CHAPTER 2
Habitats

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SNAPSHOT

Habitats for Species of Greatest Conservation Need

- ✓ ***Northeast terrestrial and aquatic habitat classifications are used to facilitate communication and conservation action across state boundaries.***
- ✓ ***Pennsylvania remains approximately 60% forested, primarily in the Appalachian Plateaus Province- 70% of forests are in private ownership.***
- ✓ ***Pennsylvania has lost nearly 60% of its wetlands since pre-Colonial time.***
- ✓ ***90% of streams in the High Plateau physiographic sections have vegetation along the banks, which helps to prevent erosion and enhance water quality.***

Summary of Changes to the Habitat Descriptions Since 2005

The goal of congressionally required Element 2 is to "identify the extent and condition of wildlife habitats and community types essential to the conservation of the species identified under Element 1." Although commonly used by biologists, the word 'habitat' can be interpreted in many ways. Two main definitions of habitat are: 1) the specific needs of a particular species, and 2) classification of vegetation or other underlying structure. In this section, we define habitat based upon the classification of vegetation at the landscape scale, addressing broadly the vegetation classification, while providing for the species-specific habitat descriptions needed for Element 1, Species.

Approach

State Wildlife Action Plans must describe the extent and condition of habitats and community types that are essential to the conservation of Species of Greatest Conservation Need (SGCN). The national *Best Practices for State Wildlife Action Plans* (AFWA 2012) recommends a regional approach and specifically mentions the Northeast Habitat Classification System (Terrestrial and Aquatic) as examples. While the northeastern states used different vegetation classification systems in their 2005 Wildlife Action Plans, the Northeastern Terrestrial Wildlife Habitat Classification System – based on ecological systems developed by NatureServe© – and Northeastern Aquatic Habitat Classification System were developed with funding from the northeast states, as they determined this was an essential tool for use in multi-state species recovery efforts. Additional work by The Nature Conservancy (TNC) provided the most applicable and feasible method to describe and quantify habitat condition, consistent with the choice to use the habitat classification systems developed for the region. This approach is more information-rich than simple land cover approaches. The Northeast Habitat Maps integrate well with the Pennsylvania community classification used by the Pennsylvania Natural Heritage Program.

Standard Terminology

We adopted the terminology of Formation, Macrogroup, and Habitat as described in the Northeast Terrestrial and Aquatic Habitat Classification Systems (Anderson et al. 2013b).

Introduction

Pennsylvania hosts a broad diversity of habitats, from deep forests, wetlands, beaches, and natural lakes, to shale and serpentine barrens. Pennsylvania habitats have been shaped by the interactions of climate, topography, geology, soils, and both natural and anthropogenic disturbances. About 300 million years ago, two super-continents collided and the results of that collision are still visible today as a series of mountainous ridges separated by broad valleys. Along the ridgetops, rocky talus slopes and barrens ecosystems support rare species like the Allegheny woodrat and the timber rattlesnake. Where the ridges meet the valley floor, one finds ephemeral wetlands known as vernal (seasonal) pools, which are home to rare species such as the northeastern bulrush and a fascinating group of animals called mole salamanders. Geology and soils are one of the most significant predictors of species occurrence in the northeast (Anderson and Ferree 2010).

More recently – a mere 100,000 years ago – a moving sea of ice more than two miles thick descended on the northeastern (e.g., Pike County) and northwestern (e.g., Erie County) parts of the state. When these glaciers retreated, they left behind depressions and holes, while scattering much of the rock and debris they were carrying. Today innumerable wetlands, bogs, and fens dot these areas of the state, hosting an amazing diversity of highly adapted, and often rare, plants and animals. The water draining from these wetlands flows into streams that are home to diverse assemblages of freshwater mussels, one of North America's most imperiled fauna.

Wildlife habitats in Pennsylvania today are dominated by forest, covering nearly two-thirds of the Commonwealth. More than 35% of the state has been converted away from natural cover into agriculture or developed into roads, towns, and cities. Smaller patch habitats such as barrens, grasslands, wetlands, and lakes make up the remainder. To maintain healthy, viable populations of native Pennsylvania wildlife, habitat in sufficient quality and quantity is necessary to meet the diverse needs of the state's wildlife species. Habitat is the key to animal abundance. Land development, as well as direct and indirect habitat degradation, are the primary causes of species declines in Pennsylvania and worldwide (Ehrlich and Ehrlich 1981; Ehrlich and Wilson 1991; Noss et al.1995). To that end, this chapter presents information about the status and extent of these habitats in Pennsylvania and relative to the habitat in the northeast region, threats that affect their quality, and the actions that can be taken to address threats.

A number of models have been developed and used to identify and map wildlife habitat:

- Regions, such as the physiographic provinces, describe areas of discreet biotic (living) and abiotic (non-living) conditions across large regional areas (Sevon 2000). Major watershed boundaries can be used in a similar way to describe major groups of aquatic diversity.

- The National Land Cover Dataset (NLCD) has a finer spatial resolution than physiographic provinces and describes the landscape using over 15 different coarse land cover classes (Fry et al. 2011).
- The Nature Conservancy (TNC) has developed habitat models (e.g., the Northeast Terrestrial Habitat Classification Map) at a relatively fine spatial resolution and based on NatureServe© Ecological Systems (Anderson et al. 2013b). Similar products have been developed for aquatic habitats as well.

While each of these models is useful by itself as a conservation tool, they do not completely bridge the gap between research and on-the-ground management. To address the needs of land-use planners and land managers involved in wildlife conservation, the 2015 Pennsylvania Wildlife Action Plan (Plan) presents information from these conservation tools and adapts their habitat data to best suit these needs.

Since 2005, the overarching goal of the Wildlife Action Plan has been to move toward proactive management of the species and habitats for which Pennsylvania has regional, national, or global responsibility. This move from reactive to proactive management can increase conservation success on the ground, while allowing for more efficient use of limited staff capacity and funding resources.

Statewide Status of Habitat

The following sections present an overview of the general habitat types in Pennsylvania. Throughout, we present several analyses of habitat within organizing units of physiographic provinces and major watersheds. Physiographic provinces can serve as broad scale units or surrogates of biodiversity. Similarly, watersheds define units of connected hydrology, which tend to contain similar species.

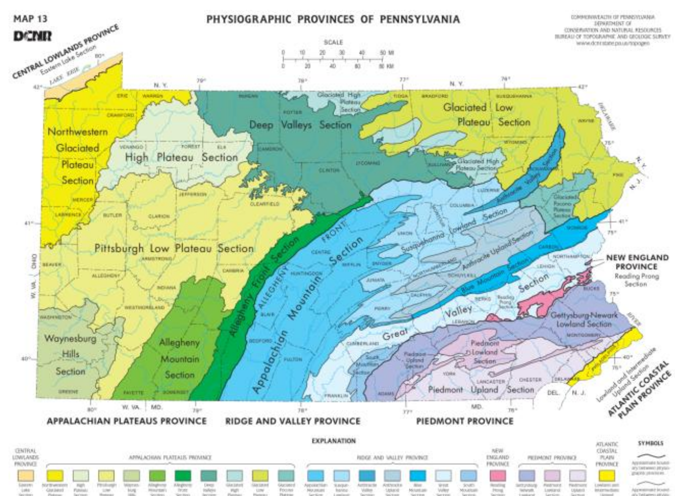

Fig. 2.1. Physiographic provinces and sections of Pennsylvania. Map courtesy of Sevon (2000).

A *physiographic province* is a geographic region in which all parts are similar in geologic structure and climate, and which has a unified geomorphic or surficial history. This means that the landforms on the surface were formed similarly, and have comparable bedrock and climate (Sevon 2000). A region's topography, climate, and geology affect the development of soils, hydrology (movement, distribution, and quality of water), and land-use patterns. These factors also influence the distributions of plant and animal life. Because of the differences in climate and soils, certain plants and animals are expected to occur within some physiographic provinces and not others. Pennsylvania is located at the intersection of six physiographic provinces (listed from the southeast corner to the northwest corner):

1. Atlantic Coastal Plain Province – What is now the Philadelphia metropolitan area was once home to thousands of acres of freshwater tidal marsh. The boundary of the coastal plain is the fall line that marks the boundary between uplands and the coastal plain.
2. Piedmont Province – Land that was never glaciated, characterized by gently-rolling hills and valleys upon which dry oak woods and moist forests occur on remnant sites, steep slopes, and ridgelines.
3. New England Province – A small and fragmented geologic feature, called the Reading Prong that enters northeastern Pennsylvania and is similar to the crystalline bedrock found in much of New England.
4. Ridge and Valley Province – The second-largest province in the state containing severely folded rocks with numerous anticlines and synclines that plunge and fold back over each other.
5. Appalachian Plateau Province – The largest province in the state. Most of the rocks in this region are neither folded nor faulted and sit relatively flat. Valleys are formed by the erosion caused by streams and glaciers, making the province to appear to be mountainous.
6. Central Lowlands Province – Part of the Great Lakes watershed, existing along a glacial escarpment adjacent to Lake Erie.

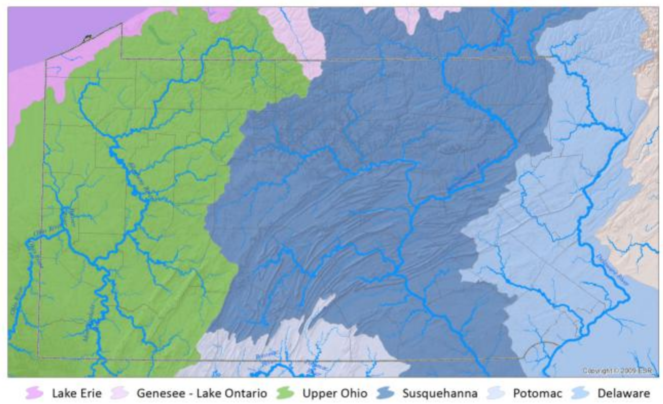

Fig. 2.2. Major watersheds of Pennsylvania.

Physiographic provinces can be further subdivided into sections that describe specific features across the province (Fig. 2.1).

Nearly two-thirds of Pennsylvania drains into the Atlantic Ocean via the Potomac, Susquehanna, and Delaware Basins. The majority of the western half of the state is drained through the Ohio Basin, toward the Gulf of Mexico, while a small portion of the state drains north toward the Great Lakes, via the Erie and Genesee basins (Fig. 2.2). Watersheds play a biogeographic role in wildlife species diversity. Amphibian, fish, and freshwater mussel species richness in Pennsylvania is strongly correlated to river drainage distribution (Myers et al. 2000). For example, a greater number of freshwater mussel species (*n*=54) occur in Ohio drainage watershed, compared to those that drain into the Atlantic (*n*=18) (Welte 2015). Watersheds are primarily represented in Pennsylvania through Hydrologic Unit Codes (HUCs), or Watershed Boundary Datasets, developed by the U.S. Geological Survey (USGS). These units are based on a six-level hierarchy ranging from Regions to Sub-watersheds (Seaber et al. 1987). Where relevant in this report, we have summarized aquatic habitat information by sub-basins (HUC08), which divide the state into 57 units.

Land Cover and Habitat

The 2005 Pennsylvania Wildlife Action Plan largely described habitat in terms of land cover, as defined by the Pennsylvania GAP Analysis Project (Myers and Bishop 1999). The terms are similar to those used in the National Land Cover Dataset (NLCD), the spatial data referenced for the 2015 Plan. The NLCD has a finer spatial resolution than physiographic provinces and describes the landscape using 15 land-cover classes at a 30 x 30 meter resolution (Fry et al. 2011). The most recent version of the NLCD was released in 2011 (Jin et al. 2013; Homer et al. 2015; Fig. 2.3). The 2011 NLCD provides the capability to assess "wall-to-wall", spatially explicit, land cover changes and trends from 2001 to 2011.

Forests are the dominant land cover in Pennsylvania, comprising approximately 60% of the state's 29 million acres (11.7 million hectares). Agriculture, largely in the form of pastureland, hayfields, and row crops, covers 23% of Pennsylvania, and development accounts for nearly 12% of the state. The 5% remainder is largely composed of barren land and wetlands. Land cover patterns are not equally distributed among the physiographic sections, although patterns tend to be similar within each province (Fig. 2.4). For example, agriculture is a dominant land cover in the Piedmont, with a nearly equal proportion of development. On the other hand, the Ridge and Valley is predominantly forested, with an exception for the Great Valley section, where much of the fertile limestone valley has promoted a greater relative proportion of agriculture. One limitation of the NLCD is that it does not aduaquately identify small patch habitats such as barrens and small wetlands. Several other important habitat types, such as limestone, shale, and serpentine barrens, are linked directly to the geology and geomorphic history of the state.

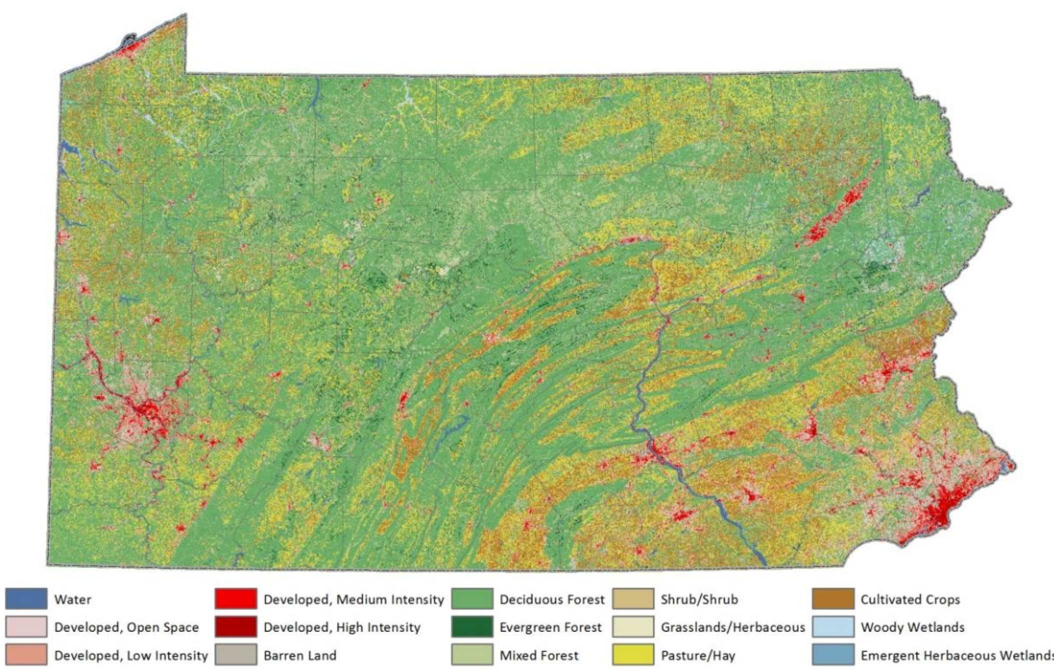

Fig. 2.3. The 2011 NLCD for Pennsylvania. Urban areas are shown in shades of red, agriculture in shades of yellow, and forests in shades of green.

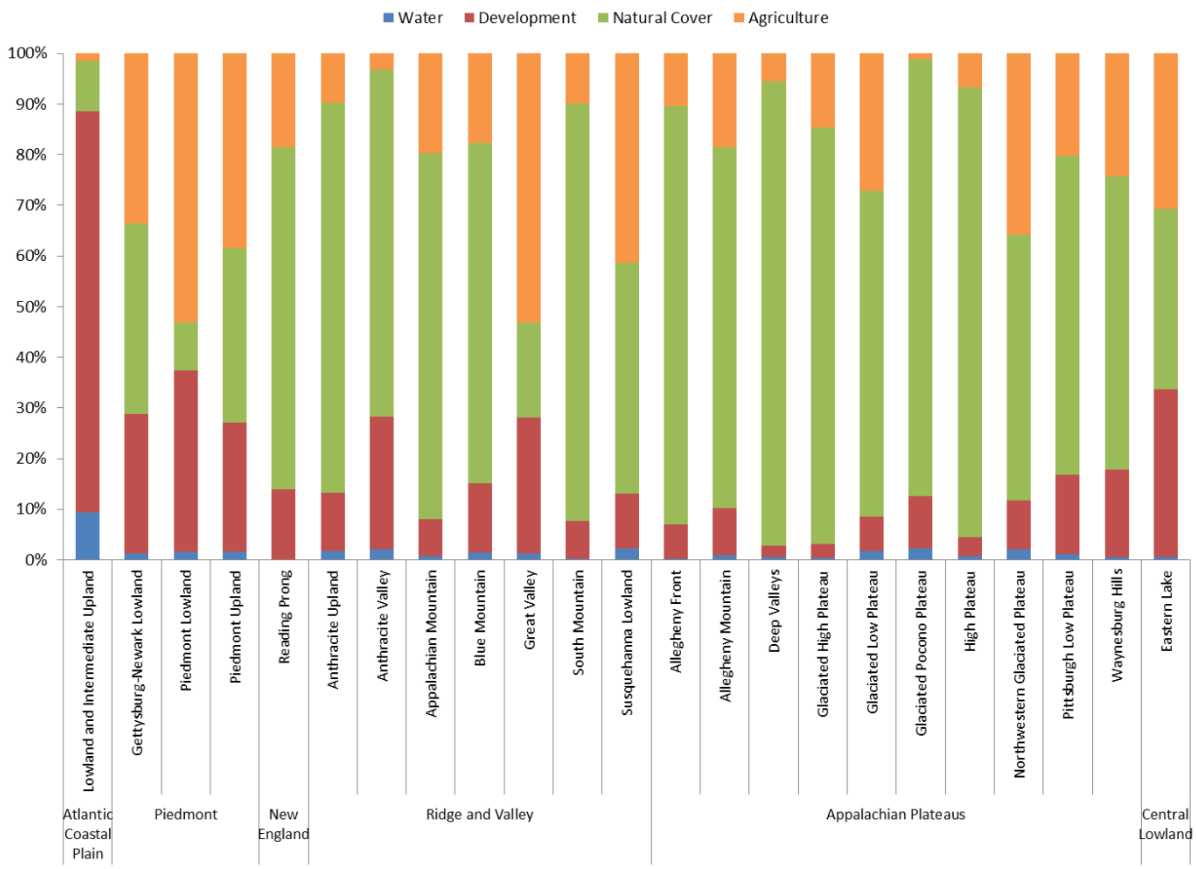

Figure 2.4. Distribution of Pennsylvania land cover types among physiographic sections (Source: NLCD 2011).

Forests and Natural Cover

Figure 2.5. Distribution of forest land cover across Pennsylvania since 2001 based on the National Landcover Dataset.

The nearly 17 million acres (6.87 million hectares) of forest within Pennsylvania provide an array of valuable resources including clean air and water, recreational opportunities, wood products and habitat for thousands of plant and animal species. The distribution of forests varies across the state, with the greatest amount of forest remaining in the more rugged and remote sections of the state. The Pennsylvania Natural Heritage Program has identified 23 types of terrestrial forest communities in Pennsylvania, as well as several more woodland types (Zimmerman et al. 2012). These range from deciduous types like “red oak-mixed hardwood forests” to coniferous forests like the “hemlock (white pine) forest.” Most of the state is second- or third-growth forest; only a few thousand acres of unharvested forest remain in the state (Davis 1993).

Approximately 30% of the state's forested area is in public ownership, while 70% is in private ownership (McCaskill 2014). Private forest ownership presents unique challenges for wildlife habitat in Pennsylvania as a large percentage of the forest exists in relatively small, fragmented parcels.

Trends

Maintaining forest cover is fundamentally necessary to maximize the full set of resources that forests can provide. Overall, Pennsylvania's forested land area has been very stable since 1965 (McCaskill 2014). The amount of forested land in the Commonwealth has remained relatively stable over the past 15 years (Fig. 2.5); however, developed land classes have increased, mostly at the expense of agriculture. A closer look at the data reveals that some areas of the state gained forest, while others have lost forest. For example, recent Forest Inventory and Analysis National Program (FIA; Chapter 5, Monitoring) data from the U.S. Forest Service shows that counties around Harrisburg, Philadelphia, and Pittsburgh have lost a significant amount of forestland since 2000, largely due to urban and suburban sprawl. Though the percent of forest has remained relatively unchanged between 2001 and 2011, there has been considerable variation in gains and losses across physiographic sections (-3.6% to +7.4%). An estimated 28,000 acres of forest have been lost to residential, commercial, and industrial development each year (PADCNR 2010b). Much of Pennsylvania's forestland that is secured from permanent land cover change (e.g. state ownership, conservation easements) occurs in the northcentral portion of the state and typically along major ridgelines at higher elevations. Therefore, lower elevation forests are likely at an increased risk of development, due to higher accessibility, as well as less likelihood of protection.

As natural cover is converted for human use through development and agriculture, the remaining natural areas are increasingly fragmented into smaller and more isolated patches. Not only is there is a loss of overall habitat available for animal and plant species, this trend isolates populations and increases the amount of edge habitat. Increased edge habitat is deleterious to many of Pennsylvania forest-interior specialist bird SGCN that require large blocks of contiguous forest away from roads or other fragmenting features to maintain healthy breeding populations. The remaining edge habitat is largely subject to a variety of human disturbances and invasion by weedy and exotic species that present challenges to land managers. However, where edge habitat is necessary adjacent to forests (e.g., rights-of-way) there is an opportunity to benefit SGCN requiring early successional (i.e., young) forest (e.g., prairie warbler, blue-winged warbler) that favor grasses and shrubs by leaving low native shrubs, thus resulting in a softer edge between the opening and forest (Brittingham & DeLong 1998).

Human dispersal across the United States and in Pennsylvania has resulted in relatively rapid development of city fringes and rural areas, especially where there are recreational and aesthetic amenities. This shift in development patterns has changed the size of the wildland-urban interface (WUI) – the area where structures and other human development meet or intermingle with undeveloped wildland (Radeloff 2005; Fig. 206). The intermix WUI represents areas where housing and vegetation intermingle; whereas interface WUI are areas with housing in the vicinity of contiguous wildland vegetation.

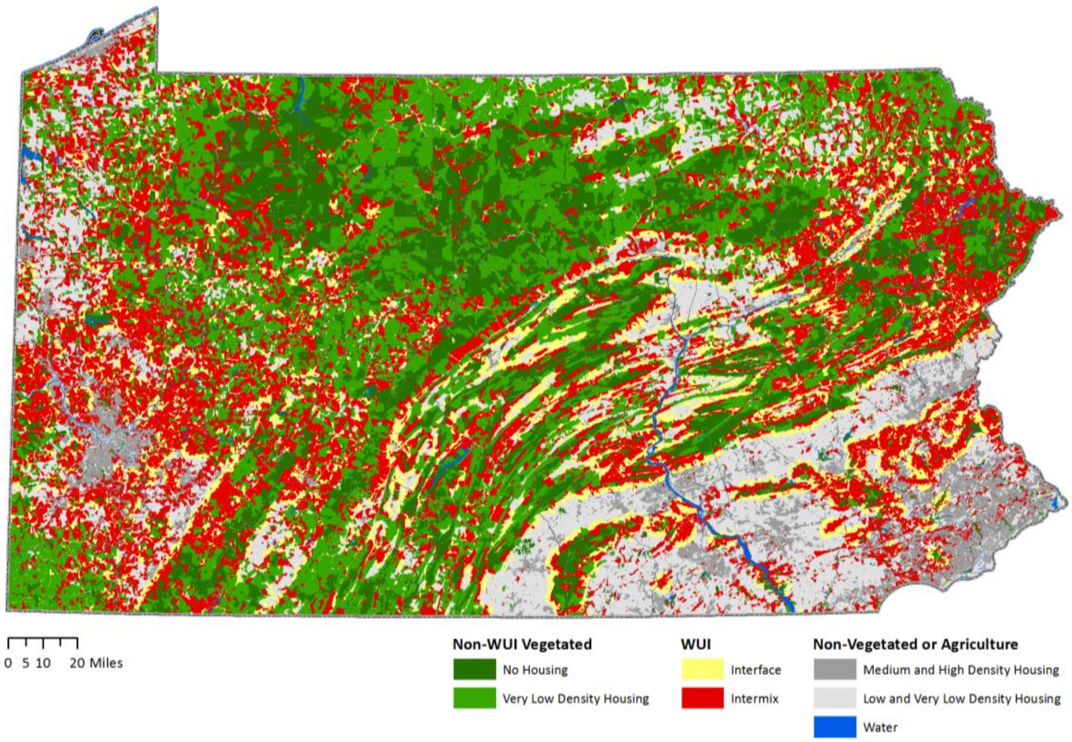

Fig. 2.6. The Wildland-Urban Interface (WUI) for Pennsylvania (Radeloff 2005**)**.

The increase in development in and adjacent to wildlands may have impacts on wildlife, especially for wide-ranging species. Management of natural resources through forestry practices, prescribed fire, and other methods increases in difficulty as the proportion WUI increases.

The more recent development of Pennsylvania's shale gas resources has the potential to cause substantial landscape disturbance (Johnson et al. 2010; Drohan et al. 2012). Development was well underway in parts of the state by the time the 2011 National Land Cover Dataset was produced, but shale gas infrastructure across northern and central areas was in an early stage of development at that time and evaluation effects are not known.

Early successional forests are decreasing in area due to declines in timber harvests and maturation of existing young forests (Fig. 2.7). Forest Inventory and Analysis data indicate that the area of Pennsylvania's forests in the sapling-seedling class has declined by more than 50% since 1950, and may be at the lowest percentage since record-keeping began (McWilliams et al. 2004). These early successional forest habitats are ephemeral, quickly growing beyond the dense tree sapling and shrub stage needed by many SGCN, such as the golden-winged warbler and the Appalachian cottontail. Thus, active management, following best management practices, within the range of species dependent on young forest habitat will continue to be a priority in coming years.

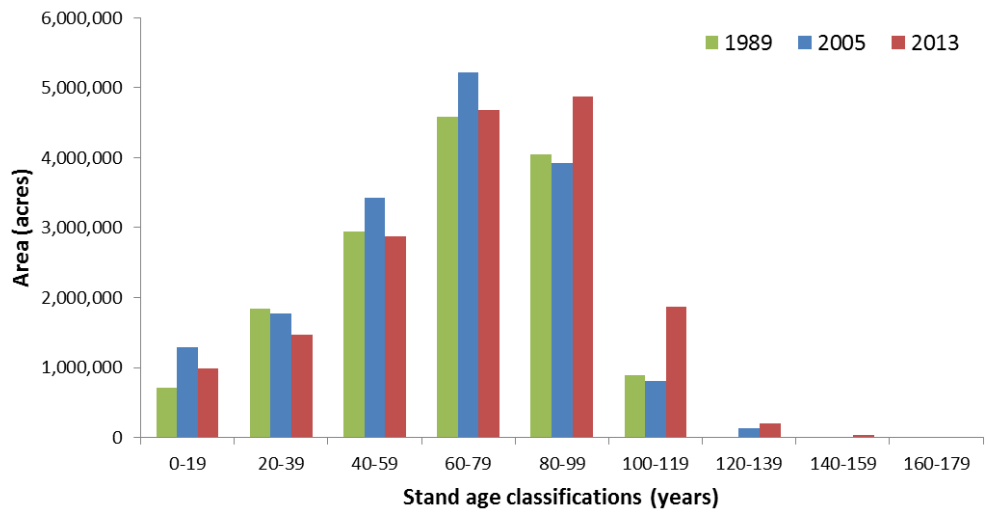

Fig. 2.7. Stand age classification for Pennsylvania's forests across three survey periods beginning in 1989 (O'Connell et al. 2014).

Condition Assessment

Landscape Condition

Forest Habitat Loss – Loss of natural cover from permanent, human-associated land use change is arguably the most serious challenge to Pennsylvania's forests and other habitats, potentially leading directly to the decline and loss of wildlife species. The loss of this natural habitat in Pennsylvania today is due largely to the consumption of open space and wildlife habitats by sprawling human development. Although the population of Pennsylvania has not increased substantially, the amount of suburban and urban land being consumed by development continues to increase. Some rural counties have seen an increase in housing units exceeding 20% in recent decades (Pennsylvania State Data Center 2011). Uncontrolled sprawl, and the resulting habitat loss and degradation, is now the No. 1 threat to wildlife in the state.

Residential and Commercial Development was the most often-identified threat categories to SGCN in the species accounts (Chapter 1, Species; Appendix 1.4). If the rate of loss of open space continues to increase, as it did from 1992 to 1997, it is estimated that current acreage of wildlife habitat lost in Pennsylvania may now actually be 350 acres (142 hectares) per day. Whereas sprawl and development are primarily affecting farmland, both cultivated crops and pastureland, it also has a direct impact on forested landscapes. In addition, residential development of forests is a growing threat to wildlife in many areas. Once developed, terrestrial habitats can rarely be reclaimed or restored for wildlife.

Habitat Fragmentation – In addition to habitat loss from conversion to non-habitat (e.g., forest to parking lot), a process known as habitat fragmentation can negatively influence habitat quality (Morrison et al. 1992). Habitat fragmentation is the division of large, contiguous, areas into smaller pieces of habitat. These pieces are typically separated by roads, agriculture, utility corridors, buildings, or other human infrastructure development. Fragmentation affects wildlife when patches of undisturbed habitat are surrounded by human-altered landscapes such as roads, cities or farms. This creation of physical barriers limits movement of species and interrupts ecological processes that happened within previously connected natural vegetation. Species respond differently to the effects of forest fragmentation, but for many species fragmentation has negative effects (Fahrig 2003).

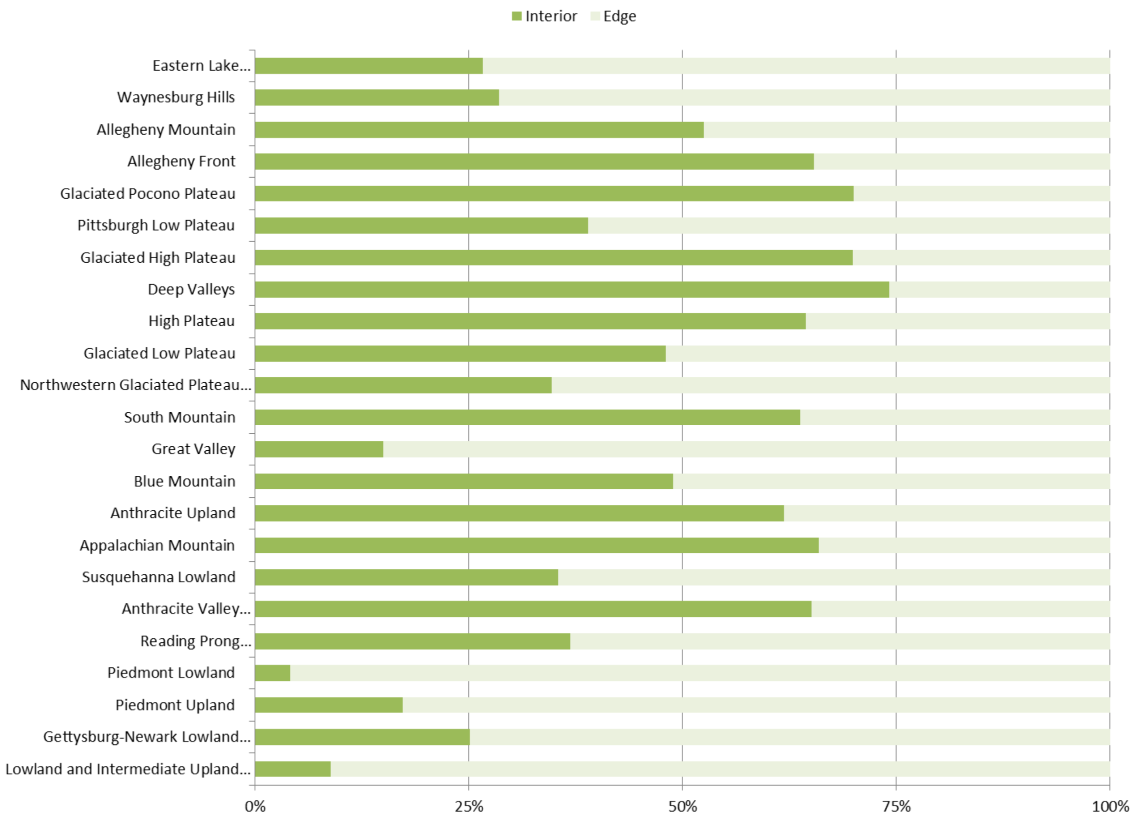

Fig. 2.8. Proportion of edge and interior forest patches across physiographic sections in Pennsylvania.

An additional impact of forest fragmentation is the creation of more habitat edges, which may benefit some species of wildlife, but these often favor generalist species (e.g., robins, blue jays) over forest interior species (e.g., black-throated green warbler) (Askins 1994; Faaborg et al. 1995). Great proportions of edge habitat are present in physiographic sections that are more developed (e.g., Lowland and Intermediate Upland) or agriculture (e.g., Piedmont Lowland) compared to sections that are more remote (e.g., Deep Valleys) (Fig. 2.8).

Numerous studies have shown that the landscape surrounding an isolated habitat patch can influence the quality of the patch by causing changes in temperature and moisture regimes within the patch or more commonly by influencing the abundance of competitors, predators, and brood parasites within the patch (Morrison et al. 1992; Faaborg et al. 1995). Fragmented habitat tends to be particularly vulnerable to non-native invasive plants and animals, one of the more serious threats facing native species.

While any large-scale canopy disturbance affects a forest, it is important to distinguish between a forest fragmented by development from human-built infrastructure and a forest of mixed ages and varied canopy closure that results from forest management. The former is typically several times more damaging to forest health and habitat quality, usually with permanent, negative effects, whereas the latter supports dynamic characteristics and multiple seral, or intermediate, stages across the forested landscape.

Connectivity between habitat patches and maintenance of natural corridors that connect forests, wetlands, and waterways is of critical importance for many species. For example, many amphibians and dragonflies use an aquatic or wetland habitat in one phase of their life, and then migrate to an upland, forested habitat for their adult life. Connectivity metrics vary between species based on dispersal distance, sensitivity to barriers, and other ecological factors.

Habitat Condition

Healthy forests are typically highly resilient. They maintain forest processes and are structurally complex, ecologically productive, and composed of diverse native plants and animals. Forest integrity measures the ability to support and maintain species assemblages, to support ecosystem elements such soil and water, and to support ecological processes. However the condition (health) of the forest has been reduced over time. Principal factors that have negatively affected forest health in Pennsylvania include insects and diseases, fire exclusion, invasive plants, inadequate forest regeneration, and overabundant deer populations. Climate change poses an additional challenge to forest health in the region (Chapter 3, Threats). The majority of Pennsylvania's forests are from 95 to 125 years old, having originated from the widespread clearing that occurred during the final decades of the 19th century to fuel the industrial revolution (PADCNR 2010b). This has led to forests that are relatively uniform, with a homogeneous forest canopy structure. Such a lack of habitat structure and diversity is a negative influence on SGCN as a whole. Many biologists believe the state has a shortage of both early successional and late successional (i.e., older) forests. In addition, the oak-pine woodlands and savanna noted by early settlers are nearly gone in Pennsylvania and across the eastern United States (Brose et al. 2014). These habitats, maintained by regularly occurring fires, were likely important to many SGCN such as red-headed woodpecker, prairie warbler, and eastern spotted skunk. Where such woodlands are being restored, positive responses by SGCN are being noted.

Forest regeneration has been an ongoing area of concern within Pennsylvania's conservation community, including foresters and habitat managers. When young trees are not produced to replace harvested, older, or dead and dying trees, the forest is fundamentally threatened. Over the past 5 decades multiple factors, and interactions among them, have negatively affected forests. Factors have included white-tailed deer overabundance, fire exclusion, acid deposition, poor timber harvest practices, and non-native diseases and pests (PADCNR 2003). However, the forest regeneration outlook today is brighter than in the past, due largely to sustainable deer management and the Pennsylvania Game Commission's harvest allocation model that takes forest habitat into account (see Rosenberry et al. 2009). Such management will be integral for SGCN into the future as the agency continues to balance wildlife, habitat, and societal needs.

Many tree species have been lost from our forests due to pests and diseases. American chestnut trees (*Castanea dentata*), once abundant, were lost throughout the state to the chestnut blight fungus (*Cryphonectria parasitica)*, which was introduced into the United States in the early 1900s and decimated chestnuts throughout all of eastern North America. Currently, chestnut trees are seen only as small sprouts, which then succumb to the fungus before reaching maturity. Hemlock woolly adelgid (HWA) (*Adelges tsugae*) is another invasive pest that harms hemlock populations and thus, associated wildlife species. The emerald ash borer (*Agrilus planipennis*), an invasive insect first identified in the state in 2007, has recently affected ash trees. Nine invertebrate SGCN are dependent on these tree species. These and other forest pests are discussed in Chapter 3.

Open Terrestrial Habitats

In addition to forests, there are several types of open habitats in Pennsylvania that are important for SGCN. The 2005 Plan broadly defined these open habitats as grasslands and, while generally true, this may not specifically describe the range and conditions of open habitats occurring in the state. The historical extent of these open habitats in Pennsylvania is not known; however, there is ample evidence that barrens and native grasslands have been part of the landscape for thousands of years. Open habitats in Pennsylvania today consist of 4 primary types: naturally occurring barrens, agricultural land, reclaimed surface mines, and miscellaneous anthropogenic sites.

Naturally Occurring Barrens

Natural terrestrial openings in Pennsylvania include several types of barrens, which typically are areas with thin soil and xeric (i.e., very dry) conditions. Nearly all barrens habitats share certain environmental characteristics such as dry, sunny conditions and well-drained, nutrient-poor soils. The Pennsylvania Natural Heritage Program recognizes 5 types of barrens (Fig. 2.9) in the terrestrial community classification, and The Nature Conservancy (TNC) recently provided management guidelines for each (Orndorff and Coleman 2008):

- <u>Serpentine barrens</u> – The serpentine barrens are located along the Pennsylvania and Maryland border in Lancaster and Chester counties, making this the largest expanse of serpentine vegetation in eastern temperate North America. These barrens consist of ultramafic (i.e., igneous rock with very low silica content and rich in minerals) bedrock, which is either exposed or is near enough to the surface that it has an influence on soil properties. The serpentine barrens contain the largest number of endangered plant and animal (largely invertebrate) species in Pennsylvania and are under constant threat from urban sprawl and development (Noss et al. 1995).
- <u>Scrub oak-pitch pine barrens</u> – These are located in the central and south-central portions of the state, where uncharacteristic temperature ranges including frost in midsummer. The largest known complex is State Game Land 176 in Centre County, locally known as Scotia Barrens. Scrub oak-pitch pine barrens are important habitat for the golden-winged warbler, Appalachian cottontail, ruffed grouse, eastern whip-poor-will and many other bird, plant, and invertebrate species.

- Shale barrens – Located in southcentral Pennsylvania, a shale barren is a steep south-facing slope where the bedrock is composed of shale that can reach temperatures of over 130°F (55°C) (Platt 1951). Despite the dry living conditions, many species have become adapted to this habitat including many globally rare moth and plant species.
- Ridgetop acidic barrens – Typically represented by the pitch pine-scrub oak or heath types, these barrens are restricted primarily to the highest, most exposed portions of the ridge and are surrounded by mixed hardwood forests.
- Mesic till barrens – While the above 4 types of barrens are xeric types, this type is unusual as it is a wet-occurring glacial till. They occur along the southern edge of the Pocono Plateau in Monroe County. These barrens contain one of the highest concentrations of globally rare plant and animal species in Pennsylvania (Davis et al. 1991).

Limestone glades and grasslands were not represented in the TNC management plan, but they represent an important barrens community type (Thorne et al. 1995; McPherson 2013). Another type of open habitat includes dunes and beaches, which are largely restricted to Presque Isle State Park along the shore of the Lake Erie.

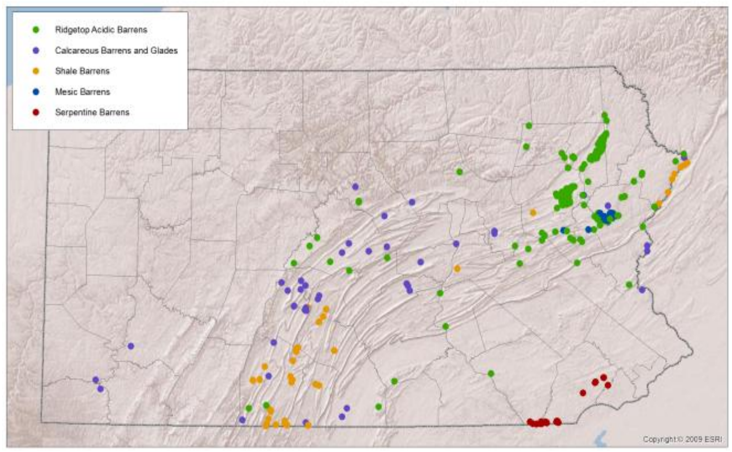

Fig. 2.9. Distribution of barren communities in Pennsylvania.

Agriculture

Historically, Pennsylvania's small family farms situated within a forested landscape provided abundant and diverse wildlife habitat. Most of these small farms practiced rotational cropping that resulted in idle areas dominated by dense herbaceous vegetation (Helinski 2001). The number of farms and amount of land devoted to farms peaked in 1900 when about two-thirds of Pennsylvania was cleared (McWilliams and Brauning 2000).

Reclaimed Surface Mines

Reclaimed surface mines provide extensive non-agricultural grassland habitat in Pennsylvania with more than 2 million acres (0.8 million hectares) in the Commonwealth (Yahner and Rohrbaugh 1996a). Generated by resource extraction activities and once considered wastelands, some sites can be restored to quality habitat for grassland-associated species. The acidic, nutrient-poor soils of reclaimed sites provide little potential for agricultural or timber production, and grasses and legumes tend to be the most successful and persistent vegetation types. These relatively undisturbed fields have a slow rate of ecological plant succession and are ideal for grasshopper sparrows (*Ammodramus savannarum*), and compatible for many other grassland-associated birds (Bajema et al. 2001). Therefore, management of reclaimed surface mine areas as grassland reserves may help prevent some species from declining, notably Henslow's sparrow (*Ammodramus henslowii*) (Mattice et al. 2005).

Anthropogenic sites
These are large human-dominated sites such as airstrips, military installations, and reclaimed landfills that consist of level expanses of short grass fields that can offer excellent habitat for breeding colonies of upland sandpipers (*Bartramia longicauda*) and other SGCN. Some urban or suburban areas also could be included in this description, especially parks, large lawn areas, golf courses, and recreational fields.

Trends
Breeding bird surveys provide an indicator of open habitat decline; 9 of 13 species associated with agricultural land and grasslands declined between the first and second Pennsylvania Breeding Bird Atlases(Wilson et al. 2012). Only 2 species, the sedge wren and bobolink exhibited strong positive increases. Succession to shrubland and forest is a threat to reclaimed grasslands. Although poor soil quality and a lack of nutrients slow successional processes on these strip mines, many sites are now becoming colonized by woody vegetation. Many of these colonizing plant species are non-native and low-quality species such as black locust, autumn olive, multiflora rose. Recent success with planting blight-resistant American chestnut on abandoned mine lands (McCarthy et al. 2008) has converted some mine land to a forested condition. To maintain the suite of grassland-associated species in these areas, woody growth needs to be managed.

Private development is an emerging threat to some of these open terrestrial sites. Serpentine barrens and pitch pine-scrub oak barrens in Centre County (e.g., Scotia Barrens) are heavily impacted by suburban sprawl, either from habitat conversion or due to constraints around management activities such as prescribed fire. The PGC is a major landowner of reclaimed grassland in southwestern Pennsylvania, but land acquisition has slowed due to budget constraints and the increasing land values of the sites. Some reclaimed grasslands are desirable for recreational development. Pennsylvania has lost over 1.1 million acres (0.44 million hectares) of farmland since the 1960s. Since that time, major declines have occurred in almost all groups of grassland-associated wildlife. Support for U.S. Department of Agriculture Farm Bill conservation programs can assist in regaining some of these losses.

Condition Assessment
No formal condition assessment of open habitats has been done for the state. Landscape condition metrics for certain barren habitats described in the Plan are presented in Appendix 2.1.

Wetlands
Wetlands provide critical habitat for many plant and animal species, and provide valuable ecosystem services such as water filtration and flood control. Wetlands are defined as "areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (USEPA 2012). Wetlands generally include swamps, marshes, bogs, and similar areas" (USEPA 2015). As with upland ecosystems, wetlands are heavily influenced by local soil type, disturbance history, bedrock composition, and hydrologic regime. Saturation by water influences the soil development, which, in turn, influences the type of plants and animals able to use that habitat. Wetlands differ across the state based on topographic position, geology, climate, hydrology, vegetation, and human influences (Stewart 2001). The National Wetlands Inventory (NWI) is the primary and most

complete mapping product for wetlands in the state (Tiner and Finn 2012). Pennsylvania wetlands fall into three classifications: *alluvial wetlands* associated with rivers and streams, *basins* located in depressions and low areas, and *tidal wetlands*. More than 410,009 acres (165,924 hectares) of palustrine (e.g., marshes, swamps) wetland have been identified within Pennsylvania according to the NWI. An additional 643 acres (260 hectares) of estuarine habitat are located in the southeastern region, along the Delaware River.

Fig. 2.10. Wetland distribution in Pennsylvania based on the National Wetland Inventory (NWI) dataset. Wetland polygons are enlarged for clarity. Note that the NWI dataset may be incomplete for some areas and not all known wetlands are presented.

Wetlands in Pennsylvania are largely concentrated in the northwestern and northeastern corners of the state, where glacial influence modified the landscape (Fig. 2.10). However, wetlands associated with river and stream floodplains, mountaintop peatlands, vernal pools, and other relatively small types occur throughout the state. Many of Pennsylvania's wetlands are associated with streams and rivers. These include floodplain forest, floodplain grasslands, shrub swamps, herbaceous marshes, and vernal pools. Floodplain forests occur along rivers and streams in low-lying areas. These locations are periodically inundated by floodwaters resulting from spring runoff and intense storm events. Floodplain forest communities can receive severe disturbances from floodwaters including erosion, scouring by ice and debris and the deposition of considerable quantities of sediment. Only species with adaptations or tolerance for these kinds of conditions can survive here. The Pennsylvania Natural Heritage Program (PNHP) has identified over 75 types of wetland communities in the state (Zimmerman et al. 2012). Many of these wetland types are frequently rich in species diversity and provide important breeding habitat for numerous amphibians, reptiles, invertebrates, and birds.

Vernal pools, also known as seasonal or ephemeral pools, are wetlands that fill annually from precipitation, surface runoff, and rising groundwater (Kenney and Burne 2000; Brown and Jung 2005).

Typically through evaporation, these pools become completely dry by late spring or early summer. Because these ponds dry-up, they cannot support fish populations. During the brief spring period when pools contain water, they serve as important breeding sites for many amphibian species (e.g., salamanders and frogs); many of which breed solely in vernal pools due to the absence of fish. PNHP has initiated a Vernal Pool Registry, to map vernal pool locations, yet vernal pools are likely underrepresented in this database (Fig. 2.11).

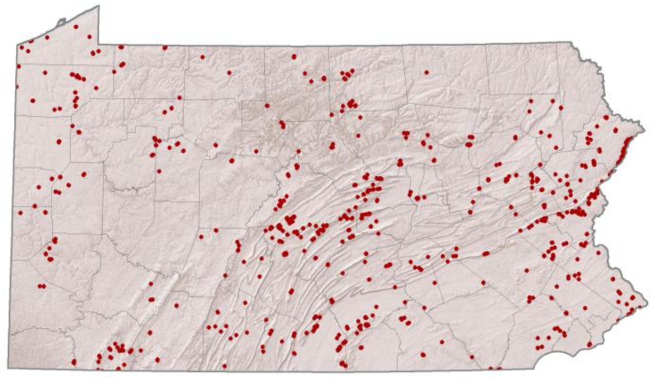

Fig. 2.11. Distribution of documented vernal pools in Pennsylvania (Source: PNHP).

Many animal groups such as amphibians, reptiles, dragonflies, damselflies, moths, and butterflies depend on specific wetland habitats for all or a portion of their life cycles. Wetlands are relatively rare throughout much of Pennsylvania (Fig. 2.10) but provide critical, free ecosystem services and are an important home for wildlife and the unique plant communities on which they depend.

Trends

Pennsylvania may have lost about 56% of its total wetlands since pre-Colonial times, leaving an estimated 404,000 acres (163,000 hectares), or approximately 1.4%, of the state as wetlands (Tiner 1990). One of the largest losses of wetland was the 10 to 20 square miles (6,400 to 12,800 acres) (2,589 to 5,179 hectares) of tidal wetlands lost around Philadelphia; only about one-quarter of an acre of tidal marsh remains in Philadelphia County today. The Philadelphia tidal marshes would have been an important breeding and migratory location for many bird, mammal, fish, and insect species. Nationwide, wetland losses peaked between 1954 and 1974, but have since moderated largely due to stronger protections and restoration efforts (Adler et al. 1993).

Condition Assessment

Despite the major focus on documenting condition for wetland management, comprehensive condition assessment for all of Pennsylvania's wetlands is not currently available. The requirement of Section 305(b) of the Clean Water Act that all waters of the United States be assessed every two years has been historically ignored for wetlands (Wardrop et al. 2007). To that end, the U.S. Environmental Protection Agency (USEPA) is currently conducting a National Wetland Condition Assessment, to statistically assess the condition of the nation's wetlands, including several sites in Pennsylvania. Although not complete, the EPA project will help determine the ecological integrity of wetlands at regional and national scales.

In the meantime, several smaller regional wetland condition assessment studies have been completed in areas across Pennsylvania. A method for assessing the condition of wetlands on a watershed basis from landcover maps in the mid-Atlantic region was developed by Brooks et al. (2004). Additionally, Wardrop et al. (2007) compared landscape condition to on-the-ground rapid assessment techniques in the Juniata basin, and found that rapid condition assessments tend to estimate condition more accurately than modeled landscape approaches, in addition to more accurately gauging the issues related to wetland condition. Moon and Wardrop (2013) looked at 8 headwater wetland complexes in Pennsylvania as part of a study to link landscapes to habitat condition. In their study, they related wetland processes to landscape-driven stressors, through pre-existing knowledge about the links between stressors and wetland structure. Overall, monitoring of wetland condition provides information that can be used to target areas for protection, restoration prioritizing, and choosing best management practices.

Streams and Rivers

Pennsylvania contains more than 86,000 miles (138,403 kilometers) of streams and rivers ((PADEP 2014a). These systems support more than 1,000 aquatic species, including 201 species of fish and the majority of federally listed species (PNHP 2015). These flowing waters form aquatic systems of great diversity within the state. They typically begin as small brooks which form from surface runoff, springs, and seeps. These are the headwaters which unite to become larger stream and river systems lower in the watershed (Fig. 2.2).

Each of these primary drainages can be further subdivided into smaller watersheds that contain an interconnected network of streams and often serve as a focus for local conservation efforts. Physiographic provinces with the greatest total length of streams include the Northern Ridge and Valley province (21,605 miles; 34,769 kilometers), the Ohio Hills (also known as the Pittsburgh Low Plateau) (14,588 miles; 23,477 kilometers), and the portion of the Northern Plateau province encompassing the Allegheny High Plateau (16,526 miles; 26,596 kilometers). As the small brooks coalesce into streams and rivers, the larger aquatic systems offer a variety of microhabitats that support many stream-dwelling organisms.

The River Continuum Concept (RCC) describes these ecological processes, moving from headwater streams to larger rivers (Vannote et al. 1980). In this model, headwater streams are likely to be characterized by abundant aquatic insects on rocky stream bottoms with small fishes serving as the secondary consumers. In these streams, the primary sources of energy are from trees and other terrestrial contributors) and consist of coarse particulate organic matter. Moving further downstream, the larger streams and rivers may be slow-moving and muddy. Here, a combination of fine organic matter and primary production are sources of energy, and floodplain and backwater habitats also may contribute to overall production. Invertebrates shift from collector/gatherers to filter feeders. Sunlight strikes the water’s surface as canopy trees cover only shorelines and do not extend across the width of the channel. Larger streams and rivers are generally inhabited by larger fish and mud-dwelling organisms. The RCC provides a framework for viewing stream functions and processes.

The two major stream microhabitats are riffles and pools. Riffles are shallow, fast flowing, well-aerated rapids flowing over rocky sections of the stream bottom. They support a diverse animal community dominated by insects, crustaceans, mussels, and fish. Interspersed between riffle sections are pools; quiet, deeper water habitats that tend to support a different stream biota than the riffle sections. These pools become important habitat during this dry portion of the year.

As the hydrology, ecology, and other stream features are related to stream size, a commonly used approach to understanding stream systems is to classify them according to size and location within a drainage hierarchy. Stream order (Strahler 1952), which has often been used to characterize stream size, is based on stream connectivity (e.g., first-order, second-order, where second-order streams are formed by the joining of two first-order streams). The condition of these low-order streams is critical to the health of the waters downstream (USEPA 2000).

The Pennsylvania Department of Environmental Protection (DEP) estimates that 52,516 miles (84,516 kilometers) (63%) of Pennsylvania streams have been designated Cold Water Fishery, 10,153 miles (12%) Trout Stocking Fishery, and 21,296 miles (34,272 kilometers) (25%) Warm Water Fishery. An estimated 3,076 miles (or about 4%) of the state's streams have been awarded additional protection as Exceptional Value streams, while 22,563 miles (36,311 kilometers) (or about 27%) have been classified as High Quality. The PADEP, as part of the Clean Water Act, has designated all streams as Unimpaired or Impaired, based on macroinvertebrate and habitat condition data collected by the Statewide Surface Water Assessment Program (SSWAP). A stream labeled as 'impaired' is no one no longer able to support one or more of its designated uses.

Trends

Activities such as mining, forestry, industry, agriculture, residential development, pipeline construction, road building and maintenance have degraded water quality in Pennsylvania. Sedimentation from road and pipeline construction is a major issue in some portions of the state. Protecting the quality of surface and groundwater resources from degradation contributes to the future wellbeing of all plants and animals, including human communities.

For much of the last 100 years, sand and gravel has been mined from the Allegheny and Ohio rivers by commercial dredgers. This activity has greatly altered habitat for many SGCN, especially freshwater mussels by removal of the substrate and creation of deep pits up to 70 feet (21 meters) deep. Declines of sand and gravel reserves and recent regulatory changes have largely eliminated dredging activity in the area (Thomas 2013).

Stream trends are difficult to measure and vary due to location and timeframe. For example, the Pennsylvania range of native brook trout, a species that prefers cold, high-quality streams, has been reduced by 66 percent and most of the remaining populations have been reduced from historical numbers – mirroring patterns throughout its range (Eastern Brook Trout Joint Venture 2006).

Condition Assessment

Riparian cover – Riparian areas, defined here as the narrow 328 foot (100 meter) zone flanking all streams and rivers, are important for stream function and habitat, as they act as a filtering system against pollutants and sediments. Vegetated riparian areas serve as protective buffers against erosion, provide cooling shade to the waterway, filter pollutants and excessive nutrients from runoff, and help alleviate flood damage along many of the area's creeks. Furthermore, intact, forested riparian buffers preserve the water temperature, food resources, and cover necessary for healthy populations of game fish such as the native brook trout (Welsch 1991). Elimination of riparian vegetation removes the capacity of floodplains to buffer the effects of the surrounding landscape and floodwaters, and consequently reduces the water quality in the stream. Nearly a third of the riparian area in the state has been converted away from natural cover. Riparian cover ranges from 23% in the Piedmont Lowland Section to 90% in the High Plateau Section. Only 16% of the total riparian buffer area in the state is protected against development.

Water quality – The most significant pollution impacts on aquatic habitats and the species that depend on them comes from non-point source runoff. Non-point source pollution originates from nutrient-rich runoff from agricultural lands or urban and suburban neighborhoods, sewage overflows from combined sewers in our older towns and cities, or acid drainage from mine lands. No matter the source, non-point source pollution affects chemical composition and water quality. While the volume of non-point source pollution has decreased from historical highs during the 20th century, water quality in streams is still negatively impacted by point-source pollutants, such as industrial discharges. Sedimentation smothers the substrate in silt, reducing the quality of aquatic habitats and nursery areas for many species. Additional factors such as a lack of adequate riparian buffers, PCBs (polychlorinated biphenyls), and other issues are present in our streams as well. DEP monitors water quality and presents impairment data through its 305(b) program (Fig. 2.12).

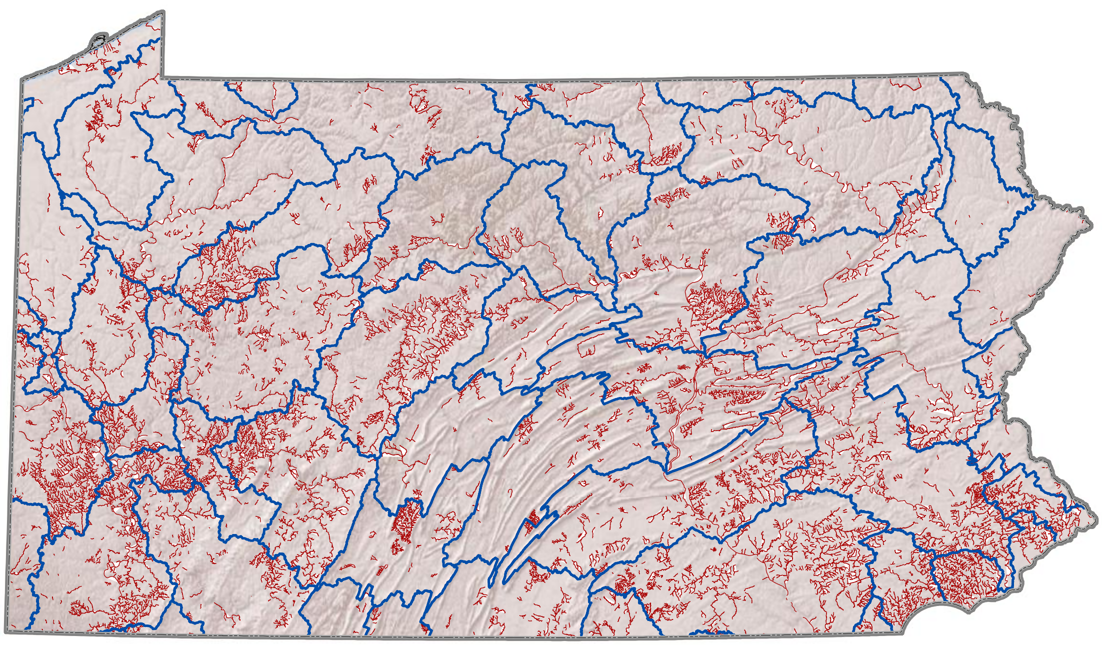

Fig. 2.12. Impaired stream reaches in Pennsylvania (red) within sub-basin watersheds (HUC08)(dark blue).

Reasons for waterway impairment vary. The Lower Susquehanna HUC08 is highly influenced by agriculture. The source of impairment for the Schuylkill and Lower Monongahela HUC08s relate to urban development, while the Conemaugh and Upper West Branch Susquehanna are related to the impacts of abandoned mine drainage (AMD). In the increasingly urbanized areas of the southeast (Philadelphia area and Delaware, Chester and Montgomery counties) and southwest (Pittsburgh area and Allegheny, Armstrong and Butler counties), habitat quality of many streams is impacted by channelization, surface runoff from streets and highways, and other forms of urban pollution. In other portions of the southeast (Lancaster, Berks, York counties), the quality of some historic localities may be negatively affected by siltation and agricultural runoff. Similarly, stream habitats in the west-central and northwest may suffer the impacts of acid mine drainage (AMD). The Ohio drainage hosts 80% of state-listed fish species as well as the majority of known mussel species in the state, suggesting this system is a high priority for conservation efforts. Amphibian diversity is similarly higher in these western drainages (Myers et al. 2000).

Ecosystem flows – Because of its natural abundance, Pennsylvania historically has taken water supply for granted. However, as the state's population has grown and shifted, per capita water use has risen, causing increasing conflicts among water users. Water quantity may be an increasingly important issue for wetland and stream conservation, as some species can survive only in cool, fast-flowing streams. The Nature Conservancy (TNC) and partners have produced a series of ecosystem flow studies (DePhilip and Moberg 2010, 2013a, 2013b; Taylor et al. 2013) that provide ecologically-based flow recommendations to guide instream flow protection for sustaining aquatic ecosystems in the state's streams and rivers. These types of flow studies could be useful especially to guide conservation actions in streams containing SGCN. Additionally, seasonal wetlands, such as vernal pools and other shallow wetlands, also are highly susceptible to water-quantity issues. Restoration of wetlands and protection of remaining wetlands and streams are especially critical given the severe decline this habitat type has endured. Of particular concern are the long-term impacts of groundwater withdrawals, which can be difficult to quantify and characterize.

Aquatic connectivity – Similar to the fragmentation of terrestrial habitats, linear aquatic habitats, such as streams and rivers, can be fragmented by – and sustain flow impairment – dams and other barriers. The fragmentation of river habitats through dams and poorly designed culverts is one of the primary threats to aquatic species (Collier et al. 1997; Graf 1993). The impact of fragmentation on aquatic species generally involves loss of access to quality habitat for one or more life stages of a species and may limit reproduction and/or dispersal of a species. TNC recently completed a Northeast Aquatic Connectivity Project (NAC) (Martin and Apse 2011), in which it created a regional, error-checked, geographic information system (GIS) database of dams throughout the Northeast. According to Martin and Apse (2011), there are over 3,000 dams in Pennsylvania. These dams range from small low-head dams on small streams and creeks to larger flood-control, hydroelectric, and navigational dams on the large rivers (Chapter 3). Future restoration projects should reconnect strategically fragmented aquatic habitats by targeting removal or bypass of key barriers to fish passage. An additional, but less well understood impact to connectivity is fragmentation of aquatic habitats by stream impairment, such as AMD.

Lakes and Ponds

Pennsylvania's lake and pond habitats are most abundant in Pike and Wayne counties. Small ponds, many of which are farm ponds, number more than 67,000 statewide. These systems may have similar vegetation in some of the wetland communities around their shallow edges (the littoral zone) and support a diverse fauna including fish, reptiles, amphibians, and insects (Majumdar et al. 1989).

Lake Erie is the shallowest of the Great Lakes with an average depth of 62 feet (19 meters) and a maximum depth of 210 feet (64 meters). Due to its southern location and complex basin shape, Lake Erie is the most biologically productive of the Great Lakes and thus, supports a rich diversity of habitats and species. Over 500 square miles of Pennsylvania drains into Lake Erie, much of which has been converted to agricultural or developed land. This makes Lake Erie the most ecologically stressed Great Lake (Evans 2014; Scharold et al. 2015).

Pennsylvania's only other natural lakes are the result of glacial activity and are located in both of northwestern and northeastern corners of the state. Most of the lakes formed at the end of the last ice age, by melting blocks of ice forming kettle holes. The 8 glacial lakes in northwestern counties are calcareous, and thus have a greater richness of plant and animal species, compared to the acidic lakes of northeastern counties. Lake Pleasant, in Erie County, is the least impaired and most species-rich of the northwestern glacial lakes and is the subject of conservation efforts by the Western Pennsylvania Conservancy (WPC) (Bissell et. al. 1989; WPC 2005). Several of these natural lake environments were altered by shoreline development and wetlands destruction, impacts from recreational, water-level manipulation, and pollution. In addition, invasive exotic plants and animals, such as the zebra mussel, have invaded many of these lakes, posing significant threats to their ecological integrity.

The remainder of Pennsylvania's lakes and ponds are reservoirs and man-made impoundments created by the damming of rivers and streams for flood control, water supply, and recreation. These impoundments can provide habitat for many species of waterfowl and wading birds throughout their breeding, migration, and wintering seasons. The age, depth, disturbance amount, and history of these man-made lakes and ponds vary, which may determine the wildlife present.

Trends

Lake succession progresses through several increasing stages of biological productivity: 1) oligotrophic, 2) mesotrophic, 3) eutrophic, and 4) hypereutrophic states (Pennsylvania Lake Management Society 2004). Oligotrophic lakes are typically nutrient-poor, clear, deep, cold, biologically unproductive lakes. Hypereutrophic lakes, at the other end of the spectrum, are extremely nutrient-rich, often with algal bloom-induced conditions, and characterized by abundant aquatic plant populations in shallower areas, fish kills, and high levels of sedimentation.

Although lakes naturally go through the trophic states in a slow successional process, anthropogenic influences can greatly accelerate the progression. Human activity within the lake watershed typically hastens the eutrophication process and often results in increased algal growth stimulated by an increase in nutrients. Increased plant growth also can ensue from this nutrient-rich environment, along with expanding shallow areas, resulting from high rates of sedimentation. Where human pressures on lakes are severe, this process of nutrient accumulation, referred to as "cultural eutrophication," can be accelerated to mere decades, instead of hundreds or thousands of years.

Condition Assessment

The main water-quality concerns relating to Pennsylvania lakes are conditions associated with eutrophication, particularly from cultural sources. All lakes undergo eutrophication, an aging process that ensues from the gradual accumulation of nutrients and sediment, resulting in increased productivity and slowly filling of the lake with silt and organic matter from the surrounding watershed. DEP conducts lake monitoring to provide lake status information that is required by Section 314 of the Federal Clean Water Act; specifically to define the trophic condition of all publicly owned freshwater lakes and to control pollution sources and restore lake quality for maximum public use benefit.

Lakes in Pennsylvania are highly accessible; nearly all (>99%) are less than one mile (1.6 kilometers) from a road, which suggests that most of the lakes are impacted by pollution, invasive species and other issues that are associated with human development. Due to the large number of impoundments in the state, dams are fairly ubiquitous, with even some natural lakes having been impounded to raise water levels. These dams have likely altered the temperatures and other conditions of these natural lakes.

Subterranean Habitats

In Pennsylvania, caves are found primarily in 3 physiographic sections: the Appalachian Mountains (522 caves), Allegheny Mountains (322 caves), and Great Valley (238 caves), with a modest number caves scattered elsewhere throughout the state (Fig. 2.13). While there are several different types of caves, 4 different cave communities are recognized currently in Pennsylvania (Thorne 1995):

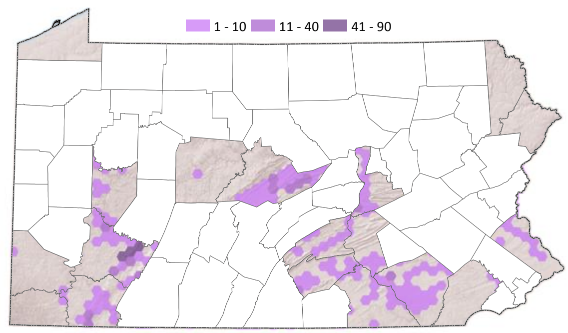

Fig. 2.13. Count of known caves across Pennsylvania summarized by 10 kilometer (6.2 mile) hexagons.

1. Terrestrial solution caves – The largest and most common type of cave in Pennsylvania, occurring in limestone bedrock.
2. Aquatic solution caves – Similar to terrestrial solution caves, these flooded systems are habitat for many species of invertebrates such as flatworms, isopods, and amphipods, some of which are found nowhere else in the world.
3. Tectonic caves – These are essentially wide, subsurface cracks due to the movement of bedrock (typically sandstone). They are usually dry and also used by bats and woodrats.
4. Talus caves – Formed from masses of boulders piled in a way that creates openings between and beneath rocks. These are typically used by reptiles and small mammals.

In addition to natural caves, extensive mining in Pennsylvania has resulted in numerous man-made subterranean excavations that also sometimes function as caves for animal species (Mohr 1942; Johnson et al. 2006). The distribution of mines in Pennsylvania is associated with the northeastern and southwestern portions of the state. Use of mines is likely an artifact of historic use of rock habitats, but it does indicate that these man-made sights can contribute significantly to the conservation of SGCN. Conservation efforts aimed at protecting these man-made habitats should be stressed as hibernating bats are threatened increasingly by both human-induced mortality, as well as the spread of white-nose syndrome (WNS). Other man-made habitats that are used by bats include limestone mines, abandoned tunnels and other structures that have appropriate conditions (Hart 2001).

Trends

The most significant threats to cavern wildlife are alteration of habitat and disturbance. Cave-associated species in Pennsylvania are subject to direct disturbance from humans wherever there is recreational use of caves. Human visitation, which spans the spectrum from commercialized tourism to recreational spelunking, can alter temperature, disturb hibernating bats, and introduce pollutants. Gated caves show increases in bat numbers through the years, suggesting that ungated caves are disturbed often and bat numbers reduced (Hart 2001).

Condition Assessment

To our knowledge, there has been no formal assessment of the condition of subterranean habitats across the state, although the Appalachian Landscape Conservation Cooperative (AppLCC) initiated a project to map and classify all cave and karst resources within the Appalachian region (AppLCC 2013; Culver et al. 2014). The AppLCC covers approximately 80% of the state, therefore not all of Pennsylvania is included in the analysis; however, this information will greatly enhance our knowledge regarding this resource. About 13% of the known caves occur on conservation land and, thusly, are likely protected from conversion or land disturbance. However, given the complex distribution of water sources, protecting lands draining into caves will be important. One factor that could be measured is the land use/cover in the immediate vicinity of cave entrances, as land cover can affect air flow through the cave and foraging conditions for resident bats. Additionally, the surface area necessary to maintain the temperature, air flow, humidity, foraging, and disturbance regime that support conditions for bat use should be retained.

Northeast Habitat Classification Overview

While simple land cover approaches can provide guidance and mapping concerning wildlife habitats, they offer only coarse classes of vegetation structure or current land use. A need identified in the 2005 State Wildlife Action Plan was development of a consistent habitat classification framework and map across the northeast region, because it is critical for developing habitat-based conservation efforts. Many of these habitats can be mapped at a regional scale, facilitating interstate approaches to wildlife conservation.

Scale is an important consideration in developing any habitat classification (Gawler 2008). Individual animals within populations are mostly responding to very local conditions – a particular type of tree canopy cover, or the availability of standing deadwood, or a litter layer, or the presence of surface water for a certain period, or myriad other factors. However, a regional map cannot represent such fine-scale detail. Instead, we are basing our habitat mapping on the widely used convention referred to as the "coarse filter," in which more broadly defined habitats or community types represent habitat for more than one species (Groves 2003; USFWS 2006; Chadwick 2007). The coarse filter approach can then be supplemented on a local basis by a "fine filter" approach for species-specific needs not otherwise addressed. Plant community associations (i.e., Terrestrial and Palustrine Plant Communities of

Pennsylvania, Zimmerman et al. 2012) and the associated vegetation mapping based on this classification are one fine filter approach.

As discussed below, the Terrestrial Habitat Map and the Aquatic Habitat Map are complementary.

Terrestrial Habitat Classification and Map

The Northeastern Terrestrial Wildlife Habitat Classification System (hereafter Terrestrial Habitat Classification) (Figure 2.14) was developed in 2008 to provide a coarse but cohesive system to describe the physical and biological characteristics relevant to wildlife conservation (Gawler 2008). A key aspect of the Northeast Habitat Map is the interchangeable concept of a habitat and an ecological system (Ferree & Anderson 2013). As defined by Gawler (2008), a terrestrial habitat is "the environment – physical and biological – that provides the necessary food, shelter, and other needs, of a species or groups of species." Similarly, NatureServe© (Comer et al. 2003) defines an ecological system as a "mosaic of plant community types that tend to co-occur within landscapes with similar ecological processes, similar substrates, and/or similar environmental gradients, in a pattern that repeats itself across landscapes." Therefore, the terrestrial habitat is a conceptual idea, while the ecological system is the tangible and mappable classification unit (Ferree & Anderson 2013). In concept and in mapping, the larger systems provide an effective tool for the "coarse filter" approach to conservation planning, as they represent habitat for wide ranges of plant and animal species.

In this Plan, terrestrial habitats include all upland and wetland habitats, but not river or lake aquatic habitats. The Terrestrial Habitat maps are hierarchically arranged by Formation Class, Formation, Macrogroup, and Habitat. For example, the full classification of the "Laurentian-Acadian Northern Hardwood Forest" habitat type would be:

Forest and Woodland Formation Class
└ Northeast Upland Forest Formation
└ Northern Hardwood & Conifer Macrogroup
└ Laurentian-Acadian Northern Hardwood Forest Habitat

Throughout the Northeast, the Terrestrial Habitat Classification describes 120 ecological systems occurring at a wide range of scales from small distinct patch-forming systems (e.g., a sparsely vegetated talus-slope) to extensive matrix-forming forest types.

The habitat system corresponds to NatureServe©'s Ecological Systems Classification, augmented with additional information from individual state wildlife classifications and other information specific to wildlife managers. For the entire northeast, 143 habitat types within 35 Macrogroups were mapped. The 37 terrestrial habitats identified in Pennsylvania are presented in Table 2.2.

The Terrestrial Habitat Map was developed by assembling spatial datasets for the region that describe geology, elevation, landform, land cover, and climate. Approximately 60 variables were derived for use in the analysis and model. Detailed methods, results, and validation can be found in Ferree & Anderson (2013). The Macrogroups from the Terrestrial Habitat Map are presented in Fig. 2.14.

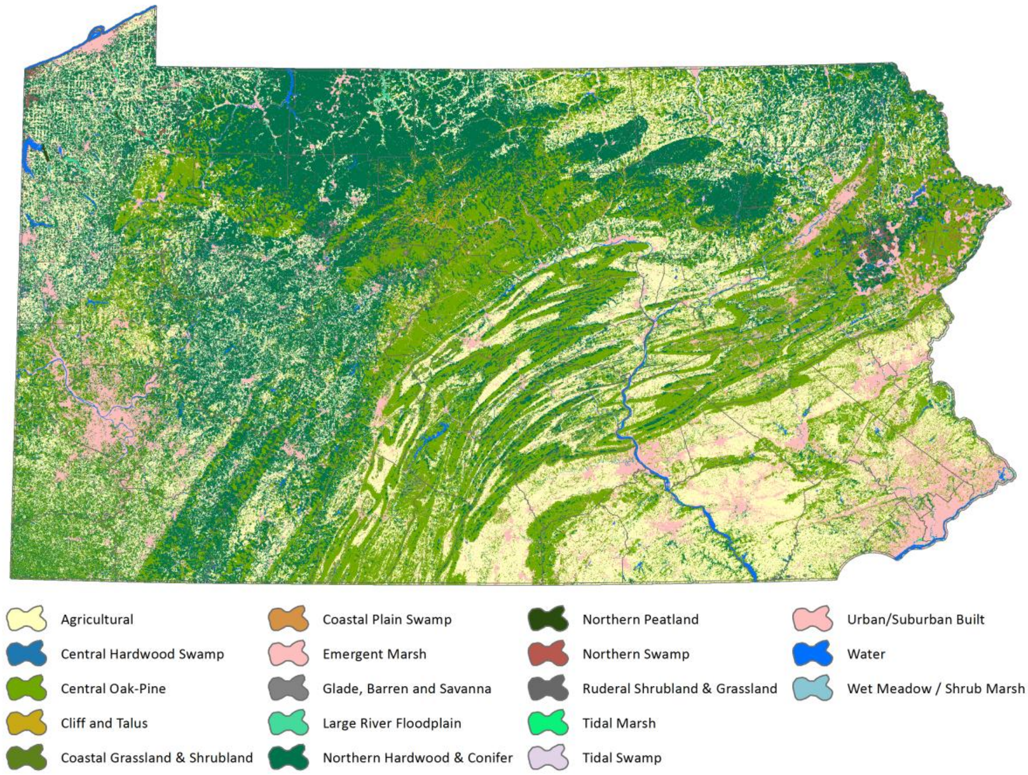

Fig. 2.14. Macrogroups from the Northeast Terrestrial Habitat Map.

The bulk of Pennsylvania's forests are found within two Macrogroups; Northern Hardwood & Conifer and Central Oak-Pine. Each Macrogroup has one or more associated habitats (Table 2.1). Detailed reports of each habitat, its extent, condition, as well as associated SGCN, are presented in Appendix 2.1.

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Table 2.1. Distribution (in acres) of Northeast Habitat Classification Macrogroups among Pennsylvania physiographic sections.

Physiographic Section	Central Hardwood Swamp	Glade And Savanna	Coastal Grassland Shrubland	Northern Hardwood Conifer	Northern Swamp	Coastal Plain Swamp	Central Oak Pine	Cliff And Talus	Northern Peatland	Ruderal Shrubland Grassland	Wet Meadow/Shrub Marsh	Emergent Marsh
Eastern Lake	519		382	41,611	10,227			147		4,807	806	1,252
Northwestern Glaciated Plateau	512			815,535	70,381		38,116	341	6,111	45,755	19,861	11,290
Glaciated Low Plateau				829,253	58,585		734,735	8,393	9,995	290	6,268	9,971
High Plateau				873,348	16,842		336,947	7,009	597	3,365	468	1,297
Deep Valleys		42		1,583,489	21,943		679,999	176,657	985	813	1,136	4,412
Glaciated High Plateau				481,769	4,419		42,294	6,770	4,165		1,101	1,279
Anthracite Valley	25	2,510		27,592	5,178		145,677	792	16	7,641	450	257
Pittsburgh Low Plateau				1,933,948	16,428		1,013,320	2,421	37	83,407	4,653	4,463
Glaciated Pocono Plateau				125,489	32,676		98,589	220	8,242		511	196
Susquehanna Lowland	123	23,868		268,051	11,655		447,470	1,333	3	3,497	2,012	3,396
Allegheny Front		3,435		246,002	839		431,858	627		349	511	367
Appalachian Mountain	35	61,752		439,448	6,634		1,613,246	4,386		2	1,034	1,431
Anthracite Upland	183	19,033		119,425	3,941		563,152	1,609			1,642	590
Blue Mountain	26	4,418		50,366	4,705		256,030	796	14	18	464	391
Great Valley	256	3,043		5,497	14,604		257,287	88		794	929	4,298
Reading Prong		35		5,467	816		84,228	152		1	93	253
Allegheny Mountain		479		641,910	3,416		282,259	1,116			2,093	1,370
Gettysburg-Newark Lowland	3	15		44,306	21,203	150	369,779	701			1,144	7,721
Waynesburg Hills				282,113	862		338,317	90		8,965	217	595
Lowland and Intermediate Upland						6,803	8,092				623	2,607
Piedmont Upland		27		72,796	8,047	182	252,056	1,045			739	4,121
Piedmont Lowland	18	6		3,819	3,607		14,447	30			139	2,624
South Mountain		122		16,621	1,036		140,659	32			18	100
Total (Acres)	1,700	118,785	382	8,907,855	318,044	7,135	8,148,557	214,755	30,165	159,704	46,912	64,281

Table 2.2. Relationship between Formation, Macrogroup, and Habitat levels for the Pennsylvania portion of the Northeast Terrestrial Habitat Classification.

Formation	Macrogroup	Habitat	Acres	%
Cliff & Rock	Cliff and Talus	Acidic Cliff and Talus	204,782	0.7%
		Calcareous Cliff and Talus	118	0.0%
		Circumneutral Cliff and Talus	9,865	0.0%
Coastal Scrub-Herb	Coastal Grassland & Shrubland	Great Lakes Dune and Swale	371	0.0%
Freshwater Marsh	Emergent Marsh	Laurentian-Acadian Freshwater Marsh	48,595	0.2%
	Wet Meadow / Shrub Marsh	Laurentian-Acadian Wet Meadow-Shrub Swamp	39,799	0.1%
Grassland & Shrubland	Glade, Barren, and Savanna	Appalachian Shale Barrens	407	0.0%
		Central Appalachian Alkaline Glade and Woodland	118,774	0.4%
		Eastern Serpentine Woodland	3,968	0.0%
	Ruderal Shrubland & Grassland	Shrubland & grassland (NLCD 52/71)	159,711	0.6%
Northeastern Upland Forest	Central Oak-Pine	Allegheny-Cumberland Dry Oak Forest and Woodland	60,862	0.2%
		Central Appalachian Dry Oak-Pine Forest	1,496,409	5.2%
		Central Appalachian Pine-Oak Rocky Woodland	310,510	1.1%
		North Atlantic Coastal Plain Hardwood Forest	10,632	0.0%
		Northeastern Interior Dry-Mesic Oak Forest	6,264,763	21.6%
		Southern Appalachian Montane Pine Forest and Woodland	1,079	0.0%
	Northern Hardwood & Conifer	Appalachian (Hemlock)-Northern Hardwood Forest	8,223,296	28.4%
		Laurentian-Acadian Northern Hardwood Forest	6,276	0.0%
		Laurentian-Acadian Pine-Hemlock-Hardwood Forest	102,383	0.4%
		North-Central Interior Beech-Maple Forest	41,819	0.1%
		South-Central Interior Mesophytic Forest	533,075	1.8%
		Southern Atlantic Coastal Plain Mesic Hardwood Forest	139	0.0%
Northeastern Wetland Forest	Central Hardwood Swamp	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	653	0.0%
		North-Central Interior Wet Flatwoods	1,049	0.0%
	Coastal Plain Swamp	North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	5,882	0.0%
	Larger River Floodplain	North-Central Appalachian Large River Floodplain	59,922	0.2%
		North-Central Interior Large River Floodplain	37,542	0.1%
	Northern Swamp	High Allegheny Headwater Wetland	112	0.0%
		North-Central Appalachian Acidic Swamp	213,278	0.7%
		North-Central Interior and Appalachian Rich Swamp	28,121	0.1%
		Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	2[a]	0.0%
	Tidal Swamp	North Atlantic Coastal Plain Tidal Swamp	1,271	0.0%
Peatland	Northern Peatland	North-Central Interior and Appalachian Acidic Peatland	30,165	0.1%
Salt marsh	Tidal Marsh	North Atlantic Coastal Plain Tidal Salt Marsh	1,635	0.0%
Agricultural	Agricultural	Agriculture (NLCD 81-82)	7,175,822	24.8%
Developed	Urban/Suburban Built	Developed (NLCD 21-24 & 31)	3,406,779	11.8%
Water	Water	Open Water (NLCD-NHD open water)[a]	391,834	1.4%

[a] This habitat is likely more extensive across Pennsylvania.

Relationship to the Pennsylvania Terrestrial and Palustrine Classifications

As in the 2005 Pennsylvania Wildlife Action Plan, we included crosswalks to association level classifications in the Pennsylvania Natural Communities Classification (Zimmerman et al. 2012), where applicable. Plant communities are groups of plants sharing a common environment that interact with each other, animals, and the physical environment. As plant communities tend to co-occur on the landscape due to shared environmental requirements, they provide a valuable framework for organizing biological information and creating mapped units for land management and conservation planning.

Communities often are defined by dominant plant species and these plant associations provide useful habitat information for many animal species and an efficient starting point for biological surveys. This product represents the Pennsylvania Natural Heritage Program's best approximation of the upland and wetland plant community types of Pennsylvania and can be used to classify and describe patterns in vegetation seen across the landscape. However, the relationship between ecological systems and association is not necessarily nested within the systems in a one-to-one (or even one-to-many) representation; some associations may have been excluded or otherwise omitted.

Crosswalk from the 2005 Plan to the Northeast Terrestrial Habitat Classification

The 2005 Plan was one of the coarser categorizations of habitat in the northeast region (Gawler 2008). The use of the Terrestrial Habitat Map as the basis of our classification has greatly increased our ability to map wildlife habitat on the ground. For example, what was identified in the 2005 Plan as "rock habitats" (only effectively mapped by the Barren Land NLCD class), now has been identified as 3 habitat types (Acidic Cliff and Talus, Calcareous Cliff and Talus, and Circumneutral Cliff and Talus) within the Cliff and Talus Macrogroup. A complete crosswalk between the 2005 classification and the Terrestrial Habitat Map is presented in Appendix 2.2.

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Aquatic Habitat Classification and Map

Within freshwater ecoregions, there are finer-scale patterns of stream channel, size, gradient, substrate, temperature, watershed physiography, and local zoogeographic sources that influence aquatic biological assemblages. These differences, along with variation in water temperature and tidal influence, create particular physical habitat templates for freshwater biota.

Streams and Rivers

In 13 states, from Virginia to Maine, the Northeast Aquatic Habitat Classification stratifies stream reaches by major environmental factors to map regional flowing-water habitats. Habitat factors used to classify streams included stream size, gradient, buffering capacity, stream temperatures, and tidal influence. Aquatic biodiversity is expected to vary across habitat types. A parallel project, Pennsylvania Aquatic Community Classification (Walsh et al. 2007), grouped species with similar ecological requirements that commonly occur together, known as communities. Comparisons of communities and aquatic habitat types informed the Northeast Aquatic Habitat Classification and helped to refine the habitat types in the development of the types.

The primary classification variables of size, gradient, geology, temperature, and tidal regime define a set of major stream and river habitat types (Table 2.3). All 5 variables influence stream and river habitats; however, some were more important in structuring stream habitats versus riverine habitats. Tidal habitats were split by 3 size classes. Aquatic habitats of Pennsylvania are presented at the Macrogroup level (Fig. 2.15). Summary statistics for the total length for the habitats within the Macrogroups are presented in Table 2.3.

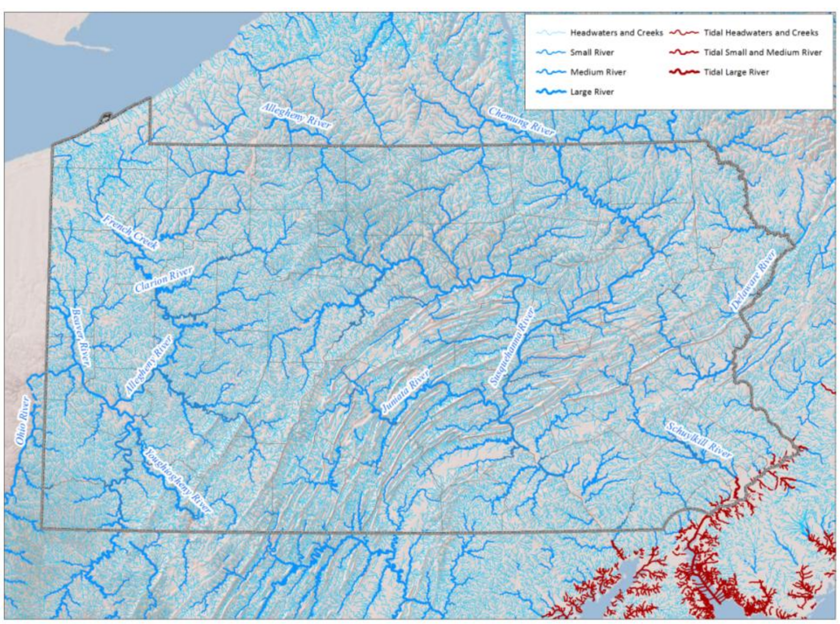

Fig. 2.15. Stream and river Macrogroups from the Aquatic Habitat Map.

Table 2.3. Aquatic Macrogroups and their nested flowing water habitats in Pennsylvania.

Macrogroups	Habitat	PA (mi)[a]	PA (km)	%
Headwaters and Creeks	High Gradient, Cold, Headwaters and Creeks	8835.7	14219.7	21.8
	High Gradient, Cool, Headwaters and Creeks	3867.1	6223.5	9.5
	High Gradient, Warm, Headwaters and Creeks	3.2	5.2	0.0
	Moderate Gradient, Cold, Headwaters and Creeks	5437.5	8750.8	13.4
	Moderate Gradient, Cool, Headwaters and Creeks	10069.1	16204.6	24.8
	Moderate Gradient, Warm, Headwaters and Creeks	782.2	1258.8	1.9
	Low Gradient, Cool, Headwaters and Creeks	3149.7	5069.0	7.8
	Low Gradient, Warm, Headwaters and Creeks	1631.7	2625.9	4.0
Small Rivers	Moderate Gradient, Cool, Small River	2091.6	3366.1	5.2
	Moderate Gradient, Warm, Small River	781.1	1257.0	1.9
	Low Gradient, Cool, Small River	575.7	926.4	1.4
	Low Gradient, Warm, Small River	781.1	1257.0	1.9
Medium Rivers	Cool, Medium River	353.7	569.2	0.9
	Warm, Medium River	1188.9	1913.4	2.9
Large Rivers	Warm, Large River	1308.4	2105.7	3.2
Tidal Headwaters and Creeks	Tidal Headwaters and Creeks	22.8	36.8	0.1
Tidal Small-Medium Rivers	Tidal Small-Medium Rivers	24.0	38.6	0.1
Tidal Large Rivers	Tidal Large Rivers	72.7	117.0	0.2

[a] The total stream mileage for the Pennsylvania portion of the Terrestrial Habitat Map is approximately 54,799 miles, which is less than the 83,000 miles indicated in the DEP dataset. This is due to differences in scale, most notably in the smallest headwater streams, between the two datasets.

Lakes and Ponds

The Nature Conservancy expanded the Aquatic Habitat Classification to include lakes and ponds via the Northeast Lake Classification (Olivero-Sheldon et al. 2014). This project developed a mapped classification of lakes and ponds. Key classification variables included trophic state, light penetration zone, presence of cold-water habitats, and alkalinity class. The project also developed related condition information such as the impoundment status and type of associated dams, impervious surfaces and basic measures of human alteration to land cover around the waterbody.

In this Plan, we represent lakes by their trophic state and alkalinity (Fig. 2.16), as both of these variables to tend to have a great influence on the species present in the lake (C. Bier, personal communication). Trophic state, measured by surrogate variables for algal biomass, was classified as one of four types:

1. Oligotrophic, which are nutrient-poor and clear lakes.
2. Mesotrophic, which fall somewhere in between oligotrophic and eutrophic .
3. Eutrophic, which are nutrient-rich and have high rates of primary production.
4. Hypereutrophic, which are very high nutrient lakes, often resulting from an excess of human activity.

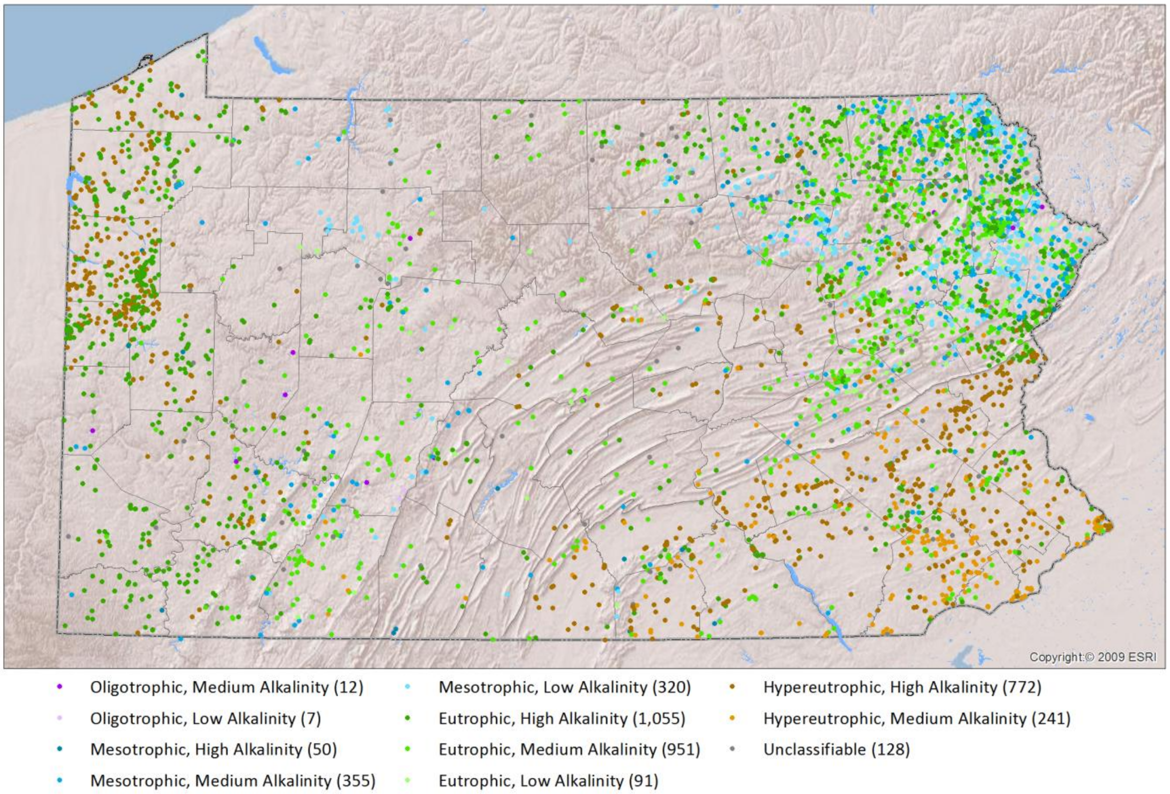

Fig. 2.16. Two-way classification by trophic state and alkalinity for 3,982 lakes and ponds in Pennsylvania.

Alkalinity measures buffering capacity from acidification. Highly buffered lakes often are found in limestone watersheds naturally, and in some cases are created by man through large inputs of lime in agriculturally dominated watersheds (Olivero-Sheldon et al. 2014). Lake acidification in poorly buffered systems has the potential to disrupt the life cycles of fish and other aquatic organisms as it lowers the water pH and intensifies the mobilization and bioaccumulation of toxic mercury compounds in the food web. The northeast lake classification recognized three classes of buffering capacity:

- High alkalinity, >=50mg/L
- Medium alkalinity, >=12.5 < 50mg/L
- Low alkalinity, <12.5mg/L

Crosswalk from the 2005 PA SWAP to the Northeast Aquatic Habitat Classification

Similar to the Terrestrial Habitats, aquatic habitat classification in the 2005 Pennsylvania Wildlife Action Plan was coarse. Using the Aquatic Habitat Map as the basis of classification in this Plan has greatly increased our ability to map wildlife habitat in aquatic habitats. A complete crosswalk between the 2005 classification and the Aquatic Habitat Map is presented in Appendix 2.2.

Linking Species of Greatest Conservation Need (SGCN) to Habitat

To prioritize conservation activities for SGCN, we need to link SGCN occurrences to specific habitats. This will allow us to use the habitat map for planning, habitat management, and other conservation actions. Due to differences in survey effort, both across habitats and among taxa groups, simple counts of SGCN richness often do not sufficiently define the relationship between a species and its habitat. Working with partners (Mark Anderson, TNC and Steven Fuller, NALCC), we devised the following method to associate species with habitat.

Methods

We collected locality data for SGCN from various databases (Fig. 2.17). Sources of data and the number of observations or documented occurrences are presented in Table 2.4. Through this search, we were able to find spatial data for 415 (63%) of the 664 SGCN. Species records included in this analysis were selected using standard Pennsylvania Natural Heritage Program (PNHP) methodology. In most cases, we did not use species observation records older than 1980. However, some exceptions were made for the inclusion of older records based on the following criteria: 1) a lack of current records, 2) a reasonable certainty of mapping precision, and 3) habitat appeared to be extant at that location. All efforts were made to account for taxonomic changes and other similar issues in our database queries. All polygon and line data were converted to centroids.

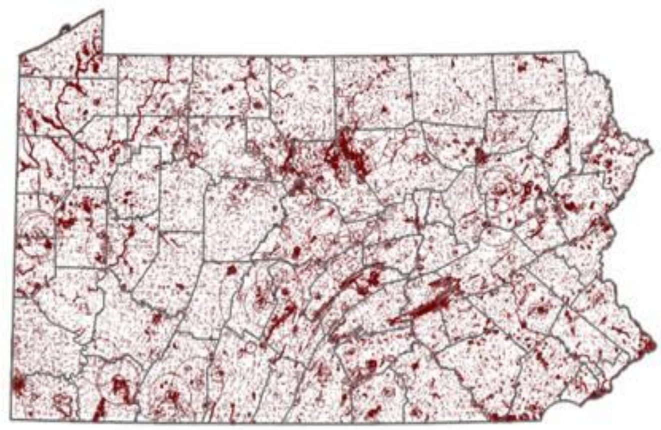

Fig. 2.17. Species of Greatest Conservation Need (SGCN) occurrences and observations used to link SGCN to habitats.

Table 2.4. Species of Greatest Conservation Need data source and count of documented occurrences or observation.

	Biotics	CPP	PNHP	BAMONA	BBA Volunteer	BBA_PtCt	BBA2_A	BBS	eBird	BOMONA	Dillion2014	FIND	GBIF	iNaturalist	J&Sinvert	MDNHP	PGC	SWGmoths	TimPearce	TREC	Xerces	Total
Amphibian	24	127											5									156
Bees													7								23	30
Birds	117	911			34,284	48,475	270	2	15,0555													234,614
Caddisflies		1																				1
Cave Invertebrates		69																				69
Crayfish													36									36
Fish		161											3									164
Lepidoptera	53	494	110	9						28		2	5	23	38	2		4		20		788

	Biotics	CPP	PNHP	BAMONA	BBA Volunteer	BBA_PtCt	BBA2_A	BBS	eBird	BOMONA	Dillion2014	FIND	GBIF	iNaturalist	J&Sinvert	MDNHP	PGC	SWGmoths	TimPearce	TREC	Xerces	Total
Mammals	185	702															4,341					5,228
Mussels	82	523																				605
Odonates	2	499											2							11		514
Planariidae		2																				2
Reptile	248	856																				1,104
Snails	14	3									14		7						194			232
Spiders	7																					7
Tiger Beetles	11																			9		20
Total	**743**	**4,348**	**110**	**9**	**34,284**	**48,475**	**270**	**2**	**150,555**	**28**	**14**	**2**	**65**	**23**	**38**	**2**	**4,341**	**4**	**194**	**40**	**23**	**243,570**

Next, we calculated the percentage distribution of each habitat type within Pennsylvania (Table 2.2). For terrestrial habitats, we tabulated the area for each habitat in the Terrestrial Habitat Classification and calculated the percentage. Aquatic (lotic) habitat was calculated by summing the segment lengths for each aquatic habitat type and calculating the percent of the total (Table 2.3). Lake habitats were summed by their total acreage and compared to the non-lake habitat. This was considered the expected habitat based on its distribution across the state for each species in the particular group.

We then spatially joined the occurrence points with the habitat maps:

- Terrestrial species were joined to the Terrestrial Habitat Map by the "Extract Values to Points" tool in ArcGIS.
- For species associated with flowing water habitats (lotic), the species points were snapped to the nearest stream segment in the Aquatic Habitat Map and a spatial-join was performed to tag each occurrence to the habitat.
- Lake and pond species (lentic) were spatially joined to the lake polygons in the Aquatic Habitat Map. A 100 meter (328 feet) buffer was included to account for mapping errors.

Using the results of these GIS actions, we calculated the number of observations per habitat class for each species. This number was converted to a proportion. This was considered the observed proportion.

We then subtracted the "observed proportion" from the "expected proportion" and extracted the two highest "Percent Above Expected" values and their associated habitats. These became the primary and secondary habitats. Although we do differentiate between primary and secondary habitats, in many cases, there was the same probability of occurrence for both primary and secondary habitats.

In some cases, a habitat was not mapped nor included in the Terrestrial and Aquatic Habitat Maps. Therefore, we included 2 additional habitat types that were not part of the TNC Classification: 1) A Formation/Macrogroup to represent subterranean habitats (as recommended in Crisfield 2013). A similar case could be made for Lake Erie, which was not represented in the Aquatic Habitat Map, but several SGCN were solely associated with it, therefore a manual override was done to label species as "Lake Erie."

Results and Discussion

Results of the habitat and species association summarized by Macrogroup are presented in Fig. 2.18. All of the Macrogroups except "Larger River Floodplain" and "Central Hardwood Swamp" were associated with at least one SGCN.

Upland forests provide primary habitat for the greatest proportion of SGCN (30%) with flowing water following closely at 23%. Additionally, even though wetlands comprise only 1% of the state, they support a significant proportion of Pennsylvania's biodiversity. Approximately 12% of SGCN had their primary habitat associated with wetland habitats, and more than half of the species tracked by PNHP are associated with wetlands.

The complete list of species-habitat associations is presented as part of the habitat descriptions in Appendix 2.1.

We have identified 2 main issues with the approach of this analysis. The first are issues of scale and accuracy of the Terrestrial and Aquatic Habitat Maps. Although they present some of the finest "wall-to-wall" habitat mapping available, they are at the 30 meter (98.4 feet) resolution level and have not been extensively tested in the field. The second issue relates to similar accuracy issues with the SGCN occurrence data. While it was the most abundant dataset, in terms of numbers of occurrences, accuracy issues were present. Many of the occurrence points for birds came from the Breeding Bird Survey, which is collected via road-based point counts. When compared to the habitat map, many of the species associations gravitated towards the developed road classes, even when the record was likely present in a forested class. There also was an interaction with the 30 meter (98.4 feet) scale of the habitat pixel, when the real road may be less than 10 meter (32.8 feet) wide. Additionally, eBird data quality varies tremendously, based on observer knowledge, mapping precision, and definition of 'hotspots' (Sullivan et al. 2009). These issues are probably most notable in the wintering habitat for some species where habitat seems to be biased toward areas that are developed, essentially presenting as an observer effect. An immediate priority for the future could be the collection and compilation of additional high accuracy, off-road data for SGCN species.

As mentioned in Chapter 1, Species, we more thoroughly evaluated Pennsylvania's role for passage migrant and wintering birds for this revision, using datasets such as eBird. Many of habitat associations for migratory and wintering SGCN were associated with development and/or agriculture. We suspect that much of this is due to biases in winter birding being more associated with areas where birders go (e.g., closer to home) or species are easily observed (e.g., fields and pastures). However, Tryjanowski et al. (2015) recently reported that European bird species in Poland may associate more heavily with developed areas in the winter due to increased food availability (i.e., bird feed stations). Whether or not a similar effect is present here is a potential subject for future study.

Finally, spatial data were available for only 415 of the 664 SGCN identified in this Plan; therefore, efforts should be made to collect locality data on the remaining species.

Habitat Protection

As part of each habitat's description (Appendix 2.1), we indicate in which states the habitat occurs, how many acres occur within the state, and how many of those habitat acres are managed as some form of conserved land.

A significant amount of land acquisition has taken place since the 2005 Plan. For example, the Pennsylvania Land Trust Association (PALTA) acquired 185,359 acres (75,012 hectares) between 2005 and 2013 (PALTA 2015). Of this, 58,827 acres (23,806 hectares) have been transferred to state agencies, while the remainder exists as conservation easements and fee-simple ownership by land trusts. Including acres transferred from PALTA, the PGC added 70,021 acres (28,336 hectares) to the State Game Lands system between fiscal year 2004 and 2014. In addition, the Pennsylvania Department of Conservation and Natural Resources (DCNR) acquired 78,527 acres as State Parks and State Forests within the same period (DCNR, personal communication). Conserving these landscapes in natural cover for perpetuity ensures these places will be available for wildlife, and the citizens of the Commonwealth, for this and future generations.

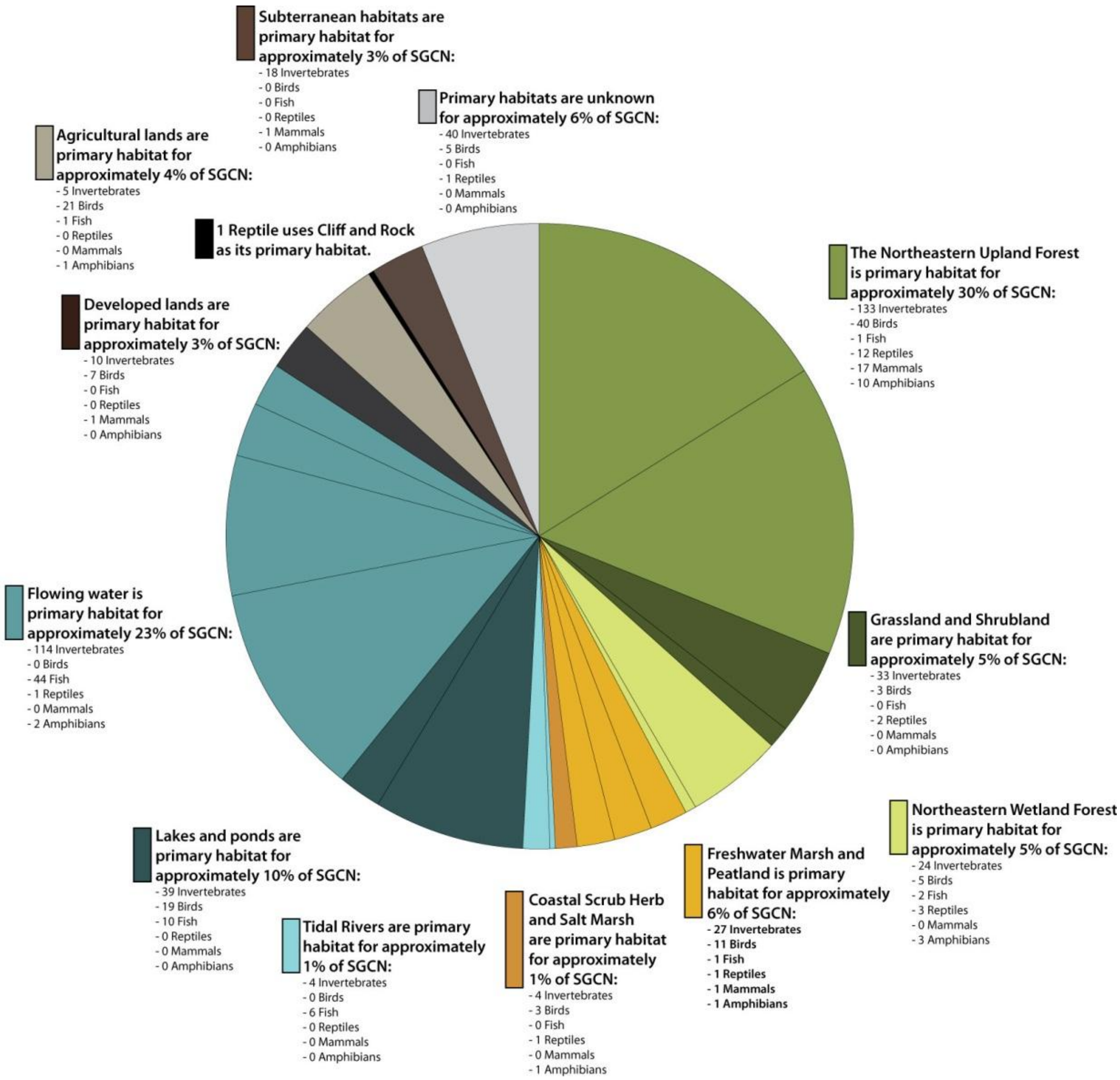

Fig. 2.18. Distribution of Species of Greatest Conservation Need among habitat Macrogroups (courtesy of E. Crisfield).

Threats to Habitat

More detailed coverage of threats to SGCN and their habitats is presented in Chapter 3. Threats to specific habitats are difficult to predict with any certainty. Table 2.5 presents a general overview of threats that may affect specific terrestrial and aquatic Macrogroups. Numbers in the table refer to the number of SGCN that had a particular threat noted for each habitat macrogroup. The Northern Hardwood Conifer and Central Oak Pine macrogroups had the highest number of threats noted across categories, largely due to their prevalence across the state as well the number of species they support.

Table 2.5. Key threats based on International Union for Conservation of Nature (IUCN) Level 1 threat categories (Salafsky et al. 2008) to Pennsylvania Macrogroups based on species-level threats (except invertebrates) for each primary habitat (Chapter 1, Appendix 1.4). Table shows the count of SGCN intersecting with each primary Macrogroup and threat.

		Residential and Commercial Development	Agriculture and Aquaculture	Energy Production and Mining	Transportation and Service Corridors	Biological Resource	Human Intrusions and Disturbance	Natural Systems Modifications	Invasive and Other Problematic Species, Genes and Diseases	Pollution	Geological Events	Climate Change and Severe Weather	Total
	IUCN Threat Code→	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	
Terrestrial	Central Hardwood Swamp												0
Terrestrial	Glade, Barren, and Savanna	3		1	3	1		1	1				10
Terrestrial	Coastal Grassland Shrubland	1		2			5		3				11
Terrestrial	Northern Hardwood Conifer	38	2	38	36	29	13	7	28	19		19	229
Terrestrial	Northern Swamp	10	2	8	8	5	4	7	3	6		5	58
Terrestrial	Coastal Plain Swamp	4		2	5		1		2	1		1	16
Terrestrial	Central Oak Pine	40	2	35	34	31	15	7	30	7	1	9	211
Terrestrial	Cliff And Talus												0
Terrestrial	Northern Peatland & Fens	1		2	2	2			3	2		2	14
Terrestrial	Ruderal Shrubland & Grassland	2			2			2	2				8
Terrestrial	Wet Meadow/Shrub Marsh	2			1			4	3	2		2	14
Terrestrial	Emergent Marsh	3		2	1	1	2	7	8	7		7	38
Terrestrial	Agricultural	28	17	19	6	1	4	20	9	9		10	123
Terrestrial	Urban/Suburban Built	10	2	2	6	4	3	6	4	3	2	4	46
Terrestrial	Subterranean		2		3	1	1	2		2		1	12
Aquatic	Headwaters and Creeks	4	3	11	2	2	2	6	4	25		20	79
Aquatic	Small Rivers	1		3	1	1		1		3		1	11
Aquatic	Medium Rivers	1	2	2	2	3		3	4	9		2	28
Aquatic	Large Rivers		4	5	7			5	1	7			29
Aquatic	Tidal Headwaters and Creeks												0
Aquatic	Tidal Small-Medium Rivers												0
Aquatic	Tidal Large Rivers	1		1	1	4	1	6	2	1		2	19
Aquatic	Lakes & Ponds	11		14	4	2	15	14	22	36		19	137

Threats to Stream and River Habitats – For a thorough discussion of the threats impacting stream and river habitats in Pennsylvania, see Chapter 3,Threats.

A finer resolution habitat-threats analysis will appear in the Conservation Opportunity Area project to be completed following approval of the 2015 Plan (Chapter 4, Actions).

Climate Change and Habitats

While current and potential impacts from climate change are covered in detail in Chapter 3, this section of the report discusses resilience of habitats. For the purposes of this section, "resilience" concerns the ability of an ecological system to adjust to climate change, moderate potential damages, take advantage of opportunities, or cope with consequences; in short, the capacity to adapt. As an outgrowth of the habitat mapping in the Northeast, TNC developed a resiliency analysis that develops an approach to conserve biological diversity while allowing species and communities to rearrange in response to a continually changing climate (Anderson et al. 2012). In this analysis, individual landscapes such as forests, wetlands, and mountain ranges were considered as collections of neighborhoods where plants and animals reside. Areas with the most complex neighborhoods in terms of topography, elevation ranges, and wetland density were estimated to offer the greatest potential for plant and animal species to "move down the block" to new habitats as climate change alters their traditional neighborhoods (Fig 2.19).

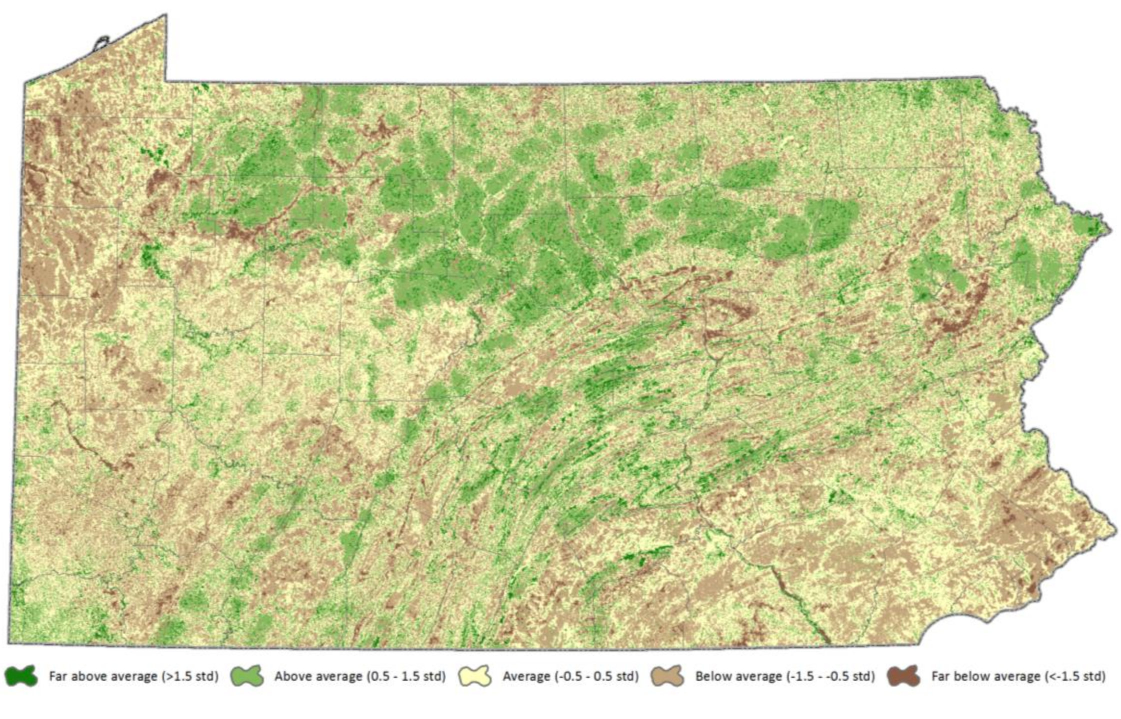

Fig. 2.19. Terrestrial habitat resiliency stratified by geophysical setting and ecoregion (Anderson et al 2012). The map shows areas in Pennsylvania predicted to be more resilient to climate change (green), or more vulnerable to climate change (brown), with respect their type of physical environment.

Therefore, as noted in Chapter 3, maintaining connectivity and condition is among the options to increase the resilience of wildlife populations in the face of climate change. However, barriers to managing Pennsylvania's forests for health and resiliency in the face of climate change are: 1) lack of knowledge; 2) large number of private forest landowners; 3) continued fragmentation of forest landscapes, and 4) many other confounding, interrelated challenges to managing forests.

Similar to the terrestrial resiliency project, TNC also produced an aquatic resiliency product (Anderson et al. 2013). Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as species compositions and hydrologic properties change in response to shifts in ambient conditions due to climate change (Fig. 2.20).

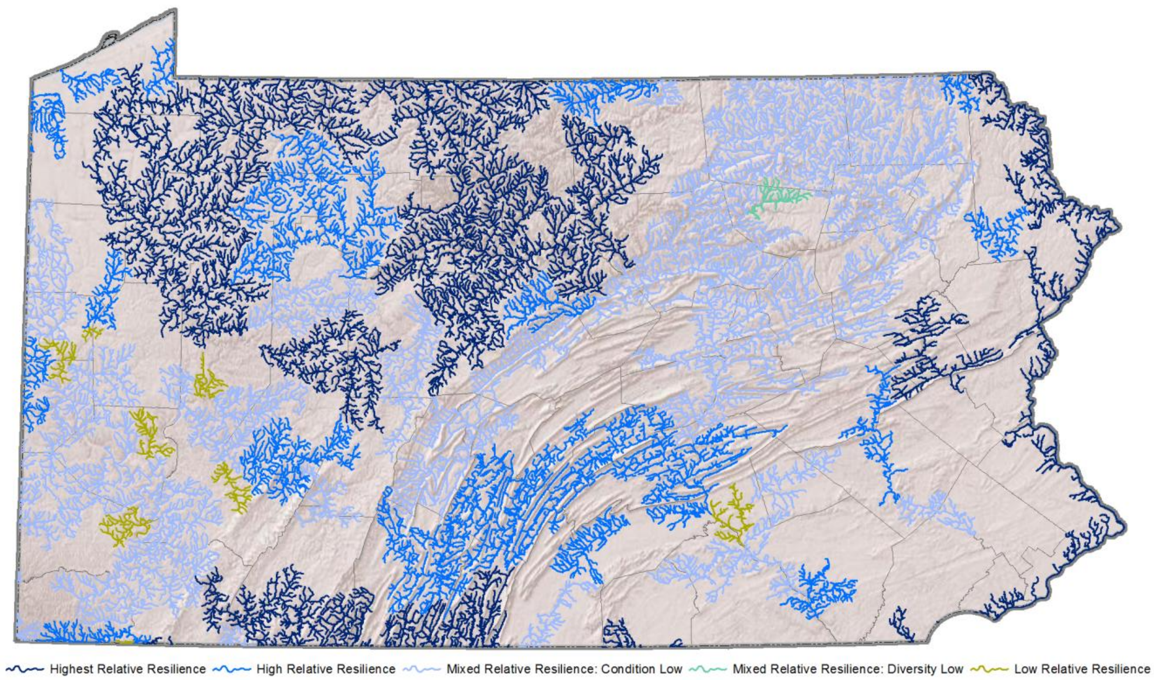

Fig. 2.20. Relative resilience scores for complex river networks (containing more than four stream orders) (Anderson et al. 2013c).

Habitat Conservation Actions

While writing species accounts (Chapter 1, Appendix 1.4), taxonomic experts used the U.S. Fish and Wildlife Service's Tracking and Reporting Actions for the Conservation of Species (TRACS) categories to identify general groupings for specific conservation actions (Chapter 1, Fig. 1.9). TRACS is a tiered categorization using three levels, with Level 1 representing the broadest category (e.g., *Direct Management of Natural Resources*) (USFWS 2015). Descriptions of IUCN conservation action categories as they apply to Pennsylvania can be found in Chapter 4, Conservation Actions. Prioritized specific conservation actions and details for each SGCN can be found in the species accounts (Chapter 1, Appendix 1.4). In this section we provide a synopsis of conservation actions at the coarsest scale (i.e., Level 1) that were identified during the species account writing process and then we present the results summarized by Terrestrial and Aquatic Macrogroups.

Planning activities were considered important for each vertebrate taxonomic group (Chapter 1, Fig. 1.9), though this action was most commonly used for amphibians, reptiles and mammals (Chapter 1, Table 1.12). This includes *Land Use Planning* to avoid or minimize impacts to SGCN and *Species and Habitat Management Planning* to ensure appropriate goals are established for populations, and habitat management practices are developed to maximize benefit to the SGCN.

The summary information presented below is not meant to be comprehensive; readers should reference individual species accounts (Chapter 1, Appendix 1.4) or the invertebrate assessment report (Leppo et al. 2015) for specifics.

Terrestrial Macrogroup Conservation Actions

We summarized actions by Macrogroup to highlight potential conservation actions identified for each species that would be important to implement in specific terrestrial habitat Macrogroups (Table 2.6).

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Table 2.6. Summary of Wildlife TRACS action categories (USFWS 2015) identified for terrestrial species, summarized by terrestrial Macrogroup. Table shows the count of SGCN intersecting with each primary Macrogroup and action.

Terrestrial Macrogroup ↓	Coordination and Administration	Direct Management of Natural Resources	Data Collection and Analysis	Education	Facilities and Area	Land/Water Rights Acquisition and Protection	Law Enforcement	Outreach	Planning	Species Reintroduction and Stocking	Technical Assistance	Law and Policy	Species Management	Total
TRACS Action Code →	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**100.0**	**101.0**	
Agricultural	6	39		1		14	1	5	9		3	2	3	83
Central Oak-Pine	6	37	1	1	4	10	9	4	54		14	6	5	151
Cliff and Talus									1					1
Coastal Grassland & Shrubland		2					2	1	1		1			7
Coastal Plain Swamp	2								7	1	6			16
Emergent Marsh		15				1					1	5		22
Glade, Barren and Savanna	3	1					1		4		2			11
Northern Hardwood & Conifer	15	38	2	1		18	4		54		16	23	8	179
Northern Peatland & Fens	2	9							2		1			14
Northern Swamp	12	12		1	2	4	2		11		11	2	1	58
Ruderal Shrubland & Grassland		4	1	1					1		1			8
Tidal Swamp									2					2
Urban/Suburban Built	3	9				2	1	5	5		3	5	2	35
Wet Meadow / Shrub Marsh		8			1	1			3			2		15

The majority of terrestrial SGCN habitat conservation actions were focused on *Direct Management of Natural Resources* (174) or *Planning* (154). Interestingly, the two forested Macrogroups – Northern Hardwood & Conifer and Central Oak-Pine – have the greatest number of associated conservation actions (298 between them).

Aquatic Macrogroup Conservation Actions

We summarized the actions by Macrogroup to highlight potential conservation actions identified for each species that would be important to implement for specific aquatic habitat Macrogroups (Table 2.7).

Table 2.7. Summary of Wildlife TRACS action categories (USFWS 2015) identified for aquatic species, summarized by aquatic Macrogroup. Table shows the count of SGCN intersecting with each primary Macrogroup and action.

Aquatic Macrogroup ↓	Coordination and Administration	Direct Management of Natural Resources	Data Collection and Analysis	Education	Facilities and Area	Land/Water Rights Acquisition and Protection	Law Enforcement	Outreach	Planning	Species Reintroduction and Stocking	Technical Assistance	Law and Policy	Species Management	Total
TRACS Action Code →	**1.0**	**2.0**	**3.0**	**4.0**	**5.0**	**6.0**	**7.0**	**8.0**	**9.0**	**10.0**	**11.0**	**100.0**	**101.0**	
Headwaters and Creeks	2	9			2		1	2	29	3	11	25	1	85
Lakes and Ponds		27	4	3	4	10	2	1	20		6	18	11	106
Large Rivers	7	9							1		9	2		28
Medium Rivers	1	5		2					14		3	1	2	28
Small Rivers					1		2		6			2		11
Tidal Large Rivers				2	4						3	4	6	19

For aquatic habitats, the majority of the conservation actions were focused *on Direct Management of Natural Resources* (50), *Planning* (70) or *Law and Policy* (52). Interestingly, actions focusing on the *Direct Management of Natural Resources* were largely contained to the Lake and Pond Macrogroup – most of those related to the management of invasive species. The *Law and Policy* actions were focused largely on enforcement of existing regulations and ensuring compliance during the project.

Research and Monitoring Needs

As noted in the throughout this plan, all of Pennsylvania's habitats are directly influenced by human activity, and the changes in the distribution and composition of the habitats have dramatic impacts on wildlife populations. Many threats identified for SGCN are tied to habitat condition. Chapter 5,Monitoring, provides an overview of an adaptive management framework embraced by the PGC and PFBC, and hopefully their conservation partners, over the next 10 years. It is important to note that the objectives of habitat monitoring and population monitoring are distinctly different. Species require habitat to survive. As habitat conditions improve, the long-term resilience of their populations improves and become better able to resist perturbations to their ecosystems.

Information about status and trend of wildlife habitat is important for resource agencies to accomplish its mission and meet its legal requirements. Land managers need to evaluate the status of habitat for wildlife and how it compares with desired conditions. The following overview of habitat monitoring actions are based on the US Forest Service Technical Guide for Monitoring Wildlife Habitat (Rowland and Vojta 2013).

Many SGCN monitoring efforts (Chapter 5, Appendix 5.1) also involve some component of habitat monitoring. This is not an exhaustive list of approaches but rather a starting place to identify next steps and potential partnerships. For SGCN habitats, factors affecting habitat distribution and condition often occur at regional scales beyond the site level (e.g. upstream conditions may affect downstream habitats). Therefore, the selection of the key habitat attributes and the sampling design are important for any habitat monitoring effort.

Habitat attributes such as vegetation composition and structure are a frequent target of monitoring efforts. The Forest Inventory and Analysis (FIA) program, within the U.S. Forest Service, maintains a rigorous spatially-balanced long-term monitoring tool for forest plants, which provides an assessment of the extent and condition of the nation's forests from a forest management perspective. These inventories can also provide an overall perspective of forest species composition, regeneration, and extent, which for decades has informed assessments of the many species dependent on forest land cover. Additionally, the U.S. Fish and Wildlife Service maintains the National Wetland Inventory, which provides mapping for wetland habitat across the state. With the importance of wetland habitats to many SGCN, documentation of the location and condition of wetland habitats is a critical need. Natural community (or stand) mapping as undertaken by PGC, PADCNR, and other agencies/organization on their land are important part of habitat monitoring and should be updated at regular intervals. Ongoing and potential monitoring actions for terrestrial forests are noted in the PACNR Forest Action Plan. The USDA-NRCS has been monitoring the extent of various agricultural crops that have direct impacts on many species associated with early successional habitats, such as hayfields and pasture.

On the aquatic side, the National Clean Water Act requires each state to monitor the quality of its surface and ground waters to determine if they support 6 designated uses, including aquatic life, fish consumption, public water supplies, recreation, and wildlife. The U.S. Environmental Protection Agency (USEPA) requires that DEP prepare biennial reports (305(b)/303(d) Water Quality Integrated Report), describing the status of water quality within the state.

Habitat models, such as the Northeast Habitat Maps used in this plan, can be used as the basis for monitoring habitat and landscape analysis. The status information provided within the Terrestrial and Aquatic habitat map reports is supplemented by additional information provided within Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework (Anderson and Olivero Sheldon 2011).

In addition to understanding localized human impacts, monitoring is also important to understand the larger, ever-present stress of climate change and its constantly varying pressure on habitats through changes in temperature and precipitation.

The habitat classification and map presented in this action plan provides a framework for conservation actions. We expect to add monitoring approaches as new techniques for the assessment, mapping, landscape modeling, and remote sensing of habitats emerge over the next decade.