PUBLIC REVIEW DRAFT

Habitats
REQUIRED ELEMENT 2

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HABITATS
Chapter Recap

- ✓ Northeast terrestrial and aquatic habitat classifications are used to facilitate communication and conservation action across state boundaries.
- ✓ Pennsylvania is approximately 60% forested, primarily in the Appalachian Plateaus province. 70% of these forests are privately owned by approximately 750,000 landowners (Albright et al. 2023).
- ✓ Pennsylvania has lost nearly 60% of its wetlands since pre-Colonial time. A 2024 report by U.S. Fish and Wildlife Service estimates net wetland loss to have increased >50% nationwide since the last report (2004-2009), with a disproportionate net loss of vegetated wetlands (Lang et al. 2024).
- ✓ 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 Habitat Classification Changes Since 2015

While many aspects of wildlife habitat extent and condition across Pennsylvania have remained relatively stable since the 2015-25 Pennsylvania Wildlife Action Plan (PA WAP), we modified the language used (lexicon) to characterize habitat types to align with lexicon changes agreed upon by the northeastern U.S states. The goal of congressionally required Element 2 is to provide "descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in the 1st element [Species of Greatest Conservation Need]." In the 2015-25 PA WAP, we adopted the Nature Conservancy terrestrial and aquatic classification and map (see Anderson et al. 2013), summarizing extent information at the 'macrogroup' level. For 2025-35, the northeastern states adopted broader classifications (Crisfield and Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2022), discussed in more detail below (see Habitat Classification section) and in Appendix 2.1.

Approach

Although commonly used by biologists, "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 chapter, we define habitat based upon the vegetation classification at the landscape scale, addressing broadly the vegetation classification while providing for the species-specific habitat descriptions needed for Element 1-Species. Additionally, we adopt the Northeast Association of

Fish and Wildlife Agency (NEAFWA) habitat definition (Crisfield and NEFWDTC 2022): *A space that provides living (biotic) and non-living (abiotic) resources needed by a species to survive*.

State Wildlife Action Plans (SWAPs) must describe the extent and condition of habitats and community types that are essential to the conservation of Species of Greatest Conservation Need (SGCN). In 2021, the Association of Fish and Wildlife Agencies' (AFWA) SWAP and Landscape Conservation Working Group authored *Leading At-risk Fish and Wildlife Conservation: A Framework to Enhance Landscape-Scale and Cross-Boundary Conservation through Coordinated State Wildlife Action Plans* (AFWA 2021). Within this report, the first Guiding Principle recommends that states "identify and apply regional and shared approaches for development, implementation and measuring [the] progress of SWAPs, to improve effectiveness, efficiency, cost-savings, and consistency."

Each Guiding Principle in the landscape report has specific Recommended Actions, associated outcomes, and a recommended implementation framework. Recommended Actions for Guiding Principle 1 include (AFWA 2021):

1.1 Using clear and consistent criteria, identify priority species, habitats, landscapes, threats, and conservation actions for regional conservation.
1.2 Develop and use a common lexicon and classification system for species, habitats, threats, and conservation actions.
1.4 Promote the development of shared science, data, research, and monitoring protocols.
1.5 Use consistent metrics and reporting tools to evaluate conservation effectiveness.

To follow these recommendations, and pursuant to the national *Best Practices for State Wildlife Action Plans* (AFWA 2012) recommendations for a regional approach that specifically mentions the Northeast Habitat Classification System (terrestrial and aquatic), we continue to adopt the Northeast AFWA (or NEAFWA) lexicon for terrestrial and aquatic habitats (Crisfield and the NEFWDTC 2022). However, the NEAFWA terrestrial habitat lexicon changed significantly between 2015 and 2025 SWAPs, opting to develop a coarser-level classification than the Nature Conservancy classification adopted for 2015 SWAPs. The revised broad classification continues to integrate with the Pennsylvania community classification used by the Pennsylvania Natural Heritage Program.

Standard Terminology

We updated the 2015-25 PA WAP habitat terminology to align with the new NEAFWA habitat lexicon (Crisfield and the NEFWDT 2022) that uses "Habitat Class," rather than "Formation," and "Habitat Type," rather than "Macrogroup". In Species Accounts (Appendix 1.4), we associate SGCN with Habitat Classes and Habitat Types, as well as Ecological Systems and Pennsylvania plant community types when possible. Appendix 2.1 provides an overview of Habitat Type acreage in Pennsylvania and the northeastern U.S., as available, associated Pennsylvania ecological communities, summary of SGCN associated with each habitat type, and protection status within the northeastern U.S. and Pennsylvania.

Introduction

Pennsylvania supports a remarkable diversity of wildlife habitats shaped by its unique and historic geology, biogeography, climate, and land-use history. Often referred to as "Penn's Woods," the Commonwealth remains dominated by forests, which cover nearly 60 percent (60%) of the state and form the foundation of its ecological systems. However, an incredibly unique, complex mosaic of diverse ecosystems also are scattered across the landscape, including a rich array of wetlands, grasslands, agricultural lands, rivers, and specialized habitats such as barrens, bogs, and cliffs. These varied ecosystems collectively sustain populations of relatively common species, and a wide array of rare or specialized species adapted to narrow ecological niches.

While forests remain the most extensive and ecologically influential habitat category in Pennsylvania, even within this category there is substantial variation. Major forest systems include oak–hickory forests across the southern and central regions, northern hardwood forests in the cooler highlands, and localized mesophytic (i.e., moderately moist) and conifer-dominated systems tied to specific soils, glacial, and fire history. These forest types differ in structure, species composition, and productivity, creating diverse conditions for wildlife—from mast-producing uplands to cool, shaded ravines critical for interior forest birds. The structural diversity of forests, including age classes and canopy complexity, is a key driver of wildlife diversity across the state.

Pennsylvania's habitat diversity expands significantly through its wetland and aquatic systems. The state contains dozens of wetland community types, including marshes, swamps, bogs, and vernal pools, each supporting distinct assemblages of plants and animals. Riparian corridors, streams, and river valleys further enhance connectivity across the landscape and provide essential habitat for migratory species and aquatic-dependent wildlife. Meanwhile, grasslands, old fields, and agricultural lands—although often human-influenced—play an important ecological role by supporting pollinators, grassland birds, and small mammals, contributing to overall landscape-level biodiversity.

Importantly, Pennsylvania's biodiversity is not solely a function of habitat types themselves, but of how these habitats are distributed, managed, and interconnected. The state currently recognizes over 120 distinct plant community types, reflecting both common and rare ecological conditions across the landscape (PNHP 2012). This diversity underpins a wide range of ecosystem functions, from nutrient cycling to pollination, and supports both game and non-game fish and wildlife species. As land management agencies increasingly emphasize conservation of entire ecosystems rather than individual species, understanding and maintaining this mosaic of habitat types has become central to sustaining Pennsylvania's wildlife heritage in the face of development, climate change, and other emerging pressures.

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). Given the critical importance of high-quality habitats to fish and wildlife SGCN, this chapter presents information about the status and extent of habitats in Pennsylvania and relative to the habitat in the northeast U.S. region, threats that affect their quality, and the actions that can be taken to address threats.

Several models have been developed and used to identify and map fish and 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 terrestrial and aquatic habitat models at a relatively fine spatial resolution and based on NatureServe© Ecological Systems (Anderson et al. 2013).

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 fish and wildlife conservation, the 2025-35 PA WAP presents information from these conservation tools and adapts their habitat data to best suit these needs. Since 2005, the overarching goal of the PA WAP 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 Habitat Status

The following sections present an overview of Pennsylvania's general habitat types. 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.

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, microbial and fungal communities, 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.

Although it varies significantly across ecoregions, Pennsylvania's soil health is foundational to the productivity and resilience of its forests, wetlands, and agricultural landscapes, yet it is often overlooked compared to aboveground biodiversity. Across the state's diverse physiographic regions—from the glaciated plateaus of the north to the Ridge and Valley and Piedmont in the south—soil composition, structure, and organic matter vary widely, shaping vegetation communities and wildlife habitat. Healthy soils support water infiltration, nutrient cycling, and carbon storage, all of which are critical to sustaining ecosystem function. Central to these processes are soil fungal communities, particularly mycorrhizal fungi, which form symbiotic relationships with plant roots and enhance nutrient uptake, drought tolerance, and resistance to stress. In Pennsylvania forests, these fungal networks are essential for maintaining tree health and regeneration, linking individual plants into complex belowground systems that mirror the diversity seen aboveground (PABS 2026).

Fungal communities also vary among the ecoregions, and yet also play a critical role in driving habitat diversity across Pennsylvania by influencing decomposition rates, soil formation, and plant community dynamics. In forested systems, saprophytic fungi break down leaf litter and woody debris, returning nutrients to the soil and supporting the development of rich organic layers characteristic of northern hardwood and mesophytic forests. In contrast, wetter habitats such as bogs and swamps often host specialized fungal assemblages adapted to low-oxygen, acidic conditions, contributing to peat formation and long-term carbon storage. Even in managed landscapes such as agricultural fields and reclaimed grasslands, soil fungal diversity can influence productivity and habitat quality for wildlife by affecting plant composition and soil stability. As conservation efforts increasingly recognize the importance of belowground biodiversity, maintaining soil health and fungal integrity has become a key consideration for sustaining Pennsylvania's mosaic of habitats and the species that depend on them.

Pennsylvania is located at the intersection of six major 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.

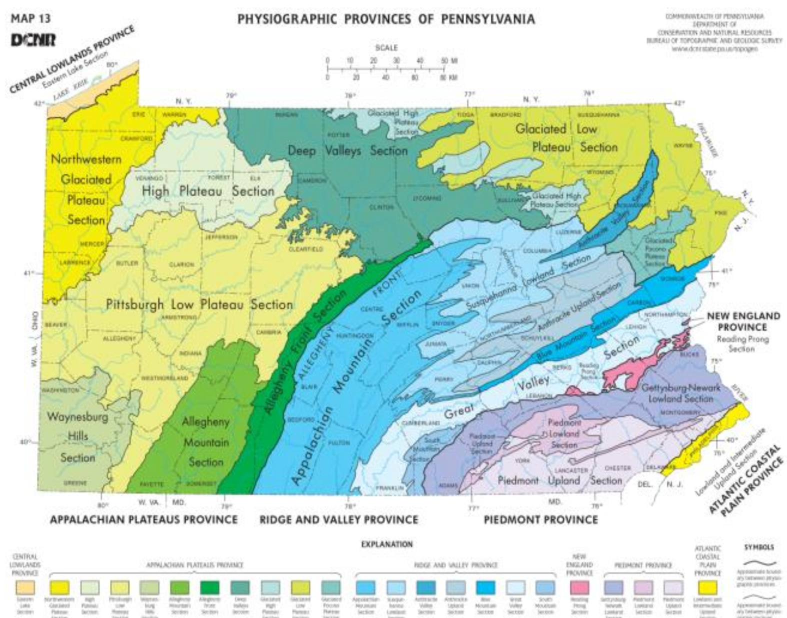

Fig. 2.1. Physiographic provinces and sections of Pennsylvania. Map courtesy of Sevon (2000).

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 appear to be mountainous.

6. Central Lowlands Province – Part of the Great Lakes watershed, existing along a glacial escarpment adjacent to Lake Erie.

Physiographic provinces are 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 (Fig. 2.2). Most 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 fish and 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 fish and mussel species occur in Ohio River watershed, compared to those that drain into the Atlantic. 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.

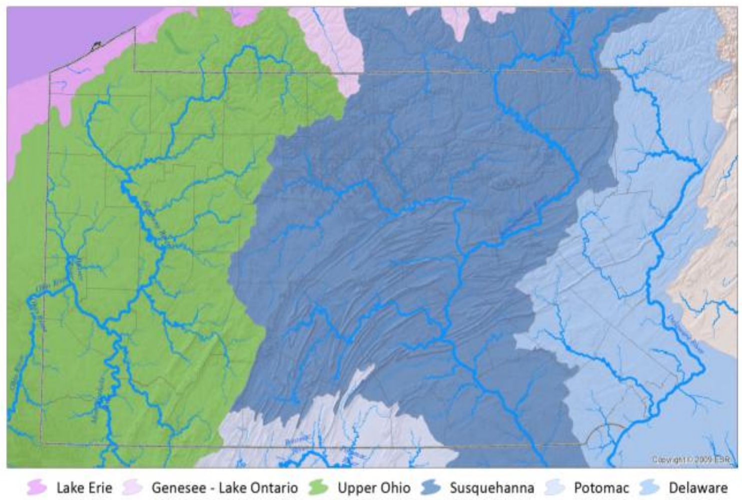

Fig. 2.2. Major watersheds of Pennsylvania.

Land Cover and Habitat

We analyzed land cover extent and changes using the National Land Cover Dataset (NLCD). 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; Fig. 2.3). Updated in 2024, this dataset provides the capability to assess “wall-to-wall”, spatially explicit land cover changes and trends from 2001 to 2024 (USGS 2025).

Forests are the dominant land cover in Pennsylvania, comprising approximately 59% of the state’s 29 million acres (11.7 million hectares). Agriculture, largely in the form of pastureland, hayfields, and row crops, covers 22% of Pennsylvania, and development accounts for nearly 15% of the state, a 3% increase from the last PA WAP. The 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.

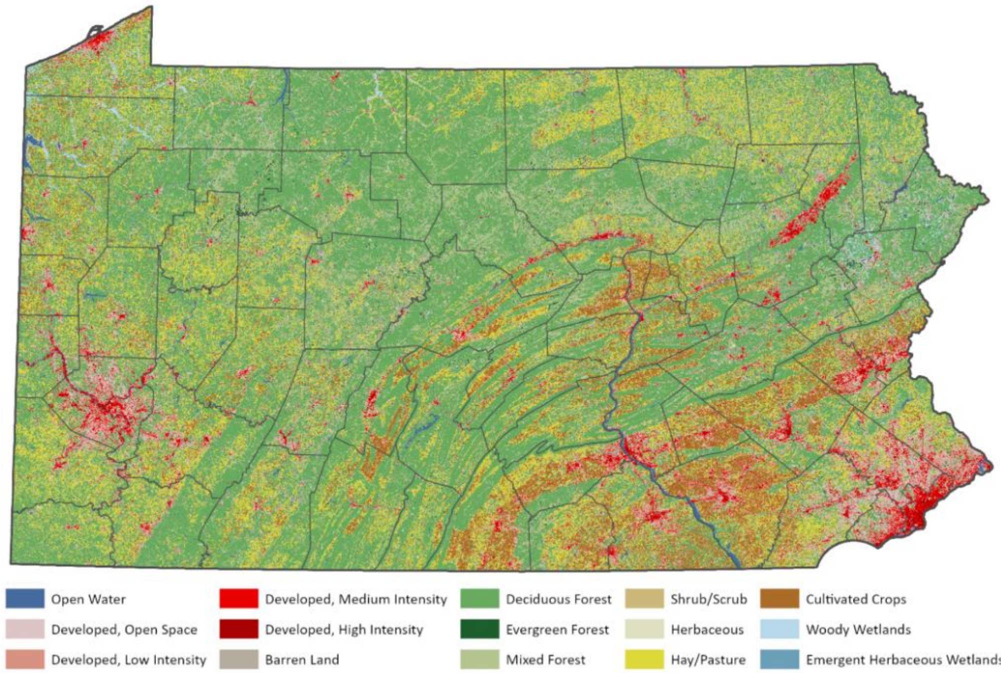

Fig. 2.3. Land use and land cover distribution in Pennsylvania (Source: National Land Cover Dataset 2024). Urban areas are shown in shades of red, agriculture in shades of yellow, and forests in shades of green.

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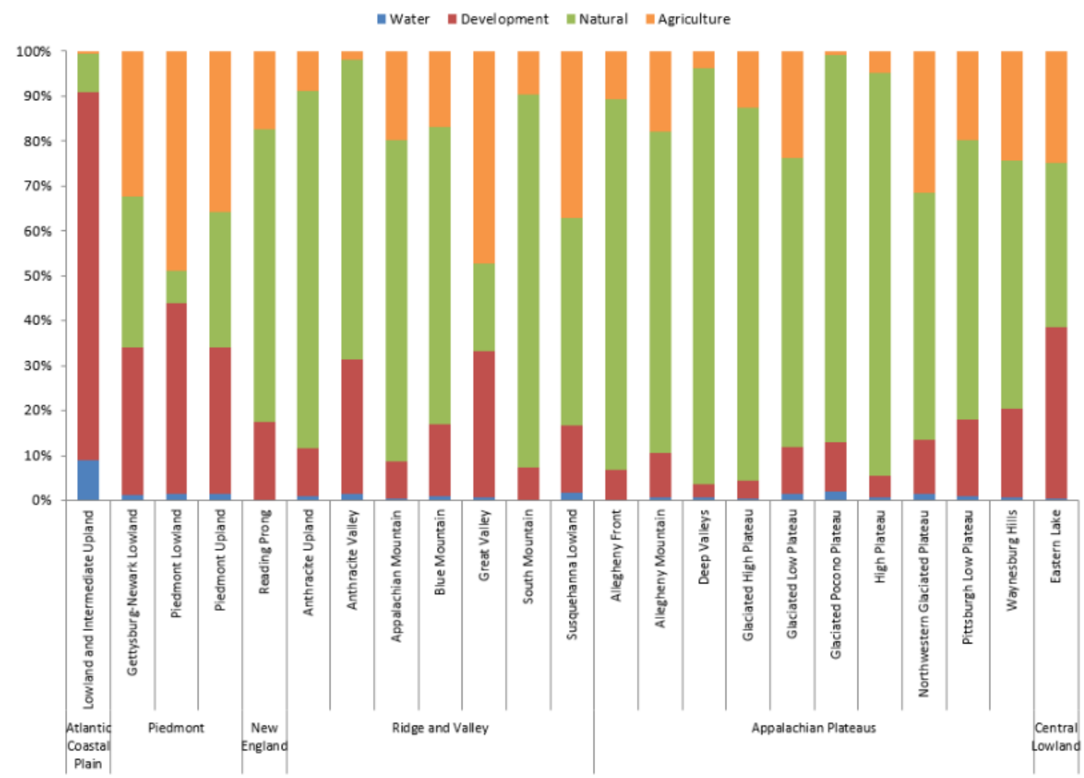

Fig. 2.4. Pennsylvania land cover type distribution among physiographic sections (Source: National Land Cover Dataset 2024).

Forests and Natural Cover

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 (PNHP) has identified 23 types of terrestrial forest communities in Pennsylvania, as well as several more woodland types (PNHP 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).

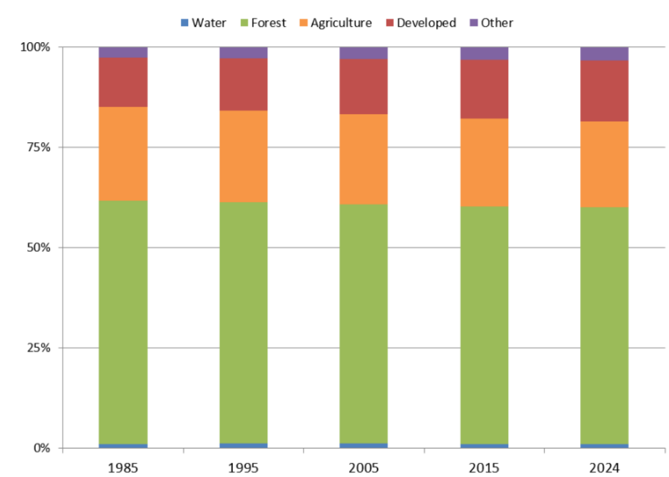

Fig. 2.5. Land cover distribution, predominantly forest (green), across Pennsylvania in 1985, 1995, 2005, 2015, and 2024 (Source: National Land Cover Dataset 2024).

Approximately 30% of the state's forested area is in public ownership (i.e., federal, state, and local governments), while 70% is in private ownership (i.e., land owned by corporations, trusts, or individuals) (USGS 2026). Private forest ownership presents unique challenges and opportunities for fish and wildlife habitat in Pennsylvania as most important land classes, including forests, open lands, and wetlands exist in relatively small, fragmented parcels.

Trends

Maintaining Pennsylvania's forest cover is fundamentally important for sustaining the full suite of ecological, economic, recreational, and cultural resources provided by forests. Pennsylvania remains one of the most heavily forested states in the eastern United States. The most recent USDA Forest Service Forest Inventory and Analysis (FIA) inventory estimates approximately 16.65 million acres of forest land in Pennsylvania in 2024, representing about 60% of the Commonwealth's land area (USDA-FS 2025).

This is similar to the 2019 estimate of 16.62 million acres, indicating that statewide forest acreage has been relatively stable over the most recent inventory period. However, statewide stability in net forest acreage should not be interpreted as an absence of forest loss/conversion. FIA estimates indicate that Pennsylvania's forest area reached approximately 17.0 million acres around 2013 and subsequently declined by roughly 378,000 acres by 2019 before leveling off in the most recent inventory (PA DOA 2020). Thus, the long-term trend is better characterized as "relatively stable" forest cover with substantial spatial and temporal turnover rather than as a consistently stable forest resource. The distinction between net forest change and gross forest loss is particularly important for Pennsylvania. Forest loss in some portions of the Commonwealth has been offset by the natural reversion of abandoned agricultural land to forest, particularly in portions of northcentral and northeastern Pennsylvania. At the same time, forests have been permanently converted to residential, commercial, industrial, transportation, energy, and other developed uses, particularly in portions of southeastern, southwestern, and northeastern Pennsylvania. The Pennsylvania DCNR Forest Action Plan identified land-use change as one of the Commonwealth's principal forest issues and emphasized that forest conversion and fragmentation can have ecological consequences that are not captured by net statewide acreage alone (PA DCNR 2020).

Recent FIA data reinforce this distinction. Between 2019 and 2024 inventories, estimated forest land increased slightly from 16,621,968 to 16,653,989 acres, while forest volume increased from approximately 54.1 billion to 56.0 billion cubic feet. Because the difference in forest acreage is small relative to sampling uncertainty, it should not be interpreted as evidence of a meaningful statewide increase in forest area. Rather, the most recent data suggest that Pennsylvania's total forest footprint has remained broadly stable while the location, condition, structure, and ownership of forests continue to change (USDA-FS 2025).

Forest ownership also has important implications for future land-use change. As previously stated, approximately 70% of Pennsylvania's forest land (approximately 12 million acres) is privately owned, compared with approximately 30% that is publicly owned. Consequently, a large proportion of the Commonwealth's forest habitat is subject to decisions made by private landowners and is potentially vulnerable to parcel subdivision, residential or commercial development, and other land-use changes.

Publicly owned forests and conservation easements provide important protection from permanent conversion, but protected lands are not distributed uniformly across the Commonwealth.

The spatial distribution of forest loss is therefore more important for fish and wildlife than the statewide forest percentage alone. Large blocks of relatively intact forest remain concentrated in northcentral and northwestern Pennsylvania and along major ridges and plateaus, whereas many lower-elevation forests closer to major metropolitan areas experience greater development pressure. Lower-elevation forests can be particularly vulnerable because they are generally more accessible, closer to existing infrastructure, and more likely to be subject to residential and commercial development. The result is a landscape in which the Commonwealth may retain a relatively high percentage of forest cover while simultaneously losing or fragmenting some of its most vulnerable and strategically important forest patches, which has implications for the quality and quantity for both terrestrial and aquatic organisms, as well as people.

Overall, the condition of Pennsylvania's forest habitat is best characterized as one of high remaining forest cover coupled with increasing spatial differentiation in forest condition. The Commonwealth retains an extensive forest resource, but development and fragmentation continue to threaten some of the most important remaining forest blocks, while forest maturation has reduced the availability of young-forest conditions. Maintaining the ecological integrity of Pennsylvania's forests will therefore require a combination of forest-land conservation, strategic land-use planning, maintenance of large contiguous forest blocks, protection of connectivity, and active management to combat invasive species and restore/maintain a diverse range of forest age classes and structural conditions.

Wildland-Urban Interface

Continued human settlement across Pennsylvania has expanded the areas where developed landscapes meet or intermingle with undeveloped forest and other natural vegetation. This wildland-urban interface (WUI) is increasingly important to wildlife and natural resource management because it combines ecological fragmentation with increasing human presence. The most recent national WUI dataset maps conditions through 2020, using census housing data and USGS land-cover information. The dataset distinguishes between intermix WUI, where houses and wildland vegetation occur together, and interface WUI, where development occurs adjacent to larger blocks of wildland vegetation.

Pennsylvania has experienced substantial expansion of forest occurring under WUI conditions. Forest Service analyses indicate that approximately 5.2 million acres of Pennsylvania forest land—about 31% of the state's forest land—were classified as WUI in 1990. By 2010, approximately 6.2 million acres, or 36% of Pennsylvania's forest land, were in WUI conditions. The updated 2020 WUI dataset provides the most recent spatial framework for evaluating this continuing trend, although Pennsylvania-specific 2020 summary statistics should be calculated directly from the current GIS dataset rather than extrapolated from the older 1990–2010 estimates (USDA-FS 2020).

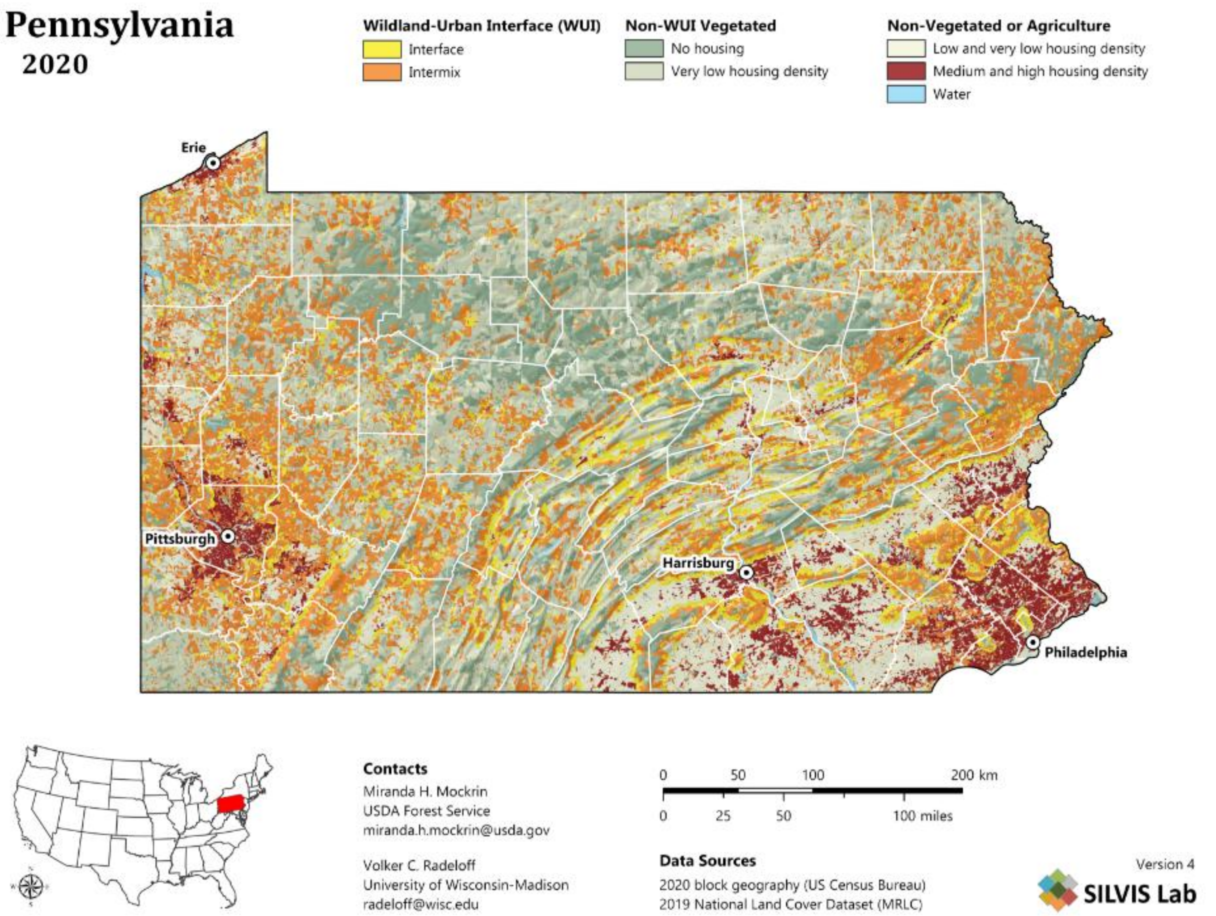

Fig. 2.6. The Wildland-Urban Interface (WUI) for Pennsylvania (USDA-FS 2020; Radeloff et. al. 2023a,b).

The broader national trend illustrates why WUI expansion remains an important management concern. Between 1990 and 2020, WUI area in the conterminous United States increased by approximately 31%, while the number of houses within the WUI increased by approximately 47%, from about 30 million to 44 million homes. By 2020, approximately 9.4% of the land area of the conterminous United States was classified as WUI, containing approximately 32% of all housing units. WUI expansion can increase habitat fragmentation, invasive-species introduction, human disturbance, wildfire exposure, and the complexity and cost of conducting forest and wildlife management.

The importance of WUI expansion is not simply a function of population growth. Pennsylvania's population increased only about 2.4% between 2010 and 2020, from 12.7 million to 13 million people, while the number of housing units increased by approximately 6%, reaching 5.74 million units in 2020 (Fig. 2.7). The most recent census estimates indicate that Pennsylvania had approximately 5.88 million housing units in 2025, while the population was approximately 13.1 million. These trends illustrate how development and housing expansion can continue even when statewide population growth is relatively modest.

The increase in development within and adjacent to wildlands has implications for SGCN, particularly wide-ranging species and species dependent on large, contiguous habitat blocks. It also makes natural-resource management increasingly complicated. Forestry, prescribed fire, habitat restoration, invasive-species control, and other management practices can become more difficult where homes, roads, utilities, and other infrastructure are interspersed with forest. WUI development also creates new sources of disturbance, including artificial lighting, domestic predators, noise, human recreation, invasive species, and increased road traffic.

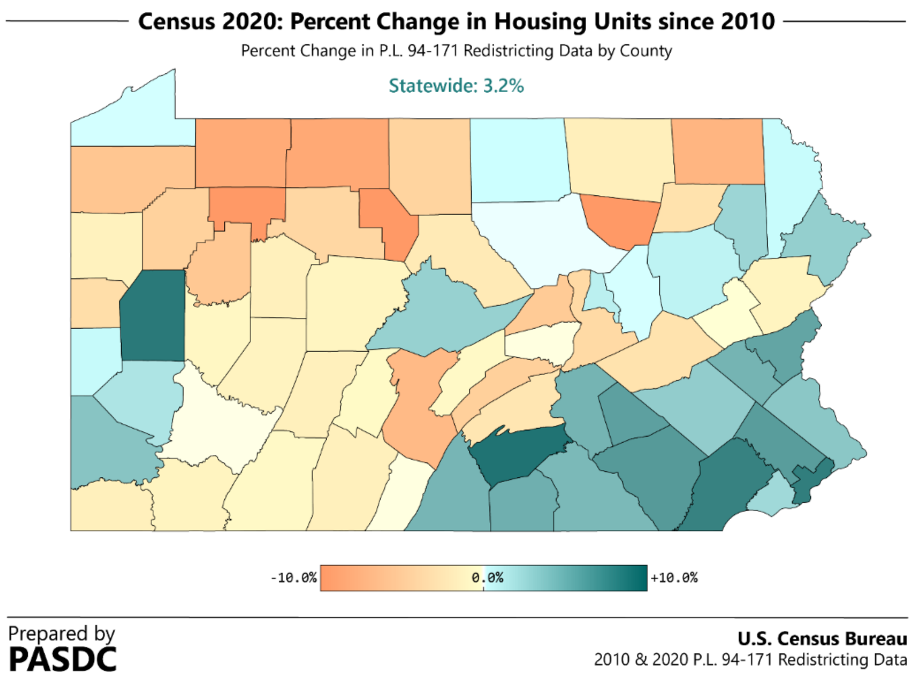

Fig. 2.7. Change in Pennsylvania housing units, 2010-2020. (Source: Pennsylvania State Data Center 2021).

Condition Assessment

Forest Habitat Loss

Permanent conversion of natural cover to human-dominated land uses remains one of the most important long-term threats to Pennsylvania's forests and other terrestrial habitats. However, the current evidence suggests that the issue should be described in terms of forest conversion, fragmentation, and spatial redistribution, rather than simply statewide forest decline. Pennsylvania retains approximately 17 million forested acres, but this total masks substantial local losses, particularly in rapidly developing portions of southeastern, southwestern, and northeastern Pennsylvania. Forest conversion can also be offset statistically by forest establishment on abandoned agricultural land, resulting in relatively stable net forest acreage while important habitat is lost in certain landscapes.

Residential and Commercial Development remains a major source of permanent land-cover conversion and a frequently identified threat to SGCN (see Chapter 1-Species; Appendix 1.4-Species Accounts, and

Chapter 3-Threats). Development pressure is particularly consequential where it affects large forest blocks, rare and unique habitats, lower-elevation forests, riparian corridors, migration routes, and other areas that provide connectivity between otherwise isolated natural habitats. Once converted to roads, buildings, parking areas, and other intensive land uses, forested/non-forested and other habitats are generally difficult and costly to restore to previous ecological condition.

Both the PA DCNR (2020), in its 2020 State Forest Action Plan, and PGC (2023), in its 2023-2026 Strategic Plan, recognize the continuing importance of this issue. Both agencies' recent forest-conservation initiatives include goals to reduce the rate of forest loss, restore non-forest lands to forest, and permanently conserve forested and other non-forested habitats vulnerable to development. These goals reflect the recognition that maintaining Pennsylvania's forest and non-forest habitat resource requires not only managing existing habitats (forested and non-forested/open) but also preventing the permanent conversion and fragmentation of strategically important lands.

Habitat Fragmentation

As natural habitats are converted to other land classes (e.g., suburban development, warehouses, data centers), energy infrastructure, (e.g., transmission corridors, large-scale solar arrays), agriculture, and other land-use changes, remaining natural areas can become increasingly fragmented into smaller and more isolated patches. This habitat fragmentation is more than a simple reduction in total habitat area and remains a major conservation concern independent of total habitat loss. Fragmenting features create barriers in native habitats and can divide formerly contiguous habitat, reduce the amount of interior habitat, alter wildlife movement, increase exposure to human disturbance, and facilitate the spread of invasive species. In addition, fragmentation can reduce core habitat, alter predator and competitor communities, increase invasive-species exposure, and disrupt ecological processes that historically operated across larger continuous landscapes. The ecological consequences can therefore be substantially greater than would be predicted from just the direct loss of habitat.

Fragmentation also creates additional edge habitat. Edge habitat can be beneficial for some wildlife species, particularly species associated with shrublands, young forest, or forest-opening interfaces. Where an edge is intentionally created as part of a habitat-management project, it can therefore provide an important conservation opportunity. For example, rights-of-way, timber harvests, utility corridors, and other openings can be managed to provide native shrub and herbaceous vegetation for species associated with early-successional habitat. However, unmanaged or poorly designed edges can also increase exposure to predators, nest parasites, invasive plants, domestic animals, roads, noise, and other human-associated disturbances. Consequently, the ecological value of an edge depends strongly on its location, width, vegetation structure, management, and relationship to surrounding habitat.

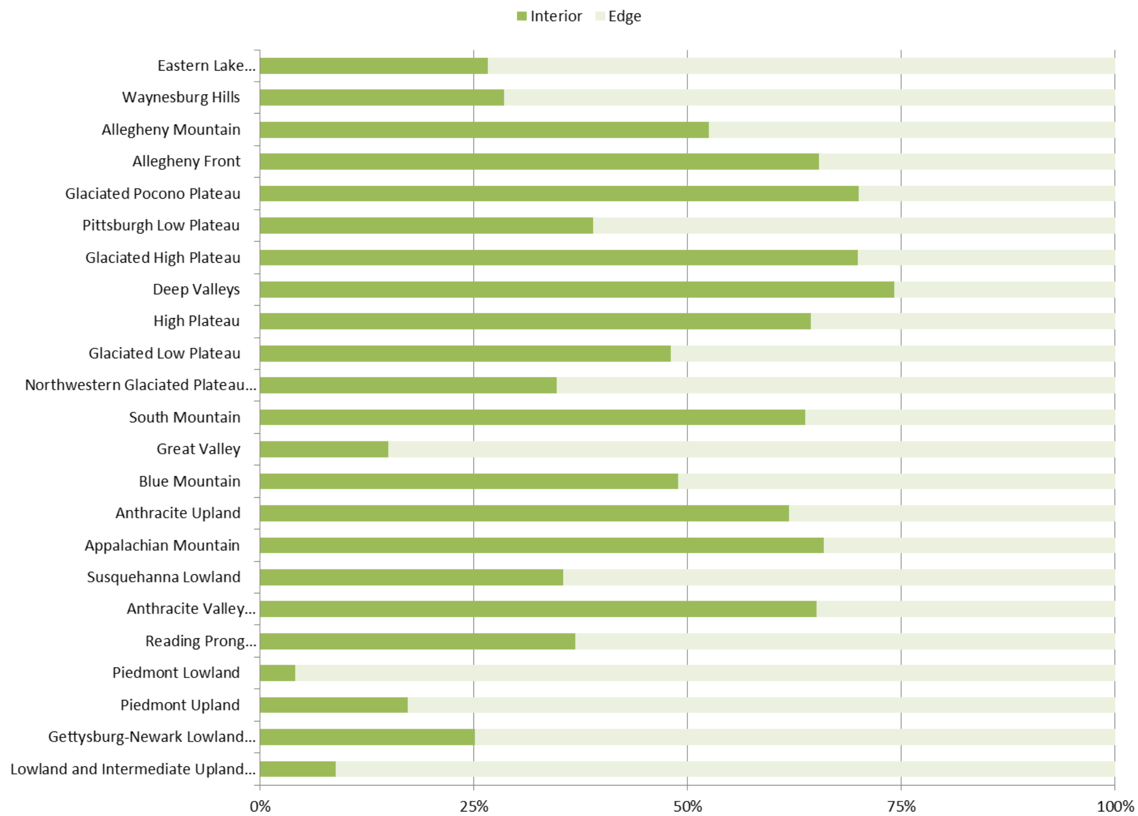

Fig. 2.8. Proportion of edge and interior forest patches across physiographic sections in Pennsylvania (PNHP 2015).

Fragmentation also interacts with Pennsylvania's expanding WUI. The combination of housing, roads, utility infrastructure, recreational development, and natural vegetation produces landscapes in which wildlife habitat is increasingly interspersed with human activity. These landscapes may continue to appear heavily forested when evaluated using broad statewide forest-cover statistics, while nevertheless experiencing substantial reductions in interior habitat and connectivity (Fig. 2.8).

The ecological consequences of fragmentation are strongly species-specific, but research increasingly demonstrates that some wildlife responses occur at landscape-scale thresholds. In the Marcellus-Utica shale gas region of the Central Appalachians, Farwell et al. (2020) found that forest-interior birds responded strongly to cumulative forest loss and that forest-interior species declined above approximately 17% forest loss within the landscapes evaluated. Such findings reinforce the importance of retaining large blocks of intact forest before they become highly fragmented rather than attempting to reconstruct connectivity after fragmentation has occurred.

For Pennsylvania's SGCN, conservation planning should therefore emphasize not only how much forest remains, but also where it remains, how large and connected the remaining blocks are, how much interior habitat they contain, and how their structural and age composition is changing. Protecting large intact forest blocks, maintaining habitat corridors, directing development away from high-value core forests, and strategically managing young-forest habitat will be increasingly important components of statewide wildlife conservation.

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).

Most of Pennsylvania forests are 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 (PA DCNR 2010). This has led to forests that are relatively uniform, with a homogeneous forest canopy structure. This lack of habitat structure and diversity can have a negative influence on SGCN. Many biologists believe the state has a shortage of both early successional (i.e., younger) 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 Alleghanian 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 forest regeneration. Factors including white-tailed deer over-browsing, the exclusion of low intensity fire, acid deposition, poor timber harvest practices, and non-native and invasive diseases and pests (PGC 2018).

Many tree species have been lost from our forests due to non-native and invasive 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 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 fish and wildlife species. The emerald ash borer (*Agrilus planipennis*), an invasive insect first identified in the state in 2007, has recently affected ash trees.

Open Upland Habitats

Though forest is the dominant land cover in Pennsylvania, there are several open terrestrial habitat types that are important for SGCN recovery. Open habitats in Pennsylvania include naturally occurring grasslands/prairies, agricultural meadows [hayfields, pasture, cool-season forage], native warm season grasslands, reclaimed surface mine lands, wet meadows, river scour grasslands, barrens, reverting shrublands, woodlands/savannas, and miscellaneous anthropogenic sites. The 2025-35 PA WAP habitat lexicon groups many of these types into broader categories of grasslands; shrublands; glades, barrens & savannas; agriculture: cropland/pastures; and cliff and talus.

The overall health and value of these open habitats to SGCN is strongly dependent on disturbance. Fire, grazing, mowing, flooding, drought, and other disturbances historically prevented woody vegetation from becoming dominant in many eastern open ecosystems. When these disturbances cease, grasslands and other open habitats often revert to more closed habitat types, and eventually mature, closed-canopy forests. Succession into closed or forested communities is not necessarily "natural improvement," and in many cases it represents the loss of a historically persistent, open (i.e., exposed) ecosystem. Effective grassland and open habitat conservation therefore requires restoring appropriate disturbance regimes—often through prescribed fire, targeted mowing, mechanical woody removal, or carefully managed grazing—while avoiding disturbance during periods when nesting birds or other vulnerable wildlife are present (see Chapter 4-Conservation Actions, Appendix 4.1 for more information on prescribed fire in Pennsylvania).

Most importantly, grasslands, shrublands, open woodlands, and mature forests should be considered complementary components of a functioning landscape rather than competing habitat objectives. A high-quality conservation landscape may contain native grassland interspersed with shrubland, young forest, savanna, and mature forest, with each habitat providing different resources at different times of the year and supporting different portions of the wildlife community. This approach is consistent with the broader direction of contemporary eastern grassland conservation, including the National Park Service's partnership to restore native grasslands while retaining and managing the surrounding ecological mosaic. The Eastern Grasslands Initiative now encompasses grassland restoration across 35 national parks from Mississippi to Maine, illustrating the growing recognition that eastern conservation requires deliberate management of open habitats rather than relying solely on passive forest recovery (National Park Service 2024, 2026). For Pennsylvania's SGCN, the goal should similarly be a dynamic landscape containing grasslands, pollinator meadows, shrublands, young forests, open woodlands, and mature forests in appropriate proportions and configurations.

Grassland Communities

Grasslands and associated open terrestrial habitats are among the most important and historically underappreciated habitats for Pennsylvania's SGCN. The PA WAP identifies hundreds of SGCNs dependent upon grasslands, shrublands, meadows, agricultural fields, barrens, savannas, and other herbaceous-dominated habitats for some portion of their life cycle (Appendix 2.1). The conservation significance of these habitats is increasingly recognized because of Pennsylvania’s unique location at the northern edge of the Central Appalachian ecoregion, and the ecological history of the Commonwealth includes substantially more grassland, savanna, prairie, and open woodland than is suggested by the modern landscape (Noss et al. 2021; Southeastern Grasslands Institute 2025). The Southeastern Grassland Institute has helped bring this historical perspective into contemporary conservation planning by emphasizing that the eastern United States was not uniformly forested prior to European settlement and that many of its grassland systems have been largely overlooked in conservation programs (Noss et. l. 2021 ; Southeastern Grasslands Institute 2025).

Pennsylvania's grasslands occur in many forms, and each provides a somewhat different combination of habitat resources. Native warm-season grasslands dominated by switchgrass, big bluestem, little bluestem, and indiangrass can provide dense nesting cover, abundant seeds, winter cover, and structural diversity for birds and mammals. Cool-season hayfields and pastures can provide important breeding habitat for Bobolink, Eastern Meadowlark, Savannah Sparrow, and other grassland birds when appropriately managed. Wet meadows and sedge-dominated fields provide different vegetation structure and moisture conditions and can be particularly important to species associated with wet grasslands. Reclaimed surface mines in western, southcentral, and northeastern Pennsylvania represent another distinctive grassland type, while serpentine barrens, shale barrens, limestone glades, river scour communities, powerline rights-of-way, airport/airstrip grasslands, and other disturbance-maintained openings can support highly specialized plant and animal communities. Thus, "grassland," in practice, should be treated as a broad ecological category encompassing a diverse suite of habitats rather than as a single vegetation type.

Emerging work from researchers studying the importance of open habitats, including the Southeastern Grasslands Institute, is especially important because it challenges a long-standing conservation bias toward forests in the eastern United States. Eastern grasslands have been described as among the most imperiled ecosystems in eastern North America and estimates that many grassland types have lost more than 90% of their historical extent, with some communities reduced by more than 99% (Southeastern Grasslands Institute 2021). This perspective is relevant to Pennsylvania because SGCN conservation, particularly those with a life stage in open habitats, requires protecting not simply "grass" but the diversity of native open ecosystems and the disturbance processes that maintain them.

The conservation urgency for protecting and restoring native grasslands is underscored by the magnitude of grassland bird declines. The 2025 *State of the Birds* report estimates that U.S. grassland bird populations have declined 43% since 1970, making grassland birds one of the most rapidly declining major bird groups in North America (North American Bird Conservation Initiative 2025). The 2022 report had already documented a 34% decline, demonstrating that the problem is not a short-term fluctuation but a persistent, decades-long population decline. Although much of the national decline is driven by the loss and degradation of Midwestern and Great Plains grasslands, the same fundamental pressures—habitat conversion, agricultural intensification, woody encroachment, altered disturbance regimes, development, and fragmentation—also affect Pennsylvania's grassland-dependent birds (North American Bird Conservation Initiative 2022, 2025).

Agricultural Meadows, Hayfields, Cool-season Forage, and Pastures

Hayfields and agricultural meadows are another important component of Pennsylvania's grassland habitat network. Bobolink (*Dolichonyx oryzivorus*), Eastern Meadowlark (*Sturnella magna*), Savannah Sparrow (*Passerculus sandwichensis*), Grasshopper Sparrow (*Ammodramus savannarum*), and other grassland birds can use hayfields for nesting and foraging, but the conservation value of these fields depends heavily on mowing timing, field size, vegetation structure, and surrounding landscape. Early or repeated mowing can destroy nests and young birds before they fledge, effectively turning otherwise suitable habitat into a population sink. Conservation programs that modify mowing schedules, maintain uncut refuges, or provide alternative nesting habitat can therefore have substantial benefits. More broadly, recent research demonstrates that heterogeneous agricultural landscapes can support both grassland and forest bird communities, emphasizing that conservation should seek strategically designed mosaics rather than a single habitat type across every acre (e.g., Grand et al. 2019, Fiss et al. 2020).

Pastures and cool-season forage (cool-season grasslands) can likewise provide important wildlife habitat, particularly when they retain native grasses, diverse forbs, structural variation, and relatively low-intensity grazing. Well-managed perennial grasslands can provide nesting and foraging habitat while simultaneously supporting insects that form the foundation of many grassland food webs. Research on native versus non-native perennial grass systems has found that native grass pastures can support greater bee richness and abundance than some non-native grass systems, demonstrating that the identity and diversity of plants matter as much as the presence of "grass" itself (Campbell et al. 2021). In Pennsylvania, this distinction argues for managing pastures as biologically diverse plant communities rather than simply maximizing forage production.

Native Warm-Season Grasslands

Although there remain concerns about these types of grasslands forming monocultures that become too dense to provide meaningful habitat, native warm-season grasslands can provide some value because their bunchgrass structure creates vertical and horizontal variation that is largely absent from dense, cool-season turf or uniform agricultural grass. Switchgrass, big bluestem, little bluestem, and indiangrass provide nesting substrate, concealment, seed production, and winter cover, while spaces between bunches provide opportunities for movement and foraging. Their warm-season growth also produces habitat structure during the summer when many grassland birds are breeding. Pennsylvania State University Extension has emphasized the value of these native warm-season grasses for ground-nesting birds and cottontails and their importance as persistent winter cover (Penn State Extension 2016).

Reclaimed Surface Mine Grasslands

Reclaimed surface mines provide extensive non-agricultural grassland habitat in Pennsylvania with more than 2 million acres (0.8 million hectares) in the Commonwealth (Carrozzino et al. 2018). 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, managing reclaimed surface mines as grassland reserves may help prevent some SGCN from declining, notably Henslow's Sparrow (*Ammodramus henslowii*) (Mattice et al. 2005).

Wet Meadows

Wet meadows, wet grasslands, and sedge-dominated openings are especially important because they combine the structural characteristics of grasslands with hydrologic conditions unavailable in upland fields. These habitats can support insects, amphibians, small mammals, and birds while providing seasonal concentrations of food resources. Henslow's Sparrow, for example, can use wet meadows and other tall, dense grasslands, while a variety of migratory birds use wet meadow complexes during migration. The conservation value of wet grasslands therefore extends beyond breeding birds: they can provide stopover habitat, invertebrate production, and landscape connectivity between wetlands, streams, and upland habitats.

River Scour Grasslands

The emerging recognition of Appalachian river scour grasslands further demonstrates the diversity of eastern grassland ecosystems. Researchers have documented exceptionally diverse riparian grasslands in Southern Appalachian river gorges, including more than 500 native plant species across several surveyed sites and numerous rare and undescribed species (Southeastern Grasslands Institute 2025). Although these examples occur south of Pennsylvania, they are directly relevant to understanding the broader Appalachian grassland continuum. They demonstrate that open habitats embedded within heavily forested landscapes can contain extraordinary biodiversity and should not automatically be regarded as degraded forest. SGI's floristic research on limestone glades, river scour communities, and other unusual grasslands has been especially valuable in changing how eastern grassland biodiversity is recognized and mapped.

Barrens Communities

Pennsylvania's variety of unique barrens communities demonstrate another important principle: some of the Commonwealth's most valuable grassland habitats are maintained by unusual soils and disturbance rather than by conventional agricultural management. Serpentine barrens support specialized plant communities adapted to nutrient-poor soils and can provide habitat for rare insects and other wildlife. Shale barrens similarly contain distinctive plant communities associated with dry, rocky substrates. These habitats are easily overlooked because they may appear sparse or unproductive from a conventional forestry or agricultural perspective. From a biodiversity perspective, however, their unusual soil conditions create ecological niches that cannot simply be replaced by planting a generic grass seed mixture elsewhere.

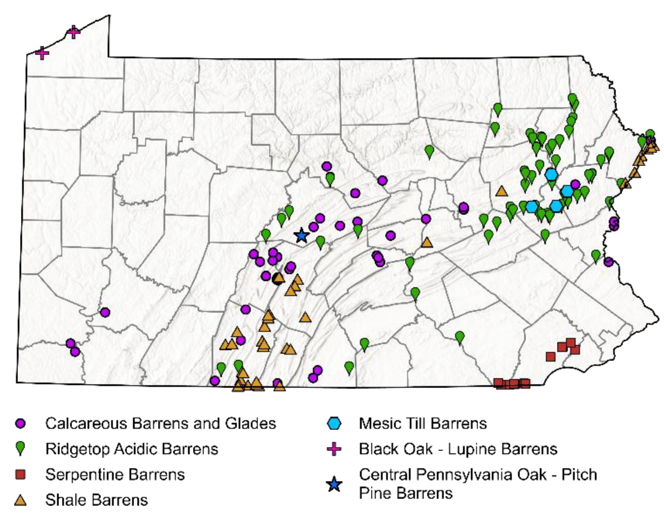

Fig. 2.9. Barren community distribution in Pennsylvania. (Source: Pennsylvania Natural Heritage Program).

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 7 barren types (Figure 2.9; https://www.naturalheritage.state.pa.us/Communities.aspx) in the terrestrial community classification):

- Calcareous barrens and glades – Typically occurs on limestone or calcareous shale or sandstone cliffs, outcrops, glades, and rocky slopes. These are open woodlands and habitats dominated by grasses and herbaceous plants. Species composition varies with the amount of moisture, soil depth, shade, and exposure. Many of the characteristic plant species found on calcareous barrens and glades in Pennsylvania are restricted to the high pH substrates found in these habitats.
- 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.
- Serpentine barrens – 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).
- 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.
- 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).
- Black oak – Lupine barrens - This barrens community is dominated by black oak (*Quercus velutina*) trees of short stature on relict dunes and beech ridges along the Lake Erie Coast. Lupine (Lupinus perennis) is often a dominant groundcover species along with other sun-loving grasses and herbaceous species. The canopy varies from open patches of open barrens or savanna to a more closed "woodland" overstory approaching a closed canopy.
- Central Pennsylvania oak – pitch pine barrens - This barrens habitat is an open, sandy, woodland that occurs in central and south-central Pennsylvania on soils derived from Gatesburg geology. The largest known complex occurs within and around State Game Land 176 in Centre County, locally known as Scotia Barrens, where recent land use practices, primarily iron and clay mining in the 1800 and early 1900s, and charcoal production, greatly influenced the area's natural community structure. Despite its origin, Central Pennsylvania Oak – Pitch Pine Barrens closely resemble barrens habitats elsewhere and is important habitat for golden-winged warbler,

Appalachian cottontail, ruffed grouse, eastern whip-poor-will and many other bird, plant, and invertebrate species.

See Orndorff and Coleman (2008) and Heilferty et al. (2023) for barrens habitat management recommendations.

Reverting Shrublands

Reverting shrublands occupy an important middle ground between open habitats and closed-canopy forests and are disproportionately valuable to a suite of Pennsylvania SGCN. These habitats are characterized by dense shrubs, saplings, young trees, vines, herbaceous vegetation, and often a highly complex vertical structure. Golden-winged Warbler (*Vermivora chrysoptera*), Prairie Warbler (*Setophaga discolor*), Field sparrow (*Spizella pusilla*), Appalachian cottontail (*Sylvilagus obscurus*) and several small mammals depend on these conditions for breeding, feeding, or cover. The PGC emphasizes that each stage of forest succession provides different combinations of food and cover, with young forests particularly valuable because their dense vegetation provides nesting, brood, escape, and soft-mast resources. Consequently, allowing every former field or shrubland to progress uninterrupted toward closed-canopy forest can reduce landscape-level habitat diversity even while increasing total forest acreage.

Reverting shrubland habitat is particularly important because Pennsylvania's forest landscape has undergone extensive maturation following agricultural abandonment and changes in timber harvesting (Fig 2.10). As former agricultural fields become increasingly dominated by trees, the amount of dense shrubland and young forest available on the landscape can decline. The result is a potential mismatch between the abundance of mature forest and the availability of early- and mid-successional habitat. Numerous bird, mammal, and reptile species are dependent to varying degrees on young forest and shrubland conditions, demonstrating that these habitats support a distinct wildlife assemblage rather than merely representing an immature version of mature forest (Oehler et al. 2006). For Pennsylvania SGCN planning, the appropriate objective is, therefore, not to maximize either young forest or mature forest independently, but to maintain a diverse and spatially connected distribution of successional stages.

Shrublands can be especially important for mammals because dense woody vegetation produces both food and security cover. Blackberry, raspberry, blueberry, dogwood, viburnums, sumac, and other shrubs provide soft mast and browse, while dense stems and low branches provide escape cover from predators and thermal protection. Appalachian cottontail is an especially important example in the broader Appalachian and northeastern region because it requires dense shrubland and young forest with substantial low woody cover. Although Pennsylvania's Appalachian cottontail population has a highly localized distribution, habitat management for this species illustrates the broader principle that structurally dense shrublands cannot be replaced simply by mature forest or open grassland. Other mammals, including meadow vole, deer mouse, masked shrew, least shrew, and a variety of bats and carnivores, also exploit the structural complexity and abundant prey associated with young woody habitats.

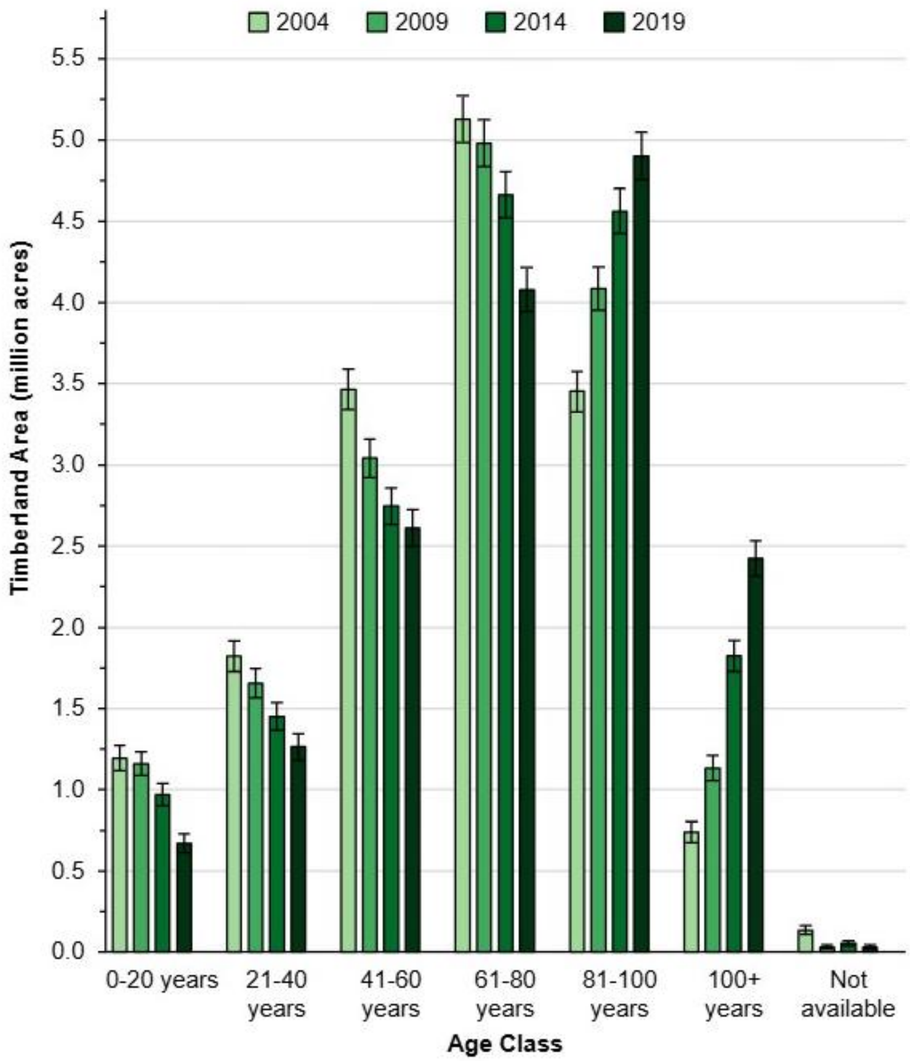

Fig. 2.10. Stand age classification for Pennsylvania's forests across four survey periods, 2004-2019 (Figure 9 *in* Albright et al. 2019).

Woodlands and Savannas

Open woodlands and savannas deserve particular attention because they occupy another poorly recognized position along the grassland–forest continuum. These systems contain substantial tree cover but retain enough sunlight to support a rich herbaceous and shrub layer. This is significant for Pennsylvania because many landscapes that are now classified simply as "forest" may historically have contained a more open canopy maintained by fire, grazing, drought, topography, or other disturbance. Emerging research on the historic extent of eastern grasslands is helping shift conservation thinking away from the assumption that every open or sparsely wooded site represents a degraded forest that should simply be allowed to advance into closed forest.

Reverting shrublands and woodlands therefore present both a conservation opportunity and a management challenge. Some shrublands should be maintained as shrublands; others should be allowed to develop into young forest and/or mature forest. At the same time, other lands may warrant periodic disturbance to maintain a more open woodland or savanna condition. The appropriate trajectory depends on soils, landscape position, historical vegetation, disturbance regime, invasive-species presence, surrounding habitat, the SGCN being targeted, and of course, management planning. Recent work on mapping shrublands in the northeastern United States demonstrates that these low-statured woody communities are sufficiently distinctive to warrant separate consideration in landscape assessment and management rather than being automatically lumped with forest (Mahoney et al. 2022). For Pennsylvania, improving the ability to identify and map these habitats would provide a better foundation for determining where natural succession should be allowed to proceed and where active management is needed to retain shrubland or open-woodland conditions.

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. Urban buildings and bridges offer nesting sites for Peregrine Falcon (*Falco peregrinus*), a population recently recovered in Pennsylvania that remains a SGCN to ensure it continues to soar.

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 (*Cistothorus stellaris*) 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 (*Robinia pseudoacacia*), autumn olive (*Elaeagnus umbellata*), and multiflora rose (*Rosa multiflora*). 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. Central Pennsylvania oak-pitch pine 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 *Scotia Barrens to Ridgelines Initiative*, led by ClearWater Conservancy, is working to restore and sustain connected aquatic and terrestrial habitats in this area.

The PGC is a major landowner of reclaimed grassland in southwestern Pennsylvania, but land acquisition has slowed due to budget constraints and increasing land values. 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. Appendix 2.1 provides extent and securement statistics as available.

Wetlands

Wetlands provide critical habitat for many plant and animal species and valuable ecosystem services such as water filtration and flood control. Wetlands are defined as "areas where water covers the soil, or is present at or near the surface of the soil all year or for varying periods of time during the year, including during the growing season" (USEPA 2026). Wetlands generally include swamps, marshes, bogs, and similar areas. 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 (Federal Geographic Data Committee 2013).

Wetlands differ across the state based on topographic position, geology, climate, hydrology, vegetation, and human influences (Lang et al. 2024). 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 504,845 acres (204,303 hectares) of palustrine (e.g., marshes, swamps) wetland have been identified within Pennsylvania according to the NWI (USFWS 2025). An additional 546 acres (221 hectares) of estuarine habitat are in the southeastern region, along the Delaware River.

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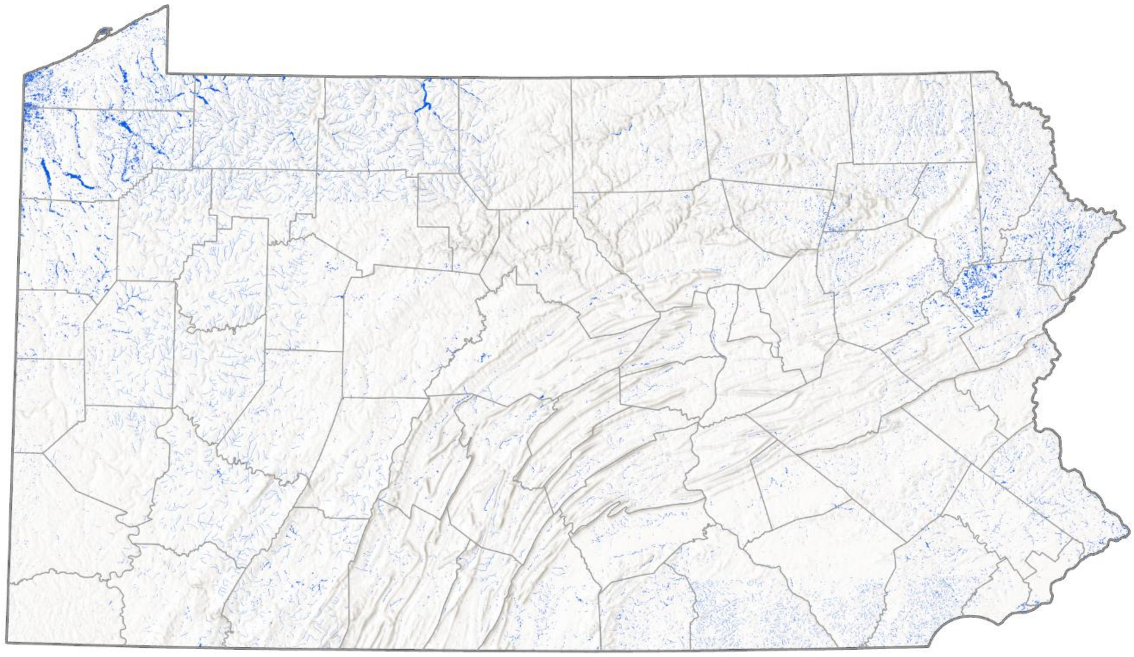

Fig. 2.11. Wetland distribution in Pennsylvania based on the National Wetland Inventory (NWI) dataset. Wetland polygons are enlarged for clarity. Note that the NWI dataset may be incomplete for some areas and not all known wetlands are presented. Estuarine and palustrine polygons have been enlarged for clarity.

Wetlands in Pennsylvania are largely concentrated in the northwestern and northeastern corners of the state, where glacial influence modified the landscape (Fig. 2.11). 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 (PNHP 2012). Many of these wetland types are frequently rich in species diversity and provide important breeding habitat for numerous SGCN 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. 2.12).

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 but provide critical, free ecosystem services and are an important home for wildlife and the unique plant communities on which they depend.

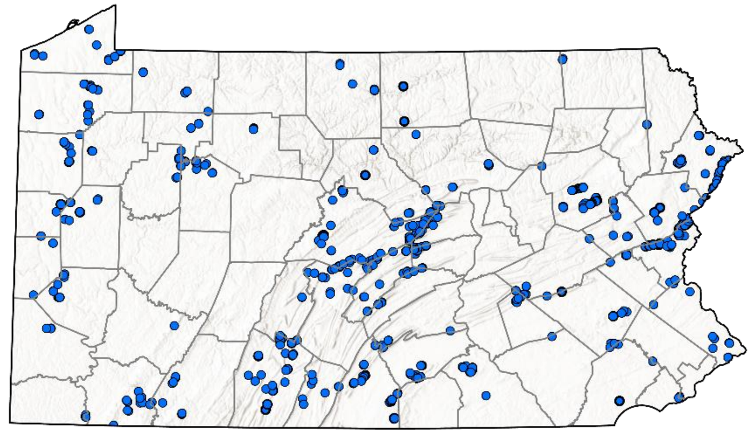

Fig. 2.12. Documented vernal pools (i.e., confirmed by a field visit) in Pennsylvania (Source: Pennsylvania Natural Heritage Program).

Trends

Pennsylvania is estimated to 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 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 birds, mammals, fishes, and insects. Nationwide, wetland losses peaked between 1954 and 1974 but have moderated largely due to stronger protections and restoration efforts (Adler et al. 1993). For example, Anderson et al. (2023) found 98% of Pennsylvania wetland acreage has been maintained in the last 20 years, with only an estimated 0.2% converted to developed land.

Condition Assessment

Despite the major focus on documenting condition for wetland management, a comprehensive condition assessment for all Pennsylvania wetlands remains unavailable; however, localized wetland condition assessment studies have been completed in areas across the Commonwealth.

Brooks et al. (2004) developed a method for assessing wetland condition on a watershed basis from landcover maps in the mid-Atlantic region. 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 wetland condition issues. 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. And, though primarily a methods publication, Fernandez et al. (2018) perhaps provide the closest reflection on a statewide wetland condition assessment through their reported metrics. While investigating landscape indicators to assess strengths and weaknesses for evaluating mapped wetland ecological condition, they found only 6% of wetlands fell into the highest ecological condition category (≥89% forest), while 45% fell into the lowest (≥47%) and only 38% of the total forest area qualified as "core forest", indicating widespread fragmentation. Not surprisingly, the Piedmont and Middle Atlantic Coastal Plain ecoregions, in southeastern Pennsylvania, had the poorest average condition scores. Further, Anderson et al. (2023) found less than 40% of all wetland acres (all types) are conserved for nature (i.e., GAP 1 or 2) or conserved for multiple uses (i.e., GAP 3) (Fig. 2.13).

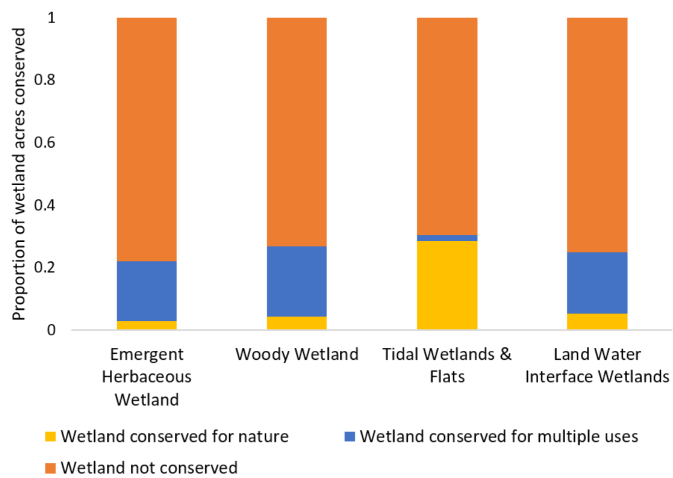

Fig. 2.13. Proportion of Pennsylvania wetlands conserved for nature, conserved for multiple uses, or not conserved. (Source: Anderson et al. 2023).

Overall, a statewide synoptic evaluation of Pennsylvania wetland condition remains a need. This information can be used to target areas for protection, restoration prioritization, and selecting best management practices.

Streams and Rivers

Pennsylvania contains more than 85,500 miles (137,599 kilometers) of streams and rivers (PA DEP 2026). These systems support the majority of federally protected species; 53% of federally listed species in Pennsylvania are fishes or mussels (PNHP 2026). 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 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 downstream water quality (USEPA 2000).

Pursuant to Pennsylvania Code Title 25 Chapter 93 (water quality standards), PA DEP maintains a list of designated uses for each stream and watershed in the Commonwealth: 29,414 miles (47,337 kilometers) (35%) are designated Cold Water Fishery, 10,417 miles (16,764 kilometers) (12%) are a Trout Stocking Fishery, and 22,573 miles (36,328 kilometers) (26%) are a Warm Water Fishery (PA DEP 2026). An estimated 4,092 miles (6,585 kilometers) (or about 5%) of the state's streams have been awarded additional protection as Exceptional Value streams, while 23,187 miles (37,316 kilometers) (or about 26%) have been classified as High Quality. Additionally, PA DEP, as required by Section 303(d) of the U.S. Clean Water Act, assesses protected water use, designating their general statuses as "supporting," "impaired," or "unassessed". A stream labeled as 'impaired' is no one no longer able to support one or more of its designated uses. Results are available biennially (even years) in PA DEP's Pennsylvania Integrated Water Quality Monitoring and Assessment Report (PA DEP 2026).

Trends

Activities such as mining, forestry, industry, agriculture, residential development, pipeline construction, road building and maintenance have degraded water quality in Pennsylvania. Sedimentation from agriculture and 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, the animals, and creation of deep pits up to 70 feet (21 meters) deep. However, declines of commercially viable sand and gravel reserves and recent regulatory changes have largely limited dredging activity to small portions of the Ohio River (Thomas 2013).

Stream trends are difficult to measure and vary due to location and timeframe. For example, the Pennsylvania range of native Brook Trout (*Salvelinus fontinalis*), a species that prefers cold, high-quality streams, has been reduced by 66% and most of the remaining populations have been reduced from historical numbers – mirroring patterns throughout its range (Eastern Brook Trout Joint Venture 2006). Trends for big river freshwater mussel SGCN are likewise difficult to survey due to visibility restrictions associated with river depths and flow, safety concerns associated with barge traffic, dam operations, and combined sewer overflows, and the resources need to deploy a dive team.

Condition Assessment

<u>Riparian cover</u> – 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). Eliminating riparian vegetation removes the floodplain's capacity to buffer effects of the surrounding landscape and floodwaters and, consequently, reduces water quality in the stream. Nearly a third of the riparian area in the state has been converted away from natural cover (Anderson et al. 2023). Riparian cover ranges from 9% in the Lowland and Intermediate Upland Section to 84% in the Deep Valley Section. 20% of the total riparian buffer area in the state is protected against development (Anderson et al. 2023).

<u>Water quality</u> – 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 to rivers and streams 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 other diffuse sources, affecting chemical composition, water quality, and the biotic community. While the non-point source pollution volume has decreased from historical highs during the 20th century, stream water quality remains negatively impacted by point-source pollutants, such as industrial discharges and acid mind drainage. 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 (**Error! Reference source not found.**2.14).

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), stream habitat quality 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

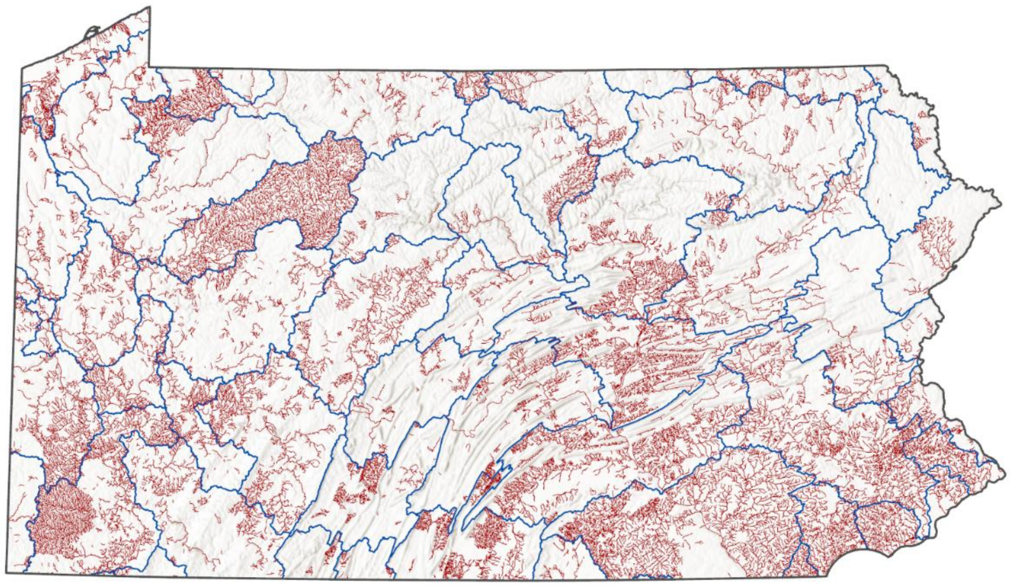

Fig. 2.14. Impaired stream reaches in Pennsylvania (red) within sub-basin watersheds (HUC08)(dark blue). (Source: Pennsylvania Department of Environmental Protection).

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 most 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), PFBC and partners have produced a series of ecosystem flow studies (DePhilip and Moberg 2010, 2013a, 2013b; Taylor et al. 2013; PFBC 2024) 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 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. Wetland and stream restoration and protection are especially critical given the severe declines endured by these habitat types. Of particular concern are the long-term impacts of groundwater withdrawals, which can be difficult to quantify and characterize.

Aquatic connectivity – Similar to terrestrial habitat fragmentation, linear aquatic habitats, such as streams and rivers, can be fragmented by – and sustain flow impairment from – dams and other barriers. River habitat fragmentation by dams and poorly designed culverts is one of the primary threats to aquatic species (Graf 1993; Collier et al. 1997); species lose access to quality habitat for one or more life stages, which limits reproduction and/or dispersal. The North Atlantic Aquatic Connectivity Collaborative (NAACC), soon to become the National Aquatic Connectivity Collaborative (NACC), started in 2015 to enhance aquatic connectivity data collection, analysis, and restoration action. To date, members of the Pennsylvania Aquatic Connectivity Team have inventoried 5,130 dams and restored thousands of streams miles, upstream and downstream of removed dams (NACC 2026). 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. 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 chemical stream impairment, such as AMD.

Lakes and Ponds

Pennsylvania's lake and pond habitats are most abundant in Pike and Wayne counties (Fig. 2.18). 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 other natural lakes are the result of glacial activity and are in the 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 eight 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 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 result 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. PA 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 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

Natural and man-made subterranean habitats are found statewide, supporting diverse wildlife adapted to live in cool, dark environments. Caves are found primarily in 3 physiographic sections: Appalachian Mountains, Allegheny Mountains, and Great Valley, with a modest number caves scattered elsewhere throughout the state (Fig. 2.15). Four cave communities are recognized in Pennsylvania (Thorne 1995):Terrestrial solution caves – The largest and most common type in Pennsylvania, occurring in limestone bedrock.

- 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.

- Tectonic caves – Wide, subsurface cracks due to the movement of bedrock (typically sandstone). They are usually dry and used by bats and Allegheny woodrats.
- Talus caves – Formed from masses of boulders piled such that openings are create between and beneath rocks. These are typically used by reptiles and small mammals.

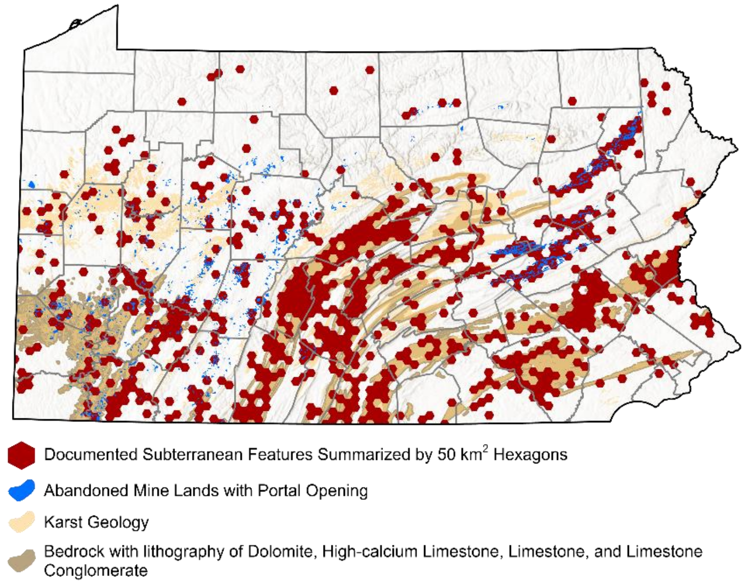

Fig. 2.15. Subterranean habitats in Pennsylvania. (Source: Pennsylvania Natural Heritage Program).

In addition to natural caves, extensive mining in the northeastern and southwestern portions of the Commonwealth has resulted in numerous man-made subterranean excavations that also can function as caves for animal species (Mohr 1942; Johnson et al. 2006). 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 SGCN conservation. 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 white-nose syndrome (WNS), a deadly fungal disease affecting cave-hibernating bats. 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 statewide subterranean habitat condition. Doctor et al. (2016) modelled the distribution of select cave-dwelling invertebrates and fishes across the Appalachian geography. These spatial layers, available through Data Basin, may assist prioritizing sites for future visual and biotic assessments.

About 13% of the known caves occur on conservation land and, thus, 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.

Habitat Classification and Extent

Adapted from Crisfield and Northeast Fish and Wildlife Diversity Technical Committee (NEFWDTC) 2022

Pennsylvania habitat descriptions are presented in Appendix 2.1, organized according to the Northeast Association of Fish and Wildlife Agencies (AFWA) NEFWDTC habitat lexicon (Crisfield and NEFWDTC 2022).

The coarse habitat classification is based on NatureServe Biotics 5 and developed for the northeast Regional Species of Greatest Conservation Need (RSGCN) Database (Terwilliger Consulting Inc. and Northeast Fish and Wildlife Diversity Technical Committee 2022). This system provides the necessary consistency at the regional scale to summarize priority conservation themes while allowing states flexibility to define focal habitats contextually. The version presented below was adapted slightly for the 2022 Lexicon to ensure that important habitats like vernal pools, mines & tunnels, caves & karst, and other subterranean were not lost by relying on modifiers that may not be used by all states. (Table 2.1).

The classification system is based on experience with RSGCN in the northeastern and midwestern U.S. and allows regional themes to be summarized at two levels. Additionally, analysis of anthropogenic habitat use as a conservation opportunity is possible by filtering on the italicized habitat types, embedded within their related natural habitats. Recommended Habitat Modifiers are a subset of the full set of modifiers developed to describe habitat requirements for RSGCN; see Terwilliger Consulting Inc. and NEFWDTC 2022 for a complete discussion. Pennsylvania did not use habitat modifiers uniformly during Wildlife Action Plan (PA WAP) development but will continue to investigate and apply habitat modifiers during PA WAP implementation, as warranted. Habitat modifiers can be useful for communicating more specific species habitat requirements to habitat managers and partners. In particular, the "Features" associated with each Habitat Class can provide important information about niches within habitat types where species can be found during certain life stages. For example, amphibians in forests sometimes require 'logs & woody debris' to provide moist shelter in late summer.

Table 2.1. Habitat classification system used in the 2025-2035 Pennsylvania Wildlife Action Plan, derived from the northeastern U.S. Regional Species of Greatest Conservation Need Database (Crisfield and Northeast Fish and Wildlife Diversity Technical Committee [NEFWDTC] 2022; Terwilliger Consulting Inc. and NEFWDTC 2022). *Italicized* habitat types are anthropogenic.

Habitat Class	Habitat Types	Recommended Habitat Modifiers (as applicable)
Forested Upland	Forests & Woodlands	Type; Age Class; Fire Dependent; Substrate;
	Agriculture: Plantations/Orchards	
	High Elevation Forests	

Open Upland	Grasslands	Substrate; Fire Dependent
	Shrublands	For agriculture: Features (no-till vs. till)
	Glades, Barrens & Savannas	
	Agriculture: Cropland/Pastures	
	Cliff & Talus	
Subterranean	Caves & Karst	Light Zone; Substrate; Soil Moisture Specialist
	Mines & Tunnels	
	Other Subterranean	
Developed	*Developed Areas*	*Density*
Riverine	Big Rivers	Major river basin; Size; Substrate
	Rivers and Streams	
Lacustrine	Great Lakes	Great Lake; Size; Trophic state
	Lakes & Ponds	
Land-Water Interface	Riparian & Floodplains	Substrate; Tree Density; Salinity; Tidal Zone
	Shorelines	
	Beaches & Dunes	
Palustrine	Non-Tidal Wetlands	Substrate (to include peat); Hydroperiod
	Vernal Pools	
Estuarine	Estuaries	Substrate; Emergent Vegetation Density; Floating Vegetation Density’ Submerged Vegetation Density
	Tidal Wetlands & Flats	
	Tidal Rivers & Streams	

The updated northeast habitat lexicon is not associated with a habitat map; thus, the Pennsylvania Natural Heritage Program (M. Moore and E. Zimmerman, unpublished data) cross-walked the Nature Conservancy’s Northeast Terrestrial Habitat Map and Classification (Anderson et al. 2013) to illustrate Pennsylvania habitat type distribution based on the new lexicon (Fig. 2.16) and summarize habitat type by physiographic section (Tables 2.2 and 2.3). Detailed reports of each habitat, its extent, condition, as well as associated SGCN, are presented in Appendix 2.1

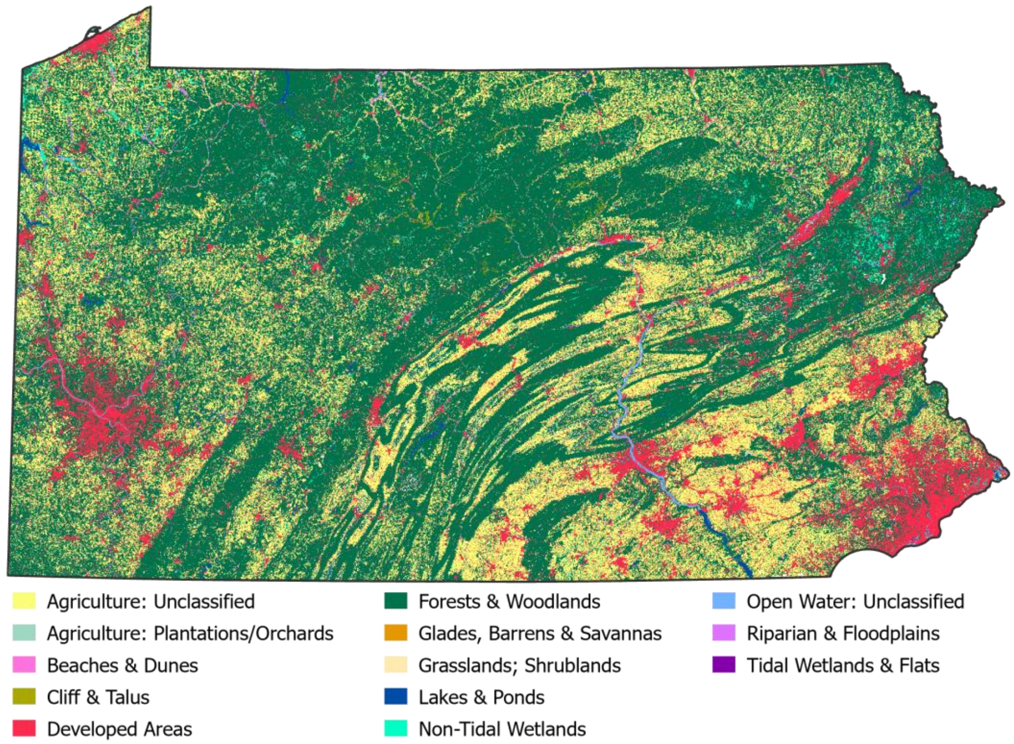

Fig 2.16. Pennsylvania habitat type distribution based on the Northeast Association of Fish and Wildlife Agencies habitat lexicon (Crisfield and NEFWDTC 2022). (Source: Pennsylvania Natural Heritage Program).

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Table 2.2. Habitat type distribution (in acres) by physiographic section in Pennsylvania, from northwest to southeast.

Physiographic Section	Agriculture: Cropland/Pastures; Agriculture: Plantations/Orchards	Agriculture: Plantations/Orchards	Beaches & Dunes	Big Rivers; Estuaries; Great Lakes; Lakes & Ponds; Rivers and Streams; Tidal Rivers & Streams	Cliff & Talus	Developed Areas	Forests & Woodlands	Forests & Woodlands; Glade, Barren, and Savanna	Glades, Barrens & Savannas	Grasslands; Shrublands	Lakes & Pond	Non-Tidal Wetlands	Riparian & Floodplains	Tidal Wetlands & Flats
Eastern Lake	41,465	2	194	1,658	282	49,426	47,386			1,614	170	10,964	457	
Northwestern Glaciated Plateau	607,588	812		22,227	272	184,576	891,178			25,858	24,406	73,231	22,058	
Glaciated Low Plateau	673,480	913		37,022	8,372	220,763	1,617,921	270	14	57,341	34,310	77,344	7,085	
High Plateau	88,502	9,653		13,527	4,434	69,914	1,175,275			25,351	2,355	15,695	6,352	
Deep Valleys	135,021	8,809		16,043	57,476	88,157	2,340,276	39		36,093	9,845	15,335	12,588	
Glaciated High Plateau	90,229	3,277		3,109	4,778	24,999	505,473		21	10,230	2,935	14,138	604	
Anthracite Valley	9,104			4,035	831	69,311	174,580	2,182		6,480	1,141	4,127	1,803	
Pittsburgh Low Plateau	1,000,168	10,252		55,758	2,970	684,773	2,750,510	2	8	168,370	14,401	16,502	9,603	
Glaciated Pocono Plateau	4,582	41		2,291	421	31,517	246,103	1,413		6,597	6,607	39,125	361	
Susquehanna Lowland	639,187	702		38,368	1,412	205,898	724,907	22,256	76	18,463	3,458	10,171	9,509	
Allegheny Front	94,953	1,817		2,083	559	48,868	648,126	2,914	19	24,362	1,413	2,771	264	
Appalachian Mountain	590,993	2,877		14,731	4,274	215,992	2,007,197	55,565	378	37,099	11,210	6,351	3,908	
Anthracite Upland	89,195	362		9,718	1,039	95,312	669,421	16,284		20,560	4,254	5,441	1,045	
Blue Mountain	83,707	195		4,744	557	66,981	305,093	4,381	23	9,338	2,823	4,761	1,576	
Great Valley	738,067	217		17,778	101	433,828	307,046	3,334	26	5,711	4,104	13,461	6,624	
Reading Prong	27,663			561	208	21,610	94,039	41		1,116	54	963	59	
Allegheny Mountain	259,940	777		9,311	679	114,746	867,283	422		38,922	6,375	5,645	842	
Gettysburg-Newark Lowland	444,376	172		19,861	735	377,174	452,455	64		5,502	5,303	25,764	3,574	14
Waynesburg Hills	260,610	256		8,759	84	171,591	566,125			39,715	1,282	1,233	855	
Lowland and Intermediate Upland	1,910			12,114		109,912	10,084			512	2,594	6,818		2,373
Piedmont Upland	426,094	15		7,198	990	307,348	369,487	5,287		3,032	16,853	11,393	342	65

Piedmont Lowland	219,374	6		6,160	32	161,904	30,343	11		381	3,605	5,614	610	
South Mountain	18,705	320		334	25	13,475	153,305	109		2,746	310	1,146	3	
Total (Acres)	**6,544,913**	**41,473**	**194**	**307,390**	**90,532**	**3,768,076**	**16,953,612**	**114,574**	**563**	**545,393**	**159,807**	**367,993**	**90,121**	**2,451**

Table 2.3. Habitat class, type, and ecological system distribution (acres and percent) in Pennsylvania (Source: Pennsylvania Natural Heritage Program). Habitat lexicon based on Crisfield and the Northeast Fish and Wildlife Diversity Technical Committee 2022 and Pennsylvania Natural Heritage Program 2012.

Habitat Class	Habitat Type	Ecological System	Area (acres)	Percent
Developed	Developed Areas	Developed	3,719,385	13.0%
Estuarine	Tidal Wetlands & Flats	Northern Atlantic Coastal Plain Tidal Salt Marsh	1,393	0.0%
		Northern Atlantic Coastal Plain Tidal Swamp	1,058	0.0%
Forested Upland	Agriculture: Plantations/Orchards	Forest - Plantation	41,473	0.1%
	Forests & Woodlands	Acadian Low-Elevation Spruce-Fir-Hardwood Forest	34	0.0%
		Allegheny-Cumberland Dry Oak Forest and Woodland	52,324	0.2%
		Appalachian (Hemlock)-Northern Hardwood Forest	8,342,875	29.3%
		Central Appalachian Dry Oak-Pine Forest	2,485,365	8.7%
		Central Appalachian Pine-Oak Rocky Woodland	209,352	0.7%
		Forest - Uncertain Type	7,881	0.0%
		North-Central Interior Beech-Maple Forest	40,837	0.1%
		Northeastern Interior Dry-Mesic Oak Forest	5,174,519	18.1%
		Northeastern Interior Pine Barrens	1,413	0.0%
		Northern Atlantic Coastal Plain Dry Oak-Hardwood Forest	12,930	0.0%
		Shrubland/grassland	95,068	0.3%
		South-Central Interior Mesophytic Forest	533,037	1.9%
		Southern Appalachian Montane Pine Forest and Woodland	414	0.0%
		Southern Atlantic Coastal Plain Mesic Hardwood Forest	136	0.0%
Land-Water Interface	Beaches & Dunes	Great Lakes Wooded Dune and Swale	295	0.0%
	Riparian & Floodplains	Central Appalachian River Floodplain	2,375	0.0%
		Central Appalachian Stream and Riparian	2,738	0.0%
		North-Central Appalachian Large River Floodplain	39,487	0.1%
		North-Central Appalachian River Floodplain	18,373	0.1%
		North-Central Interior Large River Floodplain	22,746	0.1%
		North-Central Interior River Floodplain	4,191	0.0%
		South-Central Interior Large Floodplain	284	0.0%
Open Upland	Agriculture: Cropland/Pastures	Agriculture	6,545,165	22.9%
	Cliff & Talus	Central Appalachian Alkaline Glade and Woodland	107,861	0.4%
		Central Interior Calcareous Cliff and Talus	112	0.0%
		Circumneutral Cliff and Talus	6,173	0.0%
		North-Central Appalachian Acidic Cliff and Talus	82,348	0.3%
		Northeastern Erosional Bluff	282	0.0%
		Northern Appalachian-Acadian Rocky Heath Outcrop	1,618	0.0%

	Glades, Barrens & Savannas	Appalachian Shale Barrens	563	0.0%
		Barren Land	48,984	0.2%
		Eastern Serpentine Woodland	5,315	0.0%
	Grasslands	Low Vegetation - Unclassified	545,430	1.9%
Palustrine	Non-Tidal Wetlands	Central Interior Highlands and Appalachian Sinkhole and Depression Pond	1,130	0.0%
		High Allegheny Wetland	423	0.0%
		North Atlantic Coastal Plain Basin Swamp and Wet Hardwood Forest	5,972	0.0%
		North-Central and Northeastern Seep	30	0.0%
		North-Central Appalachian Acidic Swamp	235,395	0.8%
		North-Central Interior and Appalachian Acidic Peatland	24,181	0.1%
		North-Central Interior and Appalachian Rich Swamp	30,439	0.1%
		North-Central Interior Appalachian Seepage Fen	24	0.0%
		North-Central Interior Freshwater Marsh	30,247	0.1%
		North-Central Interior Shrub-Graminoid Alkaline Fen	234	0.0%
		North-Central Interior Wet Flatwoods	1,122	0.0%
		North-Central Interior Wet Meadow-Shrub Swamp	38,551	0.1%
		Northern Appalachian-Acadian Conifer-Hardwood Acidic Swamp	450	0.0%

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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 specific physical habitat templates for freshwater biota.

Streams and Rivers

The extent of flowing water (lotic) systems in Pennsylvania is derived from Anderson et al. (2013) by associating mapped habitat groups with the updated habitat lexicon. Anderson et al. (2013), commonly referred to as the Northeast Aquatic 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.

The primary classification variables of size, gradient, geology, temperature, and tidal regime define a set of major stream and river habitat types (#Table 2..4). All 5 variables influence stream and river habitats; however, some were more important in structuring stream habitats versus riverine habitats. Pennsylvania aquatic habitats of Pennsylvania are presented at the habitat level (Fig. 2.17). Summary statistics for the total length for ecological systems within habitat types are presented in Table 2..

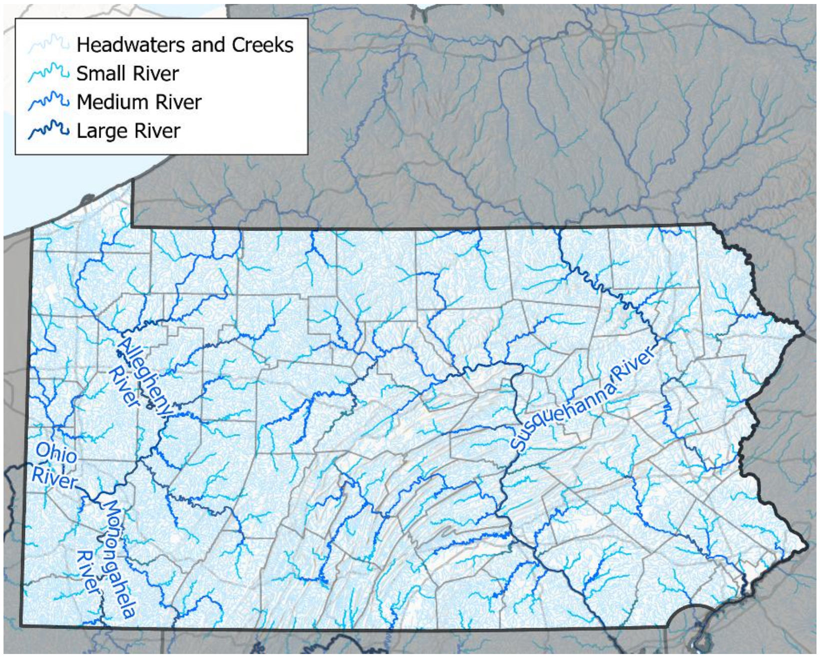

Fig. 2.17. Pennsylvania aquatic habitat type distribution based on the Northeast Association of Fish and Wildlife Agencies habitat lexicon (Crisfield and NEFWDTC 2022). (Source: Pennsylvania Natural Heritage Program).

Table 2.4. Pennsylvania flowing water (lotic) habitat types and their nested ecological systems. (Source: Pennsylvania Natural Heritage Program). Habitat lexicon based on Crisfield and the Northeast Fish and Wildlife Diversity Technical Committee 2022 and Pennsylvania Natural Heritage Program 2012.

Habitat Type	Ecological System	PA (mi)[a]	PA (km)	%
Rivers and Streams	High Gradient, Cold, Headwaters and Creeks	14291.9	23000.6	26.4
	High Gradient, Cool, Headwaters and Creeks	10094.0	16244.8	18.6
	High Gradient, Warm, Headwaters and Creeks	793.7	1277.4	1.5
	Moderate Gradient, Cold, Headwaters and Creeks	6122.9	9853.8	11.3
	Moderate Gradient, Cool, Headwaters and Creeks	12004.0	19318.6	22.2
	Moderate Gradient, Warm, Headwaters and Creeks	903.8	1454.5	1.7
	Low Gradient, Cool, Headwaters and Creeks	3901.7	6279.2	7.2
	Low Gradient, Warm, Headwaters and Creeks	2028.9	3265.2	3.7
	Moderate Gradient, Cool, Small River	293.3	472.1	0.5
	Moderate Gradient, Warm, Small River	193.0	310.5	0.4
	Low Gradient, Cool, Small River	378.3	608.8	0.7
	Low Gradient, Warm, Small River	172.7	277.9	0.3
	Cool, Medium River	366.3	589.4	0.7
	Warm, Medium River	1932.4	3109.9	3.6
Big Rivers	Warm, Large River	705.7	1135.7	1.3

[a]The total stream mileage for the Pennsylvania portion of the Northeast Aquatic Habitat Map is approximately 54,182 miles, which is less than the 85,000 miles indicated in the Integrated Water Quality Monitoring Report (Pennsylvania Department of Environmental Protection 2026). This is due to differences in scale, most notably in the smallest headwater streams, between the two datasets.

Lakes and Ponds

Olivero-Sheldon and Anderson (2014) developed a mapped classification of lakes and ponds based on 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 PA WAP, we represent lakes by their trophic state and alkalinity (Fig. 2.18), as both variables tend to have a great influence on the species present in the lake. Trophic state, measured by surrogate variables for algal biomass, are classified as one of four types:

1. Oligotrophic - nutrient-poor and clear lakes.
2. Mesotrophic - between oligotrophic and eutrophic.
3. Eutrophic - nutrient-rich and have high rates of primary production.

4. Hypereutrophic - very high nutrient lakes, often resulting from an excess of human activity.

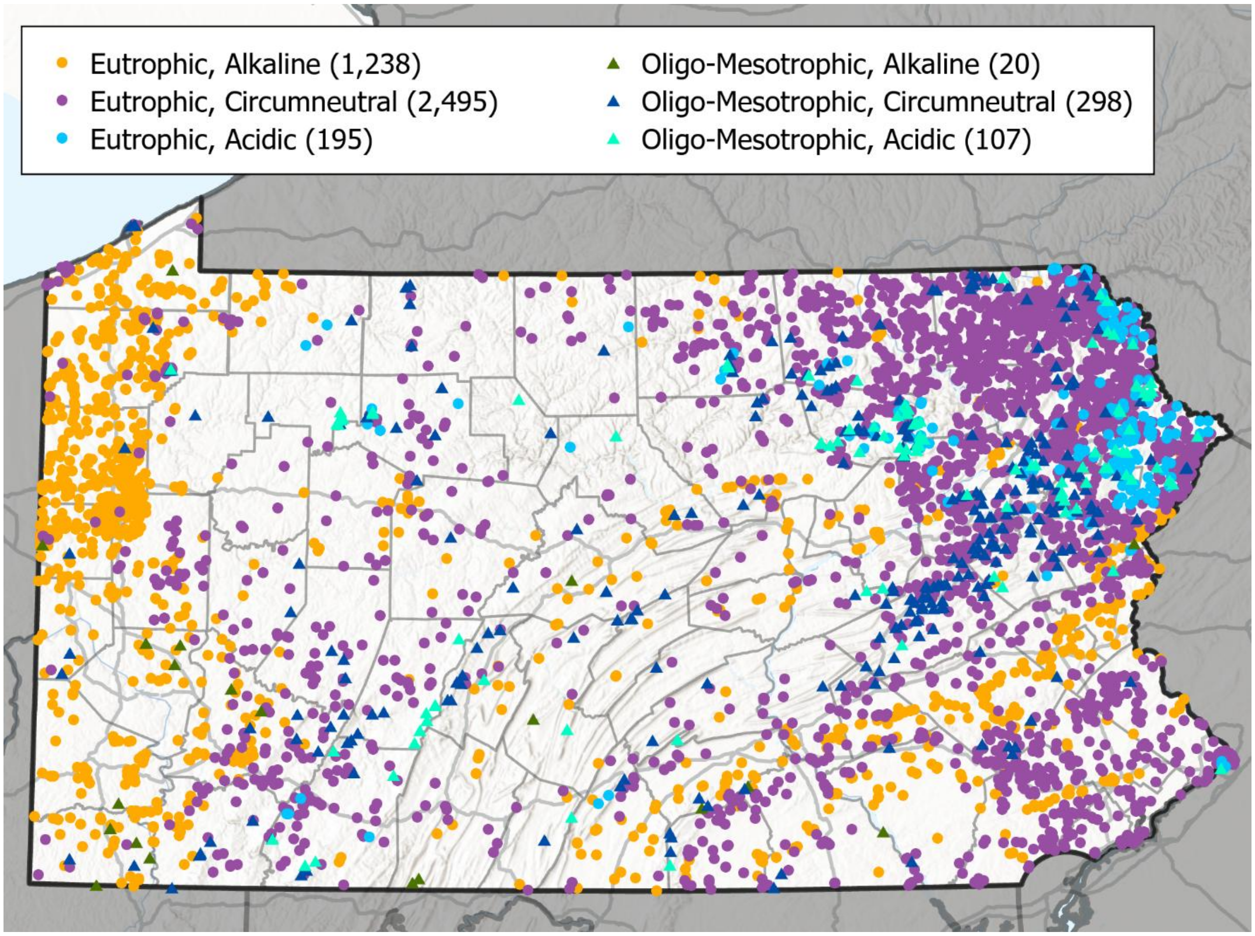

Fig. 2.18. Two-way classification by trophic state and alkalinity for 4,353 lakes and ponds in Pennsylvania. (Source: Pennsylvania Natural Heritage Program).

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.

Linking Species of Greatest Conservation Need (SGCN) to Habitat

To assist habitat prioritization for SGCN benefit, we can examine the proportion of SGCN using each habitat type as their primary habitat (Fig. 2.19). State experts developed species accounts for each SGCN (see Chapter 1-Species, Appendix 1.4), during which they identified a primary Habitat Class and Habitat Type; noting the requisite ecological system was optional.

Most SGCN (21%) are primarily associated with forests and woodlands, followed by rivers and streams (18%), glades, barrens, and savannas (14%), grasslands (13%). Additionally, though wetlands comprise only 1% of the state, they support a significant proportion of Pennsylvania's biodiversity. Approximately 12% of SGCN are primarily associated with non-tidal wetland habitats, while additional species are associated with riparian and floodplains, vernal pools/ephemeral wetlands. Refer to Appendix 2.1 for percentage of taxonomic groups within each habitat type.

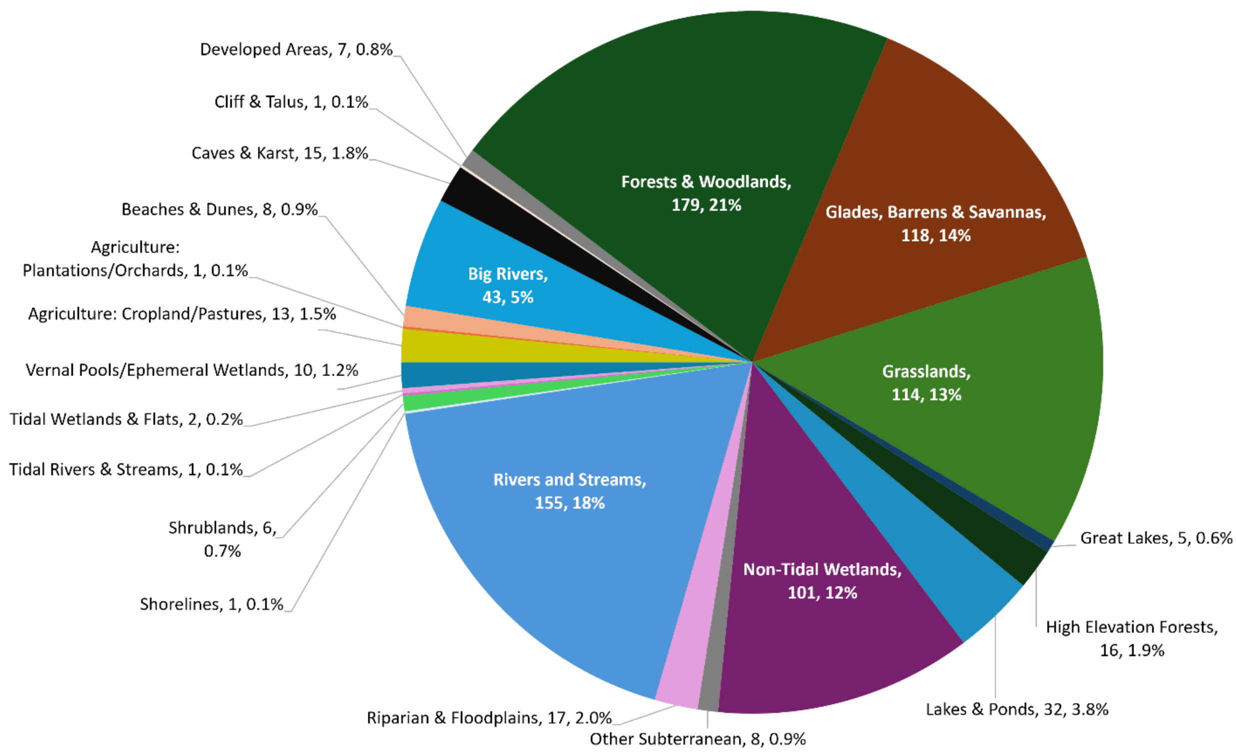

Fig. 2.19. Pennsylvania Species of Greatest Conservation Need (SGCN) count and percentage by primary habitat type identified by state experts. Habitat naming is based on Crisfield and the Northeast Fish and Wildlife Diversity Technical Committee 2022. Data are presented as habitat type name, SGCN count, and percentage of SGCN primarily associated with the habitat type. See Appendix 2.1 for proportion of taxonomic groups by habitat type.

Habitat Protection

Appendix 2.1 provides how many acres occur within the state and northeast U.S., and proportion of those acres that are conserved for nature or multiple uses.

A significant amount of land protection has occurred in Pennsylvania since the 2015 Plan. Land trusts preserved 145,900 acres (59,044 hectares) between 2014 and 2025 (WeConservePA 2026). Seventy-three percent (73%) are conservation easements, with 72% of these contributed by Western Pennsylvania Conservancy, The Nature Conservancy PA/DE Chapter, Lancaster Farmland Trust, Farm and Natural Lands Trust of York County, Land Conservancy of Adams County, Natural Lands, and Berks Nature. Additionally, the Pennsylvania Game Commission acquired approximately 38,773 acres between

July 2015 and June 2025. DCNR added 33,294 acres to the State Forest system and approximately 5,025 acres to State Parks, including 1,677 acres transferred from townships and conservancies. Conserving these landscapes in natural cover for perpetuity ensures these places will be available for fish, wildlife, and Commonwealth residents for this and future generations.

One of the global conservation targets set by the Convention on Biological Diversity (2022) is to conserve 30% of terrestrial and inland water areas by 2030. To assess progress in the northeastern U.S., Anderson et al. (2023) evaluated the proportion of protected lands for each state. At that time, Pennsylvania was 18% conserved by area, with 49% of The Nature Conservancy's Resilient and Connected Network (Anderson et al. 2016) conserved.

Habitat Threats

Chapters 1-Species, species accounts (Appendix 1.4), and Chapter 3-Threats present details regarding threats to SGCN and habitats. Though specific habitat threats vary and are difficult to evaluate with certainty, habitat loss and degradation is ubiquitously of concern (Fig. 2.20). In fact, Responsive Management (2023) found "habitat loss" was most often cited as the greatest issue or concern facing nongame wildlife among Pennsylvania residents.

Fig. 2.20. Proportion of International Union for Conservation of Nature (IUCN) Level 1 threats (Salafsky et al. 2008) to Pennsylvania habitat types based on species-level threats for each primary habitat type.

Climate Change

Chapter 3-Threats discusses climate change impacts to SGCN. Here, we discuss habitat resilience to shifting climatic conditions. We define “resilience” as 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. Anderson et al. (2012) present 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. In this analysis, they considered individual landscapes such as forests, wetlands, and mountain ranges as collections of neighborhoods where plants and animals reside. Areas with the most complex neighborhoods in terms of topography, elevation ranges, and wetland density 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 2.21). PNHP (2022) enhanced Anderson et al.’s analysis for Pennsylvania SGCN by integrating known occurrences and characterizing land parcels as a protection priority, management priority, or restoration priority. Both analyses are useful conservation planning resources, freely accessible through the Pennsylvania Wildlife Action Plan Wildlife Action Map (https://wildlifeactionmap.pa.gov) following account registration.

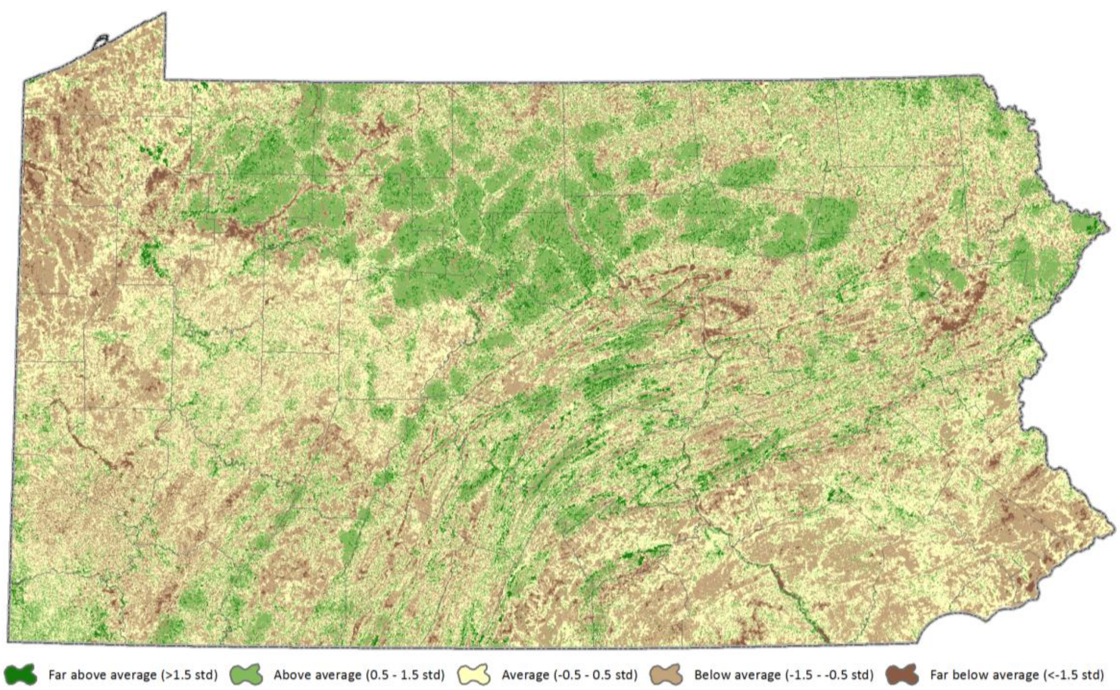

Fig. 2.21. Terrestrial habitat resiliency stratified by geophysical setting and ecoregion (Anderson et al 2012). The map shows areas in Pennsylvania predicted to be more resilient to climate change (green), or more vulnerable to climate change (brown), with respect their type of physical environment.

Like the terrestrial resiliency project, Anderson et al. (2013b) mapped aquatic resiliency. 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. 2.22).

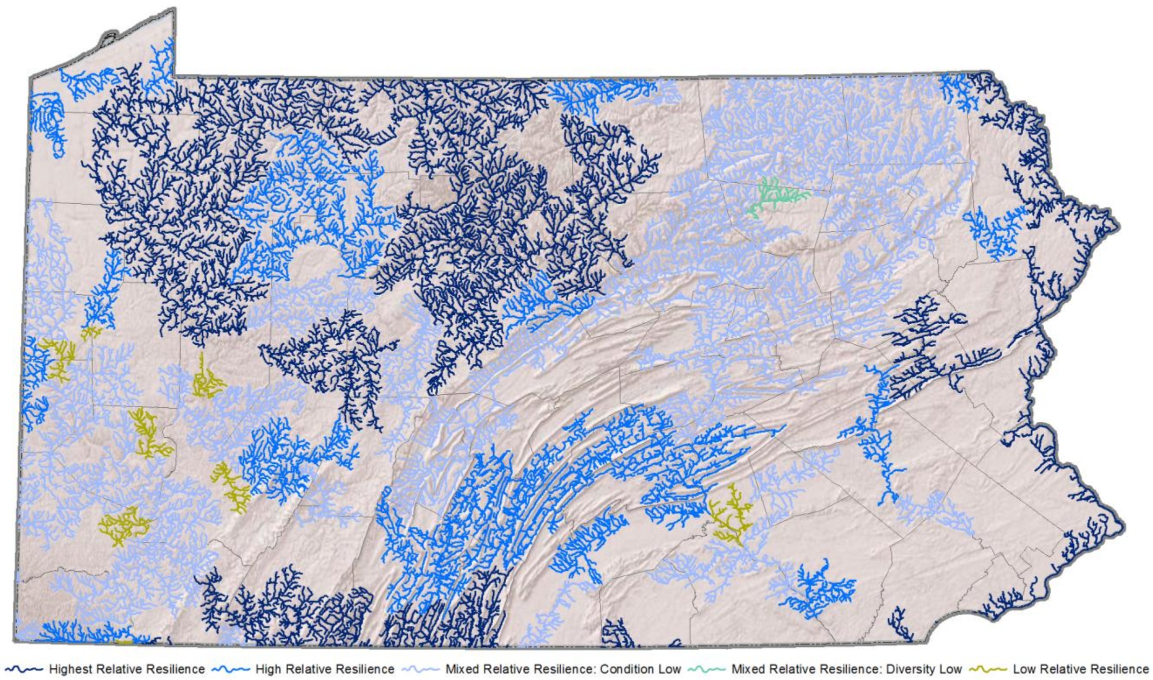

Fig. 2.22. Relative resilience scores for complex river networks (containing more than four stream orders) (Anderson et al. 2013c).

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Habitat Conservation Actions

Detailed habitat conservation action information is provided in individual species accounts (Appendix 1.4) and Chapter 4-Conservation Actions. Figure 2.23 summarizes SGCN conservation actions by habitat type to illustrate dominant categorical actions. *Direct habitat management* is prominent (45% of SGCN actions) among all habitats, but particularly for SGCN associated with Glades, Barrens, & Savannas; Forests & Woodlands; Non-tidal Wetlands; and Rivers and Streams. Twenty-eight percent (28%) of SGCN actions are classified as *design and plan conservation*, primarily for SGCN associated with Rivers and Streams and Non-tidal Wetlands. *Outreach* is the third most often cited, accounting for approximately 15% of SGCN actions among all habitat types; Tidal Wetlands & Flats and Agriculture: Plantations/Orchards are the only two types for which outreach actions may not be needed.

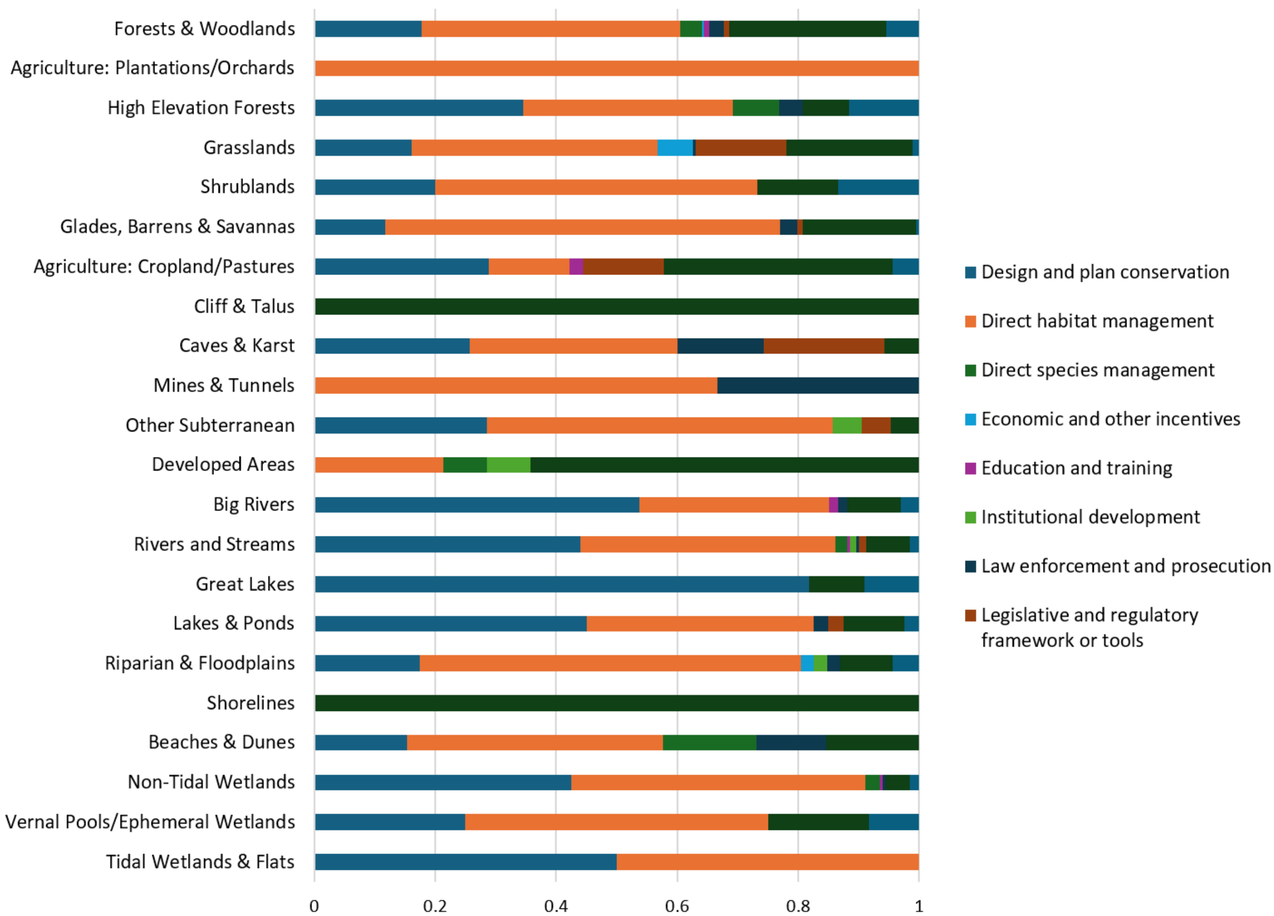

Fig. 2.23. Conservation action categories identified for Pennsylvania Species of Greatest Conservation Need, summarized by habitat type.

Research and Monitoring Needs

As noted throughout the PA WAP, all Pennsylvania 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 fish and wildlife statuses and trends is important for resource agencies to accomplish their missions and meet legal requirements. Land managers need to evaluate habitat status 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, as discussed earlier in this chapter. Natural community (or stand) mapping as conducted by PGC, PA DCNR, and other agencies/organizations on land they manage are important components to habitat monitoring and should be updated at regular intervals. Ongoing and potential monitoring actions for terrestrial forests are noted in the Pennsylvania Forest Action Plan (PA DCNR 2020). 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.

For aquatic systems, the National Clean Water Act requires each state to monitor surface and groundwater quality 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 (US EPA) requires PA DEP to prepare biennial reports (305(b)/303(d) Water Quality Integrated Report), describing the status of water quality within the state.

Habitat models can be used as the basis for monitoring habitat and landscape analysis. For example, Anderson et al. (2023) reevaluated the conservation status of northeastern U.S. habitats to provide a regional assessment of gains and losses. Notably, they found that, over the last decade, more land has been conserved than converted to a non-natural state across the region, though state statistics differed.

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 assessment, mapping, landscape modeling, and remote sensing of habitats emerge over the next decade.

Summary

SGCN are inextricably linked to habitats upon which they depend, and Pennsylvania habitat distribution is a function of geology, soils, microclimatic, and other conditions. Understanding habitat extent and condition facilitates SGCN recovery planning, particularly for species with limited distribution due to specialized habitat requirements (e.g., Allegheny woodrat [*Neotoma magister*], Piping Plover [*Charadrius melodus*], Pennsylvania cave amphipod [*Crangonyx dearolfi*]). Maintaining and restoring habitat diversity and resilience through active management is paramount to sustaining SGCN in the Commonwealth. The freely accessible PA WAP Wildlife Action Map (https://wildlifeactionmap.pa.gov), a mapping and report tool for SGCN, is an essential conservation planning resource for planning and action.

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