Snapshot 2002

BIODIVERSITY IN PENNSYLVANIA

PENNSYLVANIA BIODIVERSITY PARTNERSHIP

THE STATE OF BIODIVERSITY IN PENNSYLVANIA IN 2002

Pennsylvania Biodiversity Partnership

The Pennsylvania Biodiversity Partnership is a broad-based, public-private partnership created to promote the conservation of native species and their habitats. PBP is unique in bringing together – as equal partners – organizations and individuals with diverse interests and backgrounds. PBP members represent conservation and environmental organizations, government agencies, business and industry, scientists and academic institutions, sportsmen, and private landowners. For the first time in Pennsylvania, under the leadership of the Pennsylvania Biodiversity Partnership, there is a comprehensive and collaborative effort to address the lack of a statewide biodiversity conservation plan.

Snapshot 2002

BIODIVERSITY IN PENNSYLVANIA:

THE STATE OF BIODIVERSITY IN PENNSYLVANIA IN 2002

Published by the Pennsylvania Biodiversity Partnership

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Eastern bluebird

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Aquatic Management Techniques Used For The Conservation of Biodiversity in Pennsylvania – Jennifer DeCecco and Jay Stauffer, Pennsylvania State University, School of Forest Resources.

Inventory of Biodiversity Databases in Pennsylvania – Dessie Severson, Allegheny Institute of Natural History, University of Pittsburgh, Bradford.

Inventory of the Current State of Scientific Knowledge on Biodiversity in Pennsylvania – Roger Latham, Wallingford, PA.

Methods for the Protection of Land to Preserve Biodiversity – Robert B. McKinstry, Jr. and Michael Jacobson, Pennsylvania State University, School of Forest Resources.

Pennsylvania Law and Policy: Existing Tools to Conserve Pennsylvania's Biodiversity – James M. McElfish, Jr., Environmental Law Institute.

Public Support/Understanding of Biodiversity Issues and Educational Resources for Biodiversity – Joan Clippinger, Pennsylvania Department of Conservation & Natural Resources.

Restoration of Native Species and Habitats in Pennsylvania – Jennifer DeCecco and Jay Stauffer, Pennsylvania State University, School of Forest Resources.

Survey and Conceptual Model of Existing Best Management Practices and Best Stewardship Practices Applicable in Pennsylvania to Promote Biodiversity – Robert B. McKinstry, Jr., Emily B. Schwartz, and Curtis P. Wagner, Pennsylvania State University, School of Forest Resources.

Threats to Pennsylvania's Biodiversity – Jennifer DeCecco and Jay Stauffer, Pennsylvania State University, School of Forest Resources.

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Table of Contents

The people *have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people.*

Pennsylvania Constitution, Article 1, Section 27, adopted in 1971

River otter

Biodiversity in Pennsylvania: Snapshot 2002

- Summarizes the current status of Pennsylvania's biodiversity.
- Presents information without making judgments or recommending actions.
- Summarizes reports prepared by scientists, lawyers, and other experts.
- Serves as the base on which to build the Pennsylvania Biodiversity Conservation Plan.

About This Report

Pennsylvania's history is richly endowed with our use and enjoyment of its natural resources. The region provided a fertile hunting area for American Indians. Early European settlers marveled at the extensive forests and abundant wildlife found throughout Penn's Woods. In the 1700s, about 25 million acres (more than 80 percent) of Pennsylvania's land were heavily forested with hemlock, pine, beech, chestnut, oak, maple, and other hardwood trees. Travelers to the region noted that passenger pigeons were found in flocks so large they darkened the skies and took days to pass overhead.

Today we find a different Pennsylvania. The needs of more than 12 million Pennsylvanians for food, fuel, medicine, building products, farmland, and living space have had a major impact on the state's biological resources, with mixed results. The passenger pigeon is now extinct. The forests that still occupy about 60 percent of Pennsylvania's landscape are more fragmented and the variety of trees they contain substantially altered. Hundreds of non-native species have intentionally or unwittingly been released into natural ecosystems.

Yet, in 2002, Penn's Woods still embodies a diverse wealth of natural resources that weave an interdependent biological web to form the complex tapestry needed to sustain human life.

Pennsylvania is home to more than 25,000 species of known organisms, and perhaps many thousands more yet to be identified in the state. Over 800 plant and animal species are considered to be rare, threatened, or endangered in Pennsylvania. These resources, if used wisely, can continue to support Pennsylvania's vibrant economy and provide a healthy, valued quality of life. However, many threats to our natural biological diversity are present, ranging from the proliferation of invasive plants to the degradation of ecosystems.

While surveys indicate that many Pennsylvanians easily recognize and support the value of protecting the diversity of animals, plants, and their habitats, biodiversity is not a commonly understood term. In addition, very little is known about many groups of organisms, such as insects, fungi, and algae, including not even knowing what species live in the state.

Animals, plants, and their unique habitats are being lost every year in Pennsylvania due to natural forces, human activities, neglect, and lack of coordination. Recognizing the need for a better understanding of Pennsylvania's rich natural resources as well as the lack of a comprehensive strategy for biodiversity conservation, the Pennsylvania Biodiversity Partnership (PBP) was formed in 2000 in direct response to a recommendation by the Pennsylvania 21st Century Environment Commission.

Biodiversity in Pennsylvania: Snapshot 2002 is a summary of a year-long effort by the Pennsylvania Biodiversity Partnership to identify and consolidate information on the current state of Pennsylvania's biodiversity. This publication represents the first phase of the development of a statewide plan for biodiversity conservation in Pennsylvania, a multi-year process under the leadership of PBP.

Biodiversity in Pennsylvania: Snapshot 2002 summarizes the status of Pennsylvania's biodiversity as we presently know it, including wildlife and their habitats, laws, policies, funding, and educational resources relevant to biodiversity. It is designed to provide a baseline for future comparisons of how well we fulfill our roles as stewards of Pennsylvania's extraordinary natural wealth.

Phase Two will further pinpoint gaps in our knowledge; identify ways to fill those gaps; begin to formulate and consolidate recommendations; and provide a blueprint for how to achieve the final plan. These documents will serve as the focus for regional meetings in both Phase Two and Phase Three with expected completion of the *Pennsylvania Biodiversity Conservation Plan* in 2005.

What is Biodiversity?

The air we breathe, the water we drink, and the foods we eat are fundamental to our existence. Supplying these essentials depends on an intricate web of life involving the naturally orchestrated interaction of millions of different animals, plants, fungi, and microscopic organisms. All of these biologically diverse communities of animals and plants provide numerous ecological, economic, and esthetic benefits.

- They give us food, fuel, and medicines.
- They help clean our air, purify our water, break down wastes, and provide flood and pest control.
- They are used as the raw materials for buildings, clothing, furniture, paper, and numerous other products.
- They are a constant source of recreation and enjoyment ranging from hiking, hunting, and fishing to nature study.

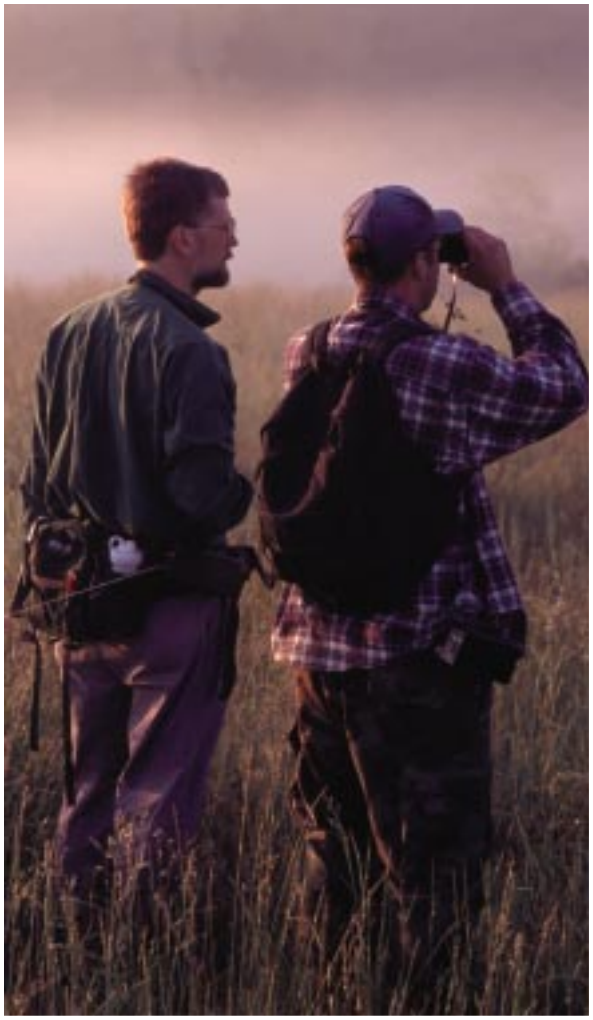
ECOSYSTEMS AND THEIR FUNCTIONS

The term ecosystem is defined as a community of living organisms combined with their associated physical environment. It is our "home system" that makes life possible. Ecosystems are the full tapestry of nature that support life and they also provide valuable services.

- Wetland ecosystems filter out toxins, clean the water, and control floods.
- Estuaries act as marine-life nurseries.
- Forest ecosystems supply fresh water, provide oxygen, control erosion, and remove carbon from the atmosphere.

Many species, working together, are needed to provide these critical services. The loss of biodiversity reduces nature's ability to perform these functions. As greater fluctuations occur, ecosystems as a whole become less stable. Instability causes ecosystems to be more vulnerable to extreme conditions and may also decrease productivity.

Biodiversity embraces all living things, including humans, and how their existence - and survival - are interconnected.



Why is Biodiversity Important?

While the term "biodiversity" may not be well known or understood, the ecological services provided by biodiversity are vital to everyday life. Not a day, hour, or even second goes by that we do not depend on biodiversity for survival.

- The air we breathe is a product of photosynthesis by green plants.
- Insects, worms, bacteria, and other tiny organisms break down wastes and aid in the decomposition of dead plants and animals to enrich soils.
- More than 90 percent of the calories consumed by people worldwide are produced from 80 plant species.
- Almost 30 percent of medicines are developed from plants and animals, and many more are derived from these sources.

Economic Impacts of Biodiversity

Biodiversity has a major impact on the economy of Pennsylvania in the form of revenue and jobs created in the state.

- The forest products industry in Pennsylvania provides 90,000 jobs in 2,500 firms and contributes more than $4.5 billion to the economy. As an added benefit, wood products are made from renewable resources that are recyclable and biodegradable.
- In 1996, activities associated with watching, feeding, or photographing wildlife generated $1.8 billion to Pennsylvania's economy, including more than $236 million contributed by visitors to the state.
- Nearly 20 percent of Pennsylvanians hunt, trap, or fish, spending more than $1 billion annually in pursuit of these outdoor sports.
- Thousands of Pennsylvanians and visitors to our state spend many hours enjoying our natural wonders through hiking, biking, cross-country skiing, and other outdoor recreation.

Executive Summary

Biodiversity

Biodiversity is a scientific concept developed to embrace all living things, including humans, and how their existence – and survival – are interconnected. Biodiversity encompasses all living organisms, their genetic makeup, their ecological roles, and their interrelationships in the natural communities where they live. Preserving these biological communities is essential to maintaining our quality of life.

Biodiversity in Pennsylvania: Snapshot 2002 summarizes the status of Pennsylvania's biodiversity as we presently know it, including wildlife and their habitats, laws, policies, funding, and educational resources relevant to biodiversity. It is designed to provide a baseline for future comparisons of how well we fulfill our roles as stewards of Pennsylvania's extraordinary natural wealth. *Snapshot 2002* represents the first phase of the development of a statewide plan for biodiversity conservation in Pennsylvania, a multi-year process being coordinated by the Pennsylvania Biodiversity Partnership.

Phase Two will further pinpoint gaps in our knowledge; identify methods and initiate processes to fill those gaps; begin to formulate and consolidate recommendations; and provide a blueprint for how to achieve the final plan. These reports will serve as the focus for regional meetings in both Phase Two and Phase Three with expected completion of the *Pennsylvania Biodiversity Conservation Plan* in 2005.

Understanding the current status of biodiversity conservation in Pennsylvania is an essential first step in determining where we want to go. To achieve the ultimate goal of a statewide plan for improved biodiversity conservation, it is important to establish a sound baseline as well as a strategy for moving forward. *Snapshot 2002* assesses various aspects of the state of biodiversity in Pennsylvania, including the current knowledge and understanding of the state's biodiversity; known threats; how biodiversity is being managed; and the organizations, laws, policies, and funding in place to protect Pennsylvania's biodiversity.

Current Knowledge and Understanding

Pennsylvania is home to more than 25,000 species of known organisms, and perhaps many thousands more yet to be identified in the state. Although no comprehensive inventory of Pennsylvania's biodiversity exists, we know that:

- Over 150 species of plants and animals have been lost from Pennsylvania and 130 species are considered to be globally endangered, threatened, or rare.
- Animals, plants, and their unique habitats are being lost every year in Pennsylvania due to natural forces, human activities, neglect, and lack of coordination.

The public consistently places a high value on protecting plants, animals, and their habitats.

Even though Pennsylvania has a long history of documenting biodiversity with records of plants and animals dating back to at least the 1740s, biodiversity information is scattered across many agencies and organizations in various formats that are often incomplete, out-of-date, or inaccessible. Gaps in information at all levels make it difficult to form a comprehensive assessment of current biodiversity conditions and inhibit our ability to determine future needs for biodiversity conservation.

At the same time, public surveys reveal that people consistently place a high value on protecting plants, animals, and their habitats. Although Pennsylvanians strongly support biodiversity conservation, their perceived knowledge about biodiversity, especially the term itself, is not high. This is not surprising since both the concept and the term are relatively new, even to scientists.

This disconnect between the public's lack of understanding of biodiversity and their support for protecting the environment may be attributed, in part, to a lack of educational materials on biodiversity. Although concepts related to biodiversity were reported in many educational programs, the subject was often limited to individual species or habitats rather than interrelationships among species. Explanations of why species have become endangered or threatened, recovery plans, and critical habitat designations were rarely addressed. The inclusion of biodiversity in the recently adopted Pennsylvania Academic Standards for Environment and Ecology may help close this gap. However, it will not help address the lack of educational materials on biodiversity available to adult audiences.

Threats to Biodiversity

Scientists agree that Pennsylvania's biodiversity is in peril for a variety of reasons, some obvious and some subtle. These threats are generally grouped into two major categories: (1) habitat loss and fragmentation and (2) pollution. Sources of these threats include changing land use patterns, an overabundance of white-tailed deer in many areas of the state, and invasive species. Aquatic organisms, such as freshwater mussels, have been especially impacted by pollution.

Although there is little doubt that human impacts have been largely responsible for a decline in biodiversity in the state, there is much that we don't know regarding how our actions affect species and ecosystems in Pennsylvania. Waiting for this information before reversing damaging patterns can also be detrimental. While progress is being made in correcting some threats, such as point-source pollution, others, such as urban sprawl and invasive species, present increasing problems.

Managing Biodiversity

Best Management Practices

Given our dependence on biological resources for survival, mankind has greatly affected natural habitats in Pennsylvania. Best management practices (BMPs) have become widely recognized and accepted as one of the most effective approaches for managing natural resources on both public and private lands. While most best management practices do not specifically target biodiversity, many are applicable to biodiversity conservation. However, biodiversity conservation can be achieved only if the stewards of private lands have the education, tools, and interest to make it happen.

Land Protection

Land protection is one of the most important components of biodiversity conservation efforts. Land protection activities, including land acquisition, regulations, incentives, education, and most importantly, good stewardship by private landowners, are all components of biodiversity conservation. Cohesive land protection strategies and coordination among agencies are essential to achieving the ultimate goal of biodiversity conservation throughout the Commonwealth.

Habitat Restoration and Species Reintroductions

When best management practices and land protection efforts have failed at conserving biodiversity, restoration and reintroduction projects have been somewhat successful in counteracting the loss of species and habitats in Pennsylvania. The serpentine aster, paddlefish, river otter, and elk are among the many species that have begun their resurgence in Pennsylvania as a result of restoration ecology. Restoration and reintroduction projects have taken many forms, ranging from wetland restoration and fire management to replanting native grasslands and translocating animals to their former ranges. Despite the success of some reintroduction efforts, most are costly and many fail.

Since the science of restoration ecology has emerged relatively recently, many questions remain regarding our ability to restore degraded habitats as well as the best methods for translocating species into their former locations. Loss of habitats and species will likely never be fully reversed, but restoration work and reintroduction of species into areas they formerly occupied can mitigate some of the damage. Nevertheless, these efforts will never be adequate substitutes for the conservation of biodiversity.

Biodiversity Organizations, Laws, Policies, and Funding

Organizations

State, federal, county, and local governmental organizations all have a role in managing the lands, waters, and biological resources of Pennsylvania and can have significant impact on biodiversity conservation. Although these multiple government units provide many tools, they sometimes have resulted in a lack of coordination in matters of land use and biodiversity conservation. For instance, responsibility for monitoring plants, birds, mammals, fish, amphibians, reptiles, mussels, and aquatic insects is divided among state agencies; and no state agency has oversight for terrestrial invertebrates – the largest group of organisms in the state.

Laws and Policies

Although some laws protecting the environment existed prior to the 1960s, there was no concerted effort to protect the use of public natural resources in the state. With passage of the Environmental Rights Clause to the Pennsylvania Constitution in 1971, the government's attitude changed to one of

No state agency has oversight for terrestrial invertebrates - the largest group of organisms in the state.

Monarch caterpillar

trustee for public natural resources. This amendment also declared that the citizens of Pennsylvania have a right to a healthy environment and guarantees public rights in preservation of natural values in the environment.

Today, Pennsylvania has numerous laws and policies that relate to biodiversity conservation. These include laws that govern public and private actions affecting lands and waters as well as ones specifically addressing conservation and restoration objectives. Other laws and policies address what biological information is collected, how it is organized, how it is made available to public and private decision-makers, and what requirements or incentives exist to ensure its use. Significant opportunities exist under current laws and policies for government agencies, business, and citizens to develop and implement strategies for conserving biodiversity.

Funding for Research and Conservation

Although there are several funding sources for biodiversity research and conservation in Pennsylvania, the amount of money available does not come close to meeting the projected needs. In particular, funding to gather information on basic questions such as what plants and animals live in the state, where they live, and their ability to reproduce and thrive is limited. Lack of such fundamental knowledge about biodiversity in the state hampers efforts at conservation.

Horsetail

Despite the importance of biodiversity and the continuing threats to biological communities, Pennsylvania lacks a statewide strategy for biodiversity conservation.

Conclusions and Next Steps

Biodiversity in Pennsylvania: Snapshot 2002 reveals that despite extensive knowledge about natural resource conservation in Pennsylvania and many activities focused on conserving wildlife and habitats, there is much we don't know about biodiversity in the state. Many gaps need to be filled.

In the face of this imperfect knowledge, one point is clear – sustainable use of our natural resources is critical for maintaining Pennsylvania's economic health, as well as the quality of life of all Pennsylvanians. Even with extensive technological advances and modern conveniences, our survival still depends on natural resources.

Despite the importance of biodiversity and the continuing threats to biological communities, Pennsylvania lacks a statewide strategy for biodiversity conservation. Critical habitats, plants, and animals are being lost every year in the Commonwealth due to development, neglect, and lack of coordination among interested parties.

This report is intended to serve as a baseline on which to build the *Pennsylvania Biodiversity Conservation Plan* and marks the completion of the first phase of this process. Phase 2 (2002-2003) will provide a blueprint for how to achieve the final plan and Phase 3 (2003-2004) will result in a *Draft Pennsylvania Biodiversity Conservation Plan*, with expected completion of the final plan in 2005. Meetings will be conducted throughout the state during Phases 2 and 3 to solicit input on local and statewide needs for biodiversity. All Pennsylvanians are welcome to participate in this process.

Pennsylvania Biodiversity Partnership

The full reports, on which Biodiversity in Pennsylvania: Snapshot 2002 *is based, are available on the Pennsylvania Biodiversity Partnership website at www.pabiodiversity.org.*

Plants, Animals, and Their Habitats

Bull frog

Assessing Pennsylvania's biodiversity requires an understanding of diversity at three levels – the diversity of species, the variation between individuals within populations (genetic diversity), and the diversity of landscapes in the state. Assessing the quality and quantity of useful information across these three levels is a critical first step in developing meaningful measures for biodiversity conservation.

SPECIES DIVERSITY

Present Species Diversity

We share Pennsylvania with at least 25,000 known native and non-native species. These species can be grouped into seven general categories: vertebrates, invertebrates, vascular plants, nonvascular plants, fungi, and bacteria and other microorganisms.

Facts About Endangered Species

More than 800 species in Pennsylvania are considered to be of conservation concern including plants and animals whose survival status is at risk not only within Pennsylvania, but also beyond our borders.

- Currently, 130 species still living in the state are ranked as globally endangered, threatened, or rare.
- The U.S. Fish and Wildlife Service tracks 17 species in Pennsylvania listed as endangered or threatened under the federal Endangered Species Act.

Many of the most critically endangered species are found in wetlands and other aquatic habitats.

- About half of Pennsylvania's 65 species of freshwater mussels are endangered or gone from Pennsylvania.
- Nearly 30 percent of Pennsylvania fish species are of conservation concern, including 28 listed as endangered.
- Almost 60 percent of endangered and threatened species of vascular plants in Pennsylvania grow in water-dependent habitats.

Species Category	Current Knowledge
Vertebrates **Animals with backbones, including mammals, birds, fish, amphibians, and reptiles**	• Despite their prominence, Pennsylvania's vertebrate species make up only 3 percent of the total number of species in the state. • Discovery of new species is highly unlikely.
Invertebrates **Animals without backbones, including earthworms, flatworms, snails, mollusks, nematodes, spiders, ticks, beetles, butterflies, moths, flies, and other insects**	• Insects and other invertebrates are the most abundant and least known multicellular organisms in Pennsylvania – less than one-half of the species in the state have been documented. • With about 12,000 species documented for Pennsylvania, invertebrates make up almost 50 percent of the total known number of species. • New state records and species new to science are common, especially of terrestrial insects.
Vascular Plants **Flowering plants, deciduous and coniferous trees, and ferns and fern allies**	• Pennsylvania's vascular plant species are fairly well documented. • Even when combined with vertebrates, these two groups comprise only about 17 percent of the animal and plant life of the state. • Discovery of new species is rare.
Nonvascular Plants **Mosses, lichens, liverworts, and green algae**	• Preliminary checklists have been developed for mosses, lichens, liverworts, and hornworts.
Fungi **Mushrooms and molds**	• Very little information helpful to conservation is known.
Bacteria and Other Microorganisms	• Almost nothing is known about the natural diversity of this group in Pennsylvania.

Changes in Species Diversity Over Time

The number of species in Pennsylvania is not constant. Over geological time, many species died out and were replaced by new ones, gradually shaping the composition and structure of today's flora and fauna. While human activities, particularly habitat destruction, have led to a reduction in native species diversity, natural forces, such as climate change, also have altered biodiversity in Pennsylvania.

Over the past 860,000 years, there have been eight episodes of global cooling severe enough to cover part of Pennsylvania in ice year-round. The interglacial period that occurred approximately 128,000 to 67,000 years ago is particularly interesting because it was most like the present one, except human influence was absent. Most species now native to the state were probably present, but they lived side-by-side with species long absent. For example, white-tailed deer, elk, and moose shared the Pennsylvania landscape with two extinct deer species, three peccaries, giant horse, two tapirs, black bear-sized beaver, two elephant-sized ground sloths, American mastodon, and woolly mammoth. The predators stalking them included black bear, timber wolf, and mountain lion as well as three other wild dog species, three other bears, two cheetahs, and jaguar.

Human Influence

Gradual change has been the hallmark of biological communities, but the appearance of one new species – humans – approximately 13,000 years ago resulted in abrupt changes in species composition and distribution.

Event	Impact
13,000 Years Ago **Arrival of humans in the New World**	• More than two dozen species of large mammals, including woolly mammoths, American mastodons, and giant beavers, became extinct within a few centuries of the arrival of humans to the area that became Pennsylvania. • People's use of fire affected biodiversity. Oak-dominated forests and native grasslands most likely are products of large-scale burning by American Indians.
1600s **A small group of Swedes set up a colony in present-day Delaware County**	• Europeans introduced new plants, animals, and microbes. • Forests were cut down and converted to agricultural land. • Natural resources were exploited far more intensively than by previous human occupants.
Mid-1800s **Industrialization rapidly accelerated the pace of change**	• Since the mid-1800s, at least 150 species have been eliminated from Pennsylvania. • Thousands of non-native species have been introduced, including 1,281 plants – more than 37 percent of the current flora – and 152 invertebrates. • Newly introduced species have often had a destructive impact on native organisms and natural ecosystems.
20th Century **Human populations continue to expand throughout Pennsylvania**	• Landscape changes occurred, including urbanization and large-scale mining and agriculture. • Natural fires were suppressed. • Use of natural resources by humans has increased to an all-time high. • Efforts to conserve biodiversity were initiated in the early 1900s and continue to this day.

GENETIC DIVERSITY

Genetic diversity within species consists of inherited variation among individuals in a single population as well as variation between different populations. Genetic diversity is important to maintenance of species. For example, genetic diversity among individuals reduces the chance that a disease will turn into an epidemic, thereby decimating entire populations or species.

Knowledge of genetic diversity can also be a useful tool for managing biodiversity. For example, genetic analysis is one method for understanding breeding systems. Determining how far seeds and pollen are carried and how far adult animals disperse in search of mates are key questions for conservation. Genetics can also be used to assess the consequences of fish and game introductions, transplantations, stocking, and harvest. However, very little is known about the genetic diversity of individual species in Pennsylvania. Only a few genetic studies have been completed, and these have focused mainly on species of conservation concern.

Undiscovered Species in Pennsylvania

It is astonishing how little we know about Pennsylvania biodiversity, especially the insects, fungi, and less showy organisms. Some species have been overlooked because they are small or have lifeways that prevent them from being easily observed. But others, such as the beautiful, but nameless, species of inchworm moth shown here (family Geometridae, genus *Metarranthis*) remain unknown because they are easily confused with other closely related species found in the same habitats. This species was first recognized as distinct from a population just west of Tyrone, but it is now known to be common elsewhere in southwestern Pennsylvania and adjacent West Virginia, and has been found from New England to North Carolina.

New moth species

Ecological Communities

Like species, different community types are ranked in terms of conservation status – whether they are rare or endangered – however, no regulations apply to these rankings. The only comprehensive effort to classify all of the state's ecological communities is an unpublished report completed in 1991. Of the 94 community types defined in that report, 50 percent are considered to be imperiled or possibly imperiled in the state, while 23 percent are not of conservation concern.

The major source of information on the distribution of community types in Pennsylvania is the County Natural Areas Inventories, which primarily focus on the best examples of ecological communities in a county. Although they give some information on the occurrence of plants and animals, especially those of conservation concern, they are not intended as comprehensive species inventories. To date, natural areas inventories have been completed for 33 of the 67 counties, with work currently underway or in the planning stages for the remainder.

LANDSCAPE DIVERSITY

Pennsylvania's landscape may be separated into seven major categories – forests, grasslands and open areas, barrens, subterranean, wetlands, aquatic, and disturbed.

Forests, by far, are the largest community type in Pennsylvania. When Europeans first arrived in Pennsylvania, more than 80 percent of the landscape was forested. Large expanses were covered by hemlock, beech, and pine in the northern part of the state and by oak, chestnut, and hickory in the ridges and valleys.

- Pennsylvania still has about 17 million acres of forest, but the age, structure, and composition of these forests have changed since Europeans first settled the state.
- There are fewer hemlock and white pine today.
- Chestnut is gone except in isolated areas.
- Wild black cherry is a major timber tree.
- Little old growth forest remains due to extensive logging in the late 1800s and early 1900s to build the infrastructure of a growing nation.
- Except for a 4,200-acre tract on the Allegheny Plateau, nearly all of the virgin forest is in fragments of less than 250 acres.
- Most of the forest ranges from 80 to 100 years old and is of uniform maturity.

Natural grasslands are rare in Pennsylvania and many in existence at the time of European settlement were the result of vegetation management with fire by American Indians. The only patches of true prairie occur in western Pennsylvania and are extensions of the midwestern prairie. Most open areas today are typically a result of disturbance by man, including revegetated strip mines, old fields, mountain balds, and forest openings.

Barrens comprise about 3 percent of Pennsylvania's land cover. They are represented by sparsely vegetated gravel/rock outcrops and slopes, grasslands, savannas, thickets, and scrub woodlands. Most barrens have shallow, nutrient-poor soils and are located on exposed ridges or slopes where wind conditions and temperatures can become extreme and fire is frequent. Because of these harsh conditions, barrens often contain highly adapted, rare species of plants and animals and, thus, although small in extent, barrens are critical in terms of biodiversity. The serpentine barrens in southeastern Pennsylvania contain the largest number of endangered plant and animal species in the state.

Subterranean areas, such as caves, are often overlooked as a habitat type. Caves, with their unique formations, temperatures, moisture conditions, and air dynamics provide an important, but fragile, habitat for many invertebrates and vertebrates. Some invertebrates in Pennsylvania caves are found nowhere else in the world. Pennsylvania's caves also provide habitat for many bats, including the state and federally endangered Indiana bat and other small mammals such as the eastern woodrat, which is listed as threatened in the state.

Status of County Natural Areas Inventories

Wetlands are transitional areas between upland and open-water habitats and are delineated on the basis of vegetation, hydrology, and soils. Most of Pennsylvania's more than 400,000 acres of wetlands are located in Crawford, Erie, Monroe, Pike, Wayne, Luzerne, and Mercer counties. Wetlands include *marshes* (dominated by herbaceous plants), *swamps* (dominated by trees), and *scrub-shrub wetlands* (dominated by shrubby plants). *Bogs* are a special category of scrub-shrub wetlands. Wetlands provide important habitat for plants and animals, and are home to some of the rarest species in the state, including bog turtles and spreading globe-flower. More than 50 percent of Pennsylvania's original wetlands have been lost or substantially degraded by filling, draining, or conversion to ponds. From 1950 through 1970, 1,200 acres of wetlands were disturbed each year, resulting in the loss of wetland plant and animal species.

Aquatic communities are habitats that continually maintain open water and include *tidal, riverine,* and *lake habitats*. These areas provide food and shelter to a diversity of plants and animals.

In Pennsylvania, *tidal wetlands* are limited to the lower Delaware River and its tributaries.

With more than 83,000 miles of streams – second only to Alaska in the number of stream miles – Pennsylvania has abundant *riverine habitats*. Many of these miles, however, have been adversely affected by industrial practices, including more than 3,100 miles impaired by abandoned mine drainage and 3,116 miles by agriculture. Of the almost 53,000 miles of rivers and streams surveyed for biological health, more than 44,000 miles support fish and aquatic uses while approximately 8,000 miles are impaired.

Most of Pennsylvania's *natural lakes* are found in the northwestern and northeastern parts of the state. Of the 65,483 acres of lakes assessed statewide for biological health, 60.1 percent were listed as impaired, with agriculture accounting for most of the damage (13,014 acres). Although often overlooked, small seasonal pools of less than one-half acre play an important role as breeding grounds for many amphibians, insects, and other aquatic invertebrates in the state.

Disturbed communities, which include cultivated land, roadsides, developed land, and backyards, are increasing at a greater rate than any other community type in Pennsylvania. In 1989, there were almost 2 million acres of lawn/turfgrass in Pennsylvania – an area that would cover the states of Delaware and Rhode Island combined. Even though disturbed habitats contain high proportions of alien species, they are important as home to a variety of native species, including woodchucks, deer mice, meadow voles, chipping sparrows, and goldenrods. Although primarily habitats for very common species, these areas can contribute to maintaining wildlife and wild plants in the state. Edges – transition zones where two habitats come together, such as where a forest meets a field – provide a particularly rich diversity of food and shelter for wildlife.

SUMMARY

Gaps in knowledge make it difficult to form a comprehensive assessment of current biodiversity conditions and inhibit our ability to determine future needs for biodiversity conservation. Information is lacking at all levels. No comprehensive inventory of Pennsylvania's plants and animals exists. Information on trends in the abundance and distribution of organisms within the state is meager, and data on genetic diversity are almost completely lacking.

No complete inventory of Pennsylvania's plants and animals exists.

Pocono Till Barrens

Penn's Creek

Sources of Information About Biodiversity

White-lip globe

Pennsylvania has a long history of documenting biodiversity with records of plants and animals dating back to at least the 1740s. However, this information is spread across many organizations and occurs in a variety of formats, including scientific papers, books, monographs, student research projects, government-sponsored reports, presentations at scientific meetings, unpublished and web-published papers, Christmas Bird Counts, electronic databases, old computer punch cards, species checklists, and even lists of birds visiting home feeders. Compounding the task of compiling all of these data is the realization that useful information does not exist for all species and habitats.

LOCATING BIODIVERSITY INFORMATION

Information on Pennsylvania's biodiversity is located within government agencies, conservation groups, academic institutions, business and consulting firms, environmental education organizations, nature centers, and with individuals. The most accessible information is contained in published books and field guides, while the ultimate sources of information are the ecological and specimen databases maintained by various organizations and individuals. Even within these sources, there are limitations on the usefulness and accessibility of the information.

Books and Field Guides. Recent books cover the major vertebrate groups and the vascular plants – flowering plants, ferns, and conifers (see Additional Reading in the Appendix). Publications on the more obscure, yet equally important, components of Pennsylvania biodiversity, such as insects and fungi, are lacking. Information on these groups, as well as in-depth information on the more charismatic species, is available only in the scientific literature and other less-accessible sources.

Museum Collections. The ultimate sources of information about Pennsylvania biodiversity are the collections of specimens and associated databases maintained by museums, such as the Carnegie Museum of Natural History in Pittsburgh, the Academy of Natural Sciences in Philadelphia, and other collections. These institutions contain hundreds of thousands of specimens from Pennsylvania annotated with collection dates and locations, and in some cases, habitat information.

This vast data storehouse is potentially an enormously powerful tool for understanding the patterns of biodiversity change over time, but the benefits of this unique resource are far from fully realized. This is partly because much of the information is not in a useful form, often lacking verification of species identification and using obsolete scientific names. Moreover, specimen data are often stored partly or completely in a paper-based format (labels or associated fieldnotes), limiting rapid access and analysis through computers.

Other Ecological and Specimen Databases. A source of ecological data on Pennsylvania biodiversity is the County Natural Areas Inventories, carried out primarily by The Nature Conservancy in eastern Pennsylvania and by the Western Pennsylvania Conservancy in the west. These inventories identify the highest quality natural areas in a county, including maps and descriptions of each site.

In addition to primary specimen and ecological databases, secondary databases, such as the Pennsylvania Natural Diversity Inventory (PNDI), are important sources of biodiversity information. PNDI is a collaborative venture of the Department of Conservation and Natural Resources (DCNR), The Nature Conservancy, and Western Pennsylvania Conservancy. It maintains data on species classified as endangered, threatened, or rare by DCNR, the Pennsylvania Game Commission, the Pennsylvania Fish and Boat Commission, and the U.S. Fish and Wildlife Service as well as data compiled by members of the Pennsylvania Biological Survey to inform rankings for species of conservation concern. PNDI also maintains data on natural community types and geologic features. It does not include data on native species thought to be common.

Additional information relevant to biodiversity may be accessible through Pennsylvania Spatial Data Access (PASDA), a system housed at Pennsylvania State University that makes geographic information systems (GIS) data publicly available for use. While PASDA is not geared to biodiversity, it contains information relevant to decisions that affect biodiversity.

Innumerable and important smaller specimen and ecological data sets have been collected by individual researchers at academic institutions, government agencies, conservation groups, business and consulting firms, environmental education organizations, and nature centers. In many situations, when the researcher leaves the institution, the collection or database is no longer maintained and is "orphaned," resulting in this information becoming even more inaccessible.

FORMAT AND ACCESSIBILITY

Given that information about Pennsylvania's biodiversity is scattered across many organizations and occurs in a variety of formats, the Pennsylvania Biodiversity Partnership initiated the Pennsylvania Biodiversity Data Inventory (PBDI) to survey the current status of information about the state's biodiversity resources. A request for information was circulated to more than 1,100 individuals and groups throughout Pennsylvania, and also outside the state, asking for a description of any relevant ecological or specimen data they possessed. Even though responses were obtained from some of the major repositories of biodiversity information in the state, the information in PBDI represents just the beginning of a comprehensive inventory.

Most of the larger databases about Pennsylvania biodiversity are either in electronic format or are in the process of being converted to electronic files. However, more than half of these records do not have accurate geographic information associated with them.

Preparing plant specimens

Information about Pennsylvania's biodiversity is scattered across many organizations.

When searching for biodiversity information, contacts need to be made with many groups, as there is no single source of biodiversity information for Pennsylvania. Most Pennsylvania biodiversity databases are not web-accessible by the public due to a variety of factors including confidentiality of data and intellectual property issues. Fees may or may not be charged and may vary, depending on the individual's institutional association and how the information will be used. PNDI's public-access list contains a rarity ranking for plant communities and plants and animals of conservation concern, but access to site-specific information is restricted to environmental review purposes.

In addition, documentation obtained for different groups of organisms in Pennsylvania varies considerably.

- 22 reports on birds and 33 on vascular plants were received.
- Only one database each on nematodes and bacteria – two of the most numerous organisms in the biosphere – were submitted.
- No databases on earthworms were reported.
- Detailed information on fish and game animals has been gathered, but this covers only a handful of species.
- Much of the state's biodiversity information contains some level of ecological information, but often this is only brief habitat information accompanying specimens.

Although most Pennsylvania biodiversity data is maintained within the state, individuals and organizations outside Pennsylvania, especially museums, also hold information. For example, the Liverpool Museum and the Linnean Herbarium, both in England, have 459 records of plants collected in Pennsylvania between 1740 and 1820.

CLOSING INFORMATION GAPS

Work to remedy data limitations and critical information gaps is underway statewide for a few areas.

- The Pennsylvania Flora Project at the University of Pennsylvania's Morris Arboretum includes information from nearly 400,000 vascular plant specimens in all of the major plant collections in Pennsylvania.
- The Pennsylvania State University Mycological Database includes more than 43,000 fungus specimens collected statewide and held in four major repositories.
- The Pennsylvania Herpetological Atlas is an effort to determine the statewide distribution of amphibians and reptiles.
- The Pennsylvania Aquatic Community Classification Project is developing a standardized aquatic community classification and reference conditions for the state.

SUMMARY

Much of the biodiversity data for Pennsylvania is incomplete or inaccessible. Some collections are accessible, but the information in them is not easily retrievable. Therefore, no comprehensive inventory of Pennsylvania biodiversity information exists.

Given that we don't know the basic fact of how many species occur in Pennsylvania, information on recent trends in their abundance and distribution is meager.

- For nearly all organisms, collections have been geographically biased toward areas near population centers and academic institutions.
- Rare, unusual, and otherwise notable species are over-represented compared with common species.
- Comprehensive surveys of population status exist for only one higher taxonomic group – birds.
- Historical records of statewide species distribution have been compiled for a few groups, but they are based on data gathered over many years and are poorly suited as a baseline.

Gaps in basic knowledge about the state's biological diversity exist. Many of these gaps can be filled by converting existing paper-based information into a digital format and making it available in a standardized format through the Internet. Other gaps can be filled through new analyses of existing information. However, many gaps will require new investigations in Pennsylvania's forests, fields, waters, and wetlands. Those investigations should especially focus on previously overlooked groups of organisms, such as terrestrial insects, as well as collecting information on the ecological context for all organisms and their associations with other species.

Pennsylvania Biodiversity Data Inventory (PBDI)

If you have records of plants and animals you have identified – studied field mice populations in a vacant field for several years; noted the growth of algae in ponds; tracked the species of tadpoles hatching each spring; counted birds in natural areas; or recorded the invasion of purple loosestrife along a stream – please report that you have such information.

The Pennsylvania Biodiversity Partnership has initiated the Pennsylvania Biodiversity Data Inventory (PBDI) to compile information about what biodiversity data exists for Pennsylvania. To add information about your data to PBDI, log on to PBP's website (www.pabiodiversity.org) and follow the instructions for PBDI. Information about data in any format is welcome, from field notes to computer databases!

Wood thrush

Threats to Biodiversity

Scientists agree that Pennsylvania's biodiversity is in peril for a variety of reasons, some obvious and some subtle. These factors may be grouped into two major categories – habitat loss and fragmentation and pollution.

Changing Land Use Patterns

- Developed and residential land in the Philadelphia metropolitan area increased by 30 percent from 1970 to 1990. Current projections indicate an increase of another 47 percent from 1990 to 2020.
- Most of this sprawl is derived from increased land use per person rather than increases in population.
- Pennsylvania has lost approximately 25 percent of its farmland to development since 1970.
- More than 500,000 acres of land were developed in Pennsylvania between 1992 and 1997, double the rate for the previous ten years.
- Pennsylvania ranks second in the nation in the amount of open space converted to development.

Habitat Loss and Fragmentation

Perhaps the greatest threat to our biodiversity is the continuing loss and alteration of natural habitats in the state. Habitat loss and fragmentation can be caused by a wide range of temporary or permanent landscape changes. While temporary fragmentation can be damaging, permanent habitat loss is the most severe threat to biodiversity. Habitat loss and fragmentation can cause disruptions to biodiversity on many levels, including loss of genetic diversity, loss of species, and loss of remaining suitable habitat.

Pollution

There is a long list of pollutants that either affect air or water quality or directly poison organisms.

Non-point source pollution originates from a wide variety of sources, including runoff from farmlands, chemicals from construction projects, herbicides and pesticides from lawns, and acid precipitation. Agriculture and abandoned mines currently are the two largest contributors to non-point source pollution in Pennsylvania.

Point source pollution comes from a discrete source, such as sewage treatment plants and industrial plants. Programs to control the amount of point source pollution entering waterways have been more successful than non-point source pollution programs. In 2000, 43 million pounds of pollution were put into Pennsylvania's waterways compared with 49 million pounds in 1999.

SOURCES OF THREATS

The threats to biodiversity in Pennsylvania have many sources, including:

- Changing land use patterns
- Deer over-abundance
- Invasive species
- Agricultural practices
- Climate change
- Mining techniques
- Acid precipitation
- Fire suppression

Changing land use patterns lead to habitat and biodiversity loss as need for additional space for homes, schools, and businesses increases. Although Pennsylvania has not seen the same overall increases in population as other parts of the country, regions of the state, especially southeastern Pennsylvania, have been impacted adversely by urban sprawl and changing land use patterns.

This increasing need for space has resulted in a loss of farmland and open space, thereby decreasing land available to all species. Furthermore, despite efforts to reduce stormwater runoff by retaining vegetation along streams and creating detention ponds, the increase in impervious surfaces, such as parking lots and rooftops, overwhelms the ability of those buffers to control non-point sources of pollution. Surprisingly, few studies document the biodiversity effects of urban sprawl.

Deer represent a major threat to biodiversity because of their present over-abundance in many areas of the state. Deer were nearly extirpated in Pennsylvania in the 19th century due to overhunting. Establishment of more favorable habitat as forests were logged and fields cleared, enforcement of strict hunting regulations, and elimination of predators resulted in an increase in the population to an estimated 1.5 million today. Their increasing numbers and broad dietary preferences have reduced forest understory plants and retarded forest regeneration. Their feeding preferences also lead to secondary impacts. For example, deer find hay-scented fern unpalatable. In areas of high deer density, hay-scented fern dominates the forest floor vegetation, forming a nearly impenetrable layer that chokes out other herbs as well as young shrubs and tree seedlings.

Invasive species are a large and growing threat to native biodiversity. Although native species, such as the elm spanworm and forest tent caterpillar, can become invasive, the greatest threats are from exotic plants and animals. While the introduction of non-native species into Pennsylvania began in the 1600s, the speed and frequency of modern travel has drastically increased opportunities for plants and animals to enter the state from other areas of the world. Most introduced species cause few problems, but others, such as the zebra mussel and gypsy moth, can cause extensive damage to both native species and ecosystems. The threats posed by invasive species include displacement of native species, hybridization, and introduction of pathogens.

The problem of introduced and invasive species is especially prevalent in plant communities. More than 37 percent of the plant species currently found in Pennsylvania did not occur here at the time of European settlement. This includes several invasive plants, such as purple loosestrife, Japanese honeysuckle, garlic mustard, Japanese knotweed, and autumn olive. Many of these, such as autumn olive, were planted as wildlife food and cover, and others, such as Japanese honeysuckle, were introduced as ornamentals.

Agriculture is Pennsylvania's primary industry and approximately one quarter of our land is farmland. Although important to our economy, working farms pose threats to biodiversity, primarily in the form of non-point source pollution from manures, fertilizers, and pesticides. Livestock allowed to enter areas near streams disrupt streambanks, thus increasing erosion and sedimentation. Loss of streamside vegetation removed for crops or livestock also degrades stream systems by destabilizing banks and increasing water temperatures. Despite the potential threats from traditional agriculture, there is also concern over the loss of farmland and other open spaces to increasing development.

Climate change has the potential to affect Pennsylvania's biodiversity, but there is little information on the specific impact on the state's biodiversity. Suggested changes in the mid-Atlantic region include a rise in sea level with damage to coastal zones; less abundant trout and other cold-water fishes; increases in invasive species that thrive in warmer and wetter climates; and replacement of maple, beech, and birch forests by oak, hickory, and pine forests.

Mining of coal and other minerals has occurred in Pennsylvania since the 18th century and has been a major contributor to the state's economic growth. At the same time, this industry has had a major negative impact on water quality, affecting more than 3,100 miles of streams. Many abandoned coal mines still leach a variety of chemicals. Aside from the direct impact of abandoned mine drainage (AMD), mining has further degraded stream channels by causing them to lose flow in areas where bedrock is broken. The loss of sport fishing due to AMD is estimated at $67 million per year.

In addition, there are approximately 250,000 acres of unreclaimed mine lands, refuse banks, and old mine shafts in 45 of Pennsylvania's 67 counties. Because they are infertile, drought-prone, and subject to extreme temperatures, abandoned mine lands support sparse, unproductive ecosystems with a low diversity of plants and animals. An estimated $5 billion or more will be required to correct the problems of abandoned mines.

Slag pile

Acid precipitation, or "acid rain," resulting from release of sulfur and nitrogen dioxides during the burning of fossil fuels, automobile exhaust, and other industrial processes, can occur as either wet (rain, snow, fog, or ice) or dry deposition. Progress is being made in this area. Although deposits were slightly more acidic in 2000 than in 1999, statistically significant trends of decreasing acidity are evident at all monitoring sites within the state from 1983 to 2000.

Fire suppression has played a critical role in reducing the size of some specific habitats in Pennsylvania. For example, serpentine barrens, found only in small areas of southeastern Pennsylvania, depend on fire to maintain their unique plant and animal communities. Likewise, pitch-pine scrub-lands in mountainous regions of northern and central Pennsylvania depend on fire for regeneration. The oak- and chestnut-dominated forests, which covered about half of Pennsylvania at the time of European settlement, and still a major component of forests in the state, owe their existence to repeated past fires.

Japanese honeysuckle

THREATS TO SPECIFIC GROUPS OF ORGANISMS

Aquatic Invertebrates. Freshwater mussels, many of which were once abundant in Pennsylvania streams, are among the most endangered species in the state. Seven species are listed as endangered under the federal Endangered Species Act. Of the 65 species native to Pennsylvania, at least 12 have been eliminated and an additional 19 should be classified as endangered. Loss of viable riverine habitats due to sedimentation from poor agricultural practices, abandoned mine drainage, and urban runoff were the primary cause of decline of mussel populations. Additional factors such as damming, channelization, loss of host fish species, and more recently, the zebra mussel, have contributed further to population loss.

Many aquatic insects are sensitive to acidified streamwater and other forms of pollution. Studies in the Laurel Hill area in southwestern Pennsylvania documented the reduction or elimination of several species due to stream conditions. While decreases in native streamside plants can impact aquatic species, little information is available on how increasing numbers of exotic plants, such as Japanese knotweed, affect water quality and thus may influence these organisms.

Terrestrial Invertebrates. Invertebrate populations may become increasingly isolated due to fragmentation and habitat loss. Although the effects on forest ecosystems of some non-native insects, such as gypsy moths, are well documented, there is virtually no information on the effects of these species on other terrestrial invertebrates. For example, a variety of biological agents and other insecti-cides used to control gypsy moth may also destroy non-target species of moths and butterflies. At least

one endangered species (although no longer found in Pennsylvania), the Karner blue butterfly, is susceptible to gypsy moth control methods.

Compounding the threats from habitat loss is the fact that so little is known about terrestrial invertebrates in Pennsylvania. Probably fewer than 50 percent of the species in the state have been documented, and the conservation status is uncertain for those species known to occur here. No Pennsylvania government agency has legal responsibility for terrestrial invertebrates, and thus inventory and management of this largely unknown group of organisms is not a priority for any state agency.

Gypsy moth females and eggs

Fish. Introduction of non-native fish, either for sport fishing or accidentally, has altered the aquatic communities of Pennsylvania. In the Mid-Atlantic Highlands Small Streams Assessment, 44 percent of the streams surveyed in the state had non-native fish species. In the Schuylkill River drainage, the primary fish in the main river are all introduced and many of these species are now also in the smaller streams.

High acidity levels in streams also affect aquatic species. The loss of brook trout in tributaries of the upper West Branch of the Susquehanna is attributed to toxicity from abandoned mine drainage. Most urbanized areas in the state contain only pollutant tolerant fish.

Dams fragment habitat by preventing fish migration, and are one of the primary reasons for declines in paddlefish in the Ohio River drainage and American shad in eastern Pennsylvania. The removal of smaller dams along the Susquehanna River and its tributaries, as well as the successful implementation of fish ladders on larger dams, have assisted the return of American shad.

Reptiles and Amphibians. Currently nine species of reptiles and amphibians are listed as threatened or endangered, including the rough green snake, bog turtle, and eastern mud salamander. Loss or alteration of wetlands is the cause of decline for many species, although for some, such as the bog turtle, collecting has also contributed to their population loss.

During the last decade, a significant number of amphibian limb abnormalities have been reported across the country. Although the northern leopard frog is most commonly reported as having deformities, other species are also affected. In Pennsylvania, frogs or newts with deformities have been reported in four counties. The causes are not completely known, but possible factors include increases in ultraviolet radiation, use of pesticides and other toxins, and flatworm infections brought on by other causes.

Acid precipitation impairs the reproduction and viability of some salamanders in Pennsylvania. For the Jefferson salamander, acidic conditions may be the major factor responsible for lack of successful reproduction in the state. Although there is less information on how frogs and toads respond to acid precipitation, wood frogs are generally more tolerant while Fowler's toads show significantly slower growth in, or are absent from, the most acidic ponds.

Collecting and hunting play a role in the decline of some amphibians and reptiles, but there is disagreement if these activities contribute to the decline of box turtles. While some groups consider collecting a major threat, the Pennsylvania Fish and Boat Commission regards urban sprawl and other development as more serious.

There are many reasons for declines in timber rattlesnakes in Pennsylvania, including habitat loss. Despite these declines, limited hunting is allowed for six weeks per year and eight to ten organized snake hunts occur annually. Hunting is not permitted for the endangered eastern massasauga rattlesnake, but other factors, such as urbanization, gravel and coal mining, and highway construction, have contributed to its decline.

Birds. Changes in diversity and population numbers are more closely monitored for birds than for any other organism in the state. National programs, such as the Christmas Bird Count, as well as state programs, including the Breeding Bird Atlas, benefit from the help of many amateur bird watchers.

Currently, 16 species are threatened or endangered in Pennsylvania. Although some of these were never common, many are dependent on aquatic habitats, the loss of which has contributed to their decline. The American bittern, king rail, and least bittern are found only in wetlands. Others, such as the yellow-crowned night heron and great egret, also suffer from loss of water-related habitats.

Habitat fragmentation and loss, especially a decline in interior forest habitat, has had a major impact on birds. In addition, the secondary effects of increased predation of nests and cowbird parasitism have played a role. Loss of open fields, shrublands, and early-growth forests has caused declines in birds associated with these habitats, primarily various species of sparrows.

Two introduced species, house sparrow and European starling, are both cavity nesters and compete with native species for nesting sites. Nest competition partially contributed to the decline of species

such as the eastern bluebird during the last century, although efforts to provide additional cavities have been largely successful.

Various contaminants may have contributed to the decline of raptor species such as Cooper's hawk. Contaminants were present in high, but sub-lethal, levels in the possibly declining sharp-shinned hawks on Kittatinny Ridge in eastern Pennsylvania.

Mammals. Many of the remaining large mammals in the state such as white-tailed deer and black bear are at historically high levels. Both mountain lions and timber wolves were intentionally eliminated from the state, although there are still unconfirmed reports of mountain lions. Beavers have staged an impressive comeback after being hunted to near extinction in the late 1800s.

There are currently six species of small mammals on the threatened and endangered list for Pennsylvania – Delmarva fox squirrel, Indiana bat, small-footed myotis, least shrew, West Virginia water shrew, and eastern woodrat. Many of these species require special habitats, the loss or degradation of which has contributed to their decline. Species of mammals with larger home ranges are also affected by habitat loss and fragmentation.

Fungi. Neither the total number of species of fungi in the state nor their abundance is known, and thus threats to these organisms are difficult to determine. Habitat loss is probably the biggest threat to fungi, although pollutants can affect the diversity of both fungi and bacteria.

Plants and Forests. Threats to the flora include habitat loss, deer over-browsing, and invasive species. For some endangered and threatened species, especially orchids such as showy lady's slipper, collecting by hobbyists has contributed to their decline. Ginseng populations in many areas have been nearly decimated by collecting for the herbal market.

The over-abundance of white-tailed deer is a major threat to plants. High densities of hay-scented fern and New York fern, which deer do not eat, in the forest understory are correlated with the loss of herbaceous species. In areas where deer fencing has been erected or deer density reduced, plants may return, although some species never repopulate. Deer also prevent the regeneration of some forest plants and trees, and therefore are changing the composition of Pennsylvania's forests.

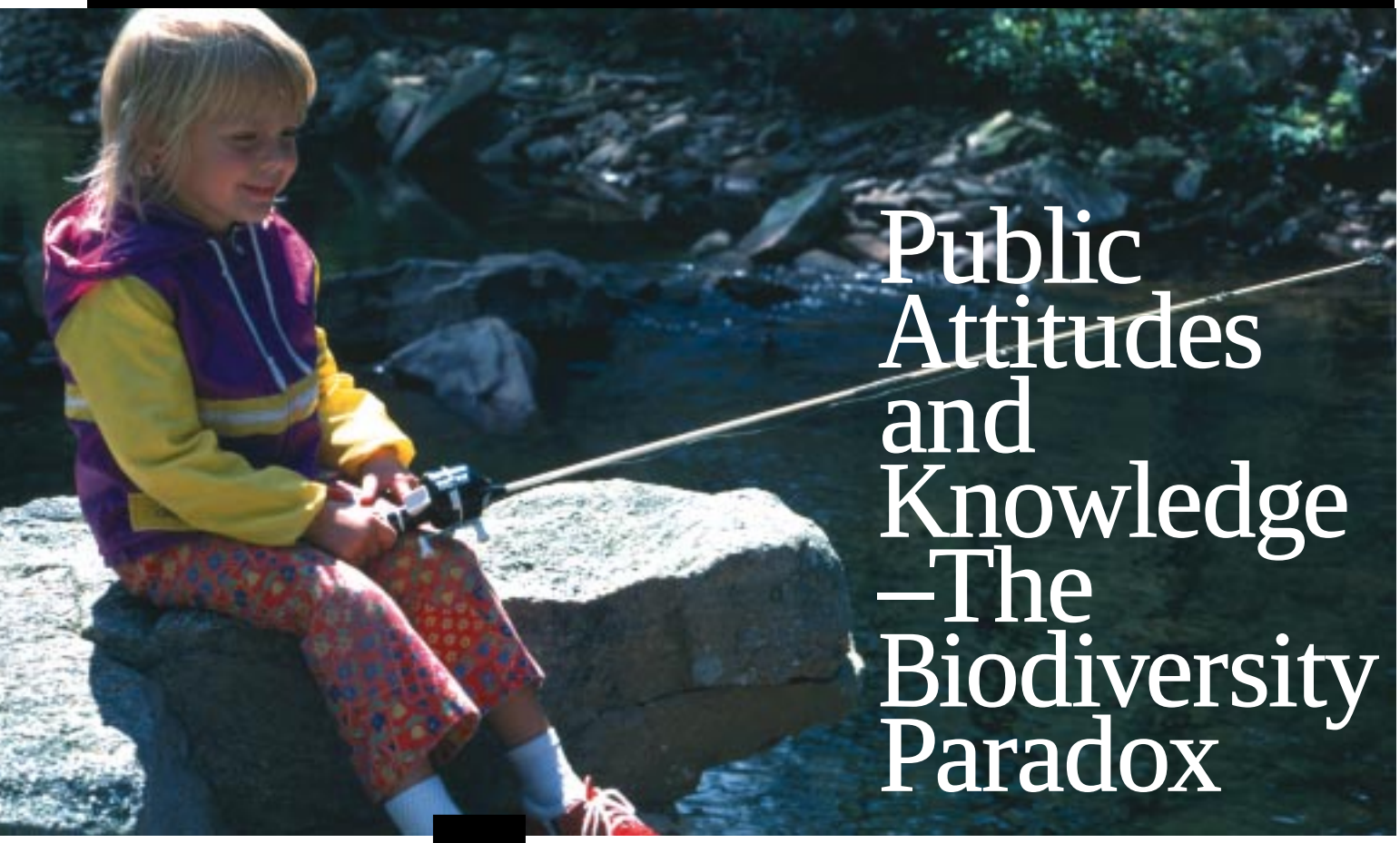
Although invasive plants thrive in disturbed habitats, they also occur in otherwise pristine habitats. Both these and introduced insect pests impact the plants and forests of Pennsylvania. Insects targeted for control include gypsy moths and woolly adelgids, a significant pest of Pennsylvania's state tree, the eastern hemlock.

The major threat to mosses and lichens is air pollution, including acid deposition, and the loss of these plants can be used as an indicator of declining air quality.

SUMMARY

Although there is little doubt that human impacts have been largely responsible for a decline in biodiversity in the state, there is much that we don't know regarding how our actions affect species and ecosystems in Pennsylvania. Waiting for this information before reversing damaging patterns can also be detrimental. While progress is being made in correcting some threats, such as point-source pollution, others, such as urban sprawl and invasive species, present increasing problems.

White-tailed deer



Public Attitudes and Knowledge –The Biodiversity Paradox

Public surveys reveal that people consistently place a high value on protecting plants, animals, and their habitats. Although Pennsylvanians strongly support biodiversity conservation, their perceived knowledge about biodiversity, especially the term itself, is not high. This is not surprising since both the concept and the term are relatively new, even to scientists.

- In the 1999 survey for the First Pennsylvania Environmental Readiness for the 21st Century Survey Report, Pennsylvanians ranked green space (91 percent) second only to personal safety (98 percent) as a priority in selecting a place to live. Most residents (64 percent) believed protecting the environment goes hand-in-hand with economic development. When asked to choose between environment and economy, they rated the value of protecting the environment higher by a two-to-one margin.
- Surveys conducted in 2000 for the Pennsylvania Greenways Plan revealed that 93 percent of the people interviewed support the creation of additional greenways. More significantly, protection of natural resources and providing habitat for wildlife were ranked as the two most important functions of greenways. Open space protection and non-motorized recreation activities, two functions often associated with greenways, were less important to the public than the biodiversity value of these areas.
- A 1996 survey by the Pennsylvania Game Commission and the Pennsylvania Fish and Boat Commission reported that 94 percent of the respondents viewed managing and conserving endangered species as important functions for these two agencies.
- 82 percent of Pennsylvania voters placed priority on habitat preservation in an April 2002 poll, and 78 percent supported guaranteed state funding to be used exclusively to protect and improve Pennsylvania's environment.

In the survey for the state's Environmental Readiness for the 21st Century Report, individuals gave the following responses to questions related to biodiversity.

- When asked to identify the meaning of the term biodiversity, 38 percent picked the correct response out of four possible answers. About 40 percent chose not to guess, but rather volunteered a response of "don't know."
- Almost three-fourths (72 percent) correctly chose destruction of habitats by humans as the most common reason an animal species becomes extinct.
- More than half of the people polled (54 percent) recognized the ecological services wetlands provide in cleaning water.
- Approximately 64 percent knew trees were an example of a renewable resource.

Similarly, in a recently released national survey of American attitudes on biodiversity conducted by the Biodiversity Project, people showed a lack of familiarity with the term, but knowledge of the concepts.

- Nearly seven in ten (67 percent) Americans agree that the number of plant and animal species is decreasing while only 8 percent think the numbers are increasing.
- Only three in ten Americans have heard the term "biodiversity," but this figure is significantly higher than the number responding positively to this question in 1996 (19 percent), showing that biodiversity education efforts are working.

Urban Biodiversity

Biodiversity is everywhere – including Pennsylvania's largest cities! Scientists and other naturalists have conducted BioBlitzes – 24-hour surveys looking for all the plants and animals in a given area – in all four major parks in Pittsburgh as well as in Philadelphia's Fairmount Park. In one day, almost 1,500 different plants, animals, and fungi were recorded in Pittsburgh's Schenley Park, from bats to mushrooms and including a bright purple centipede. A BioBlitz in Philadelphia's East and West Park resulted in a total count of 955 plant and animal species. Urban parks are reservoirs of native biodiversity that we can observe and enjoy everyday.

SUMMARY

Clearly, a paradox exists in public attitudes and knowledge about biodiversity. While Pennsylvanians show overwhelming support for biodiversity conservation and most have an understanding of specific issues, they perceive themselves as not being knowledgeable about biodiversity.

Perhaps the greatest challenge to reducing threats to Pennsylvania's biodiversity will be gaining the public's willingness to embrace these issues. This is especially true for issues relating to changing land use patterns, as an expanding population seeks to share many of the same resources. An understanding of how the loss of biodiversity is important to all species, including humans, is a key factor in the future success of biodiversity conservation.

Yellow lady's-slipper

Educational Resources

Young groundhog

Educational materials that integrate biodiversity concepts are powerful allies in fostering the conservation of natural resources. The disconnection between the public's lack of understanding of biodiversity and their support for protecting the environment may be attributed, in part, to a lack of educational materials on biodiversity.

SOURCES AND TYPES OF BIODIVERSITY EDUCATIONAL MATERIALS

In compiling information for this report, a questionnaire was sent to government, academic, environmental, and conservation organizations and programs throughout the state, asking about their educational materials related to Pennsylvania biodiversity. Although not extensive, specific materials on biodiversity exist for children and university students (examples of these materials are presented below).

One major gap was very apparent – the lack of educational materials for adults. Training programs on biodiversity and natural history topics exist for teachers, but no continuing education opportunities focusing on biodiversity are currently available to adults in general. Many organizations, such as state parks and nature centers, however, offer occasional programs that emphasize biodiversity issues for adult audiences.

Wild Resource Conservation Fund. Eleven videos on biodiversity themes are available, including specific animals (bog turtles, bats, wood rats, and others), plants, habitats, and conserving biodiversity. Companion materials – bookmarks, buttons, and posters – are available for some of the videos.

World Wildlife Fund. A curriculum supplement, *Windows on the Wild*, uses the topic of biodiversity as a "window" to help learners of all ages explore the intricate web of life. A Pennsylvania-specific version is being field tested through teacher in-service programs and workshops.

Pennsylvania State Resource Agencies. The Pennsylvania Department of Conservation and Natural Resources, the Pennsylvania Fish and Boat Commission, and the Pennsylvania Game Commission use education as a key component of conserving and managing plants and wildlife. Although the term biodiversity has not traditionally been used within their education programs, biodiversity topics include adaptation, predator/prey relationships, ecosystems, and endangered species of Pennsylvania.

Pennsylvania Department of Education. The Pennsylvania Department of Education's Office of Environment and Ecology directs the three largest national environmental education projects: *Project WET, Project Learning Tree*, and *Project WILD*. Although the interdependency of life and other biodiversity concepts are dominant throughout each of these programs, they do not specifically refer to biodiversity.

Business and Industry. Business and industry also are involved in biodiversity education in Pennsylvania. For example, PPL Corporation based in Allentown, offers a variety of programs dealing with biodiversity concepts. The Pennsylvania Department of Education and Hardwood Lumber Manufacturers Association of PA, in collaboration with the Northeastern Loggers Association and the Pennsylvania Department of Agriculture's Hardwoods Development Council, developed an educational kit on *Sustaining Penn's Woods: A Sound Use of the Land*. Students look at the three levels of biodiversity (species diversity, genetic diversity, and ecosystem diversity) to gain an understanding of how the interdependence of plants and animals are important to human survival.

Higher Education. The word biodiversity is found in some course titles and descriptions in Pennsylvania colleges and universities, but most pertinent courses concentrate on specific topics and concepts within biodiversity, such as plant taxonomy or zoology.

Professional Scientific Societies. Conceivably, professional scientific societies can do much to assist with biodiversity education. For example, the Ecological Society of America has sponsored several programs at the national level, including Schoolyard Ecology and SEEDS (Strategies for Ecology Education, Development, and Sustainability). The role of those programs toward enhancing biodiversity education in Pennsylvania is unknown.

Habitat Enhancement Programs. A wide variety of educational groups in Pennsylvania offer habitat enhancement programs, including nest box programs, maintenance of riparian buffers, and butterfly counts. Only a few of these use the term biodiversity in their descriptions.

Biodiversity Focus in 2002

In 2002 biodiversity received special attention across Pennsylvania. Biodiversity was selected as the theme for the Department of Environmental Protection's (DEP) Earth Day celebrations. In addition to being the focus of DEP's Earth Day publicity, biodiversity packets were distributed to every school and public library in the state.

Biodiversity 911, a traveling exhibit developed by the World Wildlife Fund, was on display during the summer of 2002 at the Academy of Natural Sciences in Philadelphia and the Carnegie Museum of Natural History in Pittsburgh.

The 2002 annual conferences of several groups focused on biodiversity, including the Pennsylvania Coldwater Conference hosted by Pennsylvania Trout Unlimited and the Environmental Issues Conference sponsored by Kings Gap Environmental Education and Training Center in collaboration with Shippensburg University.

National Envirothon, an environmental competition for Grades 9-12, designated their 2002 issue as Invasive Species and Their Effect on Biodiversity.

Active Learning. Although biodiversity education lends itself to active learning experiences, these types of programs are mostly in the planning stages. For example, the Pennsylvania Spatial Data Access system, Pennsylvania's official geospatial information clearinghouse, has proposed a *Pennsylvania Biodiversity Explorer Program*. This program would facilitate exploration of Pennsylvania's natural biological heritage by making biodiversity data easily available to a broad range of users.

SUMMARY

More than 90 organizations, representing all sectors from the forest products industry to higher education, reported some involvement in biodiversity education programs. Although concepts related to biodiversity were reported in many programs, the subject was often limited to individual species or habitats rather than interrelationships among species. Explanations of why species have become endangered or threatened, recovery plans, and critical habitat designations were rarely addressed.

In general, the public appears to be quite broadly aware of basic concepts about biodiversity, but the failure for that term to be used with those concepts has left the public uncertain or vague about what it means. To get the public to learn what biodiversity is, the term will have to be used explicitly when talking about biodiversity concepts and issues.

State Academic Standards

The inclusion of biodiversity in the recently adopted Pennsylvania Academic Standards for Environment and Ecology will greatly assist in increasing knowledge of the concept of biodiversity. The standards establish a rigorous knowledge level that students are expected to achieve by the end of Grades 4, 7, 10, and 12. While the term "biological diversity" is only used in the Environmental Health Standard, the concept of biodiversity supports many of the other Environment and Ecology Standards, such as Threatened, Endangered, and Extinct Species; Renewable and Nonrenewable Resources; Agriculture and Society; Ecosystems and Interactions; and Humans and the Environment.

Even with extensive technological advances and modern conveniences, our survival still depends on natural resources. Conservation of biodiversity in Pennsylvania is essential not only for Pennsylvanians, but also is a critical linking thread in the global web of life.

White-tailed deer

Best Management Practices for Biodiversity

Given our dependence on biological resources for survival, people have greatly disturbed natural habitats in Pennsylvania. In attempting to mitigate these impacts, we must not assume that no management is best for biodiversity. Best management practices (BMPs) (including "best stewardship practices") have become widely recognized and accepted as one of the most effective approaches for managing natural resources on both public and private lands.

As most of the land in Pennsylvania, and thus most of its biodiversity, is in private hands, biodiversity conservation can be achieved only if the stewards of private lands have the education, tools, and will to make it happen. Some of these tools are in the form of voluntary, non-regulatory BMPs tailored to specific types of land use practices, such as agriculture, forestry, and residential developments. While most practices do not specifically target biodiversity, more recent ones include management activities that address biodiversity.

We must not assume that no management is best for biodiversity.

EVOLUTION OF BEST MANAGEMENT PRACTICES

The evolution of BMPs from addressing only specific environmental degradation to embracing habitat restoration and biodiversity issues is exemplified by the Pennsylvania Forestry BMPs developed by the Cooperative Extension Service at Pennsylvania State University in cooperation with the forest products industry, forest landowners, and other groups. Initially, forestry BMPs were directed only at reducing water pollution from erosion and sedimentation. They eventually were expanded to address both water quality and wetlands protection issues because of their impact on wildlife habitat and threatened and endangered species. Currently, many forestry management practices in Pennsylvania directly integrate biodiversity conservation with measures for increased yield of timber and healthy forests.

Today there are a number of BMPs applicable to biodiversity in Pennsylvania. These documents cover a wide spectrum of community types and human activities (see Appendix for a list of selected management practices for enhancing biodiversity). The Pennsylvania Forest Stewardship Program presents a good model for landowner-friendly BMPs. The recommendations address issues where there is limited knowledge by applying the approach of the Hippocratic oath – "do no harm."

Consistent with the "do no harm" approach, these practices recommend minimizing habitat loss by managing for vertical structural diversity. The BMPs recommend preserving habitat for wildlife and plants in each of the different forest layers – forest floor, understory, midstory, and canopy – and note the importance of snags, logs, and cavity trees for wildlife habitat. The "do no harm" approach is also evident in BMPs that recommend preservation of unusual, rare, threatened, and endangered species and their habitats as well as habitats of exceptional value.

The Pennsylvania forestry best management practices, like virtually all biodiversity-oriented BMPs, recommend maintaining corridors between habitats to allow migratory pathways and prevent isolation of habitat "islands." They further recommend minimizing the amount of habitat edge, using buffer areas around streams, and maintaining wooded corridors as connections between habitats.

Mating green darners

SUMMARY

While some best management practices provide recommendations for conserving biodiversity, there is little research on the impact of implementing these recommendations. Therefore, it may be difficult to develop reliable indices of success given the presence of multiple influences, varying land use, and different management practices in the field. Special attention must be given to developing cost-effective BMPs with sufficient sensitivity for assessing changes in biodiversity.

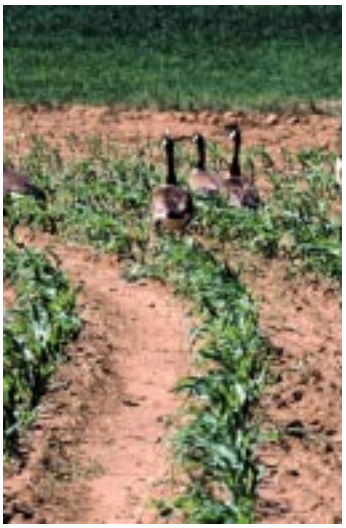
The problem of changing situations and limited knowledge suggests that procedures for periodic reassessment should be included in biodiversity BMPs. The ambiguities and knowledge limitations also suggest avoiding broad, simplistic rules such as "clean up land to its condition in 1680." Nevertheless, these limitations do not suggest inaction in the face of known threats to biodiversity globally and losses in Pennsylvania. The use of best management practices means employing the best practices that are currently available.

Limitations in our knowledge do not suggest inaction in the face of known threats to biodiversity globally and losses in Pennsylvania.

Box turtle

Land Protection Practices

Land protection activities, including land acquisition, regulations, incentives, education, and most important, good stewardship by private landowners, are all components of biodiversity conservation. Land protection practices include the strategies used to determine what lands to protect as well as the methods used to carry out these efforts.



Canada geese in cornfield

STRATEGIES

Strategies used to protect land in Pennsylvania are primarily contained in the Endangered Species Act (ESA), the Pennsylvania Natural Diversity Inventory (PNDI), The Nature Conservancy's Conservation by Design strategy, and the Smart Conservation Strategy.

Endangered Species Act. The principal federal strategy for protecting land to conserve biodiversity is embodied in the federal Endangered Species Act (ESA). ESA adopts the "fine filter" approach of protecting biodiversity by focusing efforts on protecting critical habitat for nationally threatened or endangered species.

Pennsylvania Natural Diversity Inventory. The Pennsylvania Natural Diversity Inventory collects, identifies, and describes the Commonwealth's rarest species and most significant ecological features. PNDI provides information used by state regulatory agencies for permit decisions as well as the regulatory enforcement to ensure protection for threatened and endangered species.

Conservation by Design. The Nature Conservancy's Conservation by Design strategy uses both a coarse filter (communities and ecological systems) and a fine filter (species) approach for both ecoregional and site-specific planning and implementation.

Smart Conservation Strategy. The Natural Lands Trust/Pennsylvania Environmental Council's Smart Conservation Strategy, presently under development for southeastern Pennsylvania, will provide a system for land trusts and local governments to prioritize lands for protection in order to conserve biodiversity. This strategy is developing a method of prioritizing properties for conservation based on a site's value for biodiversity, the imminence of threat, and public support.

METHODS FOR IMPLEMENTING STRATEGIES

Methods for implementing land protection strategies can be divided into three groups.

- Methods traditionally used by government agencies.
- Practices traditionally used by enterprises and private entities, but increasingly used in government programs.
- Knowledge building tools used by both government and private organizations.

Government Agencies. Land protection strategies traditionally used by government agencies include regulation; land acquisition, ownership, and management; and loans, grants, taxes, fees, and other incentives.

Regulation is the control technique most commonly associated with governmental protection of environmental resources. Regulations provide the precise standards for defining when and where a method may be used, along with encouraging conservation of biodiversity.

Land acquisition has traditionally been an effective method for conserving biodiversity. Numerous federal, state, and local public entities have the authority to acquire and manage land.

- Pennsylvania's Open Space Law provides authority for the Department of Conservation and Natural Resources, Department of Agriculture, and municipal governments to acquire open space to meet a broad range of objectives including biodiversity conservation.
- The Pennsylvania Game Commission is authorized to acquire lands by purchase through the Game Fund or donation to add to the system of State Game Lands. Over the last two decades, PGC has been a major purchaser of lands in the state and now manages 1.4 million acres of game lands in 300 separate tracts.
- The 2001 Conservation and Preservation Easement Act specifies that conservation easements can be created and held for a broad array of conservation purposes, including conserving natural resources and protecting wildlife.
- Pennsylvania's Municipal Planning Code, Township Code, Environmental Improvement Compacts Law, and Open Space Law authorize acquisition of land by local governments and authorities.

Loans, grants, taxes, fees, and incentives offer numerous opportunities to advance land protection.

- Loans and grants, provided by state and federal government agencies, are among the most frequent methods used to fund land protection. These loans and grants provide states, municipalities, or private parties support for the planning, investigation, and acquisition of lands or easements, as well as implementation of management plans.
- Federal, state, corporate, and personal tax policies provide tax incentives for the protection of land to promote biodiversity. The federal tax deduction for the donation of a conservation easement to a conservation organization is a frequently used means of protecting land.
- The Pennsylvania Clean and Green program is another land protection program that reduces real estate tax assessments for property maintained as open space, agricultural, or forest lands for a period of at least ten years.
- Fees imposed on the use of public land for recreation, such as camping, hunting, fishing, and rental of facilities, are another means for generating funds to support both land acquisition and management.

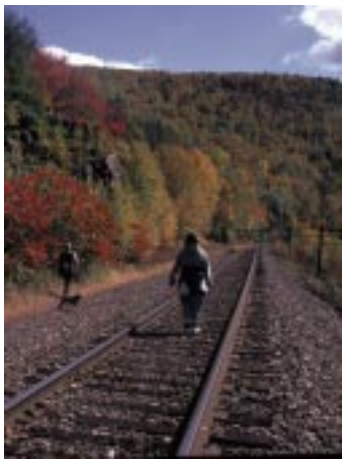
Predominantly Private Practices. Practices more typically used in the private marketplace are increasingly being used for environmental protection. Tools with an enterprise component include partnerships, property rights related programs, and certification programs.

Public-private partnerships are often formed to help with education, research, or technical and financial assistance.

- PNDI is a partnership of two private conservation organizations – The Nature Conservancy and Western Pennsylvania Conservancy – and the Department of Conservation and Natural Resources.
- The Pennsylvania Biodiversity Partnership is another example of a public-private partnership that combines the information and expertise from various interests to advance biodiversity conservation.

Private-private partnerships involve private non-profit corporations and for-profit individuals and organizations. Examples of these partnerships include:

- Land trusts that join together to provide maximum funding for land protection.
- Coalitions of non-profit and for-profit organizations that team together to allow the for-profit partners limited development or resource utilization in exchange for funds to acquire title to biologically important lands or conservation easements.



Lehigh River gorge

Private acquisition of property rights by more than 150 local land trusts comprises a major portion of land protection efforts in Pennsylvania. Most land trusts protect land by acquiring it or by using conservation easements.

Transfer development rights and in-lieu or impact fees are additional private property rights tools for land protection. For instance, rather than providing open space within a new development, a developer might voluntarily pay an in-lieu or impact fee to purchase open space elsewhere. The transfer of development rights allows municipalities to protect valuable land by prohibiting development, yet preserving the rights of the landowner. This is achieved by awarding landowners transferable development rights that can be sold to other parties for developing their properties to greater density.

Trading programs are an increasingly popular means of reducing the costs and burdens of environmental protection. Trading programs involve the authorization of "banks" by government or private entities, such as the wetlands mitigation banks established by the Department of Environmental Protection. These trading programs encourage development of wetland restoration and creation projects that can be "banked" and sold to parties requiring mitigation measures under federal or state wetlands protection programs.

Certification is another enterprise tool being used by environmental groups and industry to promote good natural resource management, and indirectly conserve biodiversity. Various programs, especially those associated with certification for sustainable forestry, such as the Forest Stewardship Council and Sustainable Forestry Initiative, reward companies by informing their customers and stockholders that they implement sustainable practices.

Education and Research. The third broad set of tools for advancing land protection is building knowledge through education and research activities. Many government and private conservation organizations have environmental education as an important component of their activities. Research projects on biodiversity are found at universities, government agencies, and museums as well as at some environmental groups and land trusts. Examples of education initiatives include:

- Landowner educational programs funded under Growing Greener to promote biodiversity through stream fencing and other watershed related programs.
- Cooperative extension programs to provide educational materials to landowners on the recreational and economic advantages of maintaining land in a natural condition.

Conservation of natural habitats is critical to the species dependent upon those habitats.

SUMMARY

Land protection is one of the most important components of biodiversity conservation efforts. Conservation of natural habitats is critical to the species dependent upon those habitats. Disturbance created by land development or other uses directly impacts plants and animals and can cause losses of both species and genetic diversity. Land use changes may also introduce invasive species, predators, and pollutants that can have the same effect. Land protection is broadly defined as the land-use activities that maintain or enhance biodiversity. These activities range from the preservation of land in its natural state; to the conservation of open space land in active use, but managed to promote biodiversity; to the management of land to conserve biodiversity in developed areas.

There are a variety of tools available in Pennsylvania to protect land ranging along a continuum from land and easement acquisition to education. These tools are frequently used in conjunction with one another, with multiple tools often employed in a single effort. Strategies are essential to determine where and how these tools should be targeted and coordinated. Such coordination is essential to achieve the ultimate goal of biodiversity conservation throughout the Commonwealth.

Habitat Restoration and Species Reintroductions

When best management practices and land protection efforts fail at conserving biodiversity, the remaining option is to attempt to restore or reintroduce what has been lost. Restoration and reintroduction projects have been somewhat successful in counteracting the loss of species and habitats in Pennsylvania. These projects have taken many forms, ranging from wetland restoration and fire management to replanting native grasslands and translocating animals to their former ranges.

HABITAT RESTORATION

Concerted efforts have been made, especially in the 1990s, to restore or repair habitat damage. Most efforts in Pennsylvania have focused on aquatic areas rather than terrestrial ones, with the exception of sites disturbed by former industrial uses (brownfields).

Wetland restoration and creation of new wetlands have been advanced by recognition of the ecological services that wetlands provide. While replacing wetlands on an equal area basis is the emphasis of most mitigation projects, there is less concern for replacing ecological functions. In addition, many mitigated wetlands are being replaced with dissimilar wetland types. For instance, while the greatest loss of wetlands has been of the scrub-shrub type, most restored wetlands are open water types, which have lower ecological value.

Despite initial optimism that created wetlands would perform the same functions as native wetlands, recent evidence suggests this is not the case. Poor wetland design, inability to establish vegetation, and the influx of invasive species are some of the reasons that wetland mitigation projects fail. In spite of such evidence, some argue that created wetlands have not been given sufficient time to achieve all of their potential ecological functions.

River otter

Terrestrial habitat restorations in Pennsylvania are attempting to establish grassland habitats on former agricultural lands, abandoned mine sites, and other disturbed areas. Abandoned mine sites, in particular, offer opportunities for creating grasslands that can attract birds and other species that prefer these habitats. Raptors such as northern harrier and American kestrel, for example, use reclaimed lands in western Pennsylvania.

REINTRODUCTIONS

Throughout the last century, several species of animals ranging from river otters to elk have been reintroduced to Pennsylvania with mixed success. For some projects, however, many additional years are needed before success can be assessed. While the definition of success varies, progress has been made especially with larger mammals and birds. Nevertheless, the difficulties and especially the high costs of many reintroduction efforts are a reminder that replacement is not a substitute for biodiversity conservation.

The majority of active reintroductions in Pennsylvania involve larger mammals, birds, or fish. These include game species such as elk, turkey, and American shad as well as raptors such as bald eagle and peregrine falcon. In many cases, animal species have been able to naturally recolonize in restored habitats, but often additional measures such as translocation of animals from other regions is necessary. And some reintroductions, such as the peregrine falcon, have had a great deal of human involvement.

American Shad. Until dams impeded their travel, American shad returned each year to the headwaters of the Susquehanna River in New York. Hundreds of thousands of fish migrated annually through Pennsylvania and were an important food source for settlers and American Indians. Although populations of shad survived below the last canal dam at Columbia, water pollution, failed fish passages, and overharvesting led to their decline.

With the establishment of four hydroelectric dams on the lower Susquehanna River in the early part of the 20th century, nearly all species of migratory fish, including shad, disappeared from the Susquehanna. Problems in the upper Chesapeake Bay due to overfishing, pollution, and flooding continued after 1971, resulting in closing of the shad fishery in Maryland by 1980.

American shad reintroduction efforts started in 1971 with the construction of a fish elevator on the Conowingo Dam and placement of 200 million eggs in hatching boxes in the river. The goal of this multi-million dollar project was to restore an annual spawning population of two million shad within 25 years. Fish lifts along three other dams on the Susquehanna River helped in the effort. At the Conowingo Dam alone, the number of returning shad has increased to a current average of more than 45,000.

River Otter. River otters declined in Pennsylvania in the 1800s and early 1900s due to habitat loss and unregulated hunting. By the 1950s, populations were limited to the Pocono Mountains. In 1982, river otters captured in New York and New Hampshire were released in Pennsylvania. In the 1990s, 82 river otters were reintroduced to five stream and river systems, primarily in northern counties that are densely forested and sparsely populated. A 1994 survey located otters in at least 47 counties. Of the 25 established populations in the state, nine are considered to be expanding, 12 stable, and four declining or unknown. Water quality problems due to pollution from sources such as abandoned mine drainage are the greatest impediment to river otter reintroduction. Accidental trapping is also as a cause of mortality, with 87 otters accidentally killed between 1989 and 1994.

Wild Turkey. Probably one of Pennsylvania's greatest reintroduction success stories is the wild turkey. Wild turkeys were eliminated in most of the eastern United States, including Pennsylvania, by the late 1800s due to overhunting and habitat loss by logging. Attempts were made throughout the 20th century to reintroduce wild turkey in Pennsylvania. Ultimately, a trap and transfer program begun in 1956, coupled with the return of preferred habitat and expansion of the remaining turkeys' range, led to their successful comeback. The population of wild turkeys was estimated at more than 400,000 birds in 2000 and continues to increase each year. Today, wild turkeys are found in every county in Pennsylvania, and are regularly seen in Pittsburgh and the Philadelphia suburbs.

Wild turkey

American shad

SUMMARY

The science of restoration ecology has emerged relatively recently. Many questions remain regarding our ability to restore degraded habitats as well as the best methods for translocating species into their former locations. Although habitat restorations or species reintroductions are possible in many situations, some areas have changed too drastically to be restored to their original states or to support populations of reintroduced animals.

Loss of habitats and species will likely never be fully reversed, but restoration work and reintroduction of species into areas they formerly occupied can mitigate some of the damage. These efforts, however, will never be adequate substitutes for the conservation of biodiversity.

Fire as a Management Tool

Historically, natural fires were essential in maintaining forest openings and certain specialized habitats, such as serpentine barrens. Over the course of the last century, the total acreage subjected to fire in Pennsylvania decreased by more than 99 percent due to fire suppression and control measures. Impacts on biodiversity include replacement of oak species in Pennsylvania forests with maple and black cherry, and invasion of oaks and pines into the serpentine grasslands.

Periodic burning is critical to maintaining fire-dependent habitats. Controlled burns are one of the management tools used in preserving habitats such as barrens. Plants like serpentine aster and hairy chickweed, both endangered species, benefit from prescribed burning to remove encroaching woody plants.

Government Organizations and Programs

Mountain laurel

State, federal, county, and local governmental organizations all have a role in managing the lands, waters, and biological resources of Pennsylvania and can have significant influence on biodiversity conservation.

Pennsylvania adopted an Environmental Master Plan in 1977, with overall environmental goals of (1) protecting natural processes and ecological relationships and (2) preserving natural, scenic, and esthetic values of the environment while meeting society's needs. While this plan was intended to be a mechanism for coordinating activities to achieve the state's environmental goals and even included mandates for a "biological survey of the Commonwealth," it has not been part of the actual process.

STATE GOVERNMENT

In practice, natural resource conservation is carried out through several state agencies. The state agencies with legislated responsibility for biodiversity in Pennsylvania are the Department of Conservation and Natural Resources (DCNR), Department of Environmental Protection (DEP), Pennsylvania Fish and Boat Commission (PFBC), and Pennsylvania Game Commission (PGC). Other state agencies also impact biodiversity, although coordination among these agencies has often been *ad hoc*.

State Government Agency	Role in Protecting Biodiversity
Department of Conservation and Natural Resources (DCNR) – primary agency for biodiversity protection	Established in 1995, DCNR has authority for: • State parks and state forests. • Pennsylvania's ecological heritage and geologic features. • Waterways and greenways. • Community open space, conservation, and recreation grants. • Wild plants.
DCNR: Bureau of Forestry	• Oversees one of the largest state forest systems in the nation with more than 2.1 million acres.
DCNR: Bureau of State Parks	• Manages 116 state parks on 283,000 acres. • Protects 22 areas of unique scenic, geological, or ecological value in the parks.
DCNR: Bureau of Recreation & Conservation	• Awards millions of dollars in conservation grants to local governments and nonprofit organizations each year. • Administers Pennsylvania's eleven heritage parks (broad geographic areas significant for tourism, history, and conservation).
DCNR: Office of Wild Resource Conservation	• Administers the Wild Resource Conservation Fund (WRCF). • Funds projects that aid in the conservation of wild plants and non-game animals and County Natural Areas Inventories. • Produces educational materials on biodiversity, including posters, videos, patches, and a newsletter.
DCNR: Pennsylvania Natural Diversity Inventory (PNDI)	• Pennsylvania's Natural Heritage Program. • Cooperative effort among the Bureau of Forestry, Western Pennsylvania Conservancy, and The Nature Conservancy. • Collects and disseminates information on endangered, threatened, and rare species and on natural community types and ecosystems. • Data used by state agencies, local governments, and consultants in planning and designing projects, and especially in avoiding impacts on threatened and endangered species and significant natural communities.
Other DCNR Initiatives **Pennsylvania Greenways Action Plan**	• Plan completed in August 2001 with a goal to support greenways plans for all counties by 2007. • In public surveys conducted for this Plan, protection of natural resources and providing habitat for wildlife were ranked as the two most important functions of greenways.
Office of Biodiversity Conservation (proposed)	• First Biodiversity Director hired in 2001. • Developing biodiversity strategy for DCNR.

Forest Certification

In 1998, all of Pennsylvania's state forests – 2.1 million acres – were provisionally certified as being managed according to recognized standards of sustainability, making Pennsylvania's state forests the largest block of certified forest under single public ownership in the nation, and possibly, the world.

Paddlefish Reintroduction

Looking like a creature from the prehistoric past, paddlefish were likely gone from the Pennsylvania drainage of the Ohio River by 1919 due to polluted waters, river channelization, and dams. Improvements in the water quality in Pittsburgh's three rivers, and the return of other fish to this area, indicate that paddlefish should be able to survive in these waters again. Their reintroduction in the state began in 1991, with release of paddlefish into the Ohio and Allegheny Rivers. Because female paddlefish can take up to 10 years to reach reproductive age, it will take many years to determine the success of this project. Since 1992, there have been 12 sightings of paddlefish in Pennsylvania. Unfortunately, two of these were found dead.

State Government Agency	Role in Protecting Biodiversity
Department of Environmental Protection (DEP) – primary regulatory agency for environmental protection	• Implements and enforces laws on air pollution; water quality; mining; oil and gas development; radiation; solid and hazardous waste management; recycling; hazardous site cleanup; and pollution prevention. • Administers more than 90 types of permits for activities affecting lands and waters. Some permit review procedures require that applicants consult PNDI to determine if threatened or endangered species may be affected by the proposed project. • Developing outcome measures for Pennsylvania's environmental health, including two indicators (out of 17) relating to biodiversity.
Pennsylvania Fish and Boat Commission (PFBC)	• Provides fishing and boating opportunities to the public through the protection and management of aquatic resources. • Responsible for both game and non-game aquatic biodiversity, including fish, amphibians and reptiles, and aquatic insects. • Establishes fishing seasons, limits, and rules. • Engages in stocking state waters. • Revenue provided from license fees.
Pennsylvania Game Commission (PGC)	• Protects, propagates, manages, and preserves the game and wildlife of Pennsylvania. • Maintains 1.4 million acres of state game lands. • Issues rules and regulations for the management of mammals and birds, including authority to protect bird and mammal species, close areas to hunting and trapping, and adjust hunting and trapping regulations to regulate animal populations. • Manages wildlife populations at biologically and socially acceptable levels. • Revenue provided from license fees.
Pennsylvania Department of Agriculture	Programs relevant to biodiversity include: • Plant pests and noxious weed control. • Farmland protection. • Promotion of sustainable agriculture and forestry.
Pennsylvania State Conservation Commission	• Responsible for oversight and support of Pennsylvania's 66 county conservation districts.
Pennsylvania Department of Transportation (PennDOT), State Transportation Commission, and Pennsylvania Turnpike Commission	• Significant impact on patterns of development and habitat protection as a result of their decisions to locate new roadways. • Required to perform environmental reviews for federally funded highway projects that may have significant impact on the environment. • Often consult PNDI for information on potential impact on species and habitats.
Department of Community and Economic Development	• Houses the Governor's Center for Local Government Services, which is responsible for land use planning assistance. • Required to issue a land use and growth management report for Pennsylvania by 2005 and every five years thereafter.
Pennsylvania Department of Military and Veterans Affairs and Pennsylvania Army National Guard	• Manage military installations in the state, including site of only known population in Pennsylvania of the regal fritillary, a rare butterfly.

FEDERAL GOVERNMENT

As in state government, several federal agencies play a role in biodiversity conservation in Pennsylvania.

Federal Government Agency	Role in Protecting Biodiversity
Environmental Protection Agency	• Responsible for oversight of programs administered by DEP that implement federal legislation to protect air, water, and land from pollution. • Provides grant funding supporting state actions to protect the environment. • Offers technical assistance to landowners and communities regarding conservation efforts.
National Park Service	• Manages several sites in Pennsylvania, including Gettysburg National Battlefield Park and the Delaware Water Gap National Recreation Area. • Administers grant programs.
U.S. Army Corps of Engineers	• Issues permits for dredging or filling wetlands and other waters following an environmental review process. • Enforces wetlands laws. • Manages land in Pennsylvania primarily for flood control and also recreational uses.
U.S. Department of Agriculture, U.S. Forest Service	• Manages Pennsylvania's 513,000-acre Allegheny National Forest. • Provides technical assistance and funding to assist private forest landowners. • Conducts forest research in Pennsylvania.
U.S. Department of Agriculture, Natural Resources Conservation Service	• Provides technical assistance to farmers. • Helps administer cost-share programs for land conservation along with the USDA Farm Services Agency.
U.S. Fish & Wildlife Service	• Administers the federal Endangered Species Act. • Conducts research and provides comments on proposed permitting activities.

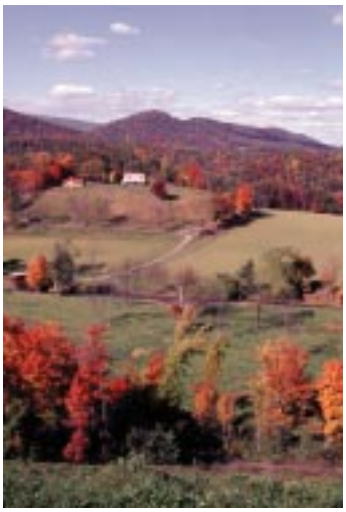
COUNTY AND LOCAL GOVERNMENT

Most land use planning and development decisions are made at the local level and thus county and local government initiatives are critical to the success of any statewide biodiversity conservation strategy. Each of Pennsylvania's 2,568 local governments has full authority over land use planning, zoning, and subdivision regulation. This makes coordination of land use planning and protection of biodiversity more difficult than it is in states where land use is regulated at a larger geographic scale, such as at the county level.

Amendments to the state's Municipal Planning Code (MPC) provide opportunities for coordination between municipalities, which is important for biodiversity conservation since most factors influencing habitats and ecological communities occur at a scale that transcends municipal boundaries. Communities may now coordinate planning and land use decisions with one another without engaging in joint planning. The MPC amendments also authorize municipalities to enter into cooperative agreements to adopt joint comprehensive plans without giving up their separate zoning boards and planning commissions. Cooperating municipalities may designate "rural resource areas" in which uses like forestry and agriculture will be encouraged and enhanced.

Regal Fritillary

The regal fritillary, a rare butterfly, once ranged from the East Coast to the Great Plains. While many western populations still remain, only two populations are known in the east – a large population at Ft. Indiantown Gap in Pennsylvania and a small population in Virginia. The Pennsylvania Department of Military and Veterans Affairs and Pennsylvania Army National Guard are responsible for the management of this rare butterfly and have partnered with The Nature Conservancy to develop and implement a conservation program.



County and Local Government Initiatives	Role in Protecting Biodiversity
County Comprehensive Plans	• All counties are required to adopt comprehensive plans. • 60 out of 67 counties have completed plans. • Plans are not binding on zoning or land use regulation by municipalities that undertake their own planning and zoning.
Municipal Comprehensive Plans	• Cities, boroughs, and townships have authority for comprehensive planning and adoption of zoning and subdivision ordinances that control the type, scale, and location of development. • 57 percent of Pennsylvania's municipalities have comprehensive plans. • Municipalities can acquire and hold open space lands.
Municipal Planning Code (MPC)	• Requires municipal comprehensive plans to address land use issues, including provisions for public grounds, parks and recreation, as well as preservation of prime agricultural lands, floodplains, and other areas. • Growing Smarter amendments covering protection of natural and historic resources, such as wetlands, woodlands, and unique natural areas were added to MPC in 2000.
Zoning Ordinances	• Govern land development and use in municipalities. • 64 percent of municipalities have enacted zoning or are covered by county zoning regulations. • May regulate land use for the protection of natural resources and may contain provisions to protect environmentally sensitive areas.
Subdivision Ordinances	• Most common form of land use control in Pennsylvania. • Control how land is subdivided into smaller parcels and impose basic requirements on building setbacks and locations. • 93 percent of municipalities regulate subdivision of land or are covered by county subdivision ordinances.
Environmental Advisory Councils	• Formed by municipalities to inventory natural resources, identify environmental problems, and obtain information on open space. • Make recommendations and advise on land acquisitions.

SUMMARY

All levels of government – from local municipalities to the federal government, each with many different agencies – are involved in biodiversity conservation in Pennsylvania. Although these multiple government units provide many tools, they have sometimes lacked coordination in matters of land use and biodiversity conservation.

Penn's Creek

Important Laws and Policies

Although some laws protecting the environment existed prior to the 1960s, there was no concerted effort to protect Pennsylvania's air, land, or water, or laws regulating use of public natural resources in the state. With passage of the Environmental Rights Clause to the Pennsylvania Constitution (see pg. 1), the government's attitude changed to one of trustee for public natural resources. This amendment also declared that the citizens of Pennsylvania have a right to a healthy environment.

This amendment serves as a guide for conservation activities by the Commonwealth and it also applies to local governments. Its wording creates a public trust in the public natural resources of the Commonwealth, and it also guarantees public rights in preservation of natural values in the environment.

Pennsylvania has numerous laws and policies that relate to biodiversity conservation. These include laws that govern public and private actions affecting lands and waters as well as ones specifically addressing conservation and restoration objectives. Other laws and policies address what biological information is collected, how it is organized, how it is made available to public and private decision-makers, and what requirements or incentives exist to ensure its use.

Beaver lodge

Regulation of invasive species not native to Pennsylvania is divided among agencies with no formal coordination of activities.

LAWS AND PROGRAMS FOR PLANT AND ANIMAL SPECIES

Threatened and Endangered Species. The *Federal Endangered Species Act* imposes limits on activities affecting federally-listed threatened or endangered species within Pennsylvania. Pennsylvania laws provide additional protection to federally-listed species, as well as to species listed by Pennsylvania agencies as threatened, endangered, rare, or of conservation concern. The Pennsylvania Game Commission (PGC) has jurisdiction over birds and mammals; the Pennsylvania Fish and Boat Commission (PFBC) is responsible for fish, amphibians, reptiles, and other aquatic organisms; and the Department of Conservation and Natural Resources (DCNR) protects plants. Terrestrial insects, spiders, snails, and other terrestrial invertebrates, which make up most of the biodiversity in the state, do not fall under the jurisdiction of any agency. There are no Pennsylvania laws requiring state agencies to adopt habitat protection requirements or to prepare and implement recovery plans.

The *Wild Resource Conservation Act* provides DCNR with jurisdiction over rare and endangered plants. It directs DCNR to classify plants, authorizes wild plant management permits for the transplantation and management of threatened and endangered plants, and authorizes acquisition of lands or aquatic habitat for public wild plant sanctuaries. DCNR may also designate sites as private wild plant sanctuaries upon request. While this does not give much additional protection, it does give recognition to these sites and provides for transplantation and propagation of species of conservation concern.

The Pennsylvania Biological Survey, a voluntary non-profit organization with members who are scientific experts, assists the state agencies in determining which species to list for conservation concern and their appropriate ranks.

Invasive Species. Regulation of invasive species not native to Pennsylvania is divided among agencies with no formal coordination of activities. PGC can prohibit the possession, importation, exportation, or release of any birds or mammals considered to be dangerous to the general public or wildlife of Pennsylvania. PFBC has similar authority over fish, reptiles, and amphibians.

Invasive plant laws are administered primarily by the Pennsylvania Department of Agriculture. The *Noxious Weed Control Law* allows designating plants as noxious weeds if they injure public health, crops, livestock, agricultural land, or other property. The law included four noxious weeds – marijuana, Canada thistle, Johnson grass, and multiflora rose – and about a dozen plants have been added to the list, including purple loosestrife, several types of thistles, kudzu, mile-a-minute weed, and jimsonweed. Sale or propagation of noxious weeds is prohibited.

The *Pennsylvania Plant Pest Act* defines plant pests as any organism that causes injury or damage to plants or plant products. The Department of Agriculture may declare a pest a public nuisance, and make its existence, maintenance, importation, transfer, or sale unlawful. The *Pennsylvania Seed Act* prohibits the sale of noxious weed seeds and plant parts.

LAWS AND PROGRAMS RELATED TO WATER

Pennsylvania's *Clean Streams Law* is the cornerstone of the state's aquatic protection programs and also provides some regulation of activities affecting terrestrial habitats. By law, every stream or waterbody in Pennsylvania has an assigned designated use as Warm Water Fishes, Trout Stocking Fishery, Cold Water Fishes, or Migratory Fishes.

In addition, streams with excellent water quality may be designated High Quality Waters (HQ) or Exceptional Value Waters (EV). The water quality in an HQ stream can be lowered only if a discharge is the result of necessary social or economic development, with all existing uses of the stream protected. EV waters are to be protected at their existing quality.

The Clean Streams Law further emphasizes the importance of clean, unpolluted waters through objectives to prevent further pollution as well as to reclaim and restore every polluted stream in Pennsylvania. Pennsylvania, like other states, is subject to the federal Clean Water Act, which requires that impaired waters and their sources of impairment be identified and plans developed to remove the impairment.

Wetlands and waterways also are protected in Pennsylvania under the *Dam Safety and Encroachments Act*. These regulations provide special protection for:

- Exceptional value wetlands, defined as habitat for threatened or endangered species or hydrologically connected to such habitat.
- Wetlands in or along the floodplain of exceptional value waters or wild and scenic rivers.
- Wetlands that support public drinking water supplies.
- Wetlands in state-designated natural areas or wilderness areas.

LAWS AND PROGRAMS FOR PRIVATE LANDS AND ACTIVITIES

Agricultural Lands. Agricultural lands can at times serve as core areas for biodiversity, provide connections between other habitat areas, and are potential areas for future restoration. For land to be designated as a *Pennsylvania Agricultural Security Area*, it must be used for production of crops, livestock, or livestock products, broadly defined as horticultural products, timber, wood and wood products, and aquatic plants and animals and their byproducts.

Perhaps Pennsylvania's largest publicly funded conservation acquisition program is its *Agricultural Easement Program*. Through this initiative, conservation easements are acquired to maintain farmland as open space and prevent development. As of December 2001, the program had acquired easements on 212,707 acres on 1,764 farms in 51 counties. Although primarily a program to conserve farmland, these easements may also help conserve populations of native plants and animals that inhabit open fields and edges.

Forest Lands. Forests cover 17 million acres of Pennsylvania – more than half of the state – with nearly 75 percent of these lands privately owned. Pennsylvania has more than 500,000 forest landowners with the median tract size less than 20 acres. DCNR's Bureau of Forestry does not regulate forestry activities on private lands, but it does provide technical assistance, education, insect control, and fire protection.

The sediment and erosion control provisions of Pennsylvania's water quality laws require detailed water quality plans for any timber harvesting and road construction. Use of voluntary forestry best management practices is generally the basis for determining compliance with these regulations.

Pennsylvania's Dam Safety and Encroachment Act provides protection for forested wetlands. While these provisions do not require permits for timber harvests, they do require permits for constructing roads over streams, depositing material for road construction or skid trails, and other activities.

At the local level, Pennsylvania law allows municipalities to adopt ordinances to regulate forestry, but prohibits local governments from unreasonably restricting forestry activities. Local governments may adopt requirements for tree conservation and mitigation when forest land is under development or subdivision.

Rhodora at Long Pond

Other Lands. Under Pennsylvania law, non-coal mines must submit reclamation plans and provide for postmining revegetation of the reclaimed areas. Revegetation with native species is the most desirable approach, but non-native plants may be used if they meet the requirements of state and federal introduced species statutes and are not listed as noxious weeds.

Coal mines are subject to detailed reclamation planning and revegetation requirements, as are coal refuse disposal sites. As with non-coal mines, a diverse permanent vegetative cover must be established. Introduced species may be used as necessary to achieve the postmining land use plan.

The *Pennsylvania Oil and Gas Act* provides for protection of natural resources, environmental rights, and the environmental values stated in the Pennsylvania Constitution. The law and regulations require well site restoration and sediment and erosion control measures, but contain no specific provisions regarding revegetation or conservation of biological resources.

Pennsylvania's Land Recycling Program (commonly known as Act Two) establishes alternative cleanup standards for industrial lands for reuse. The program works in conjunction with a "Green Opportunities for Brownfields" program, which is designed to link use of old industrial sites with potential greenways, recreation areas, and watershed protection. For example, a 90-acre wildlife habitat is being created on a PPG Industries parcel in Armstrong County, in connection with reuse of the remainder of the parcel.

SUMMARY

State laws and policies play a critical role in the conservation of biodiversity. There are significant opportunities under current laws and programs for Commonwealth agencies, organizations, local governments, corporations, and citizens to develop and implement a statewide strategy for protecting biodiversity. Understanding where we are is an essential first step in determining where we want to go. Pennsylvania brings many assets to that journey.

Funding for Biodiversity Research and Conservation

Eastern hognose

Funding for biodiversity research and conservation should address information needs in the context of best management practices, including baseline surveys; basic research on biological and ecological aspects of biodiversity; applied research on methods for management, control, and protection; dependable and persistent monitoring of species, populations, and habitats; methods for accurately assessing management outcomes; and protection of critical habitats.

STATE FUNDING PROGRAMS

The Commonwealth has two major sources of funding for conservation land acquisitions – tipping fees paid by waste haulers to dump trash in Pennsylvania landfills and the real estate transfer tax. Each of these sources is used not only for state land and easement acquisitions, but also to support local and nonprofit acquisitions.

The *Keystone Recreation, Park, and Conservation Fund Act* (Key 93), passed in 1993, provides funding for acquisition of natural areas and open space, using the proceeds from a portion of state realty transfer tax revenues. Key 93 programs have acquired over 31,000 acres of land in Pennsylvania.

Growing Greener, enacted in December 1999, is the other significant source for conservation funds. The original Growing Greener provisions were slated to provide $645.9 million over five years with money coming from the General Fund and money redirected from the Recycling and Hazardous Sites Cleanup funds. New funding, earmarked in 2002, will provide an average of $100 million/year for the next 10 years. Starting in 2004-2005, revenues will be derived entirely from tipping fees on landfilled municipal waste. Growing Greener supports farmland preservation, open space acquisition, watershed improvements, local grant programs, recreation and park facilities, and greenways. Funds are divided among the Department of Conservation and Natural Resources (DCNR), Department of Environmental Protection, Department of Agriculture, and PENNVEST.

State Program / Agency	Key Aspects of Funding for Biodiversity
Wild Resource Conservation Fund (administered by Office of Wild Resource Conservation, DCNR)	• Established by the Wild Resource Conservation Act in 1982. • Funds research, conservation, and restoration of wild plants and non-game animals and County Natural Areas Inventories. • Uses taxpayer-contributed funds, funds from license plate and other sales, and Growing Greener money. • Recent grants total $500,000/year, currently all derived from Growing Greener. • Future funding levels uncertain, due to declines in tax check-offs and license sales. • Funding addresses recommendations made by DCNR, Pennsylvania Game Commission, and Pennsylvania Fish & Boat Commission.
Community Conservation Partnerships Program (administered by Bureau of Recreation and Conservation, DCNR)	• Offers nearly $30 million annually in grants for community recreation, trails, river conservation, critical natural areas, open space, and heritage projects. • Uses federal funds, Pennsylvania general funds, Growing Greener, and Keystone Funds. • Land Trust Grants program gives priority to habitat for threatened and endangered species.
Department of Environmental Protection	• Various grant programs with potential impact on biodiversity, including watershed restoration, riparian buffers, mine land restoration, and oil and gas well plugging. • Manages Environmental Education Grants Program, supported by environmental fines.
Land Use Planning and Technical Assistance Program (administered by the Department of Community and Economic Development)	• Offers land use planning assistance. • Provides planning grants to local governments, with special preference for multi-municipal and cooperative planning. • Manages awards program for Local Government Excellence.
Agricultural Easement Program	• Provides for purchase of conservation easements in Agricultural Security Areas. • May acquire easements on forest lands, but generally eligible only if associated with crop land, grazing, or pasture lands. • Easements cover 212,707 acres on 1,764 farms in 51 counties as of December 2001.

Wild Resource Conservation Fund

The major state funding program with a specific focus on research on wild plants and non-game animals is the Wild Resource Conservation Fund (WRCF), established in 1982 by the Wild Resource Conservation Act. Now administered by the Office of Wild Resource Conservation in DCNR, funding from WRCF addresses recommendations from that agency as well as the Pennsylvania Game Commission and Pennsylvania Fish and Boat Commission. Long-term stable funding for WRCF remains as an unaddressed need.

PA Biodiversity Partnership

PBP is a voluntary coalition. Individuals interested in more information or supporting biodiversity conservation can contact the Pennsylvania Biodiversity Partnership, 16 Terminal Way, Pittsburgh, PA 15219; 412-481-4100; pbpinfo@pabiodiversity.org. Additional information also is available on PBP's website at www.pabiodiversity.org.

FEDERAL FUNDING PROGRAMS

Federal Program/Agency	Key Aspects of Funding for Biodiversity
Conservation Reserve Program (regular CRP) (U.S. Department of Agriculture)	• Pays landowners to convert highly erodible cropland or other environmentally sensitive acreage to native grasses, wildlife plantings, trees, filter strips, or riparian buffers. • 59,587 acres enrolled in Pennsylvania as of mid-2002.
Conservation Reserve Enhancement Program (CREP) (USDA)	• Focuses on highly erodible land and streamside buffers. • 54,000 acres enrolled out of a total maximum of 100,400 acres offered as of September 2002.
Environmental Quality Incentives Program (EQIP) (USDA)	• Provides technical, financial, and educational assistance to eleven priority areas in Pennsylvania. • 1,089 contracts written with Pennsylvania landowners obligating over $11 million through mid-2000.
Wildlife Habitat Incentives Program (WHIP) (USDA)	• Gives landowners cost-shares to provide habitat for wildlife, endangered species, and fisheries. • Enrollments in Pennsylvania include about 430 landowners, affecting 5,160 acres in 40 counties.
Forestry Incentives Program (USDA)	• Offers financial assistance to non-industrial private forest landowners to plant and maintain working forest lands.
Forest Stewardship Program (USDA)	• Provides technical assistance to landowners voluntarily seeking to enhance wildlife habitat, protect soil and water quality, increase wood production, and fulfill other multiple use objectives. • Pennsylvania landowners with five acres or more of forest land eligible to participate. • About 2,400 landowners have Forest Stewardship Plans.
Forest Legacy (USDA)	• Provides funding to purchase conservation easements on forest land to retain forest and forestall conversion to developed uses. • Pennsylvania applied to participate on a regional basis in 2001.
Partners for Wildlife (U.S. Fish & Wildlife Service)	• Provides funding and technical assistance, in cooperation with PA Game Commission, to private landowners for restoration of native wildlife habitat. • About 1,500 Pennsylvania landowners participate, with activities on 5,000 acres of wetlands, 4,000 acres of forest and upland restoration, and 150 miles of riparian buffers and streambank stabilization.
Wildlife Restoration and Conservation Program (U.S. Fish and Wildlife Service)	• Federal grants to the states to fulfill the needs of wildlife not met by other sources. • Administered by the PA Game Commission and PA Fish and Boat Commission.
National Park Service	• Administers grant programs under the Land and Water Conservation Fund and other programs. • Helps acquire and improve state lands, greenways, trails, and other conservation and recreational infrastructure.
Environmental Protection Agency	• Provides funds that support state actions to protect the environment.
Transportation Enhancement Act (TEA-21)	• Enhancements include acquisition of scenic easements or scenic sites, wildlife underpasses, rails-to-trails projects, and environmental mitigation to reduce vehicle-caused wildlife mortality while maintaining habitat connectivity. • Pilot program to make transportation and land use connections, which is intended to promote compact development and alternatives to sprawl.

LOCAL GOVERNMENT FUNDING

Local Program/Initiatives	Key Aspects of Funding for Biodiversity
Property Tax and Earned Income Tax	• Authorizes municipalities to levy property tax or earned income tax for acquiring open space, if approved by the voters. • Used by a few municipalities in rapidly developing areas.
Act 515	• Allows counties to enter into covenants with owners to maintain land in open space, farm, forest, or water supply uses in exchange for a property assessment that values the land as open space. • Five counties in eastern Pennsylvania participate, with 300,000 acres assessed.
Farmland and Forest Assessment Act (Clean and Green)	• Property tax relief program. • Allows counties to assess agricultural land, agricultural reserve land, and forest reserve land at current use value rather than market value. • More than 5 million acres in 48 counties currently assessed under Clean and Green.
Bonds	• Municipalities and other government entities authorized to issue bonds for open space acquisition and conservation easements. • Bonds are sometimes tax-exempt.

PRIVATE FUNDING

In addition to government funding, conservation organizations and land trusts raise their own funds from donors and foundations. Organizations like the Conservation Fund, Heritage Conservancy, The Nature Conservancy, Western Pennsylvania Conservancy, Wildlands Conservancy, and other members of the Pennsylvania Land Trust Association provide substantial benefits to biodiversity conservation by acquiring lands – either for management themselves, or more often, conveyance to the Game Commission, DCNR, or other public entities. Land trusts can often identify lands, put the deal together and arrange financing in a more rapid and nimble fashion than governmental agencies.

Research on Pennsylvania biodiversity is conducted by many private non-profit organizations and individual researchers at academic institutions, utilizing a variety of funding sources, including those previously listed as well as monies internal to the organizations and federal sources such as the National Science Foundation.

Pennsylvania is fortunate in having many foundations that focus at least part of their substantial assets on environmental issues within the state, including the Heinz Endowments, Laurel Foundation, McKenna Foundation, R.K. Mellon Foundation, Claneil Foundation, William Penn Foundation, and others.

SUMMARY

Although there is a diversity of funding sources for biodiversity research and conservation in Pennsylvania, the amount of money available does not come close to meeting the projected needs. For example, in 2001 the Wildlife Restoration and Conservation Program received proposals requesting more than $7 million for the $1.5 million earmarked for Pennsylvania. The Pennsylvania Biological Survey estimated in 1992 that at least $13 million per year was needed for basic research and inventory, education, and habitat acquisition.

In particular, funding to gather information on basic questions such as what plants and animals live in the state, where they live, and their ability to reproduce and thrive is limited. Lack of such fundamental knowledge about biodiversity in the state hampers efforts at conservation.

Conservation of biodiversity is vital to our ecological health, economic vigor, and the quality of life of all citizens. Government alone cannot undertake this task.

Conclusions and Next Steps

Biodiversity in Pennsylvania: Snapshot 2002 reveals that despite extensive knowledge about natural resource conservation in Pennsylvania and many activities focused on conserving wildlife and habitats, there is much we don't know about biodiversity in the state. Many gaps need to be filled.

In the face of this imperfect knowledge, one point is clear – sustainable use of our natural resources is critical for maintaining Pennsylvania's economic health, as well as the quality of life of all Pennsylvanians. Even with extensive technological advances and modern conveniences, our survival still depends on natural resources. Basic necessities, such as the air we breathe, drinkable water, and an adequate food supply, as well as medicines, fibers, and building materials are supplied by the other species that share this planet. Conserving biodiversity in Pennsylvania is essential not only for Pennsylvanians, but is also an important linking thread in the global web of life.

Despite the importance of biodiversity and the continuing threats to biological communities, Pennsylvania lacks a statewide strategy for biodiversity conservation. Critical habitats, plants, and animals are being lost every year in the Commonwealth due to development, neglect, and lack of coordination among interested parties.

This snapshot of biodiversity in Pennsylvania in 2002 provides insights that will guide a comprehensive statewide biodiversity conservation plan.

- Although scientists and naturalists have been collecting and studying Pennsylvania plants and animals for more than 250 years, no complete list of species exists.
- At least 150 species have been lost from the state and more than 350 are presently endangered.
- Biodiversity information is scattered among state agencies, museums, universities, conservation organizations, and private individuals, in a wide variety of formats not readily accessible through modern technology.
- Responsibility for monitoring plants, birds, mammals, fish, amphibians, reptiles, mussels, and aquatic insects is divided among state agencies. No government entity has oversight for terrestrial invertebrates – the most diverse group of organisms in the state.
- Many sectors of Pennsylvania's economy impacted by natural resource policies have not been involved in biodiversity conservation initiatives.
- There is still much to learn about the interrelationships among organisms and how we can better manage biodiversity.
- Realistic and measurable goals and assessment strategies are needed to know where problems exist and the degree to which reintroductions, restoration efforts, and management practices actually improve the state's biodiversity resources.
- Past natural history studies and conservation efforts focused on either the eastern or western part of the state, and rarely looked at Pennsylvania as a whole. In addition, most efforts have focused on rare and endangered species with no programs for monitoring all native species.
- We need more information on how to control the invasive species threat and how to predict which plants or animals might become invasive.
- Additional tools are needed to enable more private landowners to voluntarily enhance native biodiversity on their own lands.
- Some educational materials on biodiversity exist, but there is no organized means to augment these materials and extend them to adult audiences.
- Although diverse funding sources exist for research and conservation of Pennsylvania biodiversity, the available money does not come close to meeting the projected needs.

Pennsylvania Biodiversity Partnership

Understanding and conserving the web of life in Pennsylvania demands a comprehensive view. This can only be achieved with the participation of all organizations, agencies, and individuals involved in biodiversity studies or impacted by the loss of biodiversity. To this end, the Pennsylvania Biodiversity Partnership (PBP) was created in 2000 in direct response to a recommendation made by the Pennsylvania 21st Century Environment Commission.

PBP is a broad-based, public-private partnership formed to promote the conservation of native species and their communities. PBP is unique in bringing together – as equal partners –

What You Can Do

- Get involved in efforts to conserve Pennsylvania's biodiversity.
- Contact the Pennsylvania Biodiversity Partnership (412-481-4100; pbpinfo@pabiodiversity.org) or visit PBP's website at www.pabiodiversity.org.
- Attend regional meetings to assist in development of the Pennsylvania Biodiversity Conservation Plan.
- Participate in community dialogues on conservation issues.
- Adopt best management practices for conserving biodiversity on your own lands.

organizations and individuals with diverse interests and backgrounds. PBP members represent conservation and environmental organizations, government agencies, business and industry, scientists and academic institutions, sportsmen, and private landowners.

PENNSYLVANIA BIODIVERSITY CONSERVATION PLAN

Even though PBP members represent a wide range of backgrounds and opinions, a consensus quickly emerged on the priority of developing a comprehensive statewide plan for conserving Pennsylvania's biodiversity. *Biodiversity in Pennsylvania: Snapshot 2002* summarizes the present state of biodiversity in Pennsylvania. It is the first step in a multi-year process to formulate the *Pennsylvania Biodiversity Conservation Plan (BCP)*.

Phase One focused on a literature-based synthesis of the present status of biodiversity in Pennsylvania, which is summarized in this *Biodiversity in Pennsylvania: Snapshot 2002*. The full reports on which this summary is based are available on PBP's website at www.pabiodiversity.org.

Phase Two will build on this baseline information and concentrate on preparing the *Blueprint for the Pennsylvania Biodiversity Conservation Plan*. This document will:

- Pinpoint gaps in our knowledge of Pennsylvania's biodiversity.
- Identify ways to fill the gaps and begin the process to achieve this goal.
- Consolidate recommendations on biodiversity from existing reports and strategic plans and begin to formulate additional recommendations.
- Begin to develop criteria by which biodiversity can be objectively measured and to establish baselines against which future trends can be evaluated.
- Provide a blueprint for how to achieve the final *Pennsylvania Biodiversity Conservation Plan*.

These documents will serve as the focus of regional meetings in Phase Two and Phase Three, with expected completion of the *Pennsylvania Biodiversity Conservation Plan* in 2005. All Pennsylvanians are welcome to participate in this process.

Pennsylvania Biodiversity Conservation Plan Timetable

Phase	Activities
Phase One **Biodiversity in Pennsylvania - Snapshot 2002** **2001-2002**	• Baseline report on present state of biodiversity as we know it. • Research current conditions and information.
Phase Two **Blueprint for the Pennsylvania Biodiversity Conservation Plan** **2002-2003**	• Conduct regional meetings of organizations and individuals interested in biodiversity issues. • Pinpoint gaps in our knowledge. • Identify ways to fill gaps and begin the process to achieve this goal. • Continue information gathering. • Consolidate existing recommendations. • Provide a blueprint for achieving the Pennsylvania Biodiversity Conservation Plan.
Phase Three **Draft Pennsylvania Biodiversity Conservation Plan** **2003-2004**	• Continue regional public meetings. • Solicit additional recommendations and comments. • Prioritize recommendations. • Continue information gathering.
Phase Four **Pennsylvania Biodiversity Conservation Plan** **2005**	• Finalize and publish document. • Partners begin implementation.

Benefits of a Statewide Biodiversity Conservation Plan

- Facilitate interactions among groups concerned with biodiversity.
- Increase cooperation and coordination among government agencies, organizations, business, and individuals involved in biodiversity issues.
- Minimize duplication of efforts among organizations.
- Establish informed priorities for inventory, monitoring, and conservation at a statewide level.
- Develop educational and training materials for managing and enhancing Pennsylvania biodiversity.
- Increase voluntary stewardship of biodiversity and thus avoid the need for additional regulations.
- Increase educational opportunities regarding the impact and importance of biodiversity to our lives and to the ecological and economic health of Pennsylvania

Sustainable use of our natural resources is critical for maintaining Pennsylvania's economic health as well as the quality of life of all Pennsylvanians.

Appendix

Selected Best Management Practices for Enhancing Biodiversity in Pennsylvania

Forestry

Best Management Practices for Pennsylvania Forests. Pennsylvania State University, College of Agricultural Sciences (2001).

Finley, J.C. *Forest Biodiversity Booklet: Biodiversity Assessment*. Pennsylvania State University, College of Agricultural Sciences, Cooperative Extension.

O'Donnell, E.M., C. Pickens-Schweitzer and S. Chunko. *Forest Stewardship, Understanding and Conserving Biological Wealth in Our Forests.* Pennsylvania Forest Stewardship Program Number 9 (1996).

Stream/Riparian Management

Adams, C., et al. *Stream Corridor Restoration: Principles, Processes and Practices*. USDA (1998).

Banski, K., et al. *Establishing Vegetative Buffer Strips Along Streams to Improve Water Quality*. Pennsylvania State University, College of Agricultural Sciences (1996).

Suburban/Urban Development

Adams, L.W. and L.E. Dove. *Wildlife Reserves and Corridors in the Urban Environment – A Guide to Ecological Landscape Planning and Resource Conservation*. National Institute for Urban Wildlife, Columbia, MD (1989).

Peck, S. *Planning for Biodiversity Issues and Examples*. Island Press (1998).

Pennsylvania Handbook of Best Management Practices for Developing Areas. Pennsylvania Association of Conservation Districts, Inc., et al. (1998).

Wetland Management

Brooks, R., D. Devlin, and J. Hassinger. *Wetlands and Wildlife*. Pennsylvania State University, College of Agricultural Sciences (1993).

Cole, C.A., et al. *Managing Your Restored Wetland*. Pennsylvania State University, College of Agricultural Sciences (2000).

Landscape Management

Harker, D., et al. *Landscape Restoration Handbook*, 2nd ed. Audubon International, Lewis Publishers, New York (1999).

Szaro, R.C. and D.W. Johnston. *Biodiversity in Managed Landscapes Theory and Practice*. Oxford University Press (1996).

Agriculture

Commonly Used Conservation Practices. USDA, Natural Resources Conservation Service.

Dufour, Rex. *Farmscaping to Enhance Biological Control* ATTRA, www.attra.org (2000).

Land Management/Individual Land Plans

Leslie, M., et al. *Conserving Biodiversity on Military Lands – A Handbook for Natural Resource Managers*. Department of Defense – Biodiversity Initiative, The Nature Conservancy (1996).

Maryland's GreenPrint Program. *Preserving Our Green Infrastructure and Safeguarding Maryland's Most Valuable Ecological Land*. Maryland Department of Natural Resources, www.dnr.md.us/greenways/greenprint/greenprint.html (2001).

Wildlife Management

Devlin, D. and J. Payne. *Pennsylvania Woodland Wildlife Management*. Pennsylvania State University, College of Agricultural Sciences.

Enhancing Wildlife Habitat – A Directory of Wildlife Enhancement Demonstration Sites in Pennsylvania. Pennsylvania State University, College of Agricultural Sciences (1997).

Hassinger, J. and J. Payne. *Pennsylvania Woodlands – Dead Wood for Wildlife.* Pennsylvania State University, College of Agricultural Sciences.

Pennsylvania Wildlife Series. Pennsylvania State University, College of Agricultural Sciences (1997).

General Management

Backyard Conservation: Bringing Conservation From The Countryside to Your Backyard. USDA, National Association of Conservation Districts and Wildlife Habitat Council.

Nature Serve. www.NatureServe.org.

Vickerman, S. *National Stewardship Incentives Conservation Strategies for U.S. Landowners*. Defenders of Wildlife (1997).

Invasive Species Management

Management Plan, Meeting the Invasive Species Challenge. National Invasive Species Council, http://www.invasivespecies.gov/council/mp.pdf (2001).

Pennsylvania Department of Conservation and Natural Resources, *Invasive Plants of Pennsylvania.*

Additional Reading on Pennsylvania Biodiversity

Brauning, D.W., ed. 1992. *Atlas of Breeding Birds in Pennsylvania*. University of Pittsburgh Press, Pittsburgh, PA.

Felbaum, E, et al., eds. 1995. *Endangered and Threatened Species of Pennsylvania*. Wild Resource Conservation Fund, Harrisburg, PA.

Fergus, C. 2000. *Wildlife of Pennsylvania and the Northeast*. Stackpole Books, Mechanicsburg, PA.

Fike, J. 1999. *Terrestrial and Palustrine Plant Communities of Pennsylvania*. Pennsylvania Department of Conservation and Natural Resources, Harrisburg, PA; The Nature Conservancy, Middletown, PA: and Western Pennsylvania Conservancy, Pittsburgh, PA.

Hassinger, J.D., et al., eds. 1998. *Inventory and Monitoring of Biotic Resources in Pennsylvania*. Pennsylvania Biological Survey, University Park, PA.

Haywood, M.J. and P.T. Monk. 2001. *Wildflowers of Pennsylvania*. Venture Graphics, Inc., Pittsburgh, PA.

Hulse, A.C., C.J. McCoy, and E.J. Censky. 2001. *Amphibians and Reptiles of Pennsylvania and the Northeast*. Cornell University Press, Ithaca, NY.

Korber, K. and H. Korber. 1994. *A Viewer's Guide to Pennsylvania Wildlife*. Northwood Publications, Inc., Lemoyne, PA.

McElfish, J.M, Jr. and J.B. Wilkinson. 2000. *Forests for the Bay*. Environmental Law Institute, Washington, DC.

McWilliams, G.M. and D.W. Brauning. 2000. *The Birds of Pennsylvania*. Cornell University Press, Ithaca, NY.

Merritt, J.F. 1987. *Guide to the Mammals of Pennsylvania*. University of Pittsburgh Press, Pittsburgh, PA.

Rhoads, A.F. and T.A. Block. 2000. *The Plants of Pennsylvania: An Illustrated Manual*. University of Pennsylvania Press, Philadelphia, PA.

Steiner, L. 2002. *Pennsylvania Fishes*. Pennsylvania Fish and Boat Commission, Harrisburg, PA.

Tekiela, S. 2000. *Birds of Pennsylvania: Field Guide*. Adventure Publications, Cambridge, MN.

Thorne, S.G., et al. 1995. *A Heritage for the 21st Century: Conserving Pennsylvania's Native Biological Diversity*. Pennsylvania Fish and Boat Commission, Harrisburg, PA.

Critical habitats, plants, and animals are being lost every year in the Commonwealth due to development, neglect, and lack of coordination among interested parties.

Pennsylvania Biodiversity Partnership

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