inundata, Rhexia virginica, Scirpus cyperinus, Carex stricta, Calamagrostis canadensis, Sporobolus heterolepis, Elocharis compressa, Carex aquatilis, Justicia americana, Symplocarpus foetidus, Lipocarpha micrantha*
Associative Species- *Acorus calamus, Carex lacustris, Lythrum salicaria, Scirpus* spp., *Carex trichocarpa, Lysimachia quadriflora, Lythrum alatum, Filipendula rubra, Carex prairea, Carex buxbaumii, Cladium mariscoides, Iris versicolor, Thalictrum pubescens, Angelica purpurea, Agrostis alba, Alnus serrulata, Xanthorhiza simplicissima, Vibrunum cassinoides, Viburnum dentatum*

54. Fresh Robust Emergent Marsh (WH.FEMS): Semi-permanently- to permanently-flooded freshwater, non-tidal marshes dominated by cattails, bulrushes, or by other robust emergents. Somewhat arbitrarily separated from the wet meadow habitat type (WH.WMRH) by physiognomy, but also generally occurring in more permanently-flooded conditions. Both communities are often found together in a wetland complex. Cattail marshes occur on mineral soils or fine-grained soils (muck) where standing water is present all year. However, they can occur in a variety of topographic situations such as protected lakeshore margins, low dune swales, or along margins of slow-moving streams and rivers. Aquatic plants often form an "understory" below bulrushes and cattails. Other associates include jewelweed, arrow arum, big-leaved arrowhead, sweetflag, numerous sedges, and many others. Occurs throughout the eastern region and beyond.
Dominant/Subdominant Species- Dominant- *Typha latifolia, T. angustifolia, Scirpus tabernaemontani, S. acutus, S. fluviatilis, Phragmites australis, Lythrum salicaria, Hibiscus moscheutos*
Associative Species- *Sparganium eurycarpum*, *Peltandra virginica, Carex aquatilis, C. utriculata, C. lasiocarpa, C. lurida, C. rostrata, C. pellita, Lysimachia thyrsiflora, Verbena hastata, Thelypteris palustris, Asclepias incarnata, Impatiens capensis, Sagittaria latifolia, Scutellaria lateriflora, Scirpus americanus, Utricularia minor, U. intermedia, Lemna* spp., *Menyanthes trifoliata, Acorus* spp.

55. Seep and Rivulet (WH.SEEP): This habitat is a perennial wet seep, generally occurring at the base of a steep slope, where cold groundwater discharges at the surface throughout the year. It does not include acidic seepage bogs. Known examples of this habitat occur in Piedmont stream valleys. They tend to have substrates consisting of coarse colluvium, with limited soil development and patches of exposed gravel on some sites, and often have large (> 0.5 m diameter) pieces of exposed quartz. Species composition is highly variable, but known examples are dominated by tussock sedge, jewelweed, sensitive fern, halberd-leaf tearthumb, arrow-leaved tearthumb, skunk

cabbage, and mosses. Associates may include broad-leaf cattail, Virginia cutgrass, American sweetflag, marsh fern, false nettle, hop sedge, mild water-pepper, cottongrass bulrush, fowl mannagrass, winter bentgrass, dodders, delicate fern moss, and others. Scattered woody species may also be present, including red maple, smooth alder, black willow, and spicebush. Within the mid-Atlantic region, it generally occurs outside of the Coastal Plain.
Dominant/Subdominant Species- *Carex stricta, Impatiens capensis, Onoclea sensibilis, Polygonum arifolium, P. sagittatum, Symplocarpus foetidus, Brachythecium rivulare, Hygroamblystegium tenax*
Associative Species- *Typha latifolia, Leersia oryzoides, Acorus americanus, Thelypteris palustris, Boehmeria cylindrica, Carex lupulina, Polygonum hydropiperoides, Scirpus cyperinus, Glyceria striata, Agrostis hyemalis, Cuscuta* spp., *Thuidium delicatulum, Acer rubrum, Alnus serrulata, Salix nigra, Lindera benzoin*

56. Herbaceous Vernal Pool (WH.HVPO): This habitat includes isolated, depressional wetlands which generally become inundated during the winter and early spring, but often dry out by mid- to late-summer. Herbaceous vernal pools are often dominated by Walter's sedge, Eaton's witchgrass, twig rush, three-way sedge, Canada rush, creeping rush, boltonia, maidencane, reticulate nutrush, white waterlily, Robbin's spikerush, panic grasses, and/or spikerushes. This habitat also often includes patches of *Sphagnum* spp. Woody species occurring as isolated individuals, forming clumps, or occurring along the wetland edge may include buttonbush, sweet pepperbush, high-bush blueberry, swamp fetterbush, red maple, sweet gum, persimmon, black gum, swamp azalea or swamp white oak. Vernal pools may be perched on clay loams, or may be groundwater-fed wetlands in sandy loams. Overlying soils are generally wet to dry muck, with no peat buildup except for recently accumulated detritus. This habitat occurs throughout the mid-Atlantic. On the Coastal Plain of Delaware and Maryland, representatives of this habitat type include Coastal Plain Ponds, or Delmarva Bays.
Dominant/Subdominant Species- *Carex striata*, *Dichanthelium spretum*, *Cladium mariscoides*, *Dulichium arundinaceum*, *Juncus canadensis*, *Juncus repens*, *Boltonia asteroides*, *Panicum hemitomon*, *Scleria reticularis*, *Nymphaea odorata*, *Eleocharis robbinsii*, *Panicum* spp., *Eleocharis* spp., *Sphagnum* spp.
Associative Species- *Polygonum amphibium, P. hydropiperoides, P. pensylvanicum, Glyceria pallida, Fimbristylis autumnalis, Rhexia virginica, Leersia virginica, Proserpinaca pectinata, Bidens frondosa, Bidens discoidea, Woodwardia virginica, Scirpus cyperinus, Cephalanthus occidentalis, Clethra alnifolia, Vaccinium corymbosum, Leucothoe racemosa, Acer rubrum, Liquidambar styraciflua, Diospyros virginiana, Nyssa sylvatica, Rhododendron viscosum, Quercus bicolor*

57. Fresh Tidal Emergent Marsh (WH.FTMS): A complex of fresh emergent marsh and open water found in oligohaline to freshwater portions of tidal rivers and streams. This habitat ranges from narrow marshes along tidal creeks or sloughs to more expansive communities on levees adjacent to watercourses, and may include a variety of different communities, with some of them being quite diverse. A relatively common example is dominated by wild rice, smooth bur-marigold, arrow arum, and halberd-leaf tearthumb.

Some communities found on broad expanses of tidal muck may be dominated by a combination of jewelweed, arrowhead and arrow arum, while others situated over submerged mudflats and point bars that are exposed only at low tide may be dominated by broadleaf pondlily and American waterlily. Other, similarly-situated communities may be dominated by arrow arum and pickerelweed. Horned pondweed dominates a community found in the intertidal zone of fresh to oligohaline waters, and riverbank quillwort dominates a community found in more irregularly tidal situations. Dominant species in other communities may include Parker's pipewort, yellow pondlily, strap-leaf arrowhead, and/or mudwort. Associative species found in these various communities may include Nuttall's pondweed, river bulrush, great bur-reed, common reed, hemlock water-parsnip, rice cut-grass, water hemp, bur marigold, sweet flag, giant cordgrass, narrow-leaf cattail, broad-leaf cattail, arrow-leaved tearthumb, dotted smartweed, dodder, three-square, spikerush, spongy arrowhead, grassleaf arrowhead, American water-wort, roundfruit hedge-hyssop, floating heart, and walter millet. Soils are highly variable and are composed of varying amounts of silts, silty mucks, fine peat, to very coarse sands. Found on the Coastal Plain of Maryland, Delaware, New Jersey and other coastal areas of the mid-Atlantic.
Dominant/Subdominant Species- *Zizania aquatica*, *Bidens laevis*, *Peltandra virginica*, *Polygonum arifolium*, *Impatiens capensis*, *Sagittaria latifolia*, *Nuphar advena, Nymphaea odorata, Pontedaria cordata, Zannichellia palustris, Isoetes riparia, Eriocaulon parkeri, Nuphar lutea*, *Sagittaria subulata*, *Limosella australis*
Associative Species- *Potamogeton epihydrus*, *Scirpus fluviatilis*, *Sparganium eurycarpum, Phragmites australis*, *Sium suave*, *Leersia oryzoides*, *Amaranthus canabinus*, *Bidens bidentoides*, *Acorus calamus*, *Spartina cynosuroides*, *Typha angustifolia*, *T. latifolia*, *Polygonum sagittatum*, *P. punctatum*, *Cuscuta gronovii*, *Scirpus pungens*, *Eleocharis obtusa*, *Sagittaria calycina*, *S. graminea*, *Elatine americana*, *Gratiola virginiana*, *Nymphoides cordata*, *Echinochloa wateri*

58. Brackish Emergent Marsh (WH.BEMS): This habitat includes mesohaline tidal marshes that generally occur along estuaries between the oligohaline and polyhaline zones. The salinity of this habitat ranges from 5 to 18 ppt. Although salt-marsh cordgrass may dominate as it does in the higher-salinity low salt-marsh (WH.LSMS), this habitat is often characterized by a diverse community with no clear dominant species. In addition to salt-marsh cordgrass, this habitat often includes salt-meadow hay, big cordgrass, narrow-leaf cattail, marsh hemp, olney three-square, salt grass, marsh hibiscus, salt-marsh bulrush, common reed, beaked spike-rush, black needlerush, and many other species. Some possible associates, depending on salinity and elevation within the marsh, include switchgrass, eastern lilaeopsis, *Bidens* spp., mock bishop-weed, halberd-leaf tearthumb, Canada clearweed, spotted jewel weed, salt-marsh fleabane, pickerel weed, American bugleweed, marsh fimbry, stiff marsh bedstraw, seashore mallow, many-flowered pennywort, common three-square, black-grass rush, creeping spike-rushes, twig rush, and erect coinleaf. Found on peat or muck substrates in estuaries on the Atlantic Coastal Plain. Common in the mid-Atlantic.
Dominant/Subdominant Species- *Spartina alterniflora*, *S. patens*, *S. cynosuroides*, *Typha angustifolia*, *Amaranthus cannabinus*, *Scirpus americanus*, *Distichlis spicata*,

Hibiscus moscheutos, *Scirpus robustus*, *Phragmites australis*, *Eleocharis rostellata*, *Juncus roemerianus*
Associative Species- *Panicum virgatum, Lilaeopsis chinensis, Bidens* spp., *Ptilimnium capillaceum, Polygonum arifolium, Pilea pumila, Impatiens capensis, Pluchea odorata, Pontederia cordata, Lycopus americanus, Fimbristylis castanea, Galium tinctorium, Kosteletzkya virginica, Hydrocotyle umbellata, Scirpus pungens, Juncus gerardii, Eleocharis fallax, E. palustris, Cladium mariscoides, Centella erecta*

59. Low Salt Marsh (WH.LSMS): Regularly (diurnally) flooded salt marsh dominated by salt-marsh cordgrass, which often appears to form a monospecific stand, with infrequent associates including glassworts in pannes, sea-lavender, spearscale, seashore mallow, marsh hibiscus, salt-marsh fleabane, gama-grass, salt-meadow hay, big cordgrass, black-grass rush, black needle-rush, and salt grass. This habitat occurs on shallow to deep peats along the Atlantic Coast. Common in the mid-Atlantic.
Dominant/Subdominant Species- *Spartina alterniflora*
Associative Species- *Salicornia* spp., *Limonium carolinianum, Atriplex prostrata, Kosteletzkya virginica, Hibiscus moscheutos, Pluchea odorata*, *Tripsacum dactyloides, Spartina patens, S. cynosuroides, Juncus gerardii, J. roemerianus, Distichlis spicata*

60. High Salt Marsh (WH.HSMS): Consists of communities dominated by salt-meadow hay in the higher elevations of salt and brackish marshes where only unusually high tides reach. This species tends to dominate the high marsh where it forms meadows, characterized by cow-licked mats, at slightly higher elevations in relation to the adjacent low marsh. Other common species include salt grass which may be subdominant in some areas, sea lavender, seaside gerardia and common glasswort which are found in pannes, annual marsh pink, and black-grass rush. Some portions of the high marsh may be dominated by clumps of black needle-rush, which generally occurs at a slightly lower elevation than salt-meadow hay, and may therefore be considered transitional between high salt-marsh and low salt-marsh. Soils are very poorly drained peaty or mucky organics overtop grey or mottled sand. This habitat is found along the Atlantic Coastal Plain, and is common in the mid-Atlantic.
Dominant/Subdominant Species- *Spartina patens*, *Distichlis spicata, Juncus roemerianus*
Associative Species- *Limonium nashii, Agalinis maritima, Salicornia europaea*, *Sabatia stellaris, Juncus gerardii,*

61. Interdunal / Maritime Marsh (WH.DMMS): Interdunal swales, depressions and saturated, herb-dominated thickets occurring beyond the normal reach of tide, most often in back-dune areas. The water table is generally at or near the surface, and there is some organic soil buildup. Fresh water maintains these depressions as saturated or seasonally flooded and somewhat poorly drained. Dominant species may include round-head rush, forked rush, twig rush, common three-square, and/or switchgrass. Other herbaceous associates may include marsh St. John's-wort, panic beachgrass and other panic grasses, Eaton's witch grass, spoon-leaved sundew, southern bladderwort, zigzag bladderwort, pink-based yellow-eyed grass, twisted yellow-eyed grass, white-bract thoroughwort,

broom sedge, grassleaf rush, slender fimbry, marsh fimbry, salt-meadow hay, Canada rush, seaside goldenrod, red fescue, creeping spike-rush, wild flax, tiny-headed goldenrod, and various sedges. *Sphagnum* and other mosses may form substantial mats under dominant herbs, and creeping clubmoss may also be present. Vines, trees and shrubs may also provide limited coverage, and may include poison ivy, large cranberry, highbush blueberry, wax myrtle, groundsel bush and others, often occurring mostly around the perimeter of the wetland. Soils are characterized by a shallow organic layer overlying loamy sand or sand. This habitat occurs up and down the Atlantic Coast, and is common in the mid-Atlantic.

Dominant/Subdominant Species- *Juncus scirpoides, J. dichotomus, Cladium mariscoides, Scirpus pungens, Panicum virgatum*

Associative Species- *Triadenum virginicum, Panicum amarum, P. verrucosum, P. rigidulum, Dichanthelium spretum, Drosera intermedia, Utricularia juncea, U. subulata, Xyris difformis, X. torta, Eupatorium leucolepis, Andropogon virginicus, Juncus biflorus, Fimbristylis autumnalis, F. castanea, Spartina patens, Juncus canadensis, Solidago sempivirens, Festuca rubra, Eleocharis palustris, Linum medium, Carex albolutescens, Euthamia tenuifolia, Sphagnum* spp., *Polytrichum* spp., *Lycopodiella appressa, Toxicodendron radicans, Vaccinium macrocarpon, V. corymbosum, Myrica cerifera, Baccharis halimifolia, Aronia arbutifolia, Acer rubrum, Pinus rigida*

SPARSELY VEGETATED:

62. Rocky Cliff (SV.ROCL): Generally characterized by steep, vertical rock faces which often include crevices and intermittent horizontal steps. Occurs on a number of different rock types including sandstone, quartzite, gneiss, schist, phyllite, limestone, dolomite, shale, mudstone, and metabasalt. Examples include calcareous cliffs of limestone and dolomite geology, with a very high ($\geq$ 90%) cover of exposed bedrock. Mosses and lichens can have moderate coverage, while vascular plants occur on ledges and rooted in cracks. On south and west-facing carbonate formations, scattered scrub growth may include eastern red cedar, chinquapin oak, hairy mock-orange, and poison ivy. Herbaceous species may include black-stemmed spleenwort, wall-rue, ebony sedge, rocktwist, three-flowered melic, rock sandwort, plains muhly, cliff-brakes, moss phlox, and aromatic aster. On north-facing limestone or dolomite cliffs with limited solar exposure and more mesic conditions, woody species may include northern white cedar, basswood, slippery elm and wild hydrangea, and characteristic herbs include ebony sedge, bulblet fern, cliff stonecrop, northern bedstraw, white-flowered leafcup, walking fern, smooth rock-cress, lyre-leaf rock-cress, fernleaf phacelia and Carolina saxifrage. Cliffs on metamorphic and non-carbonate sedimentary rocks may include white ash, eastern red cedar, chestnut oak, wild columbine, rock-cresses, Allegheny stonecrop, field chickweed, maidenhair spleenwort, and blunt-lobed woodsia. Depending on geology and situation, other associates may include marginal wood fern, American alumroot, eastern few-fruit sedge, Virginia saxifrage, fragrant sumac, Virginia creeper, redbud, hickories, hop hornbeam, flowering dogwood, and many others. In the mid-Atlantic region, this habitat type occurs in several locations, including along the Potomac River in western Maryland,

along the upper Delaware River in the vicinity of the Delaware Water Gap (Pennsylvania and New Jersey), and along the lower Hudson River (New Jersey).
Associative Species- *Juniperus virginiana, Quercus muhlenbergii, Philadelphus hirsutus, Toxicodendron radicans, Asplenium resiliens, A. ruta-muraria, Carex eburnea, Draba ramosissima, Melica nitens, Minuartia michauxii, Muhlenbergia cuspidata, Pellaea atropurpurea, P. glabella, Phlox subulata, Symphyotrichum oblongifolium, Thuja occidentalis, Tilia americana, Ulmus rubra, Hydrangea arborescens, Cystopteris bulbifera, Sedum glaucophyllum, Galium boreale, Polymnia canadensis, Asplenium rhizophyllum, Arabis laevigata, A. lyrata, Phacelia bipinnatifida, Saxifraga caroliniana, Fraxinus americana, Quercus montana, Aquilegia canadensis, Sedum telephioides, Cerastium arvense, Asplenium trichomanes, Woodsia obtusa, Dodecatheon meadia, Symphyotrichum ericoides, Bouteloua curtipendula, Dryopteris marginalis, Allium cernuum, Heuchera americana, Carex oligocarpa, Arabis hirsuta, Saxifraga virginiensis, Rhus aromatica, Parthenocissus quinquefolia, Cercis canadensis, Carya* spp., *Ostrya virginiana, Cornus florida.*

63. Rocky Outcrop / Talus / Barren (SV.ROTB): Includes sparsely-vegetated, open habitats characterized by large boulders. Examples of this habitat type occur along upper perennial rivers and mountain ridges, or on xeric, rocky slopes that are often south-facing. Some areas of occurrence may be subject to periodic flood scouring. Plant species tend to inhabit small micro-sites such as rock crevices where there has been some soil formation. Although talus may be an important component of some forests such as the mixed mesophytic habitat type (UF.MIME), in this case talus is defined to include only the open, boulder-field component where significant woody cover is lacking. This habitat may also have plant communities similar to those of the high-elevation woodland (UF.HEWL), mid-low-elevation woodland (UF.MEWL) and rocky cliff (SV.ROCL) habitats, but it is generally characterized as a smaller (i.e., micro-habitat), more discrete, landscape feature which does not include adjacent or associated plant communities in its definition. Rock outcrops and open or barren talus slopes included in this habitat type are generally restricted to mountainous areas of the mid-Atlantic region, but may have some representation within the Piedmont.

64. Natural Gravel Barren (SV.GRBA): This habitat tends to occur along upper perennial stream-sides that are seasonally flooded. Unnatural occurrences are known in situations following logging or mining on steep slopes - often south-facing - where top soil has been washed away following the land disturbance activity. Such occurrences may be better characterized by the urban barren - vacant / extraction habitat (AN.UBAR) description.

65. Eroding Slope Bank (SV.ERSL): Includes eroding stream-banks or slopes disturbed by human activities which have greatly reduced soil stability (e.g., logging, agriculture). Some examples may include eroded river banks caused by frequent impacts from boat wakes or increased flows associated with upstream development, resulting in an unstable vertical or undercut bank.

66. Unconsolidated River / Lake Shore (SV.UNCS): Occurring along the lower shorelines of non-tidal rivers and lakes, this habitat has substrates lacking vegetation except for pioneering plants that become established during brief periods when growing conditions are favorable. Erosion and deposition by waves and currents produce beaches, bars and flats. This habitat also has less than 75% coverage of stones, boulders or bedrock, less than 30% pioneer plant cover, and a variety of flooding regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded to intermittently flooded and artificially flooded.

67. Sand Dune / Flat (SV.SDNF): Includes upper portions of sandy maritime beaches and irregularly-flooded barrier island flats, as well as upper portions of lakeshore beaches where large amounts of sand have accumulated. This habitat is sparsely vegetated due to wind and wave action, and associated sand deposition and erosion. It occurs in coastal areas and on sandy shores of large lakes. Along the east coast it becomes more prevalent with decreasing latitude, with beaches generally becoming wider south of New England. This habitat is very common in the mid-Atlantic region.

68. Subterranean (SV.SUBT): This habitat consists of aquatic and terrestrial habitats beneath the earth's surface, including not only large air-filled cavities with openings to the surface (caves), but also water-filled aquifers and interstitial habitats in small crevices. This habitat usually has the following features: no sunlight, relatively stable temperature and high humidity, low energy inputs, and troglodytic species. It occurs in scattered locations throughout the U.S., including the mid-Atlantic region, but those features meeting the most narrow definition of this habitat type occur primarily in the mountains.

AQUATIC

69. Freshwater Pond (AQ.POND): Includes palustrine or lacustrine wetland habitats which are semi-permanently or permanently flooded, and are too deep to support persistent vegetation but not too deep to support submerged or aquatic vegetation; also not so large as to be subjected to extensive wave scour on the shoreline (generally less than 8 hectares). This habitat may also include protected and/or shallow bays of larger lakes and reservoirs, and slow-moving segments and backwaters of rivers, including fresh tidal portions of coastal rivers which have pond-like characteristics and vegetation. Dominant species may include stoneworts, pondweeds, ditch grasses, wild celery, waterweed, water lilies, water smartweed, duckweeds, water hyacinth, bladderworts and watermeals. Soils range from unconsolidated sand and gravels to deep peats and mucks. Occurs widely throughout the eastern region and elsewhere in a wide variety of situations. In the mid-Atlantic states, ponds are especially prevalent on the Coastal Plain; they occur in the Piedmont and mountains as well. Many are man-made.

70. Freshwater Lake / Reservoir (AQ.LAKE): This habitat consists of littoral and limnetic components of lacustrine wetlands and deepwater habitats, defined as permanent freshwater bodies in depressions or dammed river channels, lacking persistent emergent

vegetation, trees and shrubs and having an area exceeding 8 ha. Water bodies smaller than 8 ha may also be included if the shoreline is wave-scoured. Submerged vegetation may be present on some sites, however floating leaf vegetation is less likely except in sheltered coves. Species present may include stoneworts, pondweeds, ditch grasses, wild celery, waterweed, bladderworts, and watermeals. Found in scattered locations in the eastern U.S., more frequently in glaciated regions of the northeast. In the mid-Atlantic, it is most common in northern New Jersey, but is also represented by numerous man-made reservoirs in other parts of the region..

71. Lower Perennial River (AQ.LPRI): Consists of relatively large, deep, channelized freshwater features on low gradients that are not under tidal influence, and are characterized by low-velocity, year-round flows which, on average, are greater than 500 cfs. The substrate consists mainly of sand and mud, and oxygen deficits may sometimes occur. The floodplain is generally well-developed. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The distance between floodplain forest canopies is greater than 75 m, and examples of this habitat are wide enough to be mapped as polygons in 1:24,000-scale mapping. Generally restricted to the Coastal Plain and lower Piedmont.

72. Lower Perennial Stream (AQ.LPST): Includes freshwater features flowing in channels, with average low flows of less than 500 cfs, and with the distance between floodplain forest canopies being less than 75 m. This habitat is characterized by low-velocity flows and soft or fine stream-bottom substrates. The floodplain is generally well-developed. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. Examples of this habitat type are too narrow to be mapped as polygons in 1:24,000-scale mapping. Found throughout the U.S.. In the mid-Atlantic region, most common on the Coastal Plain.

73. Upper Perennial River (AQ.UPRI): This habitat consists of medium-sized riverine water features with high gradients and fast velocity, and no tidal influence. Such features are wide enough to be mapped as polygons in 1:24,000-scale mapping. Water flows throughout the year and has a substrate of rock, cobble or gravel with patches of sand. There is very little floodplain development, and there are few, if any, planktonic forms. Found throughout the U.S., but rare to absent on the Coastal Plain and most common in the mountains.

74. Upper Perennial Stream (AQ.UPST): Includes water features flowing in channels, with no tidal influence, and channel width generally less than 30 meters. Such features are too narrow to be mapped as polygons in 1:24,000-scale mapping. Characterized by high-velocity flows on high gradients, with bottom substrates of rock, cobble or gravel with patches of sand. There is very little floodplain development, and there are few, if any, planktonic forms. Found throughout the U.S., but rare to absent on the Coastal Plain and most common in the mountains.

75. Intermittent Stream / River (AQ.INSR): This habitat consists of river and stream channels, or portions of channels, in which water flows for only part of the year. Also includes many agricultural ditches, as well as some road ditches, that hold water for long enough periods of time during the spring to provide habitat for amphibians.

76. Fresh Tidal River (AQ.FTRI): Consists of riverine open water habitats with low gradients and velocity fluctuating under tidal influence. The streambed is primarily mud with occasional patches of sand. The floodplain is well-developed.

77. Fresh Tidal Stream (AQ.FTST): This habitat consists of tributary streams of freshwater tidal rivers that undergo tidal influence and are too small to be mapped as polygons.

78. Fresh Intertidal Mudflat / Shore (AQ.FITM): Unconsolidated shoreline substrates that are tidally inundated, but are completely de-watered and exposed at low tide in freshwater tidal streams and rivers.

79. Estuarine Tidal River / Inlet (AQ.ESRI): Consists of water regimes and chemistry that are influenced by ocean tides, precipitation, freshwater runoff from land, evaporation and wind. Salinities range from hyperhaline to oligohaline with variable concentrations. The substrate is continuously submerged. This habitat extends from an imaginary line drawn at the inlet, upward and landward to where salinities measure less than 0.5% during periods of annual low flow. For habitat modeling and mapping purposes, open-water wetlands with the NWI oligohaline modifier were not included in this habitat, but were instead lumped with freshwater tidal, open water habitats, since certain amphibian species occur in oligohaline wetlands but are absent from habitats with higher salinities.

80. Estuarine Tidal Stream (AQ.ESST): This habitat consists of smaller tributaries of estuarine tidal rivers that are too small to be mapped as polygons but exhibit the same water chemistry and tidal influence of larger estuarine waters.

81. Estuarine Tidal Pond (AQ.ESPO): This habitat is semi-permanently or permanently flooded by tidal brackish waters and is too deep to support persistent vegetation, but is not too deep to support submerged or aquatic vegetation. It is not so large as to be subjected to extensive wave scour on the shoreline.

82. Estuarine Intertidal Mudflat / Shore (AQ.ESIM): This habitat consists of intertidal, regularly flooded mud flats and other shorelines consisting of fine, unconsolidated sediments. It is found along tidal rivers, bays, streams, sloughs, tidal ponds, and other estuarine shores. This habitat is more likely to be found in estuarine waters with fairly low energy, so it is less common adjacent to open bay waters with significant wind fetch.

83. Estuarine Intertidal Sandy Beach (AQ.ESIB): Substantial sand deposits produced by open bay waters in the mid-Atlantic with significant wind fetch and strong wave

action. This habitat is defined as the narrow intertidal beach strand along estuarine waters with substantial sand deposits; it is generally unvegetated.

84. Estuarine Subtidal Nearshore (AQ.ESNS): Defined as permanently flooded, tidally influenced, open water where fresh water mixes with salt water, and salinities range from oligohaline to polyhaline. It has a shore to shore confinement of greater than 300 meters, or if less than 300 meters, then less than 300 meters in length when measured from waters lacking such a confinement. Nearshore habitat is defined as the portion of this classification being within 300 meters of shore. The distance of 300 meters is estimated somewhat arbitrarily as the maximum distance commonly used by an assemblage of land-based vertebrates for foraging.

85. Estuarine Subtidal Offshore (AQ.ESOS): This habitat is represented by open estuarine waters separated away from shores by at least 300 meters. This distance is estimated somewhat arbitrarily as the maximum distance of land-based vertebrates for foraging. The offshore habitat is more the domain of some bay ducks, pelagic birds, and marine mammals.

86. Marine Intertidal Rocky (AQ.MAIR): This habitat is uncommon in the mid-Atlantic region, and is most often represented by artificial rock jetties, rip-rap, or other man-made structures in intertidal marine areas with considerable wave energy.

87. Marine Intertidal Sandy Beach (AQ.MAIB): This habitat is defined as the narrow intertidal beach strand along the shoreline of marine waters where there is strong wave action and substantial sand deposition. It is normally unvegetated.

88. Marine Subtidal Nearshore (AQ.MANS): This habitat is defined as open marine waters within 300 meters or less of the coast. The distance of 300 meters is estimated somewhat arbitrarily as the maximum distance commonly used by an assemblage of land-based vertebrates for foraging.

89. Marine Subtidal Offshore (AQ.MAOS): This habitat is defined as open marine waters greater than 300 meters off the coast.

ANTHROPOGENIC:

90. Agricultural Forb-Like / Row Crop (AN.AFCR): This habitat consists of cultivated land managed to produce row crops such as soybeans, corn, and asparagus. Associates of these planted alliances include weeds such as mustards, lamb's quarters, horse-nettle, wild lettuce, and morning glory.

91. Agricultural Grass-Like Crop (AN.AGCR): This habitat consists of cultivated land managed to produce monotypic grass-like crops such as buckwheat, clovers, oats, barley, rye and wheat.

92. Agricultural Shrub-Like Crop (AN.ASCR): This habitat consists of cultivated land managed to produce shrub-like crops such as blueberries, blackberries, raspberries, and grapes.

93. Agricultural Pasture (AN.APAS): This habitat consists of land managed to produce pasture for livestock grazing. Plants associated with this habitat include orchardgrass, broomsedge, fescue, lespedeza, clover and alfalfa.

94. Agricultural Orchard (AN.AORC): This habitat consists of land planted with small trees, generally fruit trees including apples, pears, cherries, peaches, etc. It has a savannah-like structure of small trees with open areas in between, often including orchard grass or other cool-season grasses.

95. Agricultural Plantation (AN.APLA): This habitat consists of timber plantations and Christmas tree farms that are usually monotypic and include loblolly pine, white pine, red pine, red spruce, balsam fir, Fraser fir, etc. It generally lacks a significant understory or herbaceous layer, and also lacks coarse woody debris and other characteristics of a natural forest ecosystem.

96. Agricultural Regenerating Clearcut (AN.ARCL): This habitat is generally barren or sparsely vegetated with herbs, shrubs, small trees, and seedlings. The soil may be significantly disturbed and compacted in places, and leaf duff may be lacking. However, stumps, brush piles, and coarse woody debris may be present.

97. Agricultural Barren - Plowed / Fallow (AN.ABAR): This habitat consists of sparsely-vegetated agricultural fields that have recently been plowed, prior to planting, or have recently been harvested. This category also includes fields recently taken out of cultivation that haven't yet succeeded to an herbaceous old field condition.

98. Agricultural Developed (AN.ADEV): This habitat includes agricultural areas with significant coverage (30% or greater) of man-made structures (e.g. buildings, concrete, asphalt, etc.). These areas are most commonly associated with farmsteads, and include houses, barns, outbuildings, silos and corrals, as well as other structures and vegetation associated with rural development.

99. Urban Low-Intensity Developed (AN.ULID): This habitat includes areas with a mixture of man-made structures and vegetation. Man-made structures and impervious surfaces account for 30-80 percent of the cover. Vegetation may account for 20-70% of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.

100. Urban High-Intensity Developed (AN.UHID): Includes dense commercial, housing, or industrial development, with large areas of impervious surface. Vegetation accounts for less than 20% of the cover. Man-made structures and impervious surfaces account for 80-100% of the cover.

101. Urban Transportation Corridor (AN.UTRA): Generally includes all highly developed areas not classified as urban high-intensity developed, such as highway and railway corridors characterized by areas of intense human activity occurring in linear patterns.

102. Urban Landscaped (AN.ULAN): This habitat consists of vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, golf courses, cemeteries, school yards, airports, and industrial parks with large lawns and sometimes including shade-trees.

103. Urban Barren - Vacant / Extraction (AN.UBAR): This habitat includes barren or sparsely-vegetated areas associated with extractive mining activities, or other highly disturbed areas associated with development.

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APPENDIX F: Primary References for Compiling Habitat Requirements Information

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APPENDIX G: HABITAT REQUIREMENTS DATA SUMMARY FORM

SPECIES-HABITAT RELATIONSHIPS SUMMARY: BIRDS- BREEDING

suitability: -1-negative suitability/influence, 0-unsuitable, 1-marginal, 2-suitable, 3-highly suitable, 4-optimal

use: N-nest, F-forage, R-roost, A-all

Species: _____ Av_code/ID: _____/____ Range: ___MD ___DE ___NJ

Reviewer: _____ Date: _____

HABITAT TYPES:

Upland Forests/Woodlands:

alpine/boreal	n___f___r___a___Boreal Conifer	n___f___r___a___Boreal Hardwood	n___f___r___a___Boreal Mixed H/C
northern/higher el	n___f___r___a___Northern Conifer	n___f___r___a___Northern Oak	n___f___r___a___Northern Oak-Conif
		n___f___r___a___Northern Hardwood	n___f___r___a___Northern Mixed H/C
mid-el/cool aspect		n___f___r___a___Mixed Mesophytic	
		n___f___r___a___Appalachian Cove	
mid/low el, dry-ex	n___f___r___a___Pine Barren	n___f___r___a___Oak-Hickory	n___f___r___a___Mid-Atl Oak-Pine
		n___f___r___a___Low Elev Mesic HW	
southern/coastal	n___f___r___a___Coastal Plain Pine		n___f___r___a___Coastal Pl Pine-Oak
southern	n___f___r___a___Southern Pine		
woodland/t	n___f___r___a___High Elev WL	n___f___r___a___Mid-Low Elev WL	n___f___r___a___Maritime For/Woodl

Wetland Forests/Woodlands:

boreal/northern	n___f___r___a___Bog Forest	n___f___r___a___Boreal Swamp	
	n___f___r___a___N Conif Swamp	n___f___r___a___N Hardwood Swamp	
coastal	n___f___r___a___Atl W-cedar Swmp		
southern/coastal	n___f___r___a___Baldcypress Swmp	n___f___r___a___Bottomland Hardw	n___f___r___a___Deep Swmp Hardw
	n___f___r___a___CP Pine Flatwood	n___f___r___a___Mixed Oak Swamp	n___f___r___a___CP Pine-Hrdw Swp
riparian	n___f___r___a___Northern Riparian		

Upland Shrubs:

alpine/montane	n___f___r___a___Alpine/Boreal Heath	n___f___r___a___Krummholz	n___f___r___a___Montane Heath Bald
oldfields	n___f___r___a___Shrub/Sap Oldfield	n___f___r___a___Mid Successional Old Field	
coastal	n___f___r___a___Pine Barrens Scrub	n___f___r___a___Dune/Maritime Thicket/Shrub	

Wetland Shrubs:

northern/boreal	n___f___r___a___Nrthn/Boreal Bog	n___f___r___a___Nrthrn/Boreal Fen	
CP/coast/maritime	n___f___r___a___Salt Marsh Scrub	n___f___r___a___MT Wet Th/Shrub	n___f___r___a___Woody Vernal Pool
ubiquitous/riparian	n___f___r___a___Saturid Shr Swmp	n___f___r___a___Flooded Shr Swmp	n___f___r___a___Rip Thicket/Shrub

Upland Herbaceous:

mountaintop/pea	n___f___r___a___Alpine Grassland/Meadow	n___f___r___a___Dry Slope Glade
ubiquitous	n___f___r___a___Herbaceous Old Field	n___f___r___a___Upland Riparian Herbaceous
maritime/coastal	n___f___r___a___Dune/Maritime Grassland	

Wetland Herbaceous:

ubiquitous	n___f___r___a___Wet Mdw/RH	n___f___r___a___Fresh Rob Emerg Marsh	n___f___r___a___Seep and Rivulet
coastal/maritime	n___f___r___a___H Vernal Pool	n___f___r___a___Fresh Tidal Em Marsh	n___f___r___a___Brackish Em Mrsh
	n___f___r___a___Low Salt Marsh	n___f___r___a___High Salt Marsh	n___f___r___a___Interdunal/Mt Marsh

Sparsely Vegetated:

n___f___r___a___Rocky Cliff	n___f___r___a___Rocky Outcr/Talus/Barr	n___f___r___a___Natural Grav Barren
n___f___r___a___Eroding Sl/Bank	n___f___r___a___Unc River/Lake Shore	n___f___r___a___Sand Dune/Flat
n___f___r___a___Subterranean		

Aquatic:

lacustrine	n___f___r___a___FW Pond	n___f___r___a___FW Lake/Reservior	
riverine	n___f___r___a___Lower Per River	n___f___r___a___Lower Per Strm	n___f___r___a___Upper Per Rivr
	n___f___r___a___Upper Per Strm	n___f___r___a___Intermittent Strm/Rivr	
tidal	n___f___r___a___Fresh Tidal River	n___f___r___a___Fresh Tidal Stream	n___f___r___a___Fresh Intertidal M/S
	n___f___r___a___Est Tidal River/Inlet	n___f___r___a___Est Tidal Stream	n___f___r___a___Est Tidal Pond
estuarine	n___f___r___a___Est Intertidl M/S	n___f___r___a___Est Intertidl Beach	n___f___r___a___Est Subtidl Nearshr
	n___f___r___a___Estuarine Subtidl Offshr		

marine n___f___r___a___Mar Intertidl Rocky n___f___r___a___Mar Intertidl Beach n___f___r___a___Mar Subtidl Nearshr
n___f___r___a___Mar Subtidl Offshr

Anthro:

agricultural n___f___r___a___Forb/Row Crop n___f___r___a___Grass-Like Crop n___f___r___a___Shrub-Like Crop
n___f___r___a___Pasture n___f___r___a___Orchard n___f___r___a___Plantation
n___f___r___a___Regenerating Clearcut
n___f___r___a___Ag Barren n___f___r___a___Ag Developed
urban n___f___r___a___LI Developed n___f___r___a___HI Developed n___f___r___a___Transportation
n___f___r___a___Landscaped n___f___r___a___Barren/Vacant

SITE CHARACTERISTICS:

Community Structure:

suitability: -1-negative response, 0-no response, 1- weak response, 2- moderate response, 3- strong response, 4- required

patch size n___f___r___a___Deep/For. Interior n___f___r___a___Patchy/Edge Areas
canopy density n___f___r___a___Dense Canopy n___f___r___a___Open Can./Woodlands n___f___r___a___Forest Openings/Clr.
tree size n___f___r___a___Old Gr./Large n___f___r___a___Second Gr./Med.-Sm. n___f___r___a___Saps/Regenerating
shrub/understory n___f___r___a___Dense Shrub Layer n___f___r___a___Open Shrub Layer n___f___r___a___Tangle/Thicket
ground layer n___f___r___a___Bare Ground n___f___r___a___Herbaceous/Grass n___f___r___a___Litter/Debris

Wetland/Water Adjacency (i.e. GIS buffer): Required (R): T or F (logical 'OR'); Priority (P): 1 - 4 (repeats OK)

suitability: -1-negative response, 0-no response, 1- weak response, 2- moderate response, 3- strong response

R	P		R	P	
__	__	n___f___r___a___ Tidal/Nontidl Stream (100 250 1000 m)	__	__	n___f___r___a___ Fresh Marsh (100 250 1000 m)
__	__	n___f___r___a___ Tidal/Nontidl River (100 250 1000 m)	__	__	n___f___r___a___ Fresh Tidal Marsh (100 250 1000 m)
__	__	n___f___r___a___ Lake/Reservoir (100 250 1000 m)	__	__	n___f___r___a___ Salt Marsh (100 250 1000 m)
__	__	n___f___r___a___ Fresh Pond (100 250 1000 m)	__	__	n___f___r___a___ Estuar Rivr/Strm/Pond (100 250 1000 m)
__	__	n___f___r___a___ Forested Swamp (100 250 1000 m)	__	__	n___f___r___a___ Salt Bay (100 250 1000 m)
__	__	n___f___r___a___ Shrub Swamp/Bog (100 250 1000 m)	__	__	n___f___r___a___ Ocean/Maritime (100 250 1000 m)
__	__	n___f___r___a___ Hrb/Shrb Vernal Pool (100 250 1000 m)	__	__	n___f___r___a___ Other: _____ (100 250 1000 m)

Physiography:

suitability: -1-negative response, 0-no response, 1- weak response, 2- moderate response, 3- strong response, 4-required

Slope (%): n___f___r___a___: _____(min) - _____(max) n___f___r___a___: _____(min) - _____(max)
Aspect (°): n___f___r___a___: _____(min) - _____(max) n___f___r___a___: _____(min) - _____(max)
Elevation (m): n___f___r___a___: _____(min) - _____(max) Location: _____
Elevation (m): n___f___r___a___: _____(min) - _____(max) Location: _____
Elevation (m): n___f___r___a___: _____(min) - _____(max) Location: _____
Other: n___f___r___a___: _____ n___f___r___a___: _____
Comments: _____

Special Habitat Features:

suitability: -1-negative influence, 0-not used, 1- rarely used, 2-used, 3-almost always used, 4-required

n___f___r___a___Cliffs n___f___r___a___Cave/Tunnels n___f___r___a___Dams, Bridges, Overpass
n___f___r___a___Nest Boxes n___f___r___a___Houses/Buildings n___f___r___a___Barns
n___f___r___a___Tree Cavity (live) n___f___r___a___Snags (>25 cm) n___f___r___a___Snags (<25 cm)
n___f___r___a___Sandy Banks n___f___r___a___Perches (low) n___f___r___a___Perches (high)
n___f___r___a___Scattered Shrubs n___f___r___a___Scattered Trees n___f___r___a___Rocky Outcrops
n___f___r___a___Fruits/Berries n___f___r___a___ _____ n___f___r___a___ _____
n___f___r___a___ _____ n___f___r___a___ _____ n___f___r___a___ _____

Area Requirements:

Not required for FAD species traditionally considered; summarize other data here:

_____
_____

Comments:

_____
_____

APPENDIX H: RARE SPECIES OF THE MDN-GAP PROJECT AREA

Rare Bird Species:

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STATUS
ABNCA02010	PODILYMBUS PODICEPS	PIED-BILLED GREBE	S2B	S1B	S1	G5
ABNFC01020	PELECANUS OCCIDENTALIS	BROWN PELICAN	S1B			G4
ABNFD01020	PHALACROCORAX AURITUS	DOUBLE-CRESTED CORMORANT	S1B	S1B		G5
ABNGA01020	BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	S2B	S1B	S3	G4
ABNGA02010	IXOBRYCHUS EXILIS	LEAST BITTERN	S3B	S1B	S3B	G5
ABNGA04010	ARDEA HERODIAS	GREAT BLUE HERON		S2B	S2	G5
ABNGA05010	CASMERODIUS ALBUS	GREAT EGRET		S1B	S3	G5
ABNGA06030	EGRETTA THULA	SNOWY EGRET		S1B	S3	G5
ABNGA06040	EGRETTA CAERULEA	LITTLE BLUE HERON	S3B	S1B	S3	G5
ABNGA06050	EGRETTA TRICOLOR	TRICOLORED HERON	S3B	S1B	S3	G5
ABNGA07010	BUBULCUS IBIS	CATTLE EGRET		S1B	S3	G5
ABNGA11010	NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT-HERON		S1B	S3	G5
ABNGA13010	NYCTANASSA VIOLACEUS	YELLOW-CROWNED NIGHT-HERON	S2B	S1B	S2	G5
ABNGE02010	PLEGADIS FALCINELLUS	GLOSSY IBIS		S1B	S3	G5
ABNJB10130	ANAS DISCORS	BLUE-WINGED TEAL	S2B	S3B		G5
ABNJB10160	ANAS STREPERA	GADWALL	S2B	S3B		G5
ABNJB20010	LOPHODYTES CUCULLATUS	HOODED MERGANSER	S1B	S1B		G5
ABNKA01010	CORAGYPS ATRATUS	BLACK VULTURE		S2B	S3	G5
ABNKC01010	PANDION HALIAETUS	OSPREY		S3B	S3	G5
ABNKC10010	HALIAEETUS LEUCOCEPHALUS	BALD EAGLE	S3B	S2B	S1	G4
ABNKC11010	CIRCUS CYANEUS	NORTHERN HARRIER	S2B	S1B	S2	G5
ABNKC12020	ACCIPITER STRIATUS	SHARP-SHINNED HAWK	S2B			G5
ABNKC12040	ACCIPITER COOPERII	COOPER'S HAWK		S1B	S2	G4
ABNKC12060	ACCIPITER GENTILIS	NORTHERN GOSHAWK	S1B		S1	G5
ABNKC19030	BUTEO LINEATUS	RED-SHOULDERED HAWK		S2B	S2	G5
ABNKC19050	BUTEO PLATYPTERUS	BROAD-WINGED HAWK		S1B		G5
ABNKD06020	FALCO SPARVERIUS	AMERICAN KESTREL		S3B		G5

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STATUS
ABNKD06070	FALCO PEREGRINUS	AMERICAN PEREGRINE FALCON	S2	SEB	S1	G4T3
ABNME03040	LATERALLUS JAMAICENSIS	BLACK RAIL	S3B	S1B	S3	G4
ABNME05020	RALLUS ELEGANS	KING RAIL	S4B	S2	S3	G4G5
ABNME08020	PORZANA CAROLINA	SORA	S1B	S2		G5
ABNME13010	GALLINULA CHLOROPUS	COMMON MOORHEN	S2B	S3B		G5
ABNME14020	FULICA AMERICANA	AMERICAN COOT		S1B	S1	G5
ABNNB03070	CHARADRIUS MELODUS	PIPING PLOVER	S1B	S1B	S1	G3
ABNNC01010	HAEMATOPUS PALLIATUS	AMERICAN OYSTERCATCHER	S3B	S1B		G5
ABNND01010	HIMANTOPUS MEXICANUS	BLACK-NECKED STILT		S2B		G5
ABNNF06010	BARTRAMIA LONGICAUDA	UPLAND SANDPIPER	S1B	SHB	S1	G5
ABNNF18010	GALLINAGO GALLINAGO	COMMON SNIPE			S3	G5
ABNNM03010	LARUS ATRICILLA	LAUGHING GULL	S1B			G5
ABNNM03120	LARUS ARGENTATUS	HERRING GULL		S3B		G5
ABNNM03210	LARUS MARINUS	GREAT BLACK-BACKED GULL		S1B		G5
ABNNM08010	STERNA NILOTICA	GULL-BILLED TERN	S1B	SHB	S3	G5
ABNNM08030	STERNA MAXIMA	ROYAL TERN	S1B			G5
ABNNM08070	STERNA HIRUNDO	COMMON TERN		S1B	S3	G5
ABNNM08090	STERNA FORSTERI	FORSTER'S TERN		S1B	S3	G5
ABNNM08100	STERNA ANTILLARUM	LEAST TERN	S2B	S1B	S2	G4
ABNNM14010	RYNCHOPS NIGER	BLACK SKIMMER	S1B	S1B	S2	G5
ABNRB02010	COCCYZUS ERYTHROPTHALMUS	BLACK-BILLED CUCKOO		S1B		G5
ABNSA01010	TYTO ALBA	COMMON BARN-OWL		S3	S3	G5
ABNSB12020	STRIX VARIA	BARRED OWL		S2	S3	G5
ABNSB13010	ASIO OTUS	LONG-EARED OWL	SHB		S2B	G5
ABNSB13040	ASIO FLAMMEUS	SHORT-EARED OWL	S1B	SHB	S1	G5
ABNSB15020	AEGOLIUS ACADICUS	NORTHERN SAW-WHET OWL	S1B			G5
ABNTA02020	CHORDEILES MINOR	COMMON NIGHTHAWK	S4B	S2B		G5
ABNTA07010	CAPRIMULGUS CAROLINENSIS	CHUCK-WILL'S-WIDOW		S3B		G5
ABNYF04040	MELANERPES ERYTHROCEPHALUS	RED-HEADED WOODPECKER		S1	S3	G5
ABNYF05010	SPHYRAPICUS VARIUS	YELLOW-BELLIED SAPSUCKER	SHB*			G5

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STATUS
ABNYF07040	PICOIDES VILLOSUS	HAIRY WOODPECKER		S3		G5
ABNYF12020	DRYOCOPUS PILEATUS	PILEATED WOODPECKER		S3		G5
ABPAE33030	EMPIDONAX ALNORUM	ALDER FLYCATCHER	S2B		S3	G5
ABPAE33040	EMPIDONAX TRAILLII	WILLOW FLYCATCHER		S3B		G5
ABPAT02010	EREMOPHILA ALPESTRIS	HORNED LARK			S3	G5
ABPAU08010	RIPARIA RIPARIA	BANK SWALLOW	S4B	S2B		G5
ABPAU09010	HIRUNDO PYRRHONOTA	CLIFF SWALLOW		S1B	S2	G5
ABPAV10110	CORVUS CORAX	COMMON RAVEN	S2		SU	G5
ABPAZ01010	SITTA CANADENSIS	RED-BREASTED NUTHATCH	S1B		S3	G5
ABPAZ01020	SITTA CAROLINENSIS	WHITE-BREASTED NUTHATCH		S3		G5
ABPAZ01040	SITTA PUSILLA	BROWN-HEADED NUTHATCH		S2		G5
ABPBA01010	CERTHIA AMERICANA	BROWN CREEPER		S1B		G5
ABPBG07010	THRYOMANES BEWICKII	BEWICK'S WREN	S1B			G5
ABPBG09050	TROGLODYTES TROGLODYTES	WINTER WREN	S2B			G5
ABPBG10010	CISTOTHORUS PLATENSIS	SEDGE WREN	S1B	S1B	S1	G5
ABPBJ05010	REGULUS SATRAPA	GOLDEN-CROWNED KINGLET	S2B			G5
ABPBJ18080	CATHARUS FUSCESCENS	VEERY		S2B		G5
ABPBR01030	LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	S1B	SHB	SN	G4
ABPBW01160	VIREO SOLITARIUS	BLUE-HEADED VIREO			S3	G5
ABPBW01170	VIREO FLAVIFRONS	YELLOW-THROATED VIREO		S3B		G5
ABPBW01210	VIREO GILVUS	WARBLING VIREO		S2B		G5
ABPBX01020	VERMIVORA PINUS	BLUE-WINGED WARBLER		S1B		G5
ABPBX01030	VERMIVORA CHRYSOPTERA	GOLDEN-WINGED WARBLER	S3B		S3	G4
ABPBX01060	VERMIVORA RUFICAPILLA	NASHVILLE WARBLER	S2B		S3	G5
ABPBX02010	PARULA AMERICANA	NORTHERN PARULA		S1B	S3	G5
ABPBX03020	DENDROICA PENSYLVANICA	CHESTNUT-SIDED WARBLER		S1B		G5
ABPBX03120	DENDROICA FUSCA	BLACKBURNIAN WARBLER	S2B			G5
ABPBX03130	DENDROICA DOMINICA	YELLOW-THROATED WARBLER		S2B		G5
ABPBX03240	DENDROICA CERULEA	CERULEAN WARBLER	S4B	S1B		G4
ABPBX05010	MNIOTILTA VARIA	BLACK-AND-WHITE WARBLER		S3B		G5

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STATUS
ABPBX06010	SETOPHAGA RUTICILLA	AMERICAN REDSTART		S1B		G5
ABPBX07010	PROTONOTARIA CITREA	PROTHONOTARY WARBLER			S3	G5
ABPBX08010	HELMITHEROS VERMIVORUS	WORM-EATING WARBLER		S3B		G5
ABPBX09010	LIMNOTHLYPIS SWAINSONII	SWAINSON'S WARBLER	S1B	SHB		G4
ABPBX10020	SEIURUS NOVEBORACENSIS	NORTHERN WATERTHRUSH	S3B			G5
ABPBX10030	SEIURUS MOTACILLA	LOUISIANA WATERTHRUSH		S3B		G5
ABPBX11010	OPORORNIS FORMOSUS	KENTUCKY WARBLER		S3B		G5
ABPBX11030	OPORORNIS PHILADELPHIA	MOURNING WARBLER	S1B			G5
ABPBX16010	WILSONIA CITRINA	HOODED WARBLER		S1B		G5
ABPBX16030	WILSONIA CANADENSIS	CANADA WARBLER	S3B			G5
ABPBX45030	PIRANGA RUBRA	SUMMER TANAGER		S3B		G5
ABPBX65010	SPIZA AMERICANA	DICKCISSEL	S2B			G5
ABPBX95010	POOECETES GRAMINEUS	VESPER SPARROW	S4B	S3B	S2	G5
ABPBX99010	PASSERCULUS SANDWICHENSIS	SAVANNAH SPARROW	S4B		S2	G5
ABPBXA0020	AMMODRAMUS SAVANNARUM	GRASSHOPPER SPARROW		S3B	S2	G5
ABPBXA0030	AMMODRAMUS HENSLOWII	HENSLOW'S SPARROW	S2B	SHB	S1	G4
ABPBXA0050	AMMODRAMUS CAUDACUTUS	SHARP-TAILED SPARROW	S3B	S3B		G4
ABPBXA303N	MELOSPIZA GEORGIANA NIGRESCENS	COASTAL PLAIN SWAMP SPARROW	S2B	S3B		G5T3
ABPBXA5020	JUNCO HYEMALIS	DARK-EYED JUNCO	S2B		S3	G5
ABPBXA9010	DOLICHONYX ORYZIVORUS	BOBOLINK		SU	S2	G5
ABPBXB2020	STURNELLA MAGNA	EASTERN MEADOWLARK		S3	S4	G5
ABPBY04020	CARPODACUS PURPUREUS	PURPLE FINCH	S3B			G5

MD: S1B = HIGHLY STATE RARE BREEDER (<= 5 occurrences statewide); S2 = STATE RARE (6 to 20 occurrences)
MD: S2B = STATE RARE BREEDER; S3B = WATCH LIST BREEDER (21 to 100 occurrences); S4B = APPARENTLY SECURE BREEDER
MD: SHB = STATE HISTORIC BREEDER; SHB* = STATE HISTORIC BREEDER (recent breeding documented)
DE: S1 = EXTREMELY RARE (<= 5 occurrences); S1B = EXTREMELY RARE BREEDER; S2 = VERY RARE (6 to 20 occurrences)
DE: S2B = VERY RARE BREEDER; S3 = RARE TO UNCOMMON (21 to 100 occurrences); S3B = RARE TO UNCOMMON BREEDER
DE: SEB = STATE ENDANGERED BREEDER; SHB = STATE HISTORIC BREEDER; SU = STATUS UNCERTAIN
NJ: S1 = CRITICALLY IMPERILED (<= 5 occurrences); S2 = IMPERILED (6 to 20 occurrences); S2B = IMPERILED BREEDER
NJ: S3 = RARE (21 to 100 occurrences); S3B = RARE BREEDER; S4 = APPARENTLY SECURE IN STATE
NJ: SN = REGULARLY OCCURRING NON-BREEDING; SU = BELIEVED IMPERILED but STATUS UNCERTAIN

GLOBAL: G3 = VERY RARE AND LOCAL (21 to 100 occurrences); G4 = APPARENTLY SECURE GLOBALLY
GLOBAL: G5 = DEMONSTRABLY SECURE GLOBALLY; T = SUBSPECIES-LEVEL RANKING IN STATE

Rare Mammal Species:

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STA-TUS
AMABA01060	SOREX LONGIROSTRIS	SOUTHEASTERN SHREW	S3S4			G5
AMABA01150	SOREX PALUSTRIS	WATER SHREW	S1		SU	G5T3
AMABA01180	SOREX FUMEUS	SMOKY SHREW	S2S3			G5
AMABA01210	SOREX DISPAR	LONG-TAILED SHREW	S2		S1	G4
AMABA01251	SOREX HOYI WINNEMANA	SOUTHERN PYGMY SHREW	S2			G5T4
AMABA01253	SOREX HOYI THOMPSONI	NORTHEASTERN PYGMY SHREW			S?	G5T5
AMABA01270	SOREX FONTINALIS	MARYLAND SHREW		SU		G4Q
AMACC01100	MYOTIS SODALIS	SOCIAL MYOTIS	S1		S1	G2
AMACC01130	MYOTIS LEIBII	EASTERN SMALL-FOOTED MYOTIS	S1B	SU	S1	G3
AMAEB01050	SYLVILAGUS TRANSITIONALIS	NEW ENGLAND COTTONTAIL			SU	G4
AMAEB01090	SYLVILAGUS OBSCURUS	APPALACHIAN COTTONTAIL	S1			G4
AMAFB07042	SCIURUS NIGER CINEREUS	DELMARVA FOX SQUIRREL		S1	S1	G5T3
AMAFB08010	TAMIASCIURUS HUDSONICUS	RED SQUIRREL		S3		G5
AMAFB09020	GLAUCOMYS SABRINUS	NORTHERN FLYING SQUIRREL			SU	G5
AMAFE01010	CASTOR CANADENSIS	AMERICAN BEAVER		S3		G5
AMAFF01010	ORYZOMYS PALUSTRIS	MARSH RICE RAT		S3	S3	G5
AMAFF08100	NEOTOMA MAGISTER	ALLEGHENY WOODRAT	S1		S1	G3G4
AMAFF11091	MICROTUS CHROTORRHINUS CAROLINENSIS	SOUTHERN ROCK VOLE	S1			G4T3
AMAFF17010	SYNAPTOMYS COOPERI	SOUTHERN BOG LEMMING	S3		S2	G5
AMAFJ01010	ERETHIZON DORSATUM	COMMON PORCUPINE	S1S2			G5
AMAJB01010	URSUS AMERICANUS	BLACK BEAR	S3S4		S3	G5
AMAJF01020	MARTES PENNANTI	FISHER	*			G5
AMAJF02010	MUSTELA ERMINEA	ERMINE			SU	G5
AMAJF02020	MUSTELA NIVALIS	LEAST WEASEL	S2S3			G5
AMAJF02050	MUSTELA VISON	MINK		S3		G5

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STA-TUS	DE STA-TUS	NJ STA-TUS	GLOBAL STA-TUS
AMAJF05010	SPILOGALE PUTORIUS	EASTERN SPOTTED SKUNK	S1			G5
AMAJH03020	LYNX RUFUS	BOBCAT	S3		S3	G5

MD: S1 = HIGHLY STATE RARE (<= 5 occurrences statewide); S2 = STATE RARE (6 to 20 occurrences)
MD: S3 = WATCH LIST (21 to 100 occurrences); S1B = HIGHLY STATE RARE BREEDER
MD: S4 = APPARENTLY SECURE (> 100 occurrences); * RARE and thought to occur in state, but species not tracked by Natural Heritage Program
DE: S1 = EXTREMELY RARE (<= 5 occurrences); S3 = RARE TO UNCOMMON (21 to 100 occurrences); SU = STATUS UNCERTAIN
DE: SR = REPORTED from the state, but no evidence of occurrence
NJ: S1 = CRITICALLY IMPERILED (<= 5 occurrences); S2 = IMPERILED (6 to 20 occurrences)
NJ: S3 = RARE (21 to 100 occurrences); S? = SPECIES NOT YET RANKED; SU = BELIEVED IMPERILED but STATUS UNCERTAIN
GLOBAL: G2 = GLOBALLY RARE (6 to 20 occurrences); G3 = VERY RARE AND LOCAL (21 to 100 occurrences); G4 = APPARENTLY SECURE
GLOBAL: G5 = DEMONSTRABLY SECURE GLOBALLY; T = SUBSPECIES-LEVEL RANKING IN STATE; Q = QUESTIONABLE TAXONOMY

Rare Reptile Species:

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STATUS	DE STATUS	NJ STATUS	GLOBAL STATUS
ARAAA01010	CARETTA CARETTA	LOGGERHEAD	S1B		SN	G3
ARAAA02010	CHELONIA MYDAS	GREEN TURTLE	S1N	S?	SN	G3
ARAAA04010	LEPIDOCHELYS KEMPII	ATLANTIC RIDLEY	S1N		SN	G1
ARAAC01010	DERMOCHELYS CORIACEA	LEATHERBACK	S1		SN	G2
ARAAD02010	CLEMMYS GUTTATA	SPOTTED TURTLE		S3		G5
ARAAD02020	CLEMMYS INSCULPTA	WOOD TURTLE		SR	S3	G4
ARAAD02040	CLEMMYS MUHLENBERGII	BOG TURTLE	S2	S1	S2	G3
ARAAD05040	GRAPTEMYS GEOGRAPHICA	COMMON MAP TURTLE	S1		S3	G5
ARAAG01030	APALONE SPINIFERA	SPINY SOFTSHELL	S1			G5
ARACH01010	EUMECES ANTHRACINUS	COAL SKINK	SU			G5
ARACH01050	EUMECES FASCIATUS	FIVE-LINED SKINK			S3	G5
ARACH01080	EUMECES LATICEPS	BROADHEAD SKINK		SH		G5
ARACH03010	SCINCELLA LATERALIS	GROUND SKINK		S1	S4	G5
ARADB03010	CEMOPHORA COCCINEA	SCARLET SNAKE	S3	SH	SU	G5
ARADB13020	ELAPHE GUTTATA	CORN SNAKE		S1	S1	G5

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STATUS	DE STATUS	NJ STATUS	GLOBAL STATUS
ARADB14020	FARANCIA ERYTROGRAMMA	RAINBOW SNAKE	S1			G5
ARADB19020	LAMPROPELTIS GETULA	COMMON KINGSNAKE		S2		G5
ARADB19050	LAMPROPELTIS TRIANGULUM	MILK SNAKE		S2		G5
ARADB22020	NERODIA ERYTHROGASTER	PLAINBELLY WATER SNAKE	S2S3	S1		G5T5
ARADB23010	OPHEODRYS AESTIVUS	ROUGH GREEN SNAKE		S2		G5
ARADB26010	PITUOPHIS MELANOLEUCUS	PINE SNAKE	SH	SR	S3	G4
ARADB27040	REGINA SEPTEMVITTATA	QUEEN SNAKE		S1	SU	G5
ARADB34010	STORERIA DEKAYI	BROWN SNAKE		S3		G5
ARADB34030	STORERIA OCCIPITOMACULATA	REDBELLY SNAKE		S1		G5
ARADB36120	THAMNOPHIS SAURITUS	EASTERN RIBBON SNAKE		S2		G5
ARADB39020	VIRGINIA VALERIAE	SMOOTH EARTH SNAKE		S1	SU	G5
ARADB39022	VIRGINIA VALERIAE PULCHRA	MOUNTAIN EARTH SNAKE	S2			G5T3T4
ARADB47010	LIOCHLOROPHIS VERNALIS	SMOOTH GREEN SNAKE			S3	G5
ARADE01010	AGKISTRODON CONTORTRIX	COPPERHEAD		S1		G5
ARADE02040	CROTALUS HORRIDUS	TIMBER RATTLESNAKE	S3		S2	G4

MD: S1 = HIGHLY STATE RARE (<= 5 occurrences statewide); S2 = STATE RARE (6 to 20 occurrences)
MD: S3 = WATCH LIST (21 to 100 occurrences); S1B = HIGHLY STATE RARE BREEDER
MD: S1N = HIGHLY STATE RARE NON-BREEDER; SU = STATUS UNCERTAIN; SH = HISTORICAL
DE: S1 = EXTREMELY RARE (<= 5 occurrences); S2 = VERY RARE (6 to 20 occurrences)
DE: S3 = RARE TO UNCOMMON (21 to 100 occurrences); S? = SPECIES NOT YET RANKED
DE: SR = REPORTED from the state, but no evidence of occurrence
NJ: S1 = CRITICALLY IMPERILED (<= 5 occurrences); S2 = IMPERILED (6 to 20 occurrences)
NJ: S3 = RARE (21 to 100 occurrences); S4 = APPARENTLY SECURE IN STATE
NJ: SN = REGULARLY OCCURRING NON-BREEDING; SU = BELIEVED IMPERILED but STATUS UNCERTAIN
GLOBAL: G1 = HIGHLY GLOBALLY RARE (<= 5 occurrences); G2 = GLOBALLY RARE (6 to 20 occurrences)
GLOBAL: G3 = VERY RARE AND LOCAL (21 to 100 occurrences); G4 = APPARENTLY SECURE GLOBALLY
GLOBAL: G5 = DEMONSTRABLY SECURE GLOBALLY; T = SUBSPECIES-LEVEL RANKING IN STATE

Rare Amphibian Species:

ELEMENT CODE	SCIENTIFIC NAME	COMMON NAME	MD STATUS	DE STATUS	NJ STATUS	GLOBAL STATUS
AAAAA01050	AMBYSTOMA JEFFERSONIANUM	JEFFERSON SALAMANDER	S3		S3	G4
AAAAA01060	AMBYSTOMA LATERALE	BLUE-SPOTTED SALAMANDER			S1	G5
AAAAA01090	AMBYSTOMA MACULATUM	SPOTTED SALAMANDER		S2	S3	G5
AAAAA01100	AMBYSTOMA OPACUM	MARBLED SALAMANDER		S3	S3	G5
AAAAA01140	AMBYSTOMA TIGRINUM	TIGER SALAMANDER	S2	S1	S2	G5
AAAAC01010	CRYPTOBRANCHUS ALLEGANIENSIS	HELLBENDER	S1			G3G4
AAAAD01010	ANEIDES AENEUS	GREEN SALAMANDER	S2			G3G4
AAAAD05040	EURYCEA LONGICAUDA	LONGTAIL SALAMANDER		S1	S2	G5
AAAAD06020	GYRINOPHILUS PORPHYRITICUS	SPRING SALAMANDER			S3	G5
AAAAD08010	HEMIDACTYLIUM SCUTATUM	FOUR-TOED SALAMANDER		S1	S3	G5
AAAAD12220	PLETHODON WEHRLEI	WEHRLE'S SALAMANDER	S2			G5
AAAAD13010	PSEUDOTRITON MONTANUS	MUD SALAMANDER		S1	S1	G5
AAAAD13020	PSEUDOTRITON RUBER	RED SALAMANDER		S3	S4	G5
AAAAE01040	NECTURUS MACULOSUS	MUDPUPPY	S1			G5
AAABC01010	ACRIS CREPITANS	NORTHERN CRICKET FROG			S3	G5
AAABC02010	HYLA ANDERSONII	PINE BARRENS TREEFROG			S3	G4
AAABC02050	HYLA CHRYSOSCELIS	COPE'S GRAY TREEFROG		S2	S2	G5
AAABC02060	HYLA CINEREA	GREEN TREEFROG		S3		G5
AAABC02100	HYLA GRATIOSA	BARKING TREEFROG	S1	S1		G5
AAABC05010	PSEUDACRIS BRACHYPHONA	MOUNTAIN CHORUS FROG	S2			G5
AAABE01010	GASTROPHRYNE CAROLINENSIS	EASTERN NARROWMOUTH TOAD	S1S2			G5
AAABH01230	RANA VIRGATIPES	CARPENTER FROG	S2	S1		G5

MD: S1 = HIGHLY STATE RARE (<= 5 occurrences statewide); S2 = STATE RARE (6 to 20 occurrences)
MD: S3 = WATCH LIST (21 to 100 occurrences); S1B = HIGHLY STATE RARE BREEDER
DE: S1 = EXTREMELY RARE (<= 5 occurrences); S2 = VERY RARE (6 to 20 occurrences)
DE: S3 = RARE TO UNCOMMON (21 to 100 occurrences)
NJ: S1 = CRITICALLY IMPERILED (<= 5 occurrences); S2 = IMPERILED (6 to 20 occurrences)
NJ: S3 = RARE (21 to 100 occurrences); S4 = APPARENTLY SECURE IN STATE
GLOBAL: G3 = VERY RARE AND LOCAL (21 to 100 occurrences); G4 = APPARENTLY SECURE GLOBALLY
GLOBAL: G5 = DEMONSTRABLY SECURE GLOBALLY

APPENDIX I: ACCURACY OF INDIVIDUAL SPECIES MODELS BY MANAGEMENT AREA, BASED ON COMPARISON WITH CHECKLISTS (M = Match; C = Commission Error; O = Omission Error)

Bird Models:

SPECIES CODE	SPECIES NAME SCIENTIFIC / COMMON	Patuxent Research Refuge 5,200 ha	Black-water NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Prime Hook NWR 3,925 ha	Great Swamp NWR 3,076 ha	Edwin B. Forsythe NWR 17,400 ha	Eastern Neck NWR 925 ha	Wallkill River NWR 1,058 ha	Brandy-wine Creek S.P. 346 ha	Cape Henlop-en S.P. 1,599 ha	Trap Pond S.P. 697 ha	Delaware Seashore S.P. 1,150 ha
ABNCA02010	*Podilymbus podiceps* Pied-billed Grebe	M		M	M		C[d]	O[f]	C				
ABNFC01020	*Pelecanus occidentalis* Brown Pelican												
ABNFD01020	*Phalacrocorax auritus* Double-crested Cormorant		O	C			C[d]						
ABNGA01020	*Botaurus lentiginosus* American Bittern		M	M	C[d]	M	O[f]	O[f]	M	C			
ABNGA02010	*Ixobrychus exilis* Least Bittern	M	M	M	M	M	M	M	M	C	C		C
ABNGA04010	*Ardea herodias* Great Blue Heron	M	M	M	M	M	M	M	M	M	M	M	M
ABNGA05010	*Casmerodius albus* Great Egret	M	M	M	M		M	C[c]		C[c]	M		M
ABNGA06030	*Egretta thula* Snowy Egret		M	M	M		M	M		C[c]	M	C[c]	M
ABNGA06040	*Egretta caerulea* Little Blue Heron		M				M	C		C[c]	C[c]		C[d]

SPECIES CODE	SPECIES NAME SCIENTIFIC / COMMON	Patuxent Research Refuge 5,200 ha	Black-water NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Prime Hook NWR 3,925 ha	Great Swamp NWR 3,076 ha	Edwin B. Forsythe NWR 17,400 ha	Eastern Neck NWR 925 ha	Wallkill River NWR 1,058 ha	Brandy-wine Creek S.P. 346 ha	Cape Henlop-en S.P. 1,599 ha	Trap Pond S.P. 697 ha	Delaware Seashore S.P. 1,150 ha
ABNGA06050	*Egretta tricolor* Tricolored Heron		C				M	C			M		M
ABNGA07010	*Bubulcus ibis* Cattle Egret		M	C[c]			M	M		C[c]		C	M
ABNGA08010	*Butorides virescens* Green Heron	M	M	M	M	M	M	M	M	M	M	M	M
ABNGA11010	*Nycticorax nycticorax* Black-Crowned Night-Heron	C	M			C	M	C	C[c]	C	M	C[c]	M
ABNGA13010	*Nyctanassa violaceus* Yellow-Crowned Night-Heron						M						
ABNGE02010	*Plegadis falcinellus* Glossy Ibis		M	M			M			C		C	C[c]
ABNJB02040	*Cygnus olor* Mute Swan	C	M		M	M	M	M	M		M		C
ABNJB05030	*Branta canadensis* Canada Goose	M	M	M	M	M	M	C	M	M	C	M	C[d]
ABNJB09010	*Aix sponsa* Wood Duck	M	M	M	M	M	M	M	M	M	C	M	C
ABNJB10010	*Anas crecca* Green-Winged Teal					O	M		C				
ABNJB10040	*Anas rubripes* American Black Duck	M	M	M	M	M	M	M	M	C	M	M	M
ABNJB10060	*Anas platyrhynchos* Mallard	M	M	M	M	M	M	M	M	M	M	M	M

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ABNJB10130	*Anas discors* Blue-Winged Teal		M	M	C[b]	O	M	O[f]			C	C	C
ABNJB10150	*Anas clypeata* Northern Shoveler		O	O[b]			M						
ABNJB10160	*Anas strepera* Gadwall		M	M	M		M				C		M
ABNJB20010	*Lophodytes cucullatus* Hooded Merganser	M			M	M			M				
ABNJB21010	*Mergus merganser* Common Merganser								M				
ABNJB22010	*Oxyura jamaicensis* Ruddy Duck						O[f]						
ABNKA01010	*Coragyps atratus* Black Vulture	M	M	M	M	C	C	M	C	M	C	C	C
ABNKA02010	*Cathartes aura* Turkey Vulture	M	M	M	M	M	C	M	M	M	C	M	C
ABNKC01010	*Pandion haliaetus* Osprey		M	M	M		M	M			M		M
ABNKC10010	*Haliaeetus leucocephalus* Bald Eagle	O[f]	M	M	M		C	M			C	M	M
ABNKC11010	*Circus cyaneus* Northern Harrier		M	M	C[d]		M		M		C		
ABNKC12020	*Accipiter striatus* Sharp-Shinned Hawk								C				

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ABNKC12040	*Accipiter cooperii* Cooper's Hawk	M	O		M	M	C		M	C		C	
ABNKC12060	*Accipiter gentilis* Northern Goshawk												
ABNKC19030	*Buteo lineatus* Red-Shouldered Hawk	M	M	O	M	M		O[f]	C[d]	C		M	
ABNKC19050	*Buteo platypterus* Broad-Winged Hawk	M	C		C	M	M		M	M		C	
ABNKC19110	*Buteo jamaicensis* Red-Tailed Hawk	M	M	M	M	M	C[d]	M	M	M	M[d]	M	M
ABNKD06020	*Falco sparverius* American Kestrel	M	C	M	M	M	M	M	M	M	M[d]	C	C
ABNKD06070	*Falco peregrinus* Peregrine Falcon						M						
ABNLC07010	*Phasianus colchicus* Ring-Necked Pheasant	C	M	M	M	C	C	C[d]	M	M	M[d]	C[d]	C
ABNLC11010	*Bonasa umbellus* Ruffed Grouse					C[e]	M		M				
ABNLC14010	*Meleagris gallopavo* Wild Turkey	M	M	M	M	M		M	M	C	C	C	C

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ABNLC21020	*Colinus virginianus* Northern Bobwhite	M	M	M	M	C[e]	M	M		M	M	M	M
ABNME03040	*Laterallus jamaicensis* Black Rail		M	C[d]	O		C[d]						
ABNME05010	*Rallus longirostris* Clapper Rail		M	M	M		M	C			M		M
ABNME05020	*Rallus elegans* King Rail		M	M	M	M		M	M		M[d]		C
ABNME05030	*Rallus limicola* Virginia Rail		M	M	M	M	M	M	M	M	C	C	C
ABNME08020	*Porzana carolina* Sora	C[e]			O[f]	M	O[f]		M				
ABNME13010	*Gallinula chloropus* Common Moorhen	C	M	M	M	M	O[f]		M	C	C		
ABNME14020	*Fulica americana* American Coot			O	O[f]		O[f]		C				
ABNNB03070	*Charadrius melodus* Piping Plover						M				M		M
ABNNB03090	*Charadrius vociferus* Killdeer	M	M	M	M	M	M	M	M	M	M	M	M
ABNNC01010	*Haematopus palliatus* American Oystercatcher		O		C		M				M		M

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ABNND01010	*Himantopus mexicanus* Black-Necked Stilt			M	O[f]		C						
ABNNF02010	*Catoptrophorus semipalmatus* Willet		M	M	M		M	C			M		M
ABNNF04020	*Actitis macularia* Spotted Sandpiper	C			O[f]	M	M	C	M	M			
ABNNF06010	*Bartramia longicauda* Upland Sandpiper								M				
ABNNF18010	*Gallinago gallinago* Common Snipe					O			C[d]				
ABNNF19020	*Scolopax minor* American Woodcock	M	M	M	M	M	M	M	M	C[d]	M	M	C[d]
ABNNM03010	*Larus atricilla* Laughing Gull		O				M				M		M
ABNNM03120	*Larus argentatus* Herring Gull		M				M				M		M
ABNNM03210	*Larus marinus* Great Black-Backed Gull		M		C		M	C			M		M
ABNNM08010	*Sterna nilotica* Gull-Billed Tern						M						
ABNNM08020	*Sterna caspia* Caspian Tern						C[d]						
ABNNM08030	*Sterna maxima* Royal Tern		O[b]										
ABNNM08070	*Sterna hirundo* Common Tern		M		C		M	C			M		M

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ABNNM08090	*Sterna forsteri* Forster's Tern		M	M	O[f]		M				M		M
ABNNM08100	*Sterna antillarum* Least Tern		O[a]		C[d]		M				M		M
ABNNM14010	*Rynchops niger* Black Skimmer		O				M				O[e]		M
ABNPB01010	*Columba livia* Rock Dove	C[d]	M	M	M	M	C	M	M	M	M	M	M
ABNPB04040	*Zenaida macroura* Mourning Dove	M	M	M	M	M	M	M	M	M	M	M	M
ABNRB02010	*Coccyzus erythropthalmus* Black-Billed Cuckoo	C[d]	C	O	M	M	M	O[f]	M	M		C	
ABNRB02020	*Coccyzus americanus* Yellow-Billed Cuckoo	M	M	M	M	M	M	M	M	M	M[d]	M	C[d]
ABNSA01010	*Tyto alba* Common Barn-Owl	C	M	M	M	C	M	M	C	C	C	M	M
ABNSB01030	*Otus asio* Eastern Screech-Owl	M	M	M	M	M	M	M	M	M	C	M	M
ABNSB05010	*Bubo virginianus* Great Horned Owl	M	M	M	M	M	M	M	M	M	M	M	M
ABNSB12020	*Strix varia* Barred Owl	M	M	M	M	M	C	M	M	M	C	M	
ABNSB13010	*Asio otus* Long-Eared Owl					C			C[d]				
ABNSB13040	*Asio flammeus* Short-Eared Owl			C[b]									

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ABNSB15020	*Aegolius acadicus* Northern Saw-Whet Owl												
ABNTA02020	*Chordeiles minor* Common Nighthawk	C			M	C	C[d]	O[f]	M		M	C	M
ABNTA07010	*Caprimulgus carolinensis* Chuck-Will's-Widow	M	M		M		C	C			M	M	M
ABNTA07070	*Caprimulgus vociferus* Whip-Poor-Will	M	M	C	M	C	M	M	C[d]		M[d]	M	M
ABNUA03010	*Chaetura pelagica* Chimney Swift	M	M	C	M	M	C	M	M	M	M	M	C[d]
ABNUC45010	*Archilochus colubris* Ruby-Throated Hummingbird	M	M	M	M	M	C[d]	M	M	M	M	M	M
ABNXD01020	*Ceryle alcyon* Belted Kingfisher	M	C	M	M	M	M	M	M	M	C[d]	C[d]	C
ABNYF04040	*Melanerpes erythrocephalus* Red-Headed Woodpecker	C[d]	M		C	M	C		C		C	C	C
ABNYF04170	*Melanerpes carolinus* Red-Bellied Woodpecker	M	M	M	M	M	C[d]	M	M	M	M	M	M

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ABNYF05010	*Sphyrapicus varius* Yellow-Bellied Sapsucker												
ABNYF07030	*Picoides pubescens* Downy Woodpecker	M	M	M	M	M	M	M	M	M	M	M	M
ABNYF07040	*Picoides villosus* Hairy Woodpecker	M	M	M	M	M	C[d]	M	M	M	M[d]	M	M
ABNYF10020	*Colaptes auratus* Northern Flicker	M	M	M	M	M	M	M	M	M	M	M	M
ABNYF12020	*Dryocopus pileatus* Pileated Woodpecker	M	M		C	M		C	M	M		M	C
ABPAE32060	*Contopus virens* Eastern Wood Pewee	M	M	M	M	M	M	M	M	M	M	M	M
ABPAE33020	*Empidonax virescens* Acadian Flycatcher	M	M	M	M	M	C[d]	M	C[d]	M		M	C
ABPAE33030	*Empidonax alnorum* Alder Flycatcher					M			M				
ABPAE33040	*Empidonax traillii* Willow Flycatcher	C		M	M	M	C[d]		M	M	C		M
ABPAE33070	*Empidonax minimus* Least Flycatcher					M			M				

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ABPAE35020	*Sayornis phoebe* Eastern Phoebe	M	M	M	M	M	M	M	M	M	C	M	M
ABPAE43070	*Myiarchus crinitus* Great Crested Flycatcher	M	M	M	M	M	C[d]	M	M	M	M	M	M
ABPAE52060	*Tyrannus tyrannus* Eastern Kingbird	M	M	M	M	M	M	M	M	M	M	M	M
ABPAT02010	*Eremophila alpestris* Horned Lark	C	M	M	M		M	M	C[d]	C	C[d]	C[d]	C[d]
ABPAU01010	*Progne subis* Purple Martin	M	M	M	M	M	M	M	M	C	M[d]	C[d]	M
ABPAU03010	*Tachycineta bicolor* Tree Swallow	M	M	M	M	M	M	M	M	M	M	M	M
ABPAU07010	*Stelgidopteryx serripennis* Northern Rough-Winged Swallow	M	C	C	M	M	C[d]	M	M	M	C	M	C[c]
ABPAU08010	*Riparia riparia* Bank Swallow	M		C	O[f]	C	M	M	M				
ABPAU09010	*Hirundo pyrrhonota* Cliff Swallow	C[c]							M				
ABPAU09030	*Hirundo rustica* Barn Swallow	M	M	M	M	M	M	M	M	M	M	M	M
ABPAV02020	*Cyanocitta cristata* Blue Jay	M	M	M	M	M	M	M	M	M	M	M	M

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ABPAV10010	*Corvus brachyrhynchos* American Crow	M	M	M	M	M	M	M	M	M	M	M	C
ABPAV10080	*Corvus ossifragus* Fish Crow	M	M	M	M	M	M	M		M	M	M	M
ABPAV10110	*Corvus corax* Common Raven												
ABPAW01010	*Parus atricapillus* Black-Capped Chickadee					M			M				
ABPAW01020	*Parus carolinensis* Carolina Chickadee	M	M	M	M		M	M		M	M	M	M
ABPAW01110	*Parus bicolor* Tufted Titmouse	M	M	M	M	M	M	M	M	M	M	M	M
ABPAZ01010	*Sitta canadensis* Red-Breasted Nuthatch					C			C				
ABPAZ01020	*Sitta carolinensis* White-Breasted Nuthatch	M	M		C	M	M	M	M	M		C	
ABPAZ01040	*Sitta pusilla* Brown-Headed Nuthatch		M		C			M[d]			C	M	M
ABPBA01010	*Certhia americana* Brown Creeper	M				M			M	C		C	
ABPBG06130	*Thryothorus ludovicianus* Carolina Wren	M	M	M	M	M	M	M	M	M	M	M	M

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ABPBG07010	*Thryomanes bewickii* Bewick's Wren												
ABPBG09010	*Troglodytes aedon* House Wren	M	M	M	M	M	M	M	M	M	M	M	M
ABPBG09050	*Troglodytes troglodytes* Winter Wren								C				
ABPBG10010	*Cistothorus platensis* Sedge Wren		O[a]	M		C[e]		O[f]	O[f]		C		C[d]
ABPBG10020	*Cistothorus palustris* Marsh Wren	C	M	M	M	M	M	M	M		M		M
ABPBJ05010	*Regulus satrapa* Golden-Crowned Kinglet								C				
ABPBJ08010	*Polioptila caerulea* Blue-Gray Gnatcatcher	M	M	M	M	M	C[d]	M	M	M	C	M	M
ABPBJ15010	*Sialia sialis* Eastern Bluebird	M	M	M	M	M	C[d]	M	M	M	M	M	M
ABPBJ18080	*Catharus fuscescens* Veery	C				M	C[d]		M	M			
ABPBJ18110	*Catharus guttatus* Hermit Thrush								C[d]				
ABPBJ19010	*Hylocichla mustelina* Wood Thrush	M	M	M	M	M	M	M	M	M	M	M	M

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ABPBJ20170	*Turdus migratorius* American Robin	M	M	M	M	M	M	M	M	M	M	M	M
ABPBK01010	*Dumetella carolinensis* Gray Catbird	M	M	M	M	M	M	M	M	M	M	M	M
ABPBK03010	*Mimus polyglottos* Northern Mockingbird	M	M	M	M	M	M	M	M	M	M	M	M
ABPBK06010	*Toxostoma rufum* Brown Thrasher	M	M	M	M	M	M	M	M	M	M	M	M
ABPBN01020	*Bombycilla cedrorum* Cedar Waxwing	M	M	M	M	M	C[d]	M	M	M	C	M	M
ABPBR01030	*Lanius ludovicianus* Loggerhead Shrike												
ABPBT01010	*Sturnus vulgaris* European Starling	M	M	M	M	M	M	M	M	M	M	M	M
ABPBW01020	*Vireo griseus* White-Eyed Vireo	M	M	M	M	M	M	M	M	M	M	M	M
ABPBW01160	*Vireo solitarius* Blue-Headed Vireo					C			C				
ABPBW01170	*Vireo flavifrons* Yellow-Throated Vireo	M	C	O	M	M		O[f]	M	M		M	
ABPBW01210	*Vireo gilvus* Warbling Vireo	C				M		M	M	M			
ABPBW01240	*Vireo olivaceus* Red-Eyed Vireo	M	M	M	M	M	M	M	M	M	M	M	M

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ABPBX01020	*Vermivora pinus* Blue-Winged Warbler	C				M	C[d]		M	M			
ABPBX01030	*Vermivora chrysoptera* Golden-Winged Warbler								O[a]				
ABPBX01060	*Vermivora ruficapilla* Nashville Warbler												
ABPBX02010	*Parula americana* Northern Parula	M	C		C		C[d]	O[f]	C[d]	C[d]		M	
ABPBX03010	*Dendroica petechia* Yellow Warbler	M	M	M	M	M	M	M	M	M	M	M	M
ABPBX03020	*Dendroica pensylvanica* Chestnut-Sided Warbler					M			M				
ABPBX03030	*Dendroica magnolia* Magnolia Warbler												
ABPBX03050	*Dendroica caerulescens* Black-Throated Blue Warbler												
ABPBX03060	*Dendroica coronata* Yellow-Rumped Warbler												

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ABPBX03100	*Dendroica virens* Black-Throated Green Warbler						C[d]		C[d]				
ABPBX03120	*Dendroica fusca* Blackburnian Warbler								C				
ABPBX03130	*Dendroica dominica* Yellow-Throated Warbler	M	M		M	C	C	M		C	C	M	C
ABPBX03170	*Dendroica pinus* Pine Warbler	M	M	C	M	C	M	M	C	C	M	M	M
ABPBX03190	*Dendroica discolor* Prairie Warbler	M	M	C	M	C	C[d]	M	M	M	M	M	M
ABPBX03240	*Dendroica cerulea* Cerulean Warbler	O[f]							M				
ABPBX05010	*Mniotilta varia* Black-And-White Warbler	M	M	C	M	M	M	O[f]	M	M	M	M	M
ABPBX06010	*Setophaga ruticilla* American Redstart	M	C	O	O[f]	M	C[d]		M	O[f]		M	
ABPBX07010	*Protonotaria citrea* Prothonotary Warbler	M	M	M	M	M	C	M	O[f]			M	C
ABPBX08010	*Helmitheros vermivorus* Worm-Eating Warbler	M	M		C	C			M	M		M	

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ABPBX09010	*Limnothlypis swainsonii* Swainson's Warbler												
ABPBX10010	*Seiurus aurocapillus* Ovenbird	M	M	C	M	M	M	M	M	M	M	M	M
ABPBX10020	*Seiurus noveboracensis* Northern Waterthrush					M			M				
ABPBX10030	*Seiurus motacilla* Louisiana Waterthrush	M	C	O	C[d]	M		M	M	M		M	
ABPBX11010	*Oporornis formosus* Kentucky Warbler	M	M	M	M	C		O[f]	M	M	C	M	C
ABPBX11030	*Oporornis philadelphia* Mourning Warbler												
ABPBX12010	*Geothlypis trichas* Common Yellowthroat	M	M	M	M	M	M	M	M	M	M	M	M
ABPBX16010	*Wilsonia citrina* Hooded Warbler	M				C	M		M	C[d]		M	
ABPBX16030	*Wilsonia canadensis* Canada Warbler					C			M				
ABPBX24010	*Icteria virens* Yellow-Breasted Chat	M	M	M	M	M	M	M	M	M	M	M	C

SPECIES CODE	SPECIES NAME SCIENTIFIC / COMMON	Patuxent Research Refuge 5,200 ha	Black-water NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Prime Hook NWR 3,925 ha	Great Swamp NWR 3,076 ha	Edwin B. Forsythe NWR 17,400 ha	Eastern Neck NWR 925 ha	Wallkill River NWR 1,058 ha	Brandy-wine Creek S.P. 346 ha	Cape Henlop-en S.P. 1,599 ha	Trap Pond S.P. 697 ha	Delaware Seashore S.P. 1,150 ha
ABPBX45030	*Piranga rubra* Summer Tanager	M	M		M	C		M			C	M	C
ABPBX45040	*Piranga olivacea* Scarlet Tanager	M	M	M	M	M	M	M	M	M	C	M	C
ABPBX60010	*Cardinalis cardinalis* Northern Cardinal	M	M	M	M	M	M	M	M	M	M	M	M
ABPBX61030	*Pheucticus ludovicianus* Rose-Breasted Grosbeak					M			M				
ABPBX63010	*Guiraca caerulea* Blue Grosbeak	M	M	M	M	C	C[d]	M	O[f]	M	M	M	M
ABPBX64030	*Passerina cyanea* Indigo Bunting	M	M	M	M	M	M	M	M	M	C	M	M
ABPBX65010	*Spiza americana* Dickcissel												
ABPBX74030	*Pipilo erythrophthalmus* Eastern Towhee	M	M	M	M	M	M	M	M	M	M	M	M
ABPBX94020	*Spizella passerina* Chipping Sparrow	M	M	M	M	M	M	M	M	M	M	M	M
ABPBX94050	*Spizella pusilla* Field Sparrow	M	M	M	M	M	C[d]	M	M	M	M	M	M
ABPBX95010	*Pooecetes gramineus* Vesper Sparrow	C			C				C		C	C[d]	

SPECIES CODE	SPECIES NAME SCIENTIFIC / COMMON	Patuxent Research Refuge 5,200 ha	Black-water NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Prime Hook NWR 3,925 ha	Great Swamp NWR 3,076 ha	Edwin B. Forsythe NWR 17,400 ha	Eastern Neck NWR 925 ha	Wallkill River NWR 1,058 ha	Brandy-wine Creek S.P. 346 ha	Cape Henlop-en S.P. 1,599 ha	Trap Pond S.P. 697 ha	Delaware Seashore S.P. 1,150 ha
ABPBX99010	*Passerculus sandwichensis* Savannah Sparrow								M				
ABPBXA0020	*Ammodramus savannarum* Grasshopper Sparrow	M	M	M	M	C	M	M	M	M		C	C
ABPBXA0030	*Ammodramus henslowii* Henslow's Sparrow		O					[e]					
ABPBXA0050	*Ammodramus caudacutus* Sharp-Tailed Sparrow		M	M	M		M				C		M
ABPBXA0060	*Ammodramus maritimus* Seaside Sparrow		M	M	M		M	M			M		M
ABPBXA3010	*Melospiza melodia* Song Sparrow	M	M	M	M	M	M	M	M	M	M	M	M
ABPBXA3030	*Melospiza georgiana* Swamp Sparrow		C	M	M	M	M		M		C		
ABPBXA4020	*Zonotrichia albicollis* White-Throated Sparrow												
ABPBXA5020	*Junco hyemalis* Dark-Eyed Junco												
ABPBXA9010	*Dolichonyx oryzivorus* Bobolink					M			M				

SPECIES CODE	SPECIES NAME SCIENTIFIC / COMMON	Patuxent Research Refuge 5,200 ha	Black-water NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Prime Hook NWR 3,925 ha	Great Swamp NWR 3,076 ha	Edwin B. Forsythe NWR 17,400 ha	Eastern Neck NWR 925 ha	Wallkill River NWR 1,058 ha	Brandy-wine Creek S.P. 346 ha	Cape Henlop-en S.P. 1,599 ha	Trap Pond S.P. 697 ha	Delaware Seashore S.P. 1,150 ha
ABPBXB0010	*Agelaius phoeniceus* Red-Winged Blackbird	M	M	M	M	M	M	M	M	M	M	M	M
ABPBXB2020	*Sturnella magna* Eastern Meadowlark	M	M	M	M	M	M	M	M	M	C	C	M
ABPBXB6060	*Quiscalus major* Boat-Tailed Grackle		M	C	M		M				M		M
ABPBXB6070	*Quiscalus quiscula* Common Grackle	M	M	M	M	M	M	M	M	M	M	M	M
ABPBXB7030	*Molothrus ater* Brown-Headed Cowbird	M	M	M	M	M	M	M	M	M	M	M	M
ABPBXB9070	*Icterus spurius* Orchard Oriole	M	M	M	M	M	M	M	M	M	C	M	M
ABPBXB9190	*Icterus galbula* Baltimore Oriole	M	C	M	M	M	C[d]	M	M	M	C	M	M
ABPBY04020	*Carpodacus purpureus* Purple Finch					C			M				
ABPBY04040	*Carpodacus mexicanus* House Finch	M	C	M	M	M	M	C[d]	M	M	M	M	M
ABPBY06030	*Carduelis pinus* Pine Siskin	M[d]											
ABPBY06110	*Carduelis tristis* American Goldfinch	M	M	M	M	M	M	M	M	M	M	M	M
ABPBZ01010	*Passer domesticus* House Sparrow	M	M	M	M	M	M	M	M	M	M	M	M

[a]Checklist states that these are species that nest "on or near" the Refuge; model results indicate that this species nests within a short distance of the Refuge
[b]Rare or sporadic nester
[c]Species is known to forage within area during nesting season; therefore, this area is considered part of species' breeding habitat even though species has not been documented nesting within managed area boundaries
[d]Checklist is known to be wrong, or is likely wrong -- Breeding Bird Atlas or other ground surveys documented recent, confirmed or probable nesting in this area
[e]Species has apparently been extirpated from area
[f]No "probable" or "confirmed" breeding records in Breeding Bird Atlas

Mammal Models:

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
AMAAA01010	*Didelphis virginiana*	Virginia Opossum	M	M	M
AMABA01010	*Sorex cinereus*	Masked Shrew	M	M	M
AMABA01060	*Sorex longirostris*	Southeastern Shrew			
AMABA01150	*Sorex palustris*	Water Shrew			
AMABA01180	*Sorex fumeus*	Smoky Shrew			M
AMABA01210	*Sorex dispar*	Long-Tailed Shrew			
AMABA01250	*Sorex hoyi*	Pygmy Shrew			
AMABA01270	*Sorex fontinalis*	Maryland Shrew			
AMABA03010	*Blarina brevicauda*	Northern Short-Tailed Shrew	M	M	M
AMABA04010	*Cryptotis parva*	Least Shrew	M	M	
AMABB03010	*Parascalops breweri*	Hairy-Tailed Mole			
AMABB04010	*Scalopus aquaticus*	Eastern Mole	M	M	C[d]
AMABB05010	*Condylura cristata*	Star-Nosed Mole	M	M	M
AMACC01010	*Myotis lucifugus*	Little Brown Myotis	M	M	M
AMACC01100	*Myotis sodalis*	Social Myotis			C
AMACC01130	*Myotis leibii*	Eastern Small-Footed Myotis			
AMACC01150	*Myotis septentrionalis*	Northern Myotis	C[b]	C	C
AMACC02010	*Lasionycteris noctivagans*	Silver-Haired Bat	C[b]	M	C
AMACC03020	*Pipistrellus subflavus*	Eastern Pipistrelle	C[b]	M	C[d]
AMACC04010	*Eptesicus fuscus*	Big Brown Bat	C[b]	M	C[d]

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
AMACC05010	*Lasiurus borealis*	Eastern Red Bat	M	M	M
AMACC05030	*Lasiurus cinereus*	Hoary Bat	C[b]	M	C
AMACC06010	*Nycticeius humeralis*	Evening Bat	C[b]	C	
AMACC08010	*Corynorhinus townsendii*	Townsend's Big-Eared Bat			
AMAEB01040	*Sylvilagus floridanus*	Eastern Cottontail	M	M	M
AMAEB01050	*Sylvilagus transitionalis*	New England Cottontail			C
AMAEB01090	*Sylvilagus obscurus*	Appalachian Cottontail			
AMAFB02230	*Tamias striatus*	Eastern Chipmunk	C[d]	M	M
AMAFB03010	*Marmota monax*	Woodchuck	M[c]	M	M
AMAFB07010	*Sciurus carolinensis*	Eastern Gray Squirrel	M	M	M
AMAFB07040	*Sciurus niger*	Eastern Fox Squirrel	M		
AMAFB08010	*Tamiasciurus hudsonicus*	Red Squirrel			M
AMAFB09010	*Glaucomys volans*	Southern Flying Squirrel	M	M	M
AMAFB09020	*Glaucomys sabrinus*	Northern Flying Squirrel			
AMAFE01010	*Castor canadensis*	American Beaver	C	M	M
AMAFF01010	*Oryzomys palustris*	Marsh Rice Rat	M	M	
AMAFF03040	*Peromyscus maniculatus*	Deer Mouse			
AMAFF03070	*Peromyscus leucopus*	White-Footed Mouse	M	M	M
AMAFF08100	*Neotoma magister*	Allegheny Woodrat			
AMAFF09020	*Clethrionomys gapperi*	Southern Red-Backed Vole			O
AMAFF11010	*Microtus pennsylvanicus*	Meadow Vole	M	M	M
AMAFF11090	*Microtus chrotorrhinus*	Rock Vole			
AMAFF11150	*Microtus pinetorum*	Woodland Vole	M	M	M
AMAFF15010	*Ondatra zibethicus*	Muskrat	M	M	M
AMAFF17010	*Synaptomys cooperi*	Southern Bog Lemming	C[b]	C	C
AMAFF21010	*Rattus rattus*	Black Rat	M	C	
AMAFF21020	*Rattus norvegicus*	Norway Rat	M	M	C[d]
AMAFF22010	*Mus musculus*	House Mouse	M	M	M
AMAFH01010	*Zapus hudsonius*	Meadow Jumping Mouse	C[b]	M	M
AMAFH02010	*Napaeozapus insignis*	Woodland Jumping Mouse			O
AMAFJ01010	*Erethizon dorsatum*	Common Porcupine			

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
AMAFK01010	*Myocastor coypus*	Nutria	M		
AMAJA01010	*Canis latrans*	Coyote	C[a]	C[a]	M
AMAJA03010	*Vulpes vulpes*	Red Fox	M	M	M
AMAJA04010	*Urocyon cinereoargenteus*	Common Gray Fox	M	M	M
AMAJB01010	*Ursus americanus*	Black Bear			M
AMAJE02010	*Procyon lotor*	Common Raccoon	M	M	M
AMAJF01020	*Martes pennanti*	Fisher			
AMAJF02010	*Mustela erminea*	Ermine			C
AMAJF02020	*Mustela nivalis*	Least Weasel			
AMAJF02030	*Mustela frenata*	Long-Tailed Weasel	M	M	M
AMAJF02050	*Mustela vison*	Mink	M	M	M
AMAJF05010	*Spilogale putorius*	Eastern Spotted Skunk			
AMAJF06010	*Mephitis mephitis*	Striped Skunk	M	M	M
AMAJF10010	*Lutra canadensis*	Northern River Otter	M	M	M
AMAJH03020	*Lynx rufus*	Bobcat			C
AMATA01010	*Equus caballus*	Feral Horse			
AMALC01050	*Cervus nippon*	Sika Deer	M		
AMALC02020	*Odocoileus virginianus*	White-Tailed Deer	M	M	M

[a]Species has greatly expanded its range in recent years; this checklist is 13 years old
[b]One of several species thought to occur, based on reported range, but which has not been officially documented within this area
[c]This is a common species which should be on the checklist; has been documented by R. McCorkle on this Refuge
[d]This is a common species which should be on the checklist but is not for unknown reasons

Reptile Models:

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Patuxent Research Refuge 5,160 ha	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
ARAAA01010	*Caretta caretta*	Loggerhead		C[c]		
ARAAA02010	*Chelonia mydas*	Green Turtle				

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Patuxent Research Refuge 5,160 ha	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
ARAAA04010	*Lepidochelys kempii*	Atlantic Ridley				
ARAAB01010	*Chelydra serpentina*	Snapping Turtle	M	M	M	M
ARAAC01010	*Dermochelys coriacea*	Leatherback		C[c]		
ARAAD01010	*Chrysemys picta*	Painted Turtle	M	M	M	M
ARAAD02010	*Clemmys guttata*	Spotted Turtle	M	M	M	M
ARAAD02020	*Clemmys insculpta*	Wood Turtle	C			M
ARAAD02040	*Clemmys muhlenbergii*	Bog Turtle				M
ARAAD05040	*Graptemys geographica*	Common Map Turtle				
ARAAD06010	*Malaclemys terrapin*	Diamondback Terrapin		M	M	
ARAAD07050	*Pseudemys rubiventris*	Red-Bellied Turtle	M	M	M	
ARAAD08010	*Terrapene carolina*	Eastern Box Turtle	M	M	M	M
ARAAD09010	*Trachemys scripta*	Slider	O		C	C
ARAAE01050	*Kinosternon subrubrum*	Eastern Mud Turtle	M	M	M	O
ARAAE02040	*Sternotherus odoratus*	Common Musk Turtle	M	M	M	M
ARAAG01030	*Apalone spinifera*	Spiny Softshell				
ARACF14130	*Sceloporus undulatus*	Fence Lizard	M	M	M	
ARACH01010	*Eumeces anthracinus*	Coal Skink				
ARACH01050	*Eumeces fasciatus*	Five-Lined Skink	M	M	M	M
ARACH01080	*Eumeces laticeps*	Broadhead Skink	M	O[b]		
ARACH03010	*Scincella lateralis*	Ground Skink	M	M		
ARACJ02110	*Cnemidophorus sexlineatus*	Six-Lined Racerunner	M			
ARADB02010	*Carphophis amoenus*	Worm Snake	M	M	M	M
ARADB03010	*Cemophora coccinea*	Scarlet Snake	C			
ARADB07010	*Coluber constrictor*	Racer	M	M	M	M
ARADB10010	*Diadophis punctatus*	Ringneck Snake	M	M	M	M
ARADB13020	*Elaphe guttata*	Corn Snake	C	M		
ARADB13030	*Elaphe obsoleta*	Rat Snake	M	M	M	M
ARADB14020	*Farancia erytrogramma*	Rainbow Snake				
ARADB17020	*Heterodon platirhinos*	Eastern Hognose Snake	M	M	M	M

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Patuxent Research Refuge 5,160 ha	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
ARADB19010	*Lampropeltis calligaster*	Prairie Kingsnake	C[d]			
ARADB19020	*Lampropeltis getula*	Common Kingsnake	M	M	M	
ARADB19050	*Lampropeltis triangulum*	Milk Snake	M	O	M	M
ARADB22020	*Nerodia erythrogaster*	Plainbelly Water Snake		M		
ARADB22060	*Nerodia sipedon*	Northern Water Snake	M	M	M	M
ARADB23010	*Opheodrys aestivus*	Rough Green Snake	M	M	M	
ARADB26010	*Pituophis melanoleucus*	Pine Snake				
ARADB27040	*Regina septemvittata*	Queen Snake	M			
ARADB34010	*Storeria dekayi*	Brown Snake	M	C	C[d]	M
ARADB34030	*Storeria occipitomaculata*	Redbelly Snake	C[d]	C	C	C
ARADB36120	*Thamnophis sauritus*	Eastern Ribbon Snake	M	M	M	M
ARADB36130	*Thamnophis sirtalis*	Common Garter Snake	M	M	M	M
ARADB39020	*Virginia valeriae*	Smooth Earth Snake	M	M[a]		M
ARADB47010	*Liochlorophis vernalis*	Smooth Green Snake				M
ARADE01010	*Agkistrodon contortrix*	Copperhead	C[d]	M		C
ARADE02040	*Crotalus horridus*	Timber Rattlesnake				

[a]Checklist includes rough earth snake, *Virginia striatula*, which does not occur in Maryland
[b]Reptiles and Amphibians check-list for Blackwater NWR states that "all turtles and snakes in this list have been identified on Blackwater Refuge by refuge staff. The occurrence of some of the more rare and secretive skinks, salamanders, frogs, and toads has not been fully substantiated."
[c]Sea turtles occurring only in estuarine open water habitats may not have been documented in surveys but may occur in these habitats within surveyed areas
[d]Species thought to possibly occur within boundaries of managed area, but not documented to date or in recent years

Amphibian Models:

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Patuxent Research Refuge 5,160 ha	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
AAAAA01050	*Ambystoma jeffersonianum*	Jefferson Salamander				C
AAAAA01060	*Ambystoma laterale*	Blue-Spotted Salamander				M
AAAAA01090	*Ambystoma maculatum*	Spotted Salamander	M	O[a]	M	C
AAAAA01100	*Ambystoma opacum*	Marbled Salamander	M	M	M	C
AAAAA01110	*Ambystoma platineum*	Silvery Salamander				
AAAAA01140	*Ambystoma tigrinum*	Tiger Salamander				
AAAAA01150	*Ambystoma tremblayi*	Tremblay's Salamander				
AAAAC01010	*Cryptobranchus alleganiensis*	Hellbender				
AAAAD01010	*Aneides aeneus*	Green Salamander				
AAAAD03040	*Desmognathus fuscus*	Dusky Salamander	M			M
AAAAD03060	*Desmognathus monticola*	Seal Salamander				
AAAAD03070	*Desmognathus ochrophaeus*	Mountain Dusky Salamander				
AAAAD05010	*Eurycea bislineata*	N. Two-Lined Salamander	M	C		C
AAAAD05040	*Eurycea longicauda*	Longtail Salamander	C[c]			C
AAAAD06020	*Gyrinophilus porphyriticus*	Spring Salamander				C
AAAAD08010	*Hemidactylium scutatum*	Four-Toed Salamander	M	C	C	M
AAAAD12020	*Plethodon cinereus*	Redback Salamander	M	M	M	M
AAAAD12070	*Plethodon glutinosus*	Slimy Salamander				M
AAAAD12080	*Plethodon hoffmani*	Valley And Ridge Salamander				
AAAAD12220	*Plethodon wehrlei*	Wehrle's Salamander				
AAAAD13010	*Pseudotriton montanus*	Mud Salamander	M	O[a]		
AAAAD13020	*Pseudotriton ruber*	Red Salamander	M	C	C[c]	C
AAAAE01040	*Necturus maculosus*	Mudpuppy				
AAAAF01030	*Notophthalmus viridescens*	Eastern Newt	M	M	C	M
AAABB01020	*Bufo americanus*	American Toad	M	M		M
AAABB01210	*Bufo fowleri*	Fowler's Toad	M	M	M	M
AAABC01010	*Acris crepitans*	Northern Cricket Frog	M	M	M	M
AAABC02010	*Hyla andersonii*	Pine Barrens Treefrog				

SPECIES CODE	SCIENTIFIC NAME	COMMON NAME	Patuxent Research Refuge 5,160 ha	Blackwater NWR 7,750 ha	Bombay Hook NWR 6,466 ha	Great Swamp NWR 3,076 ha
AAABC02050	*Hyla chrysoscelis*	Cope's Gray Treefrog	C[b]	C[b]	C[c]	
AAABC02060	*Hyla cinerea*	Green Treefrog		M	M	
AAABC02100	*Hyla gratiosa*	Barking Treefrog				
AAABC02130	*Hyla versicolor*	Gray Treefrog	M	O[b]	M	M
AAABC05010	*Pseudacris brachyphona*	Mountain Chorus Frog				
AAABC05070	*Pseudacris triseriata*	Western Chorus Frog	M	M	M	M
AAABC05090	*Pseudacris crucifer*	Spring Peeper	M	M	M	M
AAABE01010	*Gastrophryne carolinensis*	Eastern Narrowmouth Toad		O[a]		
AAABF01040	*Scaphiopus holbrookii*	Eastern Spadefoot	M	M	C[c]	
AAABH01070	*Rana catesbeiana*	Bullfrog	M	M	M	M
AAABH01090	*Rana clamitans*	Green Frog	M	M	M	M
AAABH01160	*Rana palustris*	Pickerel Frog	M	M	M	M
AAABH01200	*Rana sylvatica*	Wood Frog	M	C	M	M
AAABH01220	*Rana sphenocephala*	Southern Leopard Frog	M	M	M	M
AAABH01230	*Rana virgatipes*	Carpenter Frog				

[a]Reptiles and Amphibians check-list for Blackwater NWR states that "all turtles and snakes in this list have been identified on Blackwater Refuge by refuge staff. The occurrence of some of the more rare and secretive skinks, salamanders, frogs, and toads has not been fully substantiated."

[b]Hyla versicolor (gray treefrog) included in list but Hyla chrysoscelis (Cope's gray treefrog) not included (the two have overlapping ranges, are almost indistinguishable in the field, and their relative ranges are poorly understood)

[c]thought to occur in managed area, but not documented to date or in recent years

APPENDIX J: Gap Analysis of Vertebrate Species by Stewardship Area (Total Project Area Size = 5,039,474 ha)

AMPHIBIANS SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Jefferson Salamander	aaaaa01050	0	10446	18665	70482	10446	99593	0.00	10.49	1.98
Blue-spotted Salamander	aaaaa01060	0	5311	9711	19583	5311	34604	0.00	15.35	0.69
Spotted Salamander	aaaaa01090	0	12587	28330	133695	12587	174612	0.00	7.21	3.46
Marbled Salamander	aaaaa01100	0	39616	83210	517910	39616	640736	0.00	6.18	12.71
Tiger Salamander	aaaaa01140	0	6828	20406	73619	6828	100854	0.00	6.77	2.00
Hellbender	aaaac01010	0	160	253	3188	160	3601	0.00	4.45	0.07
Green Salamander	aaaad01010	0	5	299	1692	5	1996	0.00	0.26	0.04
Dusky Salamander	aaaad03040	0	10854	28874	176984	10854	216712	0.00	5.01	4.30
Seal Salamander	aaaad03060	0	441	2420	11665	441	14526	0.00	3.04	0.29
Mountain Dusky Salamander	aaaad03070	0	6154	18231	55297	6154	79682	0.00	7.72	1.58
Northern Two-lined Salamander	aaaad05010	0	33171	94980	614126	33171	742276	0.00	4.47	14.73
Longtail Salamander	aaaad05040	0	30110	72998	329966	30110	433075	0.00	6.95	8.59
Spring Salamander	aaaad06020	0	12003	26588	107749	12003	146340	0.00	8.20	2.90
Four-toed Salamander	aaaad08010	0	33302	111075	521709	33302	666086	0.00	5.00	13.22
Redback Salamander	aaaad12020	0	95081	298713	1562204	95081	1955998	0.00	4.86	38.81
Slimy Salamander	aaaad12070	0	48899	101891	540734	48899	691524	0.00	7.07	13.72
Valley and Ridge Salamander	aaaad12080	0	5167	21609	52741	5167	79517	0.00	6.50	1.58
Wehrle's Salamander	aaaad12220	0	3367	9544	51669	3367	64580	0.00	5.21	1.28
Mud Salamander	aaaad13010	0	10571	13632	117180	10571	141384	0.00	7.48	2.81
Red Salamander	aaaad13020	0	40594	106484	840911	40594	987989	0.00	4.11	19.61
Mudpuppy	aaaae01040	0	42	408	2887	42	3337	0.00	1.26	0.07
Eastern Newt	aaaaf01030	0	50329	129954	562013	50329	742296	0.00	6.78	14.73
American Toad	aaabb01020	0	56605	149626	2262898	56605	2469129	0.00	2.29	49.00
Fowler's Toad	aaabb01210	0	55458	241052	2722162	55458	3018671	0.00	1.84	59.90
Northern Cricket Frog	aaabc01010	0	6326	26085	149412	6326	181822	0.00	3.48	3.61
Pine Barrens Treefrog	aaabc02010	0	15385	103990	253327	15385	372702	0.00	4.13	7.40
Cope's Gray Treefrog	aaabc02050	0	22842	38879	466386	22842	528107	0.00	4.33	10.48
Green Treefrog	aaabc02060	0	9615	26945	231251	9615	267811	0.00	3.59	5.31

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Barking Treefrog	aaabc02100	0	188	1666	12209	188	14063	0.00	1.34	0.28
Gray Treefrog	aaabc02130	0	55212	154426	904598	55212	1114236	0.00	4.96	22.11
Mountain Chorus Frog	aaabc05010	0	2379	14907	64466	2379	81752	0.00	2.91	1.62
Western Chorus Frog	aaabc05070	0	56502	167302	1196312	56502	1420116	0.00	3.98	28.18
Spring Peeper	aaabc05090	0	58429	200203	1173993	58429	1432625	0.00	4.08	28.43
Eastern Narrowmouth Toad	aaabe01010	0	1925	3792	39161	1925	44879	0.00	4.29	0.89
Eastern Spadefoot	aaabf01040	0	34799	171559	1450923	34799	1657281	0.00	2.10	32.89
Bullfrog	aaabh01070	0	47657	131732	896168	47657	1075557	0.00	4.43	21.34
Green Frog	aaabh01090	0	24632	67926	447062	24632	539620	0.00	4.56	10.71
Pickerel Frog	aaabh01160	0	40553	120878	787901	40553	949333	0.00	4.27	18.84
Wood Frog	aaabh01200	0	86329	231938	1289285	86329	1607552	0.00	5.37	31.90
Southern Leopard Frog	aaabh01220	0	50553	180605	1303839	50553	1534997	0.00	3.29	30.46
Carpenter Frog	aaabh01230	0	10301	54406	158214	10301	222921	0.00	4.62	4.42
BIRDS SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Pied-billed Grebe	abnca02010	62	770	7012	24498	832	32342	0.19	2.57	0.64
Brown Pelican	abnfc01020	0	1003	168	455	1003	1627	0.00	61.67	0.03
Double-crested Cormorant	abnfd01020	1248	7536	6353	38148	8783	53284	2.34	16.48	1.06
American Bittern	abnga01020	0	2811	16765	21920	2811	41497	0.00	6.77	0.82
Least Bittern	abnga02010	0	3301	23274	38480	3301	65055	0.00	5.07	1.29
Great Blue Heron	abnga04010	611	35990	113220	801976	36602	951797	0.06	3.85	18.89
Great Egret	abnga05010	2334	28601	62081	276095	30934	369111	0.63	8.38	7.32
Snowy Egret	abnga06030	2130	27282	62213	331494	29413	423120	0.50	6.95	8.40
Little Blue Heron	abnga06040	2337	26628	32802	250779	28966	312547	0.75	9.27	6.20
Tricolored Heron	abnga06050	615	12181	15746	70828	12795	99370	0.62	12.88	1.97
Cattle Egret	abnga07010	2130	23667	47422	401086	25797	474305	0.45	5.44	9.41
Green Heron	abnga08010	2127	68335	217389	925442	70462	1213293	0.18	5.81	24.08
Black-crowned Night-heron	abnga11010	2130	67447	167073	995373	69578	1232023	0.17	5.65	24.45

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Yellow-crowned Night-heron	abnga13010	1077	12291	11106	43206	13368	67680	1.59	19.75	1.34
Glossy Ibis	abnge02010	1996	23586	48965	168520	25582	243067	0.82	10.52	4.82
Mute Swan	abnjb02040	0	9666	48318	133180	9666	191164	0.00	5.06	3.79
Canada Goose	abnjb05030	2127	38354	130907	689101	40480	860488	0.25	4.70	17.07
Wood Duck	abnjb09010	0	16092	40207	235660	16092	291959	0.00	5.51	5.79
Green-winged Teal	abnjb10010	0	43	4073	15254	43	19370	0.00	0.22	0.38
American Black Duck	abnjb10040	2127	25399	78456	224222	27526	330204	0.64	8.34	6.55
Mallard	abnjb10060	308	15769	54883	368792	16076	439751	0.07	3.66	8.73
Blue-winged Teal	abnjb10130	2127	10963	30521	91491	13090	135102	1.57	9.69	2.68
Northern Shoveler	abnjb10150	0	4	12	1174	4	1191	0.00	0.36	0.02
Gadwall	abnjb10160	611	5523	13331	35482	6134	54948	1.11	11.16	1.09
Hooded Merganser	abnjb20010	0	5249	11714	20171	5249	37134	0.00	14.14	0.74
Common Merganser	abnjb21010	0	12648	27325	88358	12648	128330	0.00	9.86	2.55
Ruddy Duck	abnjb22010	0	0	18	1115	0	1133	0.00	0.00	0.02
Black Vulture	abnka01010	2130	91194	268307	3058395	93324	3420027	0.06	2.73	67.86
Turkey Vulture	abnka02010	0	31596	116922	2466030	31596	2614548	0.00	1.21	51.88
Osprey	abnkc01010	2334	29586	73869	260653	31920	366442	0.64	8.71	7.27
Bald Eagle	abnkc10010	822	30607	68922	315425	31428	415775	0.20	7.56	8.25
Northern Harrier	abnkc11010	1158	9172	36683	117199	10330	164212	0.71	6.29	3.26
Sharp-shinned Hawk	abnkc12020	0	9122	28566	118986	9122	156674	0.00	5.82	3.11
Cooper's Hawk	abnkc12040	0	88410	301948	1619798	88410	2010156	0.00	4.40	39.89
Northern Goshawk	abnkc12060	0	5694	9722	23057	5694	38473	0.00	14.80	0.76
Red-shouldered Hawk	abnkc19030	0	81885	192040	1008711	81885	1282635	0.00	6.38	25.45
Broad-winged Hawk	abnkc19050	0	69770	160233	820635	69770	1050638	0.00	6.64	20.85
Red-tailed Hawk	abnkc19110	0	68262	273242	3610032	68262	3951535	0.00	1.73	78.41
American Kestrel	abnkd06020	0	11855	61449	1886482	11855	1959785	0.00	0.60	38.89
American Peregrine Falcon	abnkd06070	1943	5820	11095	34660	7763	53518	3.63	14.51	1.06
Ring-necked Pheasant	abnlc07010	0	7489	30005	726981	7489	764475	0.00	0.98	15.17
Ruffed Grouse	abnlc11010	0	54514	192176	646457	54514	893147	0.00	6.10	17.72
Wild Turkey	abnlc14010	0	82399	206417	2378938	82399	2667754	0.00	3.09	52.94

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Northern Bobwhite	abnlc21020	0	26630	97710	2447281	26630	2571620	0.00	1.04	51.03
Black Rail	abnme03040	0	5233	25519	33503	5233	64255	0.00	8.14	1.28
Clapper Rail	abnme05010	1953	15595	50698	93749	17549	161996	1.21	10.83	3.21
King Rail	abnme05020	0	6609	28791	65160	6609	100559	0.00	6.57	2.00
Virginia Rail	abnme05030	458	8316	30230	63305	8774	102309	0.45	8.58	2.03
Sora	abnme08020	0	185	427	3336	185	3948	0.00	4.68	0.08
Common Moorhen	abnme13010	0	3529	19983	38883	3529	62394	0.00	5.66	1.24
American Coot	abnme14020	0	89	1370	5231	89	6690	0.00	1.34	0.13
Piping Plover	abnnb03070	0	494	574	886	494	1955	0.00	25.29	0.04
Killdeer	abnnb03090	0	5124	40486	1461954	5124	1507564	0.00	0.34	29.92
American Oystercatcher	abnnc01010	956	8961	15128	30914	9917	55959	1.71	17.72	1.11
Black-necked Stilt	abnnd01010	0	1349	9848	12290	1349	23487	0.00	5.74	0.47
Willet	abnnf02010	2336	21857	56975	130882	24193	212050	1.10	11.41	4.21
Spotted Sandpiper	abnnf04020	3	2759	12084	87351	2761	102196	0.00	2.70	2.03
Upland Sandpiper	abnnf06010	0	4	3008	24071	4	27083	0.00	0.01	0.54
Common Snipe	abnnf18010	0	12	46	2008	12	2065	0.00	0.56	0.04
American Woodcock	abnnf19020	0	28396	97201	1588730	28396	1714327	0.00	1.66	34.02
Laughing Gull	abnnm03010	0	5373	10636	30691	5373	46699	0.00	11.51	0.93
Herring Gull	abnnm03120	2337	13296	15040	59689	15634	90362	2.59	17.30	1.79
Great Black-backed Gull	abnnm03210	2337	13395	16185	61858	15732	93776	2.49	16.78	1.86
Gull-billed Tern	abnnm08010	0	2758	2457	8160	2758	13375	0.00	20.62	0.27
Caspian Tern	abnnm08020	0	1000	911	5586	1000	7496	0.00	13.34	0.15
Royal Tern	abnnm08030	0	0	169	814	0	983	0.00	0.03	0.02
Common Tern	abnnm08070	2251	11534	12696	50818	13784	77298	2.91	17.83	1.53
Forster's Tern	abnnm08090	2337	11475	23759	60314	13812	97885	2.39	14.11	1.94
Least Tern	abnnm08100	127	1406	2646	19178	1533	23356	0.55	6.56	0.46
Black Skimmer	abnnm14010	1166	3493	7547	17533	4659	29740	3.92	15.67	0.59
Rock Dove	abnpb01010	0	4642	39212	1542601	4642	1586455	0.00	0.29	31.48
Mourning Dove	abnpb04040	0	50451	189317	3692943	50451	3932711	0.00	1.28	78.04
Black-billed Cuckoo	abnrb02010	0	67266	152996	1107767	67266	1328030	0.00	5.07	26.35

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Yellow-billed Cuckoo	abnrb02020	0	99793	261647	2402567	99793	2764008	0.00	3.61	54.85
Common Barn Owl	abnsa01010	1515	11872	46729	1016136	13387	1076252	0.14	1.24	21.36
Eastern Screech Owl	abnsb01030	0	51550	172777	3058863	51550	3283190	0.00	1.57	65.15
Great Horned Owl	abnsb05010	0	100314	316059	1849340	100314	2265713	0.00	4.43	44.96
Barred Owl	abnsb12020	0	81073	208251	842465	81073	1131789	0.00	7.16	22.46
Long-eared Owl	abnsb13010	0	6548	33205	248410	6548	288163	0.00	2.27	5.72
Short-eared Owl	abnsb13040	0	0	7706	4729	0	12435	0.00	0.00	0.25
Northern Saw-whet Owl	abnsb15020	0	3289	10302	14280	3289	27871	0.00	11.80	0.55
Common Nighthawk	abnta02020	0	20578	131739	1982909	20578	2135225	0.00	0.96	42.37
Chuck-will's-widow	abnta07010	0	19311	55675	994697	19311	1069683	0.00	1.81	21.23
Whip-poor-will	abnta07070	0	46049	177711	2007337	46049	2231098	0.00	2.06	44.27
Chimney Swift	abnua03010	2130	40222	158356	2835513	42352	3036221	0.07	1.39	60.25
Ruby-throated Hummingbird	abnuc45010	0	37283	129054	1668851	37283	1835188	0.00	2.03	36.42
Belted Kingfisher	abnxd01020	356	12813	40727	137668	13169	191564	0.19	6.87	3.80
Red-headed Woodpecker	abnyf04040	0	58617	114780	1008734	58617	1182132	0.00	4.96	23.46
Red-bellied Woodpecker	abnyf04170	0	83106	191530	1343096	83106	1617732	0.00	5.14	32.10
Yellow-bellied Sapsucker	abnyf05010	0	542	297	2629	542	3468	0.00	15.63	0.07
Downy Woodpecker	abnyf07030	0	97639	315709	1824003	97639	2237350	0.00	4.36	44.40
Hairy Woodpecker	abnyf07040	0	84703	219078	1232793	84703	1536575	0.00	5.51	30.49
Northern Flicker	abnyf10020	0	52897	187070	3179402	52897	3419369	0.00	1.55	67.85
Pileated Woodpecker	abnyf12020	0	65285	140177	709291	65285	914753	0.00	7.14	18.15
Eastern Wood Pewee	abpae32060	0	94783	287026	1656650	94783	2038459	0.00	4.65	40.45
Acadian Flycatcher	abpae33020	0	56165	153539	750761	56165	960465	0.00	5.85	19.06
Alder Flycatcher	abpae33030	0	1089	2281	8366	1089	11735	0.00	9.28	0.23
Willow Flycatcher	abpae33040	0	3186	12048	148801	3186	164036	0.00	1.94	3.26
Least Flycatcher	abpae33070	0	5971	23978	244042	5971	273991	0.00	2.18	5.44
Eastern Phoebe	abpae35020	0	41090	124926	1233068	41090	1399084	0.00	2.94	27.76
Great Crested Flycatcher	abpae43070	0	91100	297194	1743477	91100	2131771	0.00	4.27	42.30
Eastern Kingbird	abpae52060	0	39749	152750	3018346	39749	3210846	0.00	1.24	63.71
Horned Lark	abpat02010	0	5293	33813	1329911	5293	1369017	0.00	0.39	27.17

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Purple Martin	abpau01010	2337	40787	148689	2483459	43125	2675273	0.09	1.61	53.09
Tree Swallow	abpau03010	1891	34882	109458	1050899	36773	1197131	0.16	3.07	23.76
Northern Rough-winged Swallow	abpau07010	0	22635	107849	1896362	22635	2026846	0.00	1.12	40.22
Bank Swallow	abpau08010	0	6487	43028	514765	6487	564280	0.00	1.15	11.20
Cliff Swallow	abpau09010	0	5398	14090	358958	5398	378446	0.00	1.43	7.51
Barn Swallow	abpau09030	2337	42387	160435	2665618	44725	2870777	0.08	1.56	56.97
Blue Jay	abpav02020	0	105176	345831	2470907	105176	2921915	0.00	3.60	57.98
American Crow	abpav10010	0	53554	215405	3671924	53554	3940883	0.00	1.36	78.20
Fish Crow	abpav10080	2130	54889	185320	2264635	57019	2506974	0.08	2.27	49.75
Common Raven	abpav10110	0	14036	29394	113534	14036	156963	0.00	8.94	3.11
Black-capped Chickadee	abpaw01010	0	23760	64869	287847	23760	376476	0.00	6.31	7.47
Carolina Chickadee	abpaw01020	0	57894	204517	1287773	57894	1550184	0.00	3.73	30.76
Tufted Titmouse	abpaw01110	0	90200	234542	1532671	90200	1857413	0.00	4.86	36.86
Red-breasted Nuthatch	abpaz01010	0	7353	24528	37305	7353	69186	0.00	10.63	1.37
White-breasted Nuthatch	abpaz01020	0	80494	196448	1094978	80494	1371920	0.00	5.87	27.22
Brown-headed Nuthatch	abpaz01040	0	3978	13053	192325	3978	209356	0.00	1.90	4.15
Brown Creeper	abpba01010	0	57082	188213	586704	57082	832000	0.00	6.86	16.51
Carolina Wren	abpbg06130	0	63655	216904	2774227	63655	3054786	0.00	2.08	60.62
Bewick's Wren	abpbg07010	0	185	308	2175	185	2668	0.00	6.92	0.05
House Wren	abpbg09010	0	40759	139252	2503402	40759	2683413	0.00	1.52	53.25
Winter Wren	abpbg09050	0	10839	33556	77256	10839	121651	0.00	8.91	2.41
Sedge Wren	abpbg10010	0	573	14828	11769	573	27170	0.00	2.11	0.54
Marsh Wren	abpbg10020	1718	15538	55810	109216	17256	182282	0.94	9.47	3.62
Golden-crowned Kinglet	abpbj05010	0	758	2258	3222	758	6238	0.00	12.15	0.12
Blue-gray Gnatcatcher	abpbj08010	0	87752	252540	1157695	87752	1497988	0.00	5.86	29.73
Eastern Bluebird	abpbj15010	0	24488	98218	2019607	24488	2142314	0.00	1.14	42.51
Veery	abpbj18080	0	41567	109222	361107	41567	511896	0.00	8.12	10.16
Hermit Thrush	abpbj18110	0	7305	19647	43956	7305	70908	0.00	10.30	1.41
Wood Thrush	abpbj19010	0	86712	248346	1243674	86712	1578732	0.00	5.49	31.33
American Robin	abpbj20170	0	57748	206904	3539333	57748	3803986	0.00	1.52	75.48

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Gray Catbird	abpbk01010	0	50493	166533	2594907	50493	2811932	0.00	1.80	55.80
Northern Mockingbird	abpbk03010	0	30186	125471	2832099	30186	2987756	0.00	1.01	59.29
Brown Thrasher	abpbk06010	0	55680	182457	2517797	55680	2755934	0.00	2.02	54.69
Cedar Waxwing	abpbn01020	0	48004	156361	1832794	48004	2037158	0.00	2.36	40.42
Loggerhead Shrike	abpbr01030	0	988	2633	85063	988	88685	0.00	1.11	1.76
European Starling	abpbt01010	0	53000	194830	3542007	53000	3789837	0.00	1.40	75.20
White-eyed Vireo	abpbw01020	0	46466	136480	1549355	46466	1732301	0.00	2.68	34.37
Blue-headed Vireo	abpbw01160	0	8862	31492	98781	8862	139136	0.00	6.37	2.76
Yellow-throated Vireo	abpbw01170	0	59107	152623	586642	59107	798372	0.00	7.40	15.84
Warbling Vireo	abpbw01210	0	19709	62026	1069688	19709	1151423	0.00	1.71	22.85
Red-eyed Vireo	abpbw01240	0	86503	214474	1329938	86503	1630915	0.00	5.30	32.36
Blue-winged Warbler	abpbx01020	0	24581	85676	1053035	24581	1163291	0.00	2.11	23.08
Golden-winged Warbler	abpbx01030	0	1246	4217	49301	1246	54763	0.00	2.27	1.09
Nashville Warbler	abpbx01060	0	1606	4250	27325	1606	33180	0.00	4.84	0.66
Northern Parula	abpbx02010	0	40156	133517	360003	40156	533676	0.00	7.52	10.59
Yellow Warbler	abpbx03010	0	13579	41370	566265	13579	621214	0.00	2.19	12.33
Chestnut-sided Warbler	abpbx03020	0	6923	25054	268106	6923	300083	0.00	2.31	5.95
Magnolia Warbler	abpbx03030	0	6494	14997	70192	6494	91684	0.00	7.08	1.82
Black-throated Blue Warbler	abpbx03050	0	12734	35238	80509	12734	128480	0.00	9.91	2.55
Yellow-rumped Warbler	abpbx03060	0	2171	4283	4887	2171	11341	0.00	19.14	0.23
Black-throated Green Warbler	abpbx03100	0	13001	40016	129973	13001	182991	0.00	7.10	3.63
Blackburnian Warbler	abpbx03120	0	6758	18603	42973	6758	68334	0.00	9.89	1.36
Yellow-throated Warbler	abpbx03130	0	22102	66667	438484	22102	527253	0.00	4.19	10.46
Pine Warbler	abpbx03170	0	26670	139084	545842	26670	711596	0.00	3.75	14.12
Prairie Warbler	abpbx03190	0	27137	130055	1384221	27137	1541413	0.00	1.76	30.59
Cerulean Warbler	abpbx03240	0	37367	77768	196410	37367	311544	0.00	11.99	6.18
Black-and-white Warbler	abpbx05010	0	87015	273874	1048271	87015	1409159	0.00	6.17	27.96
American Redstart	abpbx06010	0	32115	87250	221130	32115	340496	0.00	9.43	6.76
Prothonotary Warbler	abpbx07010	0	12682	45983	153427	12682	212092	0.00	5.98	4.21
Worm-eating Warbler	abpbx08010	0	62976	141433	532789	62976	737199	0.00	8.54	14.63

SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Swainson's Warbler	abpbx09010	0	597	2933	3368	597	6898	0.00	8.66	0.14
Ovenbird	abpbx10010	0	89862	279228	1304410	89862	1673500	0.00	5.37	33.21
Northern Waterthrush	abpbx10020	0	5216	25687	45618	5216	76522	0.00	6.82	1.52
Louisiana Waterthrush	abpbx10030	0	45044	116005	481133	45044	642181	0.00	7.01	12.74
Kentucky Warbler	abpbx11010	0	40252	86715	450786	40252	577753	0.00	6.97	11.46
Mourning Warbler	abpbx11030	0	9	10	921	9	940	0.00	0.94	0.02
Common Yellowthroat	abpbx12010	0	34824	131809	1451201	34824	1617834	0.00	2.15	32.10
Hooded Warbler	abpbx16010	0	47853	140232	412286	47853	600371	0.00	7.97	11.91
Canada Warbler	abpbx16030	0	16355	57129	134295	16355	207779	0.00	7.87	4.12
Yellow-breasted Chat	abpbx24010	0	16189	41824	614280	16189	672294	0.00	2.41	13.34
Summer Tanager	abpbx45030	0	25690	101673	618493	25690	745856	0.00	3.44	14.80
Scarlet Tanager	abpbx45040	0	82472	211646	1168796	82472	1462915	0.00	5.64	29.03
Northern Cardinal	abpbx60010	0	82139	252697	3569858	82139	3904693	0.00	2.10	77.48
Rose-breasted Grosbeak	abpbx61030	0	18050	59125	383194	18050	460368	0.00	3.92	9.14
Blue Grosbeak	abpbx63010	0	23024	80037	1995830	23024	2098891	0.00	1.10	41.65
Indigo Bunting	abpbx64030	0	55666	182289	2501270	55666	2739226	0.00	2.03	54.36
Dickcissel	abpbx65010	0	103	773	74602	103	75478	0.00	0.14	1.50
Eastern Towhee	abpbx74030	0	68366	220414	1871327	68366	2160107	0.00	3.16	42.86
Chipping Sparrow	abpbx94020	0	50492	223387	3066523	50492	3340401	0.00	1.51	66.28
Field Sparrow	abpbx94050	0	8552	36062	1107458	8552	1152072	0.00	0.74	22.86
Vesper Sparrow	abpbx95010	0	1272	9568	684179	1272	695018	0.00	0.18	13.79
Savannah Sparrow	abpbx99010	0	420	3470	296457	420	300347	0.00	0.14	5.96
Grasshopper Sparrow	abpbxa0020	0	1481	12030	900545	1481	914057	0.00	0.16	18.14
Henslow's Sparrow	abpbxa0030	0	39	0	5894	39	5933	0.00	0.65	0.12
Sharp-tailed Sparrow	abpbxa0050	2130	17552	46011	94822	19683	160515	1.33	12.26	3.19
Seaside Sparrow	abpbxa0060	2127	17481	53607	106965	19607	180180	1.18	10.88	3.58
Song Sparrow	abpbxa3010	0	34219	125995	2287033	34219	2447246	0.00	1.40	48.56
Swamp Sparrow	abpbxa3030	0	9910	57238	132966	9910	200114	0.00	4.95	3.97
White-throated Sparrow	abpbxa4020	0	427	205	85	427	716	0.00	59.55	0.01
Dark-eyed Junco	abpbxa5020	0	1416	4100	28122	1416	33639	0.00	4.21	0.67

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Bobolink	abpbxa9010	0	95	2203	186580	95	188878	0.00	0.05	3.75
Red-winged Blackbird	abpbxb0010	0	19094	71040	1252077	19094	1342211	0.00	1.42	26.63
Eastern Meadowlark	abpbxb2020	1125	9487	40836	1067680	10611	1119127	0.10	0.95	22.21
Boat-tailed Grackle	abpbxb6060	2130	24034	73923	375546	26165	475634	0.45	5.50	9.44
Common Grackle	abpbxb6070	0	57394	190068	3471495	57394	3718957	0.00	1.54	73.80
Brown-headed Cowbird	abpbxb7030	0	65997	232379	3686621	65997	3984997	0.00	1.66	79.08
Orchard Oriole	abpbxb9070	0	24773	91314	2043276	24773	2159363	0.00	1.15	42.85
Baltimore Oriole	abpbxb9190	0	16594	56264	1153149	16594	1226007	0.00	1.35	24.33
Purple Finch	abpby04020	0	874	2834	26759	874	30468	0.00	2.87	0.60
House Finch	abpby04040	0	5095	41844	1507697	5095	1554635	0.00	0.33	30.85
Pine Siskin	abpby06030	0	3329	5872	6235	3329	15436	0.00	21.56	0.31
American Goldfinch	abpby06110	0	50654	189474	3424297	50654	3664425	0.00	1.38	72.71
House Sparrow	abpbz01010	0	8245	61758	2366909	8245	2436912	0.00	0.34	48.36
MAMMALS										
SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Virginia Opossum	amaaa01010	0	70431	206494	1614758	70431	1891683	0.00	3.72	37.54
Masked Shrew	amaba01010	0	44061	170097	852511	44061	1066669	0.00	4.13	21.17
Southeastern Shrew	amaba01060	0	9305	12784	196886	9305	218975	0.00	4.25	4.35
Water Shrew	amaba01150	0	2135	5566	22450	2135	30150	0.00	7.08	0.60
Smoky Shrew	amaba01180	0	7469	23310	97325	7469	128103	0.00	5.83	2.54
Long-tailed Shrew	amaba01210	0	707	4277	5851	707	10834	0.00	6.52	0.21
Pygmy Shrew	amaba01250	0	55047	85857	662458	55047	803361	0.00	6.85	15.94
Maryland Shrew	amaba01270	0	25121	41495	656078	25121	722694	0.00	3.48	14.34
Northern Short-tailed Shrew	amaba03010	1515	100516	280655	1978092	102031	2360779	0.06	4.32	46.85
Least Shrew	amaba04010	1515	18624	57764	1142631	20139	1220534	0.12	1.65	24.22
Hairy-tailed Mole	amabb03010	0	10684	34531	138187	10684	183401	0.00	5.83	3.64
Eastern Mole	amabb04010	0	25566	79576	2159851	25566	2264993	0.00	1.13	44.95
Star-nosed Mole	amabb05010	0	34430	122457	837288	34430	994175	0.00	3.46	19.73
Little Brown Myotis	amacc01010	0	61736	209623	2842518	61736	3113876	0.00	1.98	61.79

SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Social Myotis	amacc01100	0	8749	32346	107872	8749	148966	0.00	5.87	2.96
Eastern Small-footed Myotis	amacc01130	0	23206	32232	740569	23206	796008	0.00	2.92	15.80
Northern Myotis	amacc01150	0	117894	387324	3187255	117894	3692473	0.00	3.19	73.27
Silver-haired Bat	amacc02010	0	104025	328245	1908481	104025	2340751	0.00	4.44	46.45
Eastern Pipistrelle	amacc03020	0	64419	218942	2838138	64419	3121499	0.00	2.06	61.94
Big Brown Bat	amacc04010	0	45869	164367	2532408	45869	2742644	0.00	1.67	54.42
Eastern Red Bat	amacc05010	0	76610	185165	1885671	76610	2147446	0.00	3.57	42.61
Hoary Bat	amacc05030	0	28979	107700	1938427	28979	2075106	0.00	1.40	41.18
Evening Bat	amacc06010	0	39414	65047	931904	39414	1036364	0.00	3.80	20.56
Townsend's Big-eared Bat	amacc08010	0	0	0	5036	0	5036	0.00	0.00	0.10
Eastern Cottontail	amaeb01040	0	57991	205377	3567446	57991	3830814	0.00	1.51	76.02
New England Cottontail	amaeb01050	0	5712	26920	298186	5712	330818	0.00	1.73	6.56
Appalachian Cottontail	amaeb01090	0	2460	14484	60305	2460	77249	0.00	3.18	1.53
Eastern Chipmunk	amafb02230	0	55117	131035	1252929	55117	1439082	0.00	3.83	28.56
Woodchuck	amafb03010	0	39721	131779	2797606	39721	2969106	0.00	1.34	58.92
Eastern Gray Squirrel	amafb07010	0	86237	217426	1408393	86237	1712056	0.00	5.04	33.97
Eastern Fox Squirrel	amafb07040	0	12800	48561	485003	12800	546365	0.00	2.34	10.84
Red Squirrel	amafb08010	0	69269	209031	730616	69269	1008916	0.00	6.87	20.02
Southern Flying Squirrel	amafb09010	0	63013	137422	957884	63013	1158319	0.00	5.44	22.98
Northern Flying Squirrel	amafb09020	0	185	115	161	185	461	0.00	40.13	0.01
American Beaver	amafe01010	0	25792	87748	486661	25792	600200	0.00	4.30	11.91
Marsh Rice Rat	amaff01010	2336	21665	66931	221454	24001	312386	0.75	7.68	6.20
Deer Mouse	amaff03040	0	40024	90955	869882	40024	1000861	0.00	4.00	19.86
White-footed Mouse	amaff03070	0	81676	270860	3320010	81676	3672546	0.00	2.22	72.88
Allegheny Woodrat	amaff08100	0	12947	27558	127857	12947	168362	0.00	7.69	3.34
Southern Red-backed Vole	amaff09020	0	5709	34858	106394	5709	146962	0.00	3.88	2.92
Meadow Vole	amaff11010	1718	28300	105114	1079881	30018	1215013	0.14	2.47	24.11
Rock Vole	amaff11090	0	332	1172	12982	332	14486	0.00	2.29	0.29
Woodland Vole	amaff11150	0	65599	151730	1491801	65599	1709131	0.00	3.84	33.91
Muskrat	amaff15010	2337	26347	82469	292609	28684	403762	0.58	7.10	8.01

SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Southern Bog Lemming	amaff17010	0	99394	276290	2578711	99394	2954395	0.00	3.36	58.63
Black Rat	amaff21010	0	683	5339	179453	683	185475	0.00	0.37	3.68
Norway Rat	amaff21020	1977	25700	108604	2354970	27677	2491252	0.08	1.11	49.43
House Mouse	amaff22010	0	49049	183011	3521553	49049	3753613	0.00	1.31	74.48
Meadow Jumping Mouse	amafh01010	0	41194	140021	2281281	41194	2462496	0.00	1.67	48.86
Woodland Jumping Mouse	amafh02010	0	18737	58141	191922	18737	268800	0.00	6.97	5.33
Common Porcupine	amafj01010	0	3404	8910	56166	3404	68480	0.00	4.97	1.36
Nutria	amafk01010	1090	7380	14010	61051	8470	83531	1.30	10.14	1.66
Coyote	amaja01010	0	31164	112150	2062252	31164	2205566	0.00	1.41	43.77
Red Fox	amaja03010	0	64386	204477	3181998	64386	3450861	0.00	1.87	68.48
Common Gray Fox	amaja04010	0	83764	214884	1749465	83764	2048113	0.00	4.09	40.64
Black Bear	amajb01010	0	42690	104964	231912	42690	379566	0.00	11.25	7.53
Common Raccoon	amaje02010	2274	130434	376090	2889231	132709	3398030	0.07	3.91	67.43
Fisher	amajf01020	0	9603	47955	121805	9603	179363	0.00	5.35	3.56
Ermine	amajf02010	0	15286	38988	284767	15286	339042	0.00	4.51	6.73
Least Weasel	amajf02020	0	13086	26147	329535	13086	368769	0.00	3.55	7.32
Long-tailed Weasel	amajf02030	0	101234	329422	3618948	101234	4049604	0.00	2.50	80.36
Mink	amajf02050	2088	68658	220269	1073178	70746	1364193	0.15	5.19	27.07
Eastern Spotted Skunk	amajf05010	0	2251	5870	66925	2251	75046	0.00	3.00	1.49
Striped Skunk	amajf06010	0	67307	228488	3708916	67307	4004711	0.00	1.68	79.47
Northern River Otter	amajf10010	2337	61561	200794	803667	63899	1068360	0.22	5.98	21.20
Bobcat	amajh03020	0	40053	91715	734345	40053	866114	0.00	4.62	17.19
Sika Deer	amalc01050	0	7716	5377	134071	7716	147163	0.00	5.24	2.92
White-tailed Deer	amalc02020	0	109243	312689	3511403	109243	3933335	0.00	2.78	78.05
Feral Horse	amata01010	0	1602	476	838	1602	2916	0.00	54.93	0.06
REPTILES										
SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Loggerhead Seaturtle	araaa01010	207	2894	1293	7067	3101	11460	1.81	27.06	0.23
Green Turtle	araaa02010	78	315	70	403	393	866	8.99	45.39	0.02

SPECIES	SPECIES CODE	Stat 1 (ha)	Stat 2 (ha)	Stat 3 (ha)	Stat 4 (ha)	Stat 1&2 (ha)	Total 1-4 (ha)	% Stat 1	% Stat 1&2	%MDN
Atlantic Ridley	araaa04010	78	459	23	369	537	929	8.38	57.83	0.02
Snapping Turtle	araab01010	1449	40856	155826	2010543	42305	2208674	0.07	1.92	43.83
Leatherback	araac01010	207	2965	1496	12171	3172	16839	1.23	18.84	0.33
Painted Turtle	araad01010	0	20566	81770	1053745	20566	1156080	0.00	1.78	22.94
Spotted Turtle	araad02010	0	49332	181194	2469256	49332	2699782	0.00	1.83	53.57
Wood Turtle	araad02020	0	25629	82013	535913	25629	643555	0.00	3.98	12.77
Bog Turtle	araad02040	0	967	6751	16335	967	24054	0.00	4.02	0.48
Common Map Turtle	araad05040	0	201	1178	8276	201	9655	0.00	2.08	0.19
Diamondback Terrapin	araad06010	2337	22514	62033	154229	24852	241114	0.97	10.31	4.78
Redbelly Turtle	araad07050	0	7177	15891	231474	7177	254542	0.00	2.82	5.05
Eastern Box Turtle	araad08010	0	70666	197116	2684622	70666	2952403	0.00	2.39	58.59
Slider	araad09010	0	5188	42151	474558	5188	521896	0.00	0.99	10.36
Eastern Mud Turtle	araae01050	476	36139	136122	1311375	36615	1484112	0.03	2.47	29.45
Common Musk Turtle	araae02040	0	20834	61724	449598	20834	532157	0.00	3.92	10.56
Spiny Softshell	araag01030	0	241	48	2968	241	3257	0.00	7.39	0.06
Fence Lizard	aracf14130	0	43628	151954	1019326	43628	1214908	0.00	3.59	24.11
Coal Skink	arach01010	0	2212	13494	65924	2212	81631	0.00	2.71	1.62
Five-lined Skink	arach01050	0	79046	213356	1510348	79046	1802749	0.00	4.38	35.77
Broadhead Skink	arach01080	0	12211	25024	368810	12211	406044	0.00	3.01	8.06
Ground Skink	arach03010	0	19600	118415	727542	19600	865557	0.00	2.26	17.18
Six-lined Racerunner	aracj02110	0	2434	7405	173344	2434	183183	0.00	1.33	3.63
Worm Snake	aradb02010	0	77847	176667	1573683	77847	1828197	0.00	4.26	36.28
Scarlet Snake	aradb03010	0	10483	73705	225689	10483	309876	0.00	3.38	6.15
Racer	aradb07010	0	86694	299891	3364008	86694	3750593	0.00	2.31	74.42
Ringneck Snake	aradb10010	0	72662	168519	1169527	72662	1410708	0.00	5.15	27.99
Corn Snake	aradb13020	0	15379	102963	400617	15379	518959	0.00	2.96	10.30
Rat Snake	aradb13030	0	102899	298811	3341430	102899	3743140	0.00	2.75	74.28
Rainbow Snake	aradb14020	0	135	0	1998	135	2133	0.00	6.33	0.04
Eastern Hognose Snake	aradb17020	0	68441	240747	3263210	68441	3572397	0.00	1.92	70.89
Prairie Kingsnake	aradb19010	0	12807	29064	467247	12807	509118	0.00	2.52	10.10

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Common Kingsnake	aradb19020	0	41147	209479	1461195	41147	1711821	0.00	2.40	33.97
Milk Snake	aradb19050	0	77203	239744	1619365	77203	1936312	0.00	3.99	38.42
Plainbelly Water Snake	aradb22020	0	4571	6761	62792	4571	74124	0.00	6.17	1.47
Northern Water Snake	aradb22060	648	32151	106749	383686	32798	523233	0.12	6.27	10.38
Rough Green Snake	aradb23010	0	19958	63296	768143	19958	851397	0.00	2.34	16.89
Pine Snake	aradb26010	0	7534	84773	157894	7534	250202	0.00	3.01	4.96
Queen Snake	aradb27040	0	11464	16196	174057	11464	201717	0.00	5.68	4.00
Brown Snake	aradb34010	1718	114751	429926	3539746	116469	4086141	0.04	2.85	81.08
Redbelly Snake	aradb34030	0	75489	251259	1492968	75489	1819716	0.00	4.15	36.11
Eastern Ribbon Snake	aradb36120	0	46145	142539	939966	46145	1128651	0.00	4.09	22.40
Common Garter Snake	aradb36130	0	64627	233159	2717735	64627	3015521	0.00	2.14	59.84
Smooth Earth Snake	aradb39020	0	38002	130371	1735440	38002	1903814	0.00	2.00	37.78
Smooth Green Snake	aradb47010	0	2544	10506	181666	2544	194716	0.00	1.31	3.86
Copperhead	arade01010	0	27100	48635	447145	27100	522879	0.00	5.18	10.38
Timber Rattlesnake	arade02040	0	59809	194984	623681	59809	878473	0.00	6.81	17.43

APPENDIX K: Predicted Rare Vertebrate Species Hotspots on Status 3 (potential management gap) and 4 (protection gap) Lands. Note that only portions of a named area may represent hotspots, and that some portions of a hotspot may be protected (Status 1 or 2).

RARE SPECIES RICHNESS HOTSPOT	TAXONOMIC GROUP(S) FOR WHICH AREA IS A RARE SPECIES HOTSPOT	GENERAL DESCRIPTION OF HABITATS PRESENT	PHYSIOGRAPHIC PROVINCE / STATE
Youghiogheny River corridor (mostly status 4; some 3)	Mammals, Birds, Amphibians, Vertebrates	Riparian forests; Hardwood and Mixed Forests and Swamps; High Percent Forest Cover; Shrub Swamp; Vernal Pool; Stream; River; Pond	Allegheny Plateau / Maryland
Savage River State Forest / Savage River corridor (mostly status 3; some 4)	Birds, Mammals, Vertebrates	Hardwood and Mixed Forests; Riparian Forests; High Percent Forest Cover	Allegheny Plateau / Maryland
Casselman River corridor (mostly status 4)	Mammals, Vertebrates	Hardwood and Mixed Forests; Riparian Forests	Allegheny Plateau / Maryland
North Branch Potomac River and Tributaries	Mammals, Vertebrates, Reptiles	Hardwood and Mixed Forests; Riparian Forests	Allegheny Plateau / Maryland
Georges Creek tributaries (mostly status 4)	Birds, Vertebrates, Mammals	Hardwood and Mixed Forests; Riparian Forests; High Percent Forest Cover	Allegheny Plateau / Maryland
Jennings Run corridor / Piney Mountain (status 4)	Mammals, Vertebrates	Hardwood Forest; Riparian Forest; Forest Interior/High Percent Forest Cover; Stream	Allegheny Plateau / Maryland
Wills Run corriodor (status 4)	Mammals	Cool, Mesic Hardwood and Mixed Forests; High Percent Forest Cover; Stream; Pond	Ridge and Valley / Maryland
Collier Run/Mountain (status 4)	Mammals, Vertebrates	Hardwood and Mixed Forests; Riparian Forest; Forest Interior/High Percent Forest Cover; Stream; Pond	Ridge and Valley / Maryland

RARE SPECIES RICHNESS HOTSPOT	TAXONOMIC GROUP(S) FOR WHICH AREA IS A RARE SPECIES HOTSPOT	GENERAL DESCRIPTION OF HABITATS PRESENT	PHYSIOGRAPHIC PROVINCE / STATE
Green Ridge State Forest (status 3)	Vertebrates	Hardwood and Mixed Forests; Forest Interior	Ridge and Valley / Maryland
Potomac River and tributaries / C&O Canal, near confluence of South Branch Potomac (3, 4)	Reptiles	Riparian; Forest Edge; Old Field; Riverine	Ridge and Valley / Maryland
Sideling Hill Creek corridor (status 4 areas)	Vertebrates, Mammals	Hardwood and Mixed Forests; Riparian Forest; Forest Interior/High Percent Forest Cover; Stream; Wet Meadow; Pond; Shrub Swamp	Ridge and Valley / Maryland
Indian Springs WMA and surrounding areas (3 and 4)	Vertebrates	Hardwood, Mixed, and Riparian Forests; High Percent Forest Cover	Ridge and Valley / Maryland
South Mountain (status 4 areas)	Birds, Vertebrates	Hardwood and Mixed Forests; High Percent Forest Cover	Blue Ridge / Maryland
Catoctin Mountain (status 4 areas)	Birds, Vertebrates	Hardwood and Mixed Forests; Forest Interior	Blue Ridge / Maryland
Potomac River / C&O Canal tributaries (Rock Creek, Cabin John Branch and tributaries, Sandy Branch, Greenbrier Branch, Piney Branch, Watts Branch) (Status 4)	Reptiles, Amphibians	Hardwood Forest; Mixed Forest; Riparian Forest; Forest Edge; Old Field; Forested Swamp; Shrub Swamp; Vernal Pool; Wet Meadow; Stream; Pond; River	Piedmont / Maryland (Western Shore)

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Anacostia River tributaries and headwaters (Sligo Creek, Northwest Branch, Northeast Branch, Paint Branch, Little Paint Branch, Indian Creek, Beaverdam Creek) (status 3, 4)	Reptiles	Hardwood and Mixed Forests and Swamps; Riparian Forest; Forest Edge; Old Field; Vernal Pool; Shrub Swamp; Wet Meadow; Stream; Pond	Piedmont and Coastal Plain (Fall Line) / Maryland (Western Shore)
Grays Run -- tributary of Bush River (status 4)	Birds, Vertebrates	Mesic Hardwood Forest; Bottomland Hardwood Swamp; High Percent Forest Cover	Piedmont / Maryland (Western Shore)
Conowingo Creek corridor (status 4)	Birds	Mesic Hardwood Forest; Hardwood Swamp; Riparian Forest; Forest Interior	Piedmont / Maryland (Eastern Shore)
Mill Creek corridor (status 4)	Reptiles	Hardwood Forest; Riparian Forest; Forest Edge; Old Field; Wet Meadow; Shrub Swamp; Stream	Piedmont / Delaware
Red Clay Creek corridor (status 4)	Reptiles, Vertebrates	Hardwood Forest; Riparian Forest; Forest Edge; Old Field; Stream; Pond: Lake	Piedmont / Delaware
Brandywine Creek corridor (status 4 areas only)	Reptiles	Hardwood Forest; Riparian Forest; Forest Edge; Old Field; Wet Meadow; Shrub Swamp; Stream; River; Pond	Piedmont / Delaware
Principio Creek and North East River headwaters (status 4)	Vertebrates	Mesic Hardwood Forest; Hardwood Swamp; High Percent Forest Cover; Shrub Swamp; Vernal Pool; Stream; Pond	Piedmont and Coastal Plain (Fall Line) / Maryland (Eastern Shore)
Elk Neck (status 3 and 4)	Vertebrates	Hardwood and Mixed Forests and Swamps; Forest Interior; Shrub Swamp; Vernal Pool; Stream; Pond	Coastal Plain / Maryland (Eastern Shore)

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Romney Creek headwaters / Aberdeen Proving Ground Military Reservation (status 3)	Birds, Amphibians, Vertebrates	Mesic Hardwood and Mixed Forests; High Percent Forest Cover; Hardwood Swamp; Shrub Swamp; Vernal Pool; Fresh Marsh; Wet Meadow; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Patuxent River corridor (status 4 areas)	Birds, Reptiles, Amphibians, Vertebrates	Hardwood and Mixed Swamps; Mesic Hardwood; Riparian Forest; Forest Interior; Shrub Swamp; Vernal Pool; Stream; River; Pond	Coastal Plain / Maryland (Western Shore)
South River tributaries (North River, Bacon Ridge Branch, Flat Creek, Beards Creek) (status 4)	Birds, Reptiles, Amphibians, Vertebrates	Hardwood and Mixed Mesic Forests and Swamps; High Percent Forest Cover; Shrub Swamp; Old Field; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Little Round Bay / Severn River tributaries (western shore) (status 4)	Birds, Reptiles, Amphibians, Vertebrates	Hardwood and Mixed Mesic Forests and Swamps; High Percent Forest Cover; Shrub Swamp; Old Field; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Lyons Creek corridor (status 4)	Birds, Vertebrates	Hardwood and Mixed Swamps; Riparian Forest; Mesic Hardwood Forest; Stream; Shrub Swamp; Pond; Vernal Pool; Wet Meadow	Coastal Plain / Maryland (Western Shore)
[upper] Mattawoman Creek corridor (status 4)	Reptiles, Amphibians, Vertebrates	Hardwood and Mixed Forests and Swamps; Shrub Swamp; Old Field; Forest Edge; Vernal Pool; Wet Meadow; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Nanjemoy Creek headwaters and surrounding area (status 4)	Amphibians	Mesic Hardwood Forest; Hardwood and Mixed Swamps; High Percent Forest Cover; Shrub Swamp; Vernal Pool: Fresh Marsh; Wet Meadow; Stream; Pond	Coastal Plain / Maryland (Western Shore)

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Zekiah Swamp Run (status 4)	Birds, Vertebrates	Hardwood Swamp; Mixed Swamp; Mesic Hardwoods; High Percent Forest Cover; Vernal Pool; Stream	Coastal Plain / Maryland (Western Shore)
Breton Bay headwaters and Lower Patuxent River tributaries	Vertebrates, Reptiles, Amphibians	Hardwood and Mixed Forests and Swamps; High Percent Forest Cover; Forest Edge, Old Field; Shrub Swamp; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Saint Leonard Creek headwaters (status 4)	Amphibians, Vertebrates	Hardwood and Mixed Forests and Swamps; High Percent Forest Cover: Shrub Swamp; Wet Meadow; Stream; Pond	Coastal Plain / Maryland (Western Shore)
Blackbird-Millington Corridor (status 3 and 4)	Amphibians	Vernal Pool; Mesic Hardwood Forest; Hardwood Swamp; Mixed Forest and Swamp; Shrub Swamp; Stream; Pond	Coastal Plain / Maryland (Eastern Shore) and Delaware
Forests surrounding Blackwater NWR (status 4)	Reptiles	Mixed Forest; Pine Forest; Mesic Hardwood Forest; Forest Edge; Forest-Swamp Ecotone; Mixed and Hardwood Swamps; Shrub Swamp; Wet Meadow; Vernal Pool; Old Field	Coastal Plain / Maryland (Eastern Shore)
Nanticoke River – vicinity of Marshyhope Creek confluence (status 4)	Vertebrates	Hardwood and Mixed Swamps; Forest Interior	Coastal Plain / Maryland (Eastern Shore)
Nanticoke, Wicomico, and Manokin River tributaries (status 4)	Reptiles	Mixed, Pine, and Hardwood Forests; Forest Edge; Stream; Old Field; Forest-Swamp Ecotone; Hardwood and Mixed Swamps; Shrub Swamp; Fresh Marsh; Wet Meadow; Pond	Coastal Plain / Maryland (Eastern Shore) and Delaware

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Pocomoke River and tributaries (e.g., Dividing Creek) corridor (status 3 and 4)	Birds, Reptiles, Vertebrates	Hardwood and Mixed Forests and Swamps; Forest Interior; Forest-Swamp Ecotone; Forest Edge; Shrub Swamp; Stream; River; Pond; Fresh Tidal Marsh	Coastal Plain / Maryland (Eastern Shore)
Great Cypress Swamp (status 3)	Vertebrates	Mixed Forests and Swamps; Hardwood Swamp; Forest Interior; Shrub Swamp	Coastal Plain / Delaware
New Jersey Highlands – Morris, Passaic and Sussex Counties (status 3 and 4)	Vertebrates, Amphibians, Birds	Northern/Cool Mesic Forests and Swamps; Shrub Swamp; Forest Interior/High Percent Forest Cover; Wet Meadow; Stream; Pond; Lake	Highlands / New Jersey
Highlands – Passaic River tributaries (e.g., Loantaka Bk, Whippany R, Pompton R, Pequannock R, Clinton Bk, Wawayanda Cr, Morsetown Bk, Belcher Ck, Burnt Meadow Bk, West Bk, Post Bk, Matthews Bk, Apshawa Bk, Stone House Bk)	Vertebrates, Amphibians, Birds	Northern/Cool Mesic Forests and Swamps; Shrub Swamp; Forest Interior/High Percent Forest Cover; Wet Meadow; Stream; Pond; Lake	Highlands / New Jersey
Highlands – Rockaway River tributaries (e.g., Beaver Bk, Mill Bk, Stony Bk, Hibering Bk, Crooked Bk, Hatfield Bk, others)	Vertebrates, Amphibians, Birds	Northern/Cool Mesic Forests and Swamps; Shrub Swamp; High Percent Forest Cover; Wet Meadow; Stream; Pond; Lake	Highlands / New Jersey
Highlands – Raritan River tributaries (e.g., Drakes Bk, Burnett Bk, others)	Amphibians, Vertebrates	Northern/Cool Mesic Forests and Swamps; Shrub Swamp; Fresh Marsh; Wet Meadow; Stream; Pond	Highlands / New Jersey

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Kittatinny Ridge (status 3 and 4)	Vertebrates, Amphibians, Birds, Mammals	Northern/Cool Mesic Forests and Swamps; Shrub Swamp; Fresh Marsh; Wet Meadow; Vernal Pool; Stream; Pond; Lake; Forest Interior/High Percent Forest Cover	Ridge and Valley / New Jersey
Rancocas Creek headwaters (status 3 and 4)	Birds, Vertebrates	Hardwood and Mixed Swamps; Mesic Hardwood Forest; Riparian Forest; Forest Interior/High Percent Forest Cover; Forest Edge; Shrub Swamp; Wet Meadow; Stream; Pond	Coastal Plain / New Jersey
New Jersey Pine Barrens (status 3 and 4)	Reptiles	Pine Barren Woodland; Oak-Pine Forest; Old Field; Forest Edge; Woodland-Swamp Ecotone; Hardwood Forest; Pine, Hardwood, and Mixed Swamps; Stream; Shrub Swamp; Fresh Marsh; Wet Meadow; Pond	Coastal Plain / New Jersey
Mullica River headwaters (status 3 and 4)	Vertebrates, Amphibians	Riparian Forest; Hardwood and Mixed Swamps; Stream; Shrub Swamp; Pond; Wet Meadow; Forest Interior/High Percent Forest Cover	Coastal Plain / New Jersey
Maurice River headwaters and tributaries (e.g., Muskee Cr, Manumuskin River, Cranberry Gut, Dickeys Ditch) (3 and 4)	Amphibians, Reptiles	Hardwood Swamp; Shrub Swamp; Mesic Hardwood Forest; Stream; Wet Meadow; Fresh Marsh; Pond; High Percent Forest Cover (in most areas)	Coastal Plain / New Jersey

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Great Egg Harbor River and tributaries (e.g., South River, Cedar Swamp Cr, Back Run, Tuckahoe River, Stephens Cr, Gibson Cr, Powell Cr, Nell Run) (status 3 and 4)	Amphibians, Reptiles, Vertebrates	Hardwood, Coniferous and Mixed Forests and Swamps; Forest Interior/High Percent Forest Cover; Shrub Swamp; Stream; Pond; Lake	Coastal Plain / New Jersey
Dennis Creek tributaries north of Dennisville, Ludlams Pond and Johnson Pond (status 4)	Amphibians, Reptiles, Vertebrates	Hardwood and Mixed Forests and Swamps; Forest Interior/High Percent Forest Cover; Shrub Swamp; Stream; Pond	Coastal Plain / New Jersey
Middle Brook (tributary of Nantuxent Creek) (status 4)	Vertebrates, Amphibians	Hardwood and Mixed Forests and Swamps; Shrub Swamp; Stream; Wet Meadow; Pond	Coastal Plain / New Jersey
Oranoaken Creek headwaters / Bear Swamp west (status 4 areas)	Vertebrates, Amphibians	Hardwood and Mixed Forests and Swamps; Forest Interior/High Percent Forest Cover; Shrub Swamp; Stream; Fresh Emergent Marsh; Pond; Lake	Coastal Plain / New Jersey
Dividing Creek headwaters and tributaries (status 3 and 4)	Vertebrates, Amphibians	Hardwood and Mixed Forests and Swamps; Shrub Swamp; Stream; Wet Meadow; Pond; Lake	Coastal Plain / New Jersey
New England Creek headwaters (status 4)	Vertebrates, Amphibians	Hardwood Swamp; Mixed Swamp; Forest Interior/High Percent Forest Cover; Shrub Swamp; Stream	Coastal Plain / New Jersey
Absecon/Atlantic City marshes (status 4 areas)	Birds	Brackish Tidal Marsh	Coastal Plain / New Jersey

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Cape May Peninsula – Delaware Bay tributary headwaters (Fishing Cr, Green Cr, Dias Cr, Bidwell Cr, Crow Cr, Sluice Cr) (status 4 areas)	Amphibians	Hardwood Swamp; Mesic Hardwood Forest; Mixed Forests and Swamps; High Percent Forest Cover; Shrub Swamp; Stream; Pond; Wet Meadow	Coastal Plain / New Jersey