LEGACY
Conserving New York State’s Biodiversity
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Acknowledgements

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- American Museum of Natural History, Center for Biodiversity and Conservation
- New York State Biodiversity Research Institute
- New York State Department of Environmental Conservation
- New York Natural Heritage Program
- The Nature Conservancy

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New York’s landscape is large and richly varied. Our more than 47,000 square miles include mountains, plains, valleys, and seashores. More than four-fifths of our uplands consist of farmland or woodland. Our abundant water resources include more than four million acres of freshwater lakes and ponds, 70,000 miles of rivers and streams, and more than 200 miles of marine coastline. These ecosystems provide a place to live for thousands of species of plants and animals. The total of all these living things is our biodiversity.

Although biodiversity is a new word to many, most of us appreciate New York’s biodiversity in our daily lives. Some of us actively seek out a special type or group of living things. Birders, naturalists, hunters, anglers, collectors, scientists, students, hikers, tourists, and just casual observers of the natural world may seek out particular plants or animals for pleasure, for learning, or for food. Others of us simply sense the richness of the landscape when we drive past a vividly varied meadow or flaming fall forest. Perhaps we tune in to the sounds of orioles or spring peepers or katydids. Maybe we savor the differing flavors of walleye or venison or scallops—or of maple syrup or wild leeks or beach plums. Even aromas—the salt marsh at low tide, the pine woods in early morning, or the skunk in the night air—are all the bounty of our biodiversity. Most of us enjoy our biodiversity without being able to give it a name.

As you will learn in the following pages, New York’s biodiversity is continually at risk from a multitude of factors. There are many in government, conservation organizations, the academic world, and private individuals who are working to ensure a bright, healthy future for all of New York’s living things, and among the challenges we face is how we can raise everyone’s awareness of biodiversity. This book is a great place to begin. Let it teach you new things about the world around you, and share it with as many as you can.

George E. Pataki
Governor
For Wilde beasts there is Deer, Bear, Wolves, Foxes, Raccoons, Otters, Musquashes and skunks. Wild Fowl there is great store of, as Turkeys, Heath hens, quails, partridges, pidgeons, cranes, geese of several sort, Brants, Ducks, Widgeon, Teal and others. There is also the red bird, with divers sorts of singing birds whose chirping notes salute the ears of travelers with an harmonious discord, and in every pond and brook green silken frogs, who warbling forth... strive to bear a part in this music.

—Daniel Denton
A Brief Description of New York, Formerly Called New Netherlands, With the Places Thereunto Adjoining 1670
What is Biodiversity & Why Should We Care?

From the rocky summits of the Adirondack High Peaks to the hundreds of miles of shoreline along the Atlantic Ocean and the Great Lakes, New York State’s rich mosaic of wild habitats supports an abundant variety of life. The exact number of species that live in the state is not known, but there are likely tens of thousands—possibly even more.

Scientists and others concerned with the health of the planet refer to the variety of plant and animal life in any environment as its biodiversity. Biodiversity includes the variety of species in all groups of organisms—all life on Earth, even fungi, and microbes that can’t be seen by the naked eye. Biodiversity also refers to the genetic diversity within species. For example, a number of varieties of apples grow in New York State, such as Empire and Cortland; each has its own unique flavor and texture, and is adapted to particular growing conditions. Genetic diversity partially accounts for why plants, animals, or fungi of the same species have different characteristics, and why living things have been able to adapt to Earth’s wide variety of environments. Genetic variability provides raw materials as building blocks by which new species arise through evolution.

Finally, biodiversity also refers to the array of natural communities, ecosystems, and landscapes within which species evolve and coexist. Ecosystems and landscapes are all-encompassing, including not only the forms of life that exist at a place, but also the ways in which living organisms interact with each other, and with their physical environments.

Why Care About Biodiversity?

It’s hard to overstate the importance of biodiversity to the environment, to our state’s economy, and to each of us in our daily lives. Biodiversity provides us with natural resources for food, medicine, building materials, fibers, and fuel. It performs vital ecological services that maintain the environment—processes necessary for us and for other species. New York’s forests help keep our air breathable by creating oxygen through photosynthesis, removing carbon dioxide, and filtering pollutants. Our freshwater and tidal wetlands reduce the severity of floods, and keep pollutants from entering water supplies. Natural pollinators, such as bees and wasps, fertilize flowers, ensuring that farmers reap bountiful crops and that beautiful gardens abound. If our natural pollinators no longer existed, farmers would be forced to perform the task of fertilizing their fruit and vegetable crops by hand—a virtually impossible task.

A bumblebee dines on nectar from a zinnia blossom—and in the process helps propagate the plant by spreading pollen.

A great egret’s patient streamside vigil is rewarded by a fish—which may have just eaten a mouthful of aquatic insects. All are interconnected parts of the intricate web of life.

Areas along the Cattaraugus Creek in western New York provide homes for various species of fish, aquatic insects, mussels, waterfowl, and plants. All have adapted to living in these sections of river, with their riffles, pools, and cobbled riverbeds. The particular combinations of species at those locations, and the ways in which they interact with their physical and chemical environments, are what define the Zoar Valley’s river ecosystem.

Crisp and sweet, a basket of fresh-picked Cortland apples awaits eating. Several apple varieties populate New York’s orchards and backyards, enriching the state’s natural beauty, quality of life, and economy.
New York’s biodiversity gives us tangible economic benefits. The forest products and commercial fishing industries support jobs with billions of dollars in payrolls and sales. Products and services sold to hunters, anglers, and other outdoor enthusiasts generate billions more.

Biodiversity also carries immeasurable aesthetic value and helps make New York unique. Imagine our state without the splash of trout in a Catskill Mountain stream, the whisper of pines in an Allegany forest breeze, or the dawn chorus of spring birds in Central Park. We rely on biodiversity for enjoyment and recreation, spiritual fulfillment, and cultural heritage.

Perhaps most importantly, biodiversity has intrinsic value, defined as the worth of all beings in and of themselves, regardless of their value to humans or other species.

**Threats to Biodiversity**

Worldwide and within our state, biodiversity is declining. While the Earth has always experienced environmental changes and species loss, this time the changes are thought to be caused predominantly by human activity and are occurring at an unprecedented rate. The primary threat to biodiversity is the loss, fragmentation, and degradation of habitat. Other key threats include invasive species, pollution, over-consumption, and global climate change.

In New York, the Natural Heritage Program tracks 745 plant species, 433 animals, and 170 natural communities native to the state that are exemplary, rare, or of special concern. About half of these are in jeopardy (see box above). As yet, there is no good measure of the status of most invertebrate animals and microorganisms, although many of these are at risk as well.

One key step to preserving our state’s biodiversity is to increase awareness of what it encompasses and why it is so important. This is why we have created this book. The following chapters describe the rich diversity of life in New York State, beginning with the physical environment that supports this life and then highlighting some features of New York’s biodiversity, from the microscopic world of fungi and bacteria to the macroscopic landscapes of fields and forests we inhabit. The final chapter offers recommendations to ensure that the biodiversity of New York State is preserved for us, for our children, and for generations to come.
Natural Settings: New York’s Physical Environment

Life exists in such diversity in New York because our state has a great variety of physical environments. These settings have been shaped by the interplay of climate, topography, and geology. Begun millions of years ago, the sculpting of the face of our landscape is continually changing.

Climate
Residents of Montague, N.Y., won’t soon forget the winter day in 1997 when 77 inches of snow fell in a 24-hour period, setting a nationwide record. The Tug Hill Plateau region, where Montague is located, typically gets the highest snowfall east of the Rocky Mountains: 20 feet per year on average. Meanwhile, the average annual snowfall for Central Park in New York City is just over two feet, highlighting the wide range of weather extremes that can be experienced across our state. Climatologists characterize most of New York (except for Long Island) as having a humid continental climate, with fairly cold winters and hot summers. The annual mean temperature is about 45ºF with winter temperatures averaging in the teens or twenties, and summer temperatures in the mid-60s to low 70s. The length of the growing season varies greatly throughout the state. Some areas of the Adirondacks have fewer than 100 frost-free days per year, while areas of Long Island have more than double that. The average annual rainfall for the state is approximately 39 inches. This varies considerably, with some areas of the Tug Hill Plateau receiving more than 50 inches per year, while some locations near the Saint Lawrence River or Lake Champlain receive less than 30 inches.

Geology and Soils
New York State has a long and complex geologic history. It includes continental collisions, volcanic eruptions, and several periods when oceans inundated the region. These events have shaped the geologic processes, and when combined with subsequent erosion, have produced a varied mosaic of rock types that make up the state’s bedrock geology.

Sedimentary rocks such as shale, sandstone, or limestone underlie the majority of the state. However, metamorphic rocks, composed primarily of gneisses with some areas of marble, dominate the bedrock geology of the Adirondacks and southeastern parts of the state. Interestingly, biodiversity has even had a role in the formation of some of our rocks. Approximately 390 million years ago, large areas of the state were submerged under a shallow, tropical ocean. Many marine organisms flourished, including brachiopods, clams, corals, and trilobites. When these organisms died, their remains—rich in calcium carbonate—were deposited on the ocean bottom. These calcium-rich sediments eventually solidified to become limestone, which today forms a band of rocks extending from Buffalo to Albany.
For the most part, New York’s surface topography was shaped during the last invasion of glaciers—the Ice Age. Roughly 22,000 years ago, during the late Pleistocene epoch, an immense prehistoric glacier called the Laurentide Ice Sheet covered all of what is now New York State except for a small area along the Pennsylvania border and parts of Long Island and Staten Island. More than a mile thick in some places, the ice completely buried even the highest peaks in the Adirondack Mountains. As the glacier slowly advanced, it completely scoured the soils from some areas, such as the Adirondacks, and reshaped mountain ranges. The glacier also carved out existing river valleys, making them broader and deeper, processes that created the Finger Lake basins in central New York and deepened the Hudson River. At its maximum extent, an “end moraine” formed, leaving the great 100-mile-long spit of land that is today Long Island. From this point, the glacier began its retreat northward, depositing in its melting wake vast amounts
Spruce-fir forests tolerate the harsh conditions of higher altitudes in the Catskill and Adirondack mountains.

New York’s steep upper slopes of the Adirondack or Catskill mountains are characterized by a relatively cool climate and poorly developed soils, which tend to be thin and highly acidic. While these environmental conditions exclude many plants that do not tolerate such conditions, there is a group of plants that thrive here. Red spruce and balsam fir are the dominant trees, while other species such as mountain paper birch or yellow birch occasionally intermix with the conifers. Beneath the tree canopy grow small herbs such as common wood-sorrel, bunchberry, mountain wood fern, and shining clubmoss.

Biodiversity also plays a critical role in soil formation. When the glaciers receded from New York, the barren landscape was colonized by an arctic tundra-like vegetation of lichens, mosses, and sedges, which over thousands of years were replaced by the trees, shrubs, and herbs we see today. When plants grow, they stabilize soil particles at a site and prevent erosion, which helps to build up soils. Plant roots also recycle nutrients from lower layers. When they die, all living organisms, particularly plants, leave organic materials in the soils that are eaten by a diverse community of soil organisms.

When physical factors of climate, topography, geology, and soils are combined in different ways, they create distinct environments. Each environment in turn determines what species and ecosystems are able to live there. For example, the steep upper slopes of the Adirondack or Catskill mountains are characterized by a relatively cool climate and poorly developed soils, which tend to be thin and highly acidic. While these environmental conditions exclude many plants that do not tolerate such conditions, there is a group of plants that thrive here. Red spruce and balsam fir are the dominant trees, while other species such as mountain paper birch or yellow birch occasionally intermix with the conifers. Beneath the tree canopy grow small herbs such as common wood-sorrel, bunchberry, mountain wood fern, and shining clubmoss.
Inhabitants: Varieties of Life

While biodiversity represents the whole of the living natural world, and the ways in which its components interconnect, species are what come to mind when most of us think about biodiversity. We want to know what kinds of birds visit our porch feeder, what plants grow in our backyard, or what animals we might see on a hike.

Scientists define a species as a group of similar organisms that are distinct from other groups. Such distinctions can include appearance, adaptation, and behavior, but foremost is the ability of individuals in that group to interbreed. Recently developed molecular methods are also used to distinguish species by detecting genetic differences among representative members of different species.

Consider three of the 250 or so different species of birds known to nest in New York State: northern cardinals, eastern kingbirds, and American bald eagles. All three are grouped together as birds because they share certain characteristics; for example, they each have feathers and lay eggs. However, because they differ in their appearance, diet, and habitat use, and cannot mate with each other, they are considered to be separate species.

Although it is easy to spot differences between the bright red cardinal and the slate gray and white kingbird or a large, white-headed bald eagle, in some cases one cannot differentiate species simply by looking at them. Flycatchers in the genus *Empidonax*, small brownish gray birds, are so similar in appearance that they are best identified by their songs—which vary considerably.

How Many Species Are There?

Biologists have identified and named approximately 1.75 million species of plants, animals, fungi, and microbes—and more are being discovered. Between 13 million and 100 million species are estimated to exist on Earth. Even in New York State, scientists are still finding new species.
LEGACY: Conserving New York State's Biodiversity

Number of Species in New York State

**Algae:** More than 2,000 freshwater species.

**Plants:** 3,603 species of flowering plants, trees, shrubs and ferns; over 650 different kinds of mosses, liverworts, and hornworts.

**Animals:** 32 amphibian species, 40 reptile species, 471 fish species (300 marine, 171 freshwater), 103 mammal species, and 462 bird species (247 breeding).

**Insects and Spiders:** 173 mayflies, 190 dragonflies and damselflies, 415 bees, 63 vespid wasps (e.g., hornets, yellowjackets, potter wasps), 142 butterflies and skippers, 3,300 moths, 4,120 species of beetles, and over 700 spiders.

**Crabs, Shrimps, and Crayfishes:** 74 species of crabs and shrimps, 13 species of crayfishes.

**Mussels and Snails:** 41 pearly mussel species, 67 freshwater snails, and 126 species of land snails.

Note: These numbers include both native and non-native species and represent a small sample of the many different species and species groups that can be found in the state. New surveys and more detailed studies of lesser-known groups of invertebrates, microbes, bacteria, and fungi will uncover more.

*Includes cyanobacteria (K: Eubacteria) and eukaryotic algae (K: Protoctista)

The numbers of species in our state and their distributions—where they can be found—vary over time and with changing environmental conditions. These changes can be natural and may occur on a very large scale. Prior to the end of the most recent ice age 10,000 years ago, New York was home to woolly mammoths and saber-toothed cats. They roamed extensive areas of tundra—the kind of frigid landscape usually found in or near the arctic. Over thousands of years, as temperatures warmed and the huge glaciers receded, tundra gave way to grasslands, and then to forest. As these habitats and associated species migrated northward, new woodlands, wetlands, and other habitats formed that were capable of supporting different suites of species.

Changes in natural communities also occur on a relatively small scale, such as when meadows change to forests over time, or when a beaver dam diverts water to create new wetland habitat. Some plants and animals adapted to the earlier community will perish, unable to survive in the changed environment. Others will move elsewhere to more suitable habitat. Still others remain, tolerating or even thriving in the new conditions. Even now, many thousands of years after the glaciers’ retreat, plant and animal species are still expanding and/or contracting their ranges in New York State.

Some recent range extensions have been attributed to climate change of a different nature—global warming. Most scientific authorities believe that this phenomenon is caused primarily by human activities, especially from the burning of fossil fuels, and it is considered to be one of the five main threats to biodiversity mentioned earlier. Global climate change directly affects regional weather conditions, altering patterns of precipitation, temperature, and storm severity. Sea level is predicted to rise dramatically, with consequences for New York’s coastal communities. In fact, each of these changes will significantly affect New York’s natural communities and their plant and animal inhabitants.

Human activity can both directly and indirectly modify species numbers and distributions in other ways. Commercial hunting and the clearing of the extensive forests of the eastern United States led to the extinction of the passenger pigeon at the end of the 19th century. People intentionally eliminated mountain lions, wolves, and other predators from the state. Humans have also indirectly caused species loss. Fungal diseases nearly wiped out the American chestnut and American elm after these diseases evidently entered the country on infected nursery stock imported from Europe. The precipitous decline of ospreys, peregrine falcons, bald eagles, and other bird species was due to the use of pesticides such as DDT—which was intended to eradicate pest insects. DDT sprayed on agricultural fields and in forests washed into waterways, contaminating aquatic insects. Fish that ate the contaminated insects were in turn eaten by birds and other predators. The accumulation of toxins that built up in the birds’ body tissues led to reduced reproduction, and ultimately, threatened their survival.

Species specialization: Top, cardinals have cone-shaped beaks for cracking seeds. Middle, the kingbird’s beak is sharp and pointed for grabbing insects. Bottom, eagles have large, hooked beaks for tearing flesh.

The seven-spotted lady beetle has been implicated as a factor in the disappearance of New York’s nine-spotted lady beetle (above). Seven-spotted lady beetles were brought here as pest control for aphids, and may have outcompeted the native beetle for food.

**Number of Known Species per Group**

More than 80 percent of all known life on Earth is composed of insects and other invertebrates. Plants and vertebrates (animals such as fishes, amphibians, reptiles, birds, and mammals) make up only a small fraction. Source: Scientific American, Nov 2001, Vol. 285, Issue 5, p. 44.
To address species declines, the New York State Department of Environmental Conservation and the New York Natural Heritage Program track species for the purpose of determining their status—whether endangered, threatened, rare, or of special concern. Species that are in imminent danger of extinction are termed “endangered.” Those likely to become endangered within the foreseeable future are termed “threatened.” Biologists work to protect these plants and animals and to restore habitats and species to the state.

In some cases human activity has increased species diversity in New York State—for better and worse. Early settlers to New York brought herbs and medicinal plants with them: coltsfoot for cough medicine, and bouncing bet for soap. Although not native to the state, these introduced plants and hundreds of others are now commonly found in fields and vacant lots. In the past, soil conservation agencies also introduced plants such as crown vetch to control soil erosion, and people continue to buy imported plant species for their gardens. People also import animals. Sportsmen, as well as state fish and wildlife agencies, have introduced animals for hunting and fishing: ring-necked pheasant, European hare, and brown trout, among others. Some unintentional animal introductions have also occurred. Round gobies, a fish from eastern Europe, first entered the Saint Lawrence Seaway in ship ballast water, and are now causing serious damage to freshwater systems. Scientists believe the recently arrived Asian longhorned beetle, a potential threat to New York forests if it spreads, was unintentionally transported to New York City in wooden packing material.

Even if well-intentioned, the introduction of these non-native species, particularly those that become invasive, is the number two global threat to biodiversity, second only to loss and degradation of species habitat. Many invasive species wreak havoc on New York’s natural ecosystems and native species. They displace the natives, alter ecosystem processes such as decomposition and the hydrologic and nutrient cycles, and cause billions of dollars in damage to the state’s environment.

Another example is the European starling, which was introduced into Central Park in 1890. These birds are now found continent-wide, and are considered a threat to native birds such as tree swallows, eastern bluebirds (New York’s state bird), and purple martins—with which they compete for tree-cavity nest sites. Multiflora rose and bush honeysuckles, imported as food plants to attract wildlife, as well as Japanese barberry and purple loosestrife, imported by horticulturists for their attractive appearance, are overwhelming New York State’s native forests, fields, and wetlands.

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### Examples of Extinct or Missing Taxa that Previously Occurred in New York State

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific Name</th>
<th>Date of Last Rangewide Record</th>
<th>Date of Last NYS Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A looper moth</td>
<td>Lambdina canniaria</td>
<td>1944</td>
<td>1944</td>
</tr>
<tr>
<td>A borer moth</td>
<td>Papaipema aerata</td>
<td>1963</td>
<td>1963</td>
</tr>
<tr>
<td>Aweme borer</td>
<td>Papaipema aweme</td>
<td>1932</td>
<td>1932</td>
</tr>
<tr>
<td>Mammals</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Eastern cougar</td>
<td>Puma concolor couguar</td>
<td>1900</td>
<td>1894</td>
</tr>
<tr>
<td>Gull Island vole</td>
<td>Microtus pennsylvanicus nesophilus</td>
<td>1932</td>
<td>1836</td>
</tr>
<tr>
<td>Birds</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Labrador duck</td>
<td>Camptorhynchus labradorius</td>
<td>1875</td>
<td>1875</td>
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<tr>
<td>Carolina parakeet</td>
<td>Conuroopsis carolinensis</td>
<td>1914</td>
<td>1889</td>
</tr>
<tr>
<td>Passenger pigeon</td>
<td>Ectopistes migratorius</td>
<td>1914</td>
<td>1907</td>
</tr>
<tr>
<td>Eskimo curlew</td>
<td>Numenius borealis</td>
<td>1963</td>
<td>1932</td>
</tr>
<tr>
<td>Heath hen</td>
<td>Tympanchus cupido cupido</td>
<td>1932</td>
<td>1836</td>
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<td>Fish</td>
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<tr>
<td>Blue walleye (or blue pike)</td>
<td>Stizostedion vitreum glaucum</td>
<td>1971</td>
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<tr>
<td>Plants</td>
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<tr>
<td>Schweinitz’s waterweed</td>
<td>Elodea schweinitzii</td>
<td>1932</td>
<td>1816</td>
</tr>
<tr>
<td>Micranthemum</td>
<td>Micranthemum micranthemoideae</td>
<td>1941</td>
<td>1936</td>
</tr>
</tbody>
</table>

Right: A success story. New York lost its wild turkey population by the beginning of the 20th century due to unregulated hunting and loss of forest cover. After an intensive reintroduction program, coupled with regrowth of forest habitats, the species is now thriving.
Doing the Numbers
Observing where species live and recording their numbers is crucial to understanding ecosystem functions and better conserving biodiversity. Biologists in New York State have organized a number of surveys of plants, birds, amphibians, and reptiles. Volunteers search specific areas, keeping track of each species they find over several years. This information is then mapped to provide baselines of species distributions throughout the state. By repeating surveys periodically—usually every 10 to 20 years—we can see how species numbers and distributions change over time.

Since 1900, annual Christmas bird counts organized by the National Audubon Society have provided snapshots in time of which birds are present each December. Surveys of early summer breeding birds conducted since 1965 by volunteers for the U.S. Geological Survey have alerted us to the fact that many breeding populations are declining in New York and nationwide, and that we need to take action to conserve them. In New York, the Amphibian and Reptile Atlas and the Breeding Bird Atlas have identified concentrations of biodiversity, and have pinpointed areas in need of further study.

In addition to these volunteer surveys, professionals conduct scientific studies of species distributions throughout the state. Some individual specimens of species are collected as “voucher specimens” and preserved in such places as the American Museum of Natural History, the New York State Museum, the Buffalo Museum of Science, and in university museum collections. Each voucher specimen documents what was found living at a certain place and time. Of course, researchers generally do not actively collect endangered or threatened species. Much of what we know about the flora and fauna of New York’s past environments comes from reviewing these voucher specimens and museum records.

Biologists also study species distribution and abundance, behavior, interactions with other organisms, and what effects humans are having on them. By understanding these ecological factors, scientists are better able to manage populations and to prevent the decline or loss of some species.

Indiana bats are a case in point. For years, all we knew about these endangered bats was that they spent winters in certain caves and mines in New York State. Protection efforts therefore focused on these roosting sites. In 2002, biologists from the New York Department of Environmental Conservation fitted a number of the bats with radio transmitters and tracked their movements after they came out of hibernation. They found that during the summer months the bats moved out of hibernation. They found that during the summer months the bats moved

Invasion of the Worms

Even earthworms, so beneficial to agriculture, are causing problems for the forest ecosystems and processes that enliven many New York areas. Forest soil is created over many years as fungi, bacteria, and soil invertebrates break down and decompose leaf litter—the dried leaves that accumulate on the ground each year. Non-native earthworms occur in such high numbers in some forested areas that they are changing soil structure in part by consuming this leaf litter before it can be used by other forest invertebrates and fungi that are important for forest and soil health. The loss of the litter layer, in turn, makes the forest floor a less hospitable environment for birds, salamanders, insects, and forest plants. Many biologists are conducting surveys to track the spread of introduced Asian and European earthworms into our forests.
great distances to roosts under big slabs of bark on shagbark hickory, oak, and other trees, emerging at night to feed on insects at nearby wetlands. Surprisingly, many of these roost trees were found in suburban yards! The bats also established nurseries in the same trees. With this new knowledge, we can better protect this species’ summer breeding and feeding territory, as well as its over-wintering sites.

In sum, the more we know about each species and its ecological needs, the better able we are to protect the many species in our state.

Genetic Diversity

Diversity within species is remarkable—even where outward appearances might indicate otherwise. Scientists study genes to discover heretofore unsuspected differences and similarities between individuals within populations. They can do this because the genetic makeup of organisms of the same species varies. Today we continue to learn about genetic diversity with our increasing knowledge of DNA and genomics.

Though the world of genetic research may seem far removed from everyday life, genetic diversity is a critical element of biodiversity. As a general rule, the more genetic diversity a species has, the more genetically “healthy,” or adaptive, it is presumed to be. This adaptability enables a species to better respond to changes in its environment. For this reason, a lack of genetic variability such as has been found in North Atlantic right whales, cheetahs, and the Chittenango ovate amber snail—along with low population numbers—is thought to make a species vulnerable to extinction.

What is Rare?

What does it mean to be rare? Species can be considered rare if they occur over a small geographic range, in specific uncommon habitats, or if they naturally occur in low population densities. Species can be rare as a consequence of one or more of these characteristics.

• Species can be rare if they are found only in a localized area, such as the Chittenango ovate amber snail, whose entire population exists near Chittenango, New York, in an area the size of your living room. Another example of this type of rarity is the Hudson River water nymph, a plant, which has three known populations on the planet—all of them on tide-washed mudflats along the Hudson River.

• Species can be rare if they occur only in specific uncommon types of habitats, such as alpine summits or caves. For example, Boot’s rattlesnake-root is restricted to alpine summits on the highest peaks of the Adirondack Mountains and other northeastern peaks, and because its habitat is so limited, the plant is rare. In fact, only 12 known populations exist worldwide.

• Species can be rare if, whenever they are found, they occur in low population densities. The bobcat, for example, occurs throughout most of New York State, but it is secretive and occurs at such low densities that most New Yorkers have never seen one. As predators near the top of the food chain, bobcats require large areas of land to hunt for enough food to survive—hence their dispersed distribution.

• Rarity can be the result of natural circumstances or can be induced by habitat alterations caused by humans, leading to reduced population numbers in a species. For example, the silvery aster was once a common wildflower in Long Island’s maritime grasslands and pine barrens. But the silvery aster has declined as its natural habitat has been almost completely destroyed by development.

The status of such imperiled species must be considered both within New York and across their total geographic range. Species can be rare in New York but common elsewhere. This generally occurs when New York is on the edge of a species’ range—that is, the limits of the environmental conditions to which it is adapted. Shortleaf pine, for example, has only one stand in New York (on Staten Island), but is abundant farther south. Species growing at the edges of their ranges experience different environmental conditions from those in other areas. Compare the climate of Georgia, where shortleaf pine is also found, to that of New York. Through time, these differences can lead to the evolution of unique sets of genetic traits—which could help the species survive—and even lead to new species.

The degree and type of rarity and imperilment facing a species is an important consideration for state and federal officials when making decisions about listing species as endangered or threatened.
Almost every New Yorker recognizes the Canada goose, with its famous honk and distinctive color scheme of white cheeks on a black stocking. But careful observers know that not all Canada geese are the same. Genetic diversity has resulted in at least four distinct types—or subspecies—here in the Empire State. These subspecies exist because Canada geese use four separate breeding grounds, each characterized by differences in climate, food availability, and predators. Such environmental differences have led to the development of genetic differences in each breeding population, which, over time, could give rise to new species. In fact, the smallest Canada goose subspecies differs so much from the others that it is now considered to be a separate species: the cackling goose.

Scientists identify different organisms (individuals or species) and determine their relationships by mapping and comparing the variation in their DNA as they would any other physical feature. And, because this variation is handed down from generation to generation, it can help researchers track species ancestry. Such genetic information is an important tool for scientists as they determine what conservation actions to take to preserve biodiversity.

**Migration**

Many species do not live year-round in New York State but only visit during part of the year. For example, the songbirds that nest in the state’s woods and fields each summer, such as warblers, orioles, tanagers, and flycatchers, migrate to more southern regions each winter. Other birds do not even nest here, only stopping temporarily to rest during migration. Although millions of songbirds do migrate through the state each spring, most of us are unaware of their passing overhead because they fly at night. But come dawn, they land to rest and feed before continuing their journeys, a treat for early morning birders.

Each fall, cold northwest winds bring shorebirds, songbirds, waterfowl, hawks, and owls south through the state, using the Shawangunk Mountains and other ridges and coastal beaches as their guides.

Birds aren’t the only animals that migrate long distances out of state each year. Many insects also move to warmer conditions in the autumn. Monarch butterflies leave their fields of milkweed in New York to fly more than 2,000 miles to their wintering sites in the mountains of Central Mexico. They make the trip in about six weeks. American painted lady butterflies and some of our largest dragonflies, such as the green damselfly, also migrate to and from New York.

Some fish, such as striped bass, Atlantic sturgeon, and American shad, also make long migrations from river to ocean as young, then return from ocean to river to spawn as adults. Even some mammals migrate out of state. The Indiana, little brown, and many other bats remain and hibernate in abandoned mines and caves. But others, like the eastern red, hoary, and silver-haired, leave the state each fall to spend the winter in warmer climates.

Many other bats remain and hibernate in abandoned mines and caves. But others, like the eastern red, hoary, and silver-haired, leave the state each fall to spend the winter in warmer climates.
Ecological Communities: How We All Live Together

Ecological communities are recurring groups of plants and animals found in particular physical environments. New York’s diverse mosaic of these communities includes salt marshes, alpine meadows, spruce-fir forests, hay fields, and even vacant urban lots. Each community type has a unique set of environmental conditions. They support species that have evolved to live in those conditions.

These communities also tell us what is happening in a local environment. Plants are usually indicators of underlying physical and biological processes. And vegetation provides the physical structure on which most animals and microbes depend.

For the purposes of this book, we have grouped New York’s many ecological communities into the following broad categories: forests; grasslands, shrublands, and woodlands; freshwater wetlands; rivers and streams; lakes and ponds; beaches, bays, and ocean; and cities, suburbs, and farms.

**Forests**

In less than a day’s drive, a traveler passing across New York State can see forests at opposite ends of a spectrum: from dry, open, and sunlit stands of oak-pine forests on Long Island, to moist, dense, dark expanses of spruce-fir forests along the road to Whiteface Mountain in the Adirondacks. Along the way, this traveler might see more than 125 tree species.

But forests are much more than stands of trees. They are complex ecosystems encompassing the forest canopy; understory trees and shrubs; communities of flowering herbs, ferns, and mosses; the leaf litter layer; soil-dwelling organisms; and rich assemblages of wildlife. This diversity forms the core of many of our most beautiful and valued landscapes, providing year-round recreation and inspiration, from the advent of spring wildflowers to the state’s renowned pageant of autumn color.
The economic value of forests and the species that live in them is substantial. Forests provide lumber for construction, furniture, shipping materials, athletic equipment, and many other purposes. Forests also provide pulpwood for paper products, wood for fuel, fruits, and maple syrup, and stock for nurseries. In fact, New York's forests are an important source of timber products for the entire Northeast. The wood products industry is one of the largest manufacturing sectors in the state.

Ecological Processes

Forests play an integral role in the planet's basic systems. Absorbing or reflecting sunlight falling on its canopy, a forest can affect the local climate by keeping the air cooler and more humid, especially welcome during the warmer months. Forests affect the cycling of water, air, and nutrients. They maintain water quality and quantity as they capture, store, and use rainfall, runoff, and groundwater. Forest plants use carbon dioxide from the atmosphere, replacing it with oxygen. When mixed with sunlight, oxygen, and nutrients from the soil, the carbon is stored as cellulose and sugars in the plants. Carbon "travels" to other life forms as forest plants are consumed by animals, or decomposed by fungi and bacteria. Forests are home to a multitude of plants and animals. Some of our most cherished wildflowers—including "spring ephemerals" such as trillium, bloodroot, and trout lily—grow only on the forest floor. Some mammals, such as moose, black bear, and American marten, do best only in large, unfragmented forests. Similarly, more than 20 species of birds in New York State, including the large, bold goshawk and the diminutive, shy Blackburnian warbler, nest only in the interior of forests unbroken by roads or development. And our most abundant forest vertebrate, the red-backed salamander, does best in mature hardwood forests.

Decaying leaves on the forest floor—known as leaf litter or duff—support rich communities of life. The beetles, sow bugs, slime molds, and nematodes that break down and decompose these leaves ensure that the nutrients will be used over and over by many different living things. The nitrogen atom in a scarlet oak today may eventually find its way to a scarlet tanager tomorrow, thanks to forest recycling systems.

Cathedrals

Some of New York’s old forests have the tall, graceful, cathedral-like canopies and open understories that people associate with “old-growth” forests. Others appear messy—hardened survivors of hundreds of years of wind, ice storms, fires, Nor’easters, and even hurricanes. Either way, old-growth forests usually make a lasting impression on visitors.

New York has the Northeast’s greatest assemblage of old-growth forests, more than 200,000 acres, mostly in remote areas of the Adirondack and Catskill mountains. Yet this acreage represents just over 1 percent of the nearly 19 million acres of forests in New York. Allegany State Park has approximately 5,000 acres of old-growth forest, and much smaller patches are scattered throughout the state.

Old-growth is a condition of a forest, not a type of forest. The core concept in “old-growth” involves the dominance of long-lived species such as hemlock and sugar maple (which can live for more than 300 years), rather than short-lived species like jack pine and quaking aspen. Old-growth is more than just old trees. It is a stage in the life of certain forest types, and as such includes many other forest species and the ecological processes that support them.

Paradoxically, “healthy” old-growth forests are full of dying, dead, and fallen trees. While still standing, their hulks provide nesting cavities for birds like barred owls and mammals like red squirrels. Once fallen, their rotting trunks and branches enrich the soil by adding nutrients essential to the next generation of trees. The fallen trees also make the floor of an old forest uneven, peppered with pits and mounds. This is because as trees fall, their upended roots tear holes in the earth. As the roots rot, the soil captured among them falls to the ground, creating mounds. When a tree is completely gone, all that remains is a pit and a mound. Falling trees also create openings in the canopy, fostering new growth and giving old forests a wide range of tree sizes and ages. In contrast, forests that were cleared in the recent past typically have trees of similar ages and sizes.
New York’s present-day forests are products of a period of profound change. When European settlers first arrived in New York, the state was predominantly forested. However, by the 1920s less than one-quarter of these forests remained, due to land clearing for agriculture and fuel. Today, many of New York’s forests have regrown, and more than 60 percent of the state is once again covered with trees. This dramatic increase in tree cover stems mostly from regrowth on abandoned farmlands, a process that has been unfolding in many places for more than a century.

**Forest Types**

Many forest types characterize New York’s wooded landscape. Their composition and distribution are shaped by the vegetation of surrounding regions and by local soil type, moisture, and climate. Latitude and elevation are important too, with human disturbance also playing a role in determining forest makeup.

The state’s large size, its geology and topography, and its wide latitudinal (north-south) range all contribute to a varied and uneven distribution of common forest types. Adjacent regions share several of these types. Mid-southern and western New York State lie astride the woodlands of the Allegheny Plateau and the tributary watersheds of the Ohio Valley. Along the south and east are maritime forests, lowland woodlands of the mid-Atlantic floodplain, and ridge and mountain forests characteristic of the Appalachians. To the east are the hardwood and evergreen forests of New England.

To the north, especially in the mountains, we encounter forests more typical of Canada and the edges of the Arctic.

**Examples**

**Mixed Conifer-Northern Hardwood Forests**

Mixed conifer-northern hardwood forests occur throughout much of the state. Depending upon location, this widespread “mixed” forest type is dominated by eastern white or red pine, eastern hemlock, red spruce, American beech, sugar and red maple, and yellow birch. In the Adirondack and Catskill mountains, red spruce and balsam fir occupy extensive areas of high elevations. Paper and yellow birch may be typical neighbors. At the state’s highest elevations, the climate is so severe that forests can only exist as communities of stunted trees, shrubs, and wildflowers such as bunchberry, goldthread, and Canada mayflower.

The northern hardwood forests are found at higher elevations throughout the Catskills, the Adirondacks, the Tug Hill region, and the Allegheny Plateau. They consist of sugar maple, American beech, and yellow birch, with occasional appearances of American basswood, black cherry, and white ash. Oak-hickory forests grow throughout the Catskills and the Allegheny Plateau up to moderate elevations, and are widespread in the Hudson Valley. Dominant tree species in this type include four different oaks: black, chestnut, northern red, and white. They also include three hickories: pignut, shagbark, and sweet pignut, along with red maple, white ash, sweet birch, and eastern hophornbeam.

**Short but Sweet**

Listed by the state as a threatened species, the green gentian grows as a low, leafy mound for 3 to 25 years in sunny parts of rich, moist forests. It is easily overlooked by hikers and naturalists. At some point it begins to grow a six-foot tall stem capped by a mass of greenish-yellow flowers with purple spots. This is its only chance at reproduction. After releasing its pollen (and capturing some from other green gentian plants if all goes well), it disperses its seeds and dies.
Appalachian Forests

Appalachian forests are known as “rich mesophytic” forests because of their high diversity of tree species (“rich”), and their need for moderate amounts of water (“mesophytic”). Dominated by stately trees such as American beech, black cherry, sugar maple, basswood, cucumber tree, and northern red oak, the best examples of these forests are found in parts of the Southern Tier, in south central New York State.

Oak-Pine Forests

Oak-pine forests thrive in drier areas. Populated by four species of oak—northern red, scarlet, white, and black—and by red and eastern white pines, these forests are found primarily in the coastal lowlands of southern New York and the Hudson Valley, as well as in areas in western New York.

Conservation Challenges

Despite the dramatic regrowth of New York’s forests during the 1900s due in part to a decline in agriculture, many threats must be addressed if forest biodiversity is to be preserved. “Rural sprawl”—ongoing land clearing for residential development and road-building—is fragmenting forested areas into ever-smaller pieces. Fragmentation inhibits the necessary movement of native species, and facilitates invasion of non-native plants and animals.

Another effect of fragmentation is that it often creates conditions favored by white-tailed deer. Because deer feed heavily on seedlings and plants that live near the ground, an overabundance of deer can threaten the regeneration of forests, and thus reduce diversity in general. Overbrowsing can eliminate plants like the showy ladyslipper and white trillium. It can also drive away other wildlife, including ground-nesting birds like the ovenbird, which requires low-growing plants for food, cover, and nesting.

A variety of strategies are available to combat forest fragmentation threats. Public agencies and private conservation organizations continue to acquire important forest properties for protection as public parks and natural areas. Other lands can be conserved through “working forest” conservation easements—permanent legal documents that retain land in private ownership, but prohibit subdivision or development, and require sustainable forestry practices. At the local government level, sound land-use planning can steer future development away from intact forested areas. Maintaining state and federal funding for open space land acquisition efforts remains a key conservation strategy.

Unsustainable logging practices, often driven by high property taxes, present another threat to forest health. Over 80 percent of New York's forests are privately owned. Many are fragmented into small parcels with various management practices. New York administers a number of programs aimed at enhancing the stewardship of private forests. For example, the state’s Department of Environmental Conservation provides grants to assist forest owners in preparing Forest Stewardship Plans to protect wildlife habitats, water quality, and other ecological values. Similarly, landowners who agree not to develop forestland, and to manage it under a state-approved timber plan, are eligible for an 80 percent reduction in their local property taxes. Additional public funding is needed to enhance these and other programs designed to improve private lands stewardship.

In addition, several private sector programs have begun “certifying” forest owners who meet a comprehensive set of sustainable forestry practices, including biodiversity protection. Forest product companies, public land managers, and individual woodlot owners are increasingly recognizing the benefits of progressive management practices. New York State should encourage greater participation in these sustainable forestry programs.

Forest Succession

Even in areas of the state that were never cleared for farming, new generations of trees succeed old ones—a process called succession. For example, extensive forests of mature paper birch and aspen rose in the Adirondacks after wildfires that occurred in the early 1900s. As these trees reach their maximum life spans and die, they are being replaced by northern hardwoods like American beech and sugar maple, and by cone-bearing evergreens (conifers) like white spruce and balsam fir. Fifty years from now, unless natural fires set back succession, most of the paper birch and aspen that frame many of the more beautiful settings in the Adirondacks will be only a memory.
Several diseases and pests are harming our forests. Such prominent tree species as American beech, American elm, eastern hemlock, and butternut are currently being threatened by organisms imported to North America from other parts of the world. Even other tree species threaten our forest diversity. The sugar maple is at risk, not only from the Asian longhorned beetle, but also from the Norway maple, a European tree that is commonly planted as a shade tree in cities and suburbs. It is now replacing the sugar maple and other native tree species in some areas.

New York needs to join with neighboring states and the federal government to accelerate efforts to prevent introductions of new forest diseases, and to support research into mechanisms for reducing the impacts of pests and pathogens that already have found their way to the state.

Changes in the air threaten forest diversity. Acid rain is a likely contributor to spruce mortality in the Adirondack Mountains, and may be exacerbating other forest health problems, such as the inability of sugar maples to reproduce. Pollutants from the atmosphere that settle onto the land may be reducing the resiliency of forest ecosystems by acidifying the soil and adding nutrients such as nitrogen and sulfur, harming the plants and animals that live on the forest floor. Recent research has implicated the deposition of mercury in New York’s mountain forests as a threat to nesting songbirds like Bicknell’s thrush.

In the future, global climate change will place new stresses on our forest ecosystems as temperatures and precipitation patterns change. Some climate models predict that New York’s weather a century from now will have warmed to conditions found today in Roanoke, Virginia.

New York has been a national leader in taking steps to reduce airborne pollution. However, problems such as acid rain and climate change cannot be resolved at the state level alone—they require federal government action. New York State should continue to push aggressively for federal policies to address these issues.

Looking for a Sunny Rock

Timber rattlesnakes live in forests and rocky ridges along the southern and eastern edges of New York. Some 200 dens are known in the state. The species, however, has declined dramatically over the years, and continued losses are expected. Human development eliminates critical habitat, and can impede movement between habitats. Additionally, development brings more people into contact with these secretive creatures. Too often this results in the snakes being killed out of the misperception that they are a danger to humans—which, under ordinary circumstances, they are not. Timber rattlesnakes are listed as threatened in New York.

Grasslands, Shrublands, and Woodlands

In addition to its extensive forests, New York also has a diverse array of grasslands, shrublands, and woodlands. As the names suggest, these areas are dominated by shorter or sparsely growing plants such as grasses and shrubs. Although woodlands do have trees, they differ from forests as their trees are spaced very widely apart. These three communities are formed and maintained by unique soils and geology, by local or regional climatic conditions, by periodic disruptions in their natural cycles (usually by fire), or by a combination of these factors. Because of their unique nature and limited size and distribution, these communities often contain rare plant and animal species.

Ecological Processes

In some upland communities, grasslands and shrublands appear in the early to middle stages of succession, only to disappear as the plant community matures into forest.

However, this transition over time from grassland to forest can be interrupted by naturally occurring disturbances such as fire, and by human interventions such as farming. In fact, fire as a natural disturbance is a process fundamental to the persistence of many woodland and shrubland communities in New York State.

Old fields and other grasslands change over time through a process called succession. Grasses, goldenrods, and asters, for example, are gradually replaced by tall, woody vegetation until what was once a field of goldenrods and asters becomes a mature forest.
In pitch pine habitats, fire creates and maintains the community type in part by eliminating other plants that compete for resources such as light and nutrients, leaving the fire-tolerant pines to live on.

Even in the absence of disturbance, soil and other environmental conditions can maintain open terrestrial communities in certain places like rocky outcrops. Rocky summit grasslands, for example, are often found on exposed bedrock. Here, soil can be very dry and soil temperature high. Wind and other local weather conditions enable grasslands to survive, while limiting the growth of woody species.

The type of vegetation in coastal communities is determined in part by the presence of dry sandy or rocky soils left by glaciers. Although they may benefit from the relatively mild maritime climate, with its long frost-free growing season, coastal plants must also be tolerant of ocean winds and salt spray. Grasslands and shrub-land communities tend to be more typical than woodlands in these stressful environments. Fire may be important here as well, as both fire and grazing were major factors after the period of European settlement that remade the vegetative landscape familiar to us today.

Examples

Alpine Communities
Alpine plant communities are rare in New York. They cover a total of only 85 acres, all confined to 11 of the Adirondacks’ highest peaks. Several alpine plants can be found on these small patches, including a variety of lichens, mosses, liverworts, deer’s hair, alpine bilberry, lapland rosebay, bearberry willow, mountain sandwort, and alpine sweetgrass. Many are at their southern limits of distribution here.

Rocky Summit Communities
Rocky summit communities are limited to certain geologic formations, and to the environmental conditions found on exposed bedrock. These communities are generally small—often only a few acres—and contain poverty grass, little bluestem, Indian grass, ebony spleenwort, and other herbaceous plants. Hogencamp Mountain in Hartman State Park has a number of these grasslands scattered within the woodlands and forest of the mountaintop.

Coastal Communities
Several coastal communities on Long Island contain maritime grasslands and heathlands. They are found on sandy soils left behind thousands of years ago by retreating glaciers. Inhabitants may include grass species such as little bluestem, common hairgrass, and poverty grass, often with low heath shrubs and reindeer moss. Shrubs such as bearberry, beach heather, blueberry, black huckleberry, bayberry, and beach plum also can be found in these heathlands. Maritime communities dominated by shrubs often have black cherry, sumac, bayberry, arrowwood, and beach plum, and harbor several rare species, including the sandplain gerardia and the coastal burrison buck moth. Scientists believe these communities are remnants of ones that once were more widespread on Long Island and the outer islands of southern New York before being lost to development and agriculture.

They Hunt by Day

Although most of us think that all owls hunt only at night, the short-eared owl actually hunts during the day—usually at twilight. A bit smaller than crows, short-eared owls are usually seen perched on grass tussocks or fence posts, or swooping across grasslands. They primarily hunt meadow voles and mice in large, open fields, and in marshes where they nest.

Short-eared owls have declined significantly throughout North America since the 1960s. They are rare in the Northeast—New York and New England do not provide a lot of the open, prairie-like habitat they prefer—and are listed on the state’s endangered species list.
**Alvar Grasslands**

Alvar grasslands communities occur on shallow soils over level outcrops of calcium-rich bedrock—a very inhospitable environment for plants and animals. Spring runoff floods the flat, cracked limestone. Summer sun burns off the water, leaving parched soils in cracks between bare bedrock that can heat up to 110°F. Winter brings freezing temperatures that churn the soil with growing needles of ice. In New York, alvar grasslands are found in a 12- by 2-mile band of bedrock in Jefferson County near the northeastern tip of Lake Ontario. Because of the area’s natural rigors, trees can grow only in cracks where the soil is relatively deep. In the shallower soils, a wonderful variety of grasses, sedges, wildflowers, mosses, liverworts, and lichens create a mosaic of life and bare rock. These grasslands support a variety of rare animals and plants, including the upland sandpiper and hairgrass, prairie dropseed, Indian paintbrush, and the prairie smoke wildflower. Many of these plants (prairie smoke, for example) are more commonly found in the Midwest.

**Serpentine Barrens**

Serpentine barrens—which occur in shallow soils over outcrops of certain kinds of bedrock low in essential nutrients and high in concentrations of potentially toxic minerals such as nickel, chromium, and cobalt—are limited to formations found on Staten Island. Plant species found here must be tolerant of these conditions, and include little bluestem, panic grass, Indian grass, poverty grass, and white snakeroot. Woody species such as gray birch, black oak, and sassafras may form a savanna, characterized by sparsely wooded grasslands and a mixture of leafy herbaceous species. In some areas, a history of fire may also be an important factor in creating and maintaining the serpentine grassland community.

**Pitch Pine-Scrub Oak Barrens**

A massive wildfire swept across central Long Island in 1995. The fire burned so hot and fast that in places it formed rolling barrels of flame, sucking air in through the open ends and incinerating everything it touched. And yet, life there survived.

New York is home to several woodland barren communities—mosaics of pitch pine woodlands, scrub oak thicketts, and grass and heath openings. The plants and animals that live in pine barrens are especially adapted to survive and thrive after fire. Pitch pines themselves have thick bark that insulates sensitive inner layers. Extensive root systems of scrub oaks and low-bush blueberries send forth prolific sprouts after their crowns have burned. Many animals burrow into the ground. Some moths spend many months as pupae buried in the soil, thus avoiding the heat of periodic fires. Animals able to flee will return to burned patches after a fire sweeps through.

Despite the dismal connotations of their name, pine barrens provide important habitat for numerous rare species, including both the coastal and inland barrens buck moth, and other butterflies, moths, and skippers. More than a thousand species—an astonishing number from a biological perspective—have been found in the Albany Pine Bush. Some, like a rare bird-dropping moth, are unremarkable to see—if one can even find them through their camouflage—while others are brilliant. Graceful clearing moths hover on transparent wings edged with scarlet, their plump lime green abdomens bobbing in the sunlight. Inland barrens buck moths fly during the day on large black-and-white wings, and federally protected Karner blue butterflies are fluttering flashes of sapphire. Pine barrens also host several declining and vulnerable bird species, such as Eastern towhee.

**Blue Flies**

Many people think kids are picky eaters; but kids have nothing on insects such as the Karner blue butterfly. Their minute caterpillars eat the leaves of the wild lupine—and nothing else. They’ll starve to death on the leaves of other plants, including common garden lupines, because the caterpillars won’t eat them.

The creature was named by the novelist Vladimir Nabokov after the hamlet of Karner, New York, where he conducted his study. The settlement of Karner is gone today, having been swallowed up by the surrounding town of Colonie, and the butterfly is following its own path toward extinction. So many Karner blue populations from Wisconsin to New Hampshire have dropped in size dramatically or disappeared over the last 20 years that in 1993 the federal government listed the subspecies as endangered. Diligent efforts to save these flashing blue butterflies, which Nabokov called “blue snowflakes,” are under way in Albany, Saratoga, Schenectady, and Warren counties.
Pine barrens and the diversity of animal life they support are on display at the Albany Pine Bush, the Long Island Pine Barrens, the Rome Sand Plains, the pitch pine-heath barrens of Clintonville in the Adirondacks, and the sandstone pavement barrens of the St. Lawrence lowlands. The Shawangunk Mountains of southeastern New York also have extensive pine barrens. However, these are located on rock outcrops rather than in coarse sand. Differences in soils, moisture, and fire frequencies determine the tree and shrub species mixes in each pine barrens community.

Conservation Challenges

Clearly, development and land conversion are critical concerns when planning conservation measures for grasslands, shrublands, and woodlands. Related problems are human activities that disrupt wildlife, alter ecological processes, add nutrients, and increase the presence of pesticides and herbicides in developed areas. Higher densities of human population further complicate wildlife management, fire management, and other ecological strategies.

Fragmentation of habitat caused by road development magnifies each threat. Roads increase wildlife mortality due to collisions with vehicles. They can also modify animal behavior, in part by acting as barriers to movement and dispersal. They alter the physical environment (including its chemistry) as pollutants are washed off their surfaces. And they lead to the introduction of non-native species and increased use of an area by humans. The combination of each of these factors has significant effects not only on individual survival, but on the persistence of entire populations of plants and animals. Additionally, roads have a negative impact over a much wider area than just the road surface itself. In fact, the ecological effects of major roads have been shown to extend up to several thousand feet into adjacent habitats.

Areas containing these unique communities need to be protected from development and land conversion. Extensive protection efforts are under way in some high profile sites such as the Adirondacks, the Albany Pine Bush, the Long Island Pine Barrens and Montauk Peninsula, the Rome Sand Plains, and the Shawangunk Ridge in the Hudson Valley. These land protection initiatives should remain important state and local priorities. However, many of the state’s grassland and shrubland communities are small, patchy, and isolated. Improved local land-use planning, coupled with land purchases by local governments and nonprofit land trusts, is needed to protect important grassland and woodland habitats. Moreover, small grassland communities often are part of a larger matrix of forest and woodland; therefore, land protection strategies need to be undertaken in consideration of the landscape context.

Because many of these grassland, shrubland, and woodland communities are dependent on fire for their survival and maintenance, the absence of periodic fires can harm them. In addition, lack of fire—for example as a consequence of human efforts to suppress it—can lead to a buildup of highly flammable shrub and litter layers. That, in turn, can lead to catastrophic wildfires that threaten human life and property, in addition to causing major changes in the natural communities. Today, the use of prescribed fire is an important tool in managing fire-dependent communities. But technical skill is necessary to plan and carry out prescribed burns safely and effectively. Since some of these communities are near residences and other areas of human land use, effects of flames and smoke must be considered when applying fire.

Additional staff and resources need to be provided to state agencies and local fire departments to increase the amount of ecologically designed fire management in New York.

Another threat is non-native, invasive plant species, such as garlic mustard, Japanese barberry, and shrub honeysuckle. These foreign invaders compete with native species, reduce their ability to reproduce, and alter habitat for both plants and animals. “Small patch” communities are often invaded when disturbed by human activities, as evidenced by invasive species in the Albany Pine Bush and maritime communities of Long Island. Each of these communities—once surrounded by natural lands, such as large forests—are now encircled by developed areas, agriculture, and other sources of invasive species.

Additional resources are needed to enhance New York State’s response to invasive species, and to assist local governments and interested landowners in controlling non-native plants at the level of specific sites.
Finally, overbrowsing by deer and overuse by recreational visitors cause stress on grassland, shrubland, and woodland communities. Hikers, bikers, and all-terrain vehicle users all disturb soil and substrate, with significant harmful effects. Local government and public support will be needed to protect these areas, and to allow the application of sound ecological restoration and management programs.

Whatever the conservation program, a key to success is education and outreach to visitors and neighbors, to help them understand the ecological processes that maintain these biological treasures.

**Freshwater Wetlands**

New York State supports a great diversity of freshwater wetlands. Found in low-lying areas and also at higher elevations, wetlands provide a mix of conditions favorable to a variety of plants and animals. More than 40 different kinds of wetlands are recognized in the state, ranging from beds of submerged aquatic plants, such as wild celery rooted in the bottom of the Niagara River, to towering hemlock swamps in the Adirondacks. New York’s wetlands also include forested and shrub swamps, marshes, wet meadows, and peatlands. Some wetlands, such as vernal pools, may cover only a fraction of an acre. Others, such as the Montezuma Marshes between Syracuse and Rochester, are enormous, extending over many square miles. Some wetlands have standing water or water-soaked soils year-round, while others are often dry for portions of the year.

As a group, wetlands provide many different habitats for a wide array of plants and animals. Certain species are adapted to the unique conditions found in wetlands. They require wetlands, and cannot survive anywhere else. On the other hand, some organisms, such as red maple trees and yellow warblers, can live in either uplands or wetlands. Many animals frequent wetlands during some portion of their life cycles: white-tailed deer for drinking water, robins for the mud they need in their nests, big brown bats for insect meals, American toads for breeding and larval development, to name several. So the benefits of wetlands extend far beyond their watery edges.

Wetlands also provide the invaluable services of absorbing and storing floodwaters. They store and filter sediments and can protect shorelines from erosion. They protect the quality of surface- and groundwaters by removing nutrients and contaminants.

New York has about 2.5 million acres of freshwater wetlands, covering about 9 percent of the state’s landscape. About 75 percent of the state’s wetlands are in the Ontario Lake Plain, the St. Lawrence River Valley, and the Adirondacks. Freshwater wetlands are less common in the Hudson Valley, the Appalachian highlands, and the coastal lowland. Most of our wetlands are covered by forest or woody shrubs. About one sixth are characterized by sedges, rushes, grasses, and other herbaceous plants.

Scientists estimate that about half of New York’s original freshwater wetlands no longer exist. Most were lost to draining and filling for agriculture and other development. While some wetland types are still declining, others are actually increasing due to beaver activity, farm abandonment, and restoration programs. Wetland protection laws, acquisition programs, and a growing public awareness of the value of wetlands have contributed to more security for wetlands today. Nevertheless, they continue to be jeopardized by development, pollution, and invasive species.

**Ecological Processes**

Freshwater wetlands are often found at the margins of lakes, ponds, or streams. Some exist where groundwater rises to, or is close to, the land surface. Most occur where surface water is trapped—whether by impermeable soil layers, beaver dams, or man-made obstructions—in very shallow depressions.

**Small, Slow, and in Big Trouble**

Bog turtles are New York’s smallest and most imperiled turtles. The U.S. government lists bog turtles as threatened because 50 percent of their range has been lost in the last 20 years, primarily to development. Today, bog turtles live in only 12 states. In New York they are found primarily in the southeastern region; only four populations are known to occur outside Hudson River Valley counties. Bog turtles are amazingly long-lived despite their small size. Some old-timers are more than 40 years old.

Biologists from many organizations and agencies continue to search for additional populations throughout the state. As we learn where bog turtles are, landowners can help ensure their survival.
Many factors influence the types of plants and animals found at a particular site. Chemistry, physical characteristics (especially the amount of water present), age, climate, and biology all help determine what will thrive. The common thread is that plants must survive in soils that are saturated for at least a part of the growing season. This is no small feat. Most species of plants cannot live for any length of time when their roots are deprived of air. Hydrophytes—plant species that have adapted to these conditions—have evolved ways to breathe, grow, and reproduce in saturated soils.

Beaver ponds offer a familiar example of how wetlands can change over time by a process called wetland succession. Beavers build dams so that the animals can swim to their food and avoid predators. Flooding kills many of the plants and animals in the wetland, but enables others to grow. An entirely new community develops, while many of the previous plant and animal residents reestablish themselves at the edges.

The flooded condition will last as long as the beavers’ food holds out—for a few years or for decades. Once beavers decide to abandon a site, the dam falls into disrepair, and can soon breach. With the retreat of water and return of oxygen and sunlight, early successional “moist soil” plants—many of whose seeds remained alive beneath the water—can now sprout on the exposed mud. Thus, a beaver meadow flourishes. Over time, shrubs such as alder and trees such as red maple will overtake these plants. After a decade or two or three, a new generation of beavers will find it worth its while to flood and recreate the swamp. This cycle has repeated itself many times in many places since the glaciers last sculpted New York’s landscape.

Bogs and other systems with acidic waters undergo a different, usually much slower, succession. Because acidic conditions slow or prevent decomposition, some wetlands accumulate significant masses of dead plant material. A dense mat builds up over time and forms peat. After a long while—centuries—the peat can be strong and thick and dry enough to support larger plants, including trees.

So what started as a large bowl of open water eventually fills in with peat, and becomes a forest of trees such as black spruce or tamarack.

Movement of water and nutrients through a wetland also helps define the community that can exist within it. A riverine forested wetland will form in response to seasonal flooding as the river rises, as well as to the silty soils deposited by floodwaters. When groundwater flows over calcium-rich limestone bedrock and leaks out to the surface on a slope, a very special wetland known as a rich fen develops. Plants such as shrubby cinquefoil, adapted to these calcium-rich conditions, dominate the site. These fens are home to some of New York’s rarest plants and animals.

**Examples**

**Emergent Marshes**

When many hear the word “wetland,” images of marshes spring to mind. In the lexicon of wetland scientists, these most likely would be categorized as “emergent marshes.” In such communities, large stands of cattails are interspersed with open-water beds of white water lilies or yellow bullhead lilies, with their floating leaves. Beneath the deeper water may lie beds of pondweeds, coontail, or other submerged aquatic plants. Stands of wild rice, bulrushes, burreed, and pickerelweed may be scattered throughout. Bullfrogs and green frogs—and even mink frogs in more northerly waters—are often abundant. They are hunted by largemouth bass, northern water snakes, American bitterns, and pied-billed grebes, among others. Painted turtles bask on floating logs or muskrat houses, while snapping turtles hunt from the bottom. Tree swallows dart through the air after mosquitoes. Marsh wrens and sora rails search for beetles and snails among the dense stems of cattail. In a few larger marshes, the endangered black tern still nests and hunts for dragonflies and other large flying insects. A wide variety of waterfowl, especially dabbling ducks such as mallards, black ducks, and teal, are present here when the marsh is free of ice.

**No Accounting for Taste**

Some plants such as pitcher plants and sundews thrive in low-nutrient acidic peatland waters by eating insects. Pitcher plants have hollow, vase-shaped leaves, the insides of which are lined with downward-pointing hairs. Insects unlucky enough to venture into the leaves get trapped and are ultimately digested in an enzyme-rich pool of water at the leaf’s base. Sundews are living fly-paper. They capture insects on small red leaves covered with sticky hairs.
Red Maple Hardwood Swamps

Found throughout New York, red maple hardwood swamps are among our most common wetland types. Red maple may be the dominant species in the canopy, or it may share the canopy with other hardwoods such as black ash, American elm, swamp white oak, butternut, and butternut hickory. There is usually a dense understory of shrubs such as spicebush, winterberry, black chokeberry, and highbush blueberry. In more open areas, red-osier dogwood, arrowwood, and wild raiisn may predominate. Cinnamon, royal, and sensitive ferns are abundant on the ground, as are skunk cabbage, jewelweed, and skullcap. Wildlife can be found in red maple swamps at all times of year. Mole salamanders—including the marbled, Jefferson, and spotted—will use vernal pools for breeding, as will spring peepers and wood frogs. During the colder months, bands of chickadees, titmice, brown creepers, and hairy and downy woodpeckers search the trees and shrubs for overwintering insects and their eggs and larvae. Food is available to early migrating songbirds, especially pine warblers and blue-gray gnatcatchers, when the red maple blossoms attract insects in the first days of spring.

Spruce-Tamarack Bogs

Black spruce-tamarack “bogs” are scattered throughout northern portions of upstate New York. This community grows on acidic peatlands in cool, poorly drained depressions. Black spruce and tamarack are among the few tree species that can withstand such harsh and nutrient-poor environments. Numerous shrubs typically found in more northern parts of North America are often present in the understory, or as dense stands of their own. Leatherleaf, bog laurel, Labrador tea, bog rosemary, and mountain holly are common. Peat and brown mosses, sedges, and cotton grass dominate the ground layer. Pitcher plants and sundews trap and digest insects for protein. Cranberries grow in the sunnier areas; gold thread and creeping snowberry in shadier locations. Several bird species prefer bogs as habitats. Olive-sided flycatchers, rusty blackbirds, and palm warblers migrate here to breed. Three-toed and blackbacked woodpeckers, gray jays, and spruce grouse live here year-round. The four-toed salamander, although dormant during the colder months, may inhabit the sphagnum layer.

Marl Fens

New York’s rarest open peatland type is the marl fen. Marl is a white-colored deposit of calcium carbonate and clay. Trees in marl fens are stunted, and vegetation tends to be sparse, often growing only on elevated hummocks. Only four marl fens have been identified in the state, collectively covering fewer than 20 acres. In New York, two wildflowers listed by the state as endangered—small white ladyslipper and Houghton’s goldenrod—grow only in marl fens.

Vernal Pools

Temporary—also known as “ephemeral”—pools form in the spring and fall in shallow depressions. Vernal (from the Latin word for “spring”) pools are the type of temporary pools that form each spring from snowmelt, spring rains, and surface water runoff. They may be scattered within larger, floodplain wetlands (often in forested or shrub swamps), or in uplands, and they are either completely isolated from, or only seasonally connected to, groundwater. The key feature these pools share is the alternating wet-dry cycle that occurs each year. The cyclic drying prevents many invertebrate and fish predators that occur in permanent waters from establishing populations. This, in turn, provides an environment with reduced predation pressure, enabling a unique set of species to thrive. For example, fairy shrimp, a small crustacean that filter-feeds on phytoplankton, bacteria, and protozoa, cannot survive in predator-rich waters. They rely on temporary pools for survival.
Conservation Challenges

Commercial and residential development continues to threaten freshwater wetlands. Although existing laws provide strong protections for most, some wetlands are lost when social and economic needs are seen to outweigh the value of individual areas. Even when wetlands are preserved, encroachment can increase disturbance, introduce pests and pollutants, alter microclimates and water supplies, and cause habitat fragmentation.

Introduction of invasive species, including plants, animals, and microorganisms, threatens the health of otherwise intact wetlands. Purple loosestrife and common reed are well-known aggressive invasive plants that displace native species and offer little to wildlife. As they feed, Eurasian carp dislodge rooted aquatic vegetation and suspend sediment, increasing turbidity and making it difficult for other animals to find food.

Use of pesticides in and around wetlands can affect the biodiversity and health of wetland systems. Sediment and contaminants carried in storm water runoff, called nonpoint source pollution, often find their way into wetlands. Wetlands are capable of withstanding some levels of such onslaughts—by trapping sediments, using nutrients, and storing contaminants. But excess amounts of sediment can alter wetland topography or smother existing communities.

New York’s Freshwater Wetlands Program, administered through the Department of Environmental Conservation (and by the Adirondack Park Agency within the park), provides protection for many of the state’s 2.5 million acres of wetlands. It publishes maps of protected areas, notifies landowners of the existence of wetlands, and regulates most development activities within about 100 feet of the wetland boundaries. Outside the Adirondack Park, the program generally applies only to wetlands greater than 12.4 acres in size, and covers about 80 percent of the state’s total freshwater wetland resource.

Inside the Park, the Adirondack Park Agency protects all wetlands over an acre in size, or any wetland adjacent to open water. The U.S. Army Corps of Engineers administers the federal wetland protection program, mandated by the Clean Water Act. The Environmental Protection Agency, the Natural Resource Conservation Service, and the U.S. Fish and Wildlife Service also play roles in wetlands protection. A small number of local governments, mostly in the more urbanized portions of the state, have enacted wetlands protection laws of their own. Some are highly protective and well-enforced. The best ones use planning processes to direct development away from wetlands. Nongovernmental conservation organizations also have a variety of strategies to protect the biodiversity of freshwater wetlands, including restoration, acquisition, cooperative agreements with landowners, and educational efforts.

A comprehensive strategy for protecting the biodiversity of New York’s freshwater wetlands should: strengthen legal protection for smaller wetlands; encourage landscape planning by local communities so that wetlands are protected from development; implement a comprehensive program for managing nonpoint source pollution; and encourage research into the control of invasive species.

Roads through wetlands pose threats to biodiversity, including pollution and invasive species. They also can hamper movements of animals and increase predation rates.
Rivers and Streams

Moving water is a powerful force in the natural world. For most of recorded history, humans have recognized the dynamic nature of our world’s free-flowing waters, and have used streams and rivers of every size to provide water for drinking and irrigation, for fishing and aquaculture, for transportation and industry, and often as a dumping ground for unwanted and undesirable items. In recent years, flowing waters have become popular for recreational activities such as rafting and fishing. We are now beginning to appreciate their importance to biodiversity.

Although hydrologists refer to all moving water as streams, most of us think of rivers as larger and streams and creeks as smaller bodies of flowing water. Whether called streams, rills, brooks, creeks, or rivers, New York is home to many flowing waters, including parts of five major rivers and their drainage basins: The Hudson, Great Lakes and St. Lawrence, Susquehanna, Delaware, and Mississippi (via the Allegheny). Each of these drainages with their many riverine habitats supports a tremendous number of freshwater species.

In New York, all flowing waters eventually make their way to the Atlantic Ocean. The streams and rivers on Long Island have the shortest journeys, emptying into bays or sounds before becoming part of the ocean. Some go by way of lakes Erie, Ontario, or Champlain, and on to the St. Lawrence River through Canada. About a quarter of the state drains into the Hudson River. Most of the waters in New York’s Southern Tier travel through other states before reaching the ocean. Waters draining into the Delaware River join the Atlantic south of New Jersey at the mouth of Delaware Bay, those draining into the Susquehanna River do so at the mouth of the Chesapeake Bay in southern Virginia. Most circuitous of all, the Allegheny watershed drains into the Mississippi River system and meets the ocean at the Gulf of Mexico.

Ecological Processes

Biodiversity in streams, as in any system, is controlled by the history of the area and the degree of habitat variety within the system. New York’s streams are relatively young, but still possess many different habitat types. The advance and retreat of glaciers has influenced much of the current physical setting of New York’s rivers and streams, reworking and changing river drainages by altering flow patterns, combining previously separated streams or splitting streams into different drainages. Through their geological and glaciological history, New York streams have interacted in ways that have allowed species to advance into new drainages and take up residence in newly available habitats.

Physical characteristics of flowing waters change over their lengths. The composition and diversity of stream and river communities is determined by the interaction of attributes such as gradient, water velocity, temperature, depth, chemistry, stream shape, and upland surroundings. These factors determine the physical characteristics of the many kinds of habitat. For example, bottoms of fast-moving streams are usually covered with stones, rocks, and even boulders, whereas finer, lighter materials are washed downstream. Silts, sands, and organic matter—tiny particles of decayed plants and animals—collect at the bottom of low-gradient, slow-flowing streams, especially in backwaters or in the pools of mid-reach streams.
Typically, New York's rivers and larger streams begin as surface runoff from snow melt and rainfall along with water from underground seeps and springs that feed into small headwater streams. Some of these headwater streams meander through bogs and marshy wetlands, whereas other waters tumble over riffles and waterfalls. Overarching canopies of trees often shade these headwaters from sun and help keep them cool. These cold, oxygen-rich waters are home to brook trout, sculpins, dace, and insects such as mayflies, stoneflies, and caddisflies.

Above, top: The Delaware is the longest free-flowing river in the Northeastern United States. Wild and scenic, the upper Delaware River provides habitat for bald eagles today and historically for the cobblestone tiger beetle (above).

Headwater streams are tributaries. They join larger streams with fast-moving riffles that alternate with deeper pools of water. These two habitats support a wider array of species, with dace and darters favoring the faster stream sections and deep-bodied fish, such as perch, sunfish, and smallmouth bass, inhabiting the slower-moving pools.

Farther downstream, as the gradient lessens, the river or stream usually slows, widens, and warms. There may be less oxygen, but nutrients are often more available. Smaller-grained sediments are deposited on the river bottom, and these deposits—coupled with slower flow—enable rooted plants to find homes. Water celery, for example, may grow in large, extensive beds.

Amphipods (scuds) and snails abound amongst the stems and leaves. Young fish of many species find shelter and food here. Predatory fish such as chain pickerel and northern pike are joined by other hunters such as mink, river otter, great blue heron, and bald eagle. Spotted sandpipers search the shores and shallows for aquatic insects, while muskrats forage on narrow-leaf cattails or spatterdock growing from rich, organic sediments out of the main current.

Life within and around rivers and streams also depends to a large degree on whether the waters periodically overflow their banks, as many plants and animals are adapted to and may even depend on seasonal cycles of flooding and alternating high and low water flows. When these cycles are controlled by dams or interrupted by global or regional environmental changes such as drought or acid rain, the plants and animals living in these aquatic systems are harmed.

New York’s river and stream communities have been significantly altered by centuries of farming, logging, urbanization, and other human activities such as construction of canals for transportation; dams for water supply, power generation, or flood control; channelization of banks, dumping of waste; and recreation.

**Examples**

**Catkill Headwater Streams**

Catkill streams are home to New York’s official state fish, the brook trout, which is also found in other headwater and mid-elevation streams in the state. When small, this colorful predator largely feeds on “drift”—organisms such as caddisflies, stoneflies, and mayflies that are dislodged from the stream bottom and drift in the water column past the trout’s feeding stations. Stream insects show a variety of traits and behaviors that help them avoid predation. For example, many caddisfly larvae protect themselves by gluing together a tube from particles of rocks, sand, gravel, twigs, or leaves to serve as portable shelter. Sometimes this deters a predator; oftentimes it does not. When larvae of most aquatic insects become flying adults, they are susceptible to capture by a host of in-stream predators, including adult brook trout. Smaller fish, such as longnose dace and slimy sculpins, are also on the alert for food. Midge and black fly larvae, in fact almost any aquatic insect, may fit the bill, even the curious water penny. These flattened beetle larvae cling to submerged rocks, where they dine lazily on periphyton—the layer made up of algae, bacteria, fungi, and protozoans. This stony habitat can also be home to spring salamanders and two-lined salamanders. Alongside the stream, Louisiana waterthrushes or winter wrens may let loose with ringing songs from a patch of blue-petaled forget-me-nots.

**New York’s state freshwater fish, the brook trout (top right), is a favorite of anglers. The slimy sculpin (above) feeds mostly on insect larvae like that of the black fly (right), those abundant pests that residents and visitors know so well. Adult flies lay their eggs in running water. Once hatched, the larvae attach to underwater roots or logs and filter food from the water. Only a few of the dozens of species in the Adirondacks are human pests; they emerge in late spring.”
The Hudson River

Seventeenth-century explorer Henry Hudson described the river that was to bear his name as inhospitable and treacherous, with fierce currents and winds strong enough to endanger sailing vessels. The waterway begins in Lake Tear of the Clouds, high on the northwest slope of Mt. Marcy in the Adirondacks, and flows 315 miles to New York City and the ocean. It runs as deep as 200 feet or more at World’s End near West Point. Narrow and shallow at its headwaters, the river widens to nearly three and a half miles at Haverstraw Bay.

The Hudson is often referred to as an “arm of the sea,” with a 150-mile section from New York harbor to Troy influenced by tides. For this reason the Native Americans named it Muhheaknantuck, “the river that flows both ways.” In summer, the saltwater penetrates as far north as Newburgh. This brackish habitat supports a diverse mix of freshwater, estuarine, and marine species. Vast beds of submerged aquatic plants provide an important food source for waterfowl and fish, as well as habitat for aquatic invertebrates. Creatures as varied as jellyfish, blue crabs, and more than 200 species of fish, including various diadromous fish (species that migrate between fresh- and saltwater habitats) such as striped bass, American shad, and Atlantic sturgeon, call the Hudson home.

French Creek

French Creek begins in the headwaters of Chautauqua County in western New York and flows through Pennsylvania, where it ultimately joins the Allegheny River. A significant number of rare species live in French Creek’s waters. They include darters, small fish such as longhead, spotted, and variegated darters, minnows such as silverjaw minnow, blackchin, and blacknose shiner; and mussels with names like kidneyshell, mucket, and round pigtoe. All told, the creek is home to 27 native mussels and over 85 native fish species, including three federally-listed mussel species: northern riffleshell, clubshell, rayed bean, and many state-listed species (10 fish and 3 mussels in New York).

This high diversity is due in part to the fact that French Creek is part of the Mississippi River basin (one of the oldest river systems in the world) and as such had the potential to be colonized by the greatest number of fish and mussel species in North America. The creek has also been spared much of the severe environmental degradation such as industrial effluent, acid mine drainage, and impoundment for navigation that has affected other stream systems.

Flooding Forests

Straddling many of New York’s larger and slower rivers, such as the Susquehanna, are floodplain forests. These woodlands are seasonally inundated during spring floods and other periods of high water. Such periodic flooding deposits nutrient-rich soil in the adjacent river-bottom lands and helps slow the movement of surging river waters. Trees that can withstand periodic flooding of their roots, such as sycamore, silver and red maples, cottonwood, green ash, butternut, and black walnut, flourish in floodplain areas. Floodplain forest floors are often lush with stands of jewelweed, ostrich and sensitive ferns, wood nettle, jumpseed, and skunk cabbage. Up in the treetops may be birds such as yellow-throated vireos, red-bellied and pileated woodpeckers, and blue-gray gnatcatchers.

Many floodplain forests have been cleared for agriculture because of their rich soil. They are now one of the most threatened ecosystem types throughout New York.

Freshwater Mussels

New York is home to dozens of species of freshwater mussels, many with evocative names such as slippershell, three ridge, pocketbook, green floater, eastern pearlshell, rayed bean, fawnfoot, and pink heelsplitter. Some are extremely rare. One of the world’s largest populations of the dwarf wedge mussel lives in the Neversink River in the southern Catskills. Freshwater mussels may make up the largest portion of total animal biomass in a stream. As a result, mussels play a very significant role in the food web of many freshwater aquatic ecosystems. They filter tremendous volumes of water, removing suspended organic and inorganic material from the water. An extreme example of this—not beneficial to native biota—is the filtering of the Seneca and Hudson Rivers by the non-native zebra mussel. While increasing the clarity of the river, these animals remove so much suspended material that they have devastated the plankton populations that other native mussels and fish depend upon for food.
Frightful but Nice (Well, at Least Harmless)

Hellbenders look like something out of a nightmare: broad flat heads, small beady eyes, short legs, thick wrinkled olive brown-grayish skin, and strong, rudder-like tails. Growing as long as two feet, they’re the largest aquatic salamanders in North America. Yet, despite erroneous myths to the contrary, they are not venomous and they don’t feed on game fish.

Hellbenders live in fast-flowing streams where the water is clean and well-oxygenated. In New York they are found only in the Susquehanna and Allegheny River drainages. They spend the day under large, flat rocks or logs, and come out at night to feed, mostly on crayfish. In the summer, the male hollows out a nest chamber in the bottom of the stream, usually under a rock. The female deposits her eggs in this nest; but it is the male hellbender who watches over the eggs until they hatch about 10 weeks later.

Conservation Challenges

After 30 years of implementing federal and state clean water laws, tremendous progress has been made in reducing water pollution in New York State—particularly in building wastewater treatment plants to clean up municipal sewage and industrial discharges (called point source pollution). However, much remains to be done to address the point source pollution that comes from older combined sewer systems that are still used in many of the state’s cities and towns. In addition, New York needs to continue to improve water quality by addressing nonpoint water pollution. More than 90 percent of the state’s streams and rivers are still impaired in some way—most often by water pollution from a variety of sources that include nonpoint runoff from agricultural lands, residential areas, golf courses, and roads, coupled with direct discharges from industrial sources and inadequate sewage treatment. Excessive erosion and sedimentation from farmlands, forestry, and construction activities are also major problems, leading to buildups of silt in critical gravel and sand habitats used by fish, mussels, and other aquatic invertebrates. Toxic chemicals, including contaminated river bottom sediments, are a concern in some rivers.

Construction and operation of dams and reservoirs is another major threat to freshwater biodiversity. Dams create physical barriers to the movement of fish and other aquatic animals. Dams alter natural flow regimes, and in some cases can dry the riverbeds below reservoirs, they alter water temperature and chemistry. By creating standing-water environments where water once flowed freely, even the reservoirs behind the dams become barriers of a sort. The deep water can interfere with animals moving downstream, as well as those that are able to make it upstream past the dam. The environmental conditions in the reservoir differ so greatly from those in a flowing stream that plants and animals native to the system often cannot survive.

Around the world, decision makers are beginning to rethink the value of dams, balancing the many human benefits—such as water supply and clean energy—against the needs of the natural world. In some places dams are being fitted with fish ladders or even removed altogether. New York State needs to examine this issue comprehensively.

Diadromous Fish

Diadromous fish are those that spend part of their lives in freshwater and part in saltwater. Such migratory species are found in New York rivers that have direct connections to the Atlantic Ocean, including the Hudson River and its tributaries, streams on Long Island, the Saint Lawrence River, and the Delaware River in the Catskill region. In fact, prior to the building of dams in the nineteenth century, diadromous fish were found in the upper reaches of the Susquehanna River as well.

Anadromous species—striped bass, Atlantic sturgeon, blueback herring, alewife, and American shad—are those that live in the Atlantic but migrate into New York rivers each spring to lay eggs. Juvenile offspring may spend months or even years in these rivers before returning to the ocean as adults. The catadromous American eel, however, travels in the opposite direction. It lives most of its life in freshwater rivers, but travels all the way to the Sargasso Sea in the Atlantic Ocean to reproduce, swimming 3,000 miles each way.

American shad are one of New York’s most well-known anadromous fishes. Adults spend most of their lives in the Atlantic Ocean. Each spring, however, they return to spawn in rivers and streams on the East Coast from New Brunswick to Florida. Shad runs are plentiful in tributaries of the Hudson River, and in the Delaware and Neversink rivers in the Catskills. Historic shad runs in the upper Susquehanna River were reported as well. Many adult shad die after they spawn. Their decaying bodies fertilize rivers and estuaries, contributing critical nutrients such as nitrogen and phosphorous to these aquatic systems.
Lakes and Ponds

Some of the most familiar habitats in New York State are lakes and ponds—roughly 24,000 in all. These inland waters span a wide range of ecological conditions, including those found in deep, cold Adirondack lakes; groundwater-fed coastal plain ponds on Long Island; small, human-created reservoirs; shallow warm-water ponds throughout the state; and massive water basins such as the Great Lakes.

Most, however, are small, with only 7,000 or so covering more than an acre. Scientists define lakes and ponds as inland depressions containing standing water. A pond tends to be smaller than a lake, but the defining characteristic is that rooted plants can grow across much of a pond’s bottom. Lakes are so deep in most parts that not enough sunlight reaches the bottom to support photosynthetic plants.

The action of glaciers, along with geologic processes, formed most of New York’s inland waters. The aptly named “kettle lakes,” found throughout the state, were formed thousands of years ago when large blocks of ice became trapped in debris left by glaciers. As the ice melted, depressions left in the ground became basins for these lakes. Other types of inland waters include farm ponds and reservoirs created by humans for agricultural and municipal use. In some areas, landowners are converting portions of wetlands to open water to produce more pond-like habitats. As a result, plants and animals that inhabit freshwater ponds tend to be numerous throughout the state.

The introduction of non-native species is another major threat to freshwater biodiversity. Zebra mussels harm native freshwater mussels by attaching to them in great numbers, preventing them from functioning. They also compete for food. Introduced fish can prey on sensitive native fish species or alter their habitats. Invasive plants such as Eurasian watermilfoil, water chestnut, and common reed crowd out native vegetation such as pondweeds, bulrushes, cattails, and pickerelweed. Policies are needed to stem the invasion of non-native species that affects sensitive plants, fish, and wildlife native to our streams.

The predatory largemouth bass has invaded lakes throughout eastern New York, where its introduction is suspected in declines of native fishes.

Flocking To Niagara Falls

People flock to the place along the United States and Canadian border where the Niagara River makes its 176-foot plunge to the base of a monumental cliff called the Niagara Escarpment. But the area is just as popular a destination for the feathered crowd.

Because it is relatively ice-free in winter and supports abundant fish and invertebrate life, the Niagara River is an important migratory stopover and wintering site for a phenomenal number of gulls, ducks, and geese. In winter, thousands of Bonaparte’s, herring, and ring-billed gulls can be found along the river, along with flocks of wintering canvasback, common mergansers, common goldeneyes, and scaup. Occasionally seen are glaucous and Thayer’s gulls, and even king eiders. The river’s edge also provides habitat for spring and fall migratory songbirds.

The predatory largemouth bass has invaded lakes throughout eastern New York, where its introduction is suspected in declines of native fishes.
Complex communities of plants and aquatic habitats that support freshwater lakes and ponds are found in the Great Lakes basin and the Long Island coastal plain. Inland ponds with high concentrations of dissolved salts such as those in the Great Lakes basin are rare. Coastal salt ponds, much more common worldwide, are formed by the closing off of a lagoon or bay, whereas their inland cousins get their salt as input from springs that flow through salt beds, delivering salty water to the ponds. Both types—inland and coastal—have organisms such as ditchgrass uniquely adapted to salty water.

Water for lakes and ponds can come from surface runoff, streams, springs, and rainfall. Water temperature is affected by the type of water source as well as the location of the body of water in the landscape. For example, cold temperatures in ponds can be maintained by groundwater inputs from underground springs. Groundwater usually maintains much cooler and more even temperatures during the summer than surface runoff and streams, which are heated by the sun’s radiation and warm summer air. In contrast, ponds that are isolated from groundwater inputs can have higher temperatures, especially during the summer months. These factors can greatly affect the species that live in these ponds.

Though nearly all of New York’s natural lakes and ponds are freshwater, saltwater ponds are found in the Great Lakes basin and the Long Island coastal plain. Inland ponds with high concentrations of dissolved salts such as those in the Great Lakes basin are rare. Coastal salt ponds, much more common worldwide, are formed by the closing off of a lagoon or bay, whereas their inland cousins get their salt as input from springs that flow through salt beds, delivering salty water to the ponds. Both types—inland and coastal—have organisms such as ditchgrass uniquely adapted to salty water.

In addition to their great natural beauty, lakes and reservoirs (and the streams that feed them) supply much of our drinking water. For example, the Catskill watershed and the Croton Reservoir in Westchester County supply water to New York City. Part of Sterling Forest State Park in Orange County provides water to northern New Jersey.

Ecological Processes

Lakes and ponds are constantly changing. One significant but often overlooked effect is the annual layering (“stratification”) of water temperature due to seasonal changes. In the winter, when many lakes and ponds ice over, the deepest layers have the warmest water. This is because water is densest at 39°F and freezes at 32°F. Ice floats above the denser, warmer water below. In the spring, as the top layers of lakes and ponds are warmed by the sun, the layering shifts. When the temperature approaches 39°F, surface water starts to sink and mix with water below. Wind helps the turbulent mixing process, called “turnover,” resulting in nearly uniform temperatures throughout the water column. Later, as the summer sun heats the water, the lake again becomes stratified, with warmer, lighter water floating on top of the cooler, denser water. The layers resist mixing, even in windy conditions. As the water cools in the fall, the water temperature again equals around 39°F, causing a fall turnover.

Most lakes and ponds in New York are dimictic (that is, they turn over twice each year). Some lakes are monomictic, turning over only once each year. A small number do not mix at all.

Windows on Groundwater

One of New York’s most unusual natural communities is that of the coastal plain pond—a type of kettle pond. In many places on Long Island, these depressions extend below the water table, creating permanent ponds. When these ponds have no incoming or outgoing streams, they are windows on the groundwater.

Water levels in coastal plain ponds can vary seasonally by as much as seven feet. The alternately flooded and exposed habitat is filled by a remarkable diversity of wildflowers, grasses, sedges, and rushes. These species grow quickly when the water level drops, and wait out flooded periods as seeds or dormant roots. These are the only conditions suitable for some New York plants, including rose coreopsis—a striking wildflower that is globally rare but locally common on Long Island. Also home to two threatened species of damselflies, coastal plain ponds are threatened by the lowering of groundwater levels through pumping for municipal water supplies.

Ponds support many types of organisms that live in a complex mix of habitats—from shallow nearshore waters to areas of deep water. Some typical pond residents are shown here: 1—cattail, 2—duckweed, 3—water strider, 4—backswimmer, 5—mud snail, 6—painted turtle, 7—bullfrog, 8—pearly mussel, 9—American medicinal leech, 10—largemouth bass, 11—snapping turtle, 12—pumpkinseed, 13—giant water bug, 14—midge larva, 15—round worm, 16—green frog.
For those that do mix, the turnover process is important. It mixes oxygen throughout the water column, replenishing the supply to the bottom layers of the lake. It also mixes nutrients such as nitrogen and phosphorus—two substances vital to the growth of plants. Some types of algae take advantage of nutrients and they “bloom”—explode in population. This provides a rich food source for other inhabitants of the lake or pond.

Phytoplankton are microscopic organisms such as algae and cyanobacteria that float in the water column rather than swim under their own power. They are able to convert the sun’s energy into biologically useable forms, as do other plants, by a process called photosynthesis. This process plays a critical role in food webs that support aquatic life.

Zooplankton, such as copepods, cladocerans, and rotifers, are tiny organisms that feed on phytoplankton or other zooplankton. In turn, zooplankton are eaten by larger organisms such as small fish, salamanders, or waterfowl.

Since not enough sunlight penetrates for photosynthesis to occur in the deeper parts of many lakes, nearly all the species that live here consume dead or decaying matter that filters down to the bottom. Among these creatures are segmented worms, bacteria, and some midge larvae.

Examples

Great Lakes

New York State borders two of the world-famous Great Lakes: Lake Ontario and Lake Erie. A variety of native and non-native fish inhabit deepwater areas of the lakes, including lake trout, Atlantic salmon, burbot, deep-water sculpin, yellow perch, and the introduced chinook salmon. Other species include coho salmon, rainbow trout, and brown trout. Assemblages of small fish include alewife, rainbow smelt, three-spine stickleback, and emerald shiner. Near-shore communities of large, predatory species include northern pike, muskellunge, smallmouth and largemouth bass, yellow perch, lake sturgeon, and walleye. Numerous tributary streams serve as important spawning areas for salmonids—for example, rainbow trout and Atlantic salmon—and suckers. Several species of diving birds such as long-tailed duck, common goldeneye, redhead, bufflehead, canvasback, and scoters use the area as a staging ground during migration. During spring migration, Braddock Bay on the south shore of Lake Ontario serves as a major flyway for migratory raptores, especially turkey vultures and broad-winged, sharp-shinned, and red-tailed hawks. Island areas in these lakes are also important nesting areas for colonial waterbirds such as common terns, ring-billed gulls, and double-crested cormorants.

Finger Lakes

Eleven lakes make up the Finger Lakes region of central and western New York State. The basins of these long and slender lakes were carved from the earth by glacial activity during the Ice Age. The shortest, Canadice Lake, is roughly four miles long, and the longest is Cayuga Lake at 38 miles long. The deepest, Seneca Lake, is about 618 feet deep, with its bottom below sea level in its deepest parts. A variety of fish are found in these lakes, including lake trout, largemouth and smallmouth bass, yellow perch, various sunfishes, chain pickerel, brown bullhead, and rock bass. The lakes also support several species of minnow, sucker, and other nongame fish. The community is a mixture of native and non-native fishes. Shallower lakes such as Canadice Lake and Honeoye Lake are inhabited only by warm-water species such as yellow perch, brown bullhead, walleye, and smallmouth and largemouth bass. Deeper lakes have warm-water species in the surface waters and in near-shore areas, but also include cold-water species such as lake and rainbow trout. Sheltered areas of the Finger Lakes that remain free of winter ice provide excellent opportunities for viewing overwintering waterfowl, especially Canada geese. Migrating birds such as loons and other waterfowl use these lakes as stopover points on fall and spring migration.

Speedy (for a Turtle)

Which of New York’s animals has four legs and looks like a giant pancake with spots? It’s the eastern spiny softshell turtle. Whereas most of New York’s turtles have a hard shell (called a carapace), the softshell turtle’s carapace is rubbery and leathery—which may give the animal greater freedom of movement. Spiny softshells have narrow, upturned snouts that are excellent snorkels when resting or hiding in shallow water. This turtle spends almost all of its time in rivers, streams, and lakes that have sandy or muddy bottoms. It is uncommon in New York, with the best populations in the central and western parts of the state.

Diatoms, with their elegantly shaped silicon cell walls, are one type of alga. Some diatom species live as free-floating plankton, while others grow attached to submerged surfaces of rocks, plants, and logs. They are an important food source for many aquatic organisms such as frog tadpoles and caddisflies.

Driftwood collects on a shore of Lake Erie. The Great Lakes are the largest system of fresh surface water in the world, containing 18 percent of the planet’s surface freshwater.

LEGACY: Conserving New York State’s Biodiversity
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Adirondack Lakes

Many lakes of the Adirondack region tend to be transparent with blue or green waters. This is because they are nutrient-poor whereas others that drain swampy areas tend to be browner, stained with tannic acid. The haunting tremolo calls of common loons can be heard across many of these lakes during the summer breeding season. Tracks of mink can be seen around lake perimeters, where they forage at night for rodents such as muskrats, snakes, frogs, and crayfish. Lake trout inhabit deeper areas of well-oxygenated lakes for most of the year, then move to shallower waters with rocky substrate for fall spawning.

A variety of native fish can be found in the Adirondacks, including brook trout, white sucker, creek chub, and common shiner. Non-native species commonly found include largemouth bass, chain pickerel, brown bullhead, pumpkinseed, bluegill, and golden shiner. Painted and snapping turtles can often be seen on sunny days basking on rocks or floating logs. Green frogs and bullfrogs wait patiently for an insect to fly by, or an aquatic invertebrate to swim along. Algae-eating snails and omnivorous crayfish are found on pond bottoms, along with leeches, segmented worms, and flatworms. Insects such as water boatmen, backswimmers, predaceous diving beetles, and giant water bugs are also common in warm-water ponds and other types of ponds and lakes.

Conservation Challenges

The most immediate threats to biodiversity in New York’s lakes and ponds result from excessive nutrient enrichment, sedimentation, introduction of invasive species, and acid rain. Except for the rain—the poisonous content of which comes mainly from areas west of the state—these threats result from human activities in the surrounding watershed. Problems in the water often indicate incompatible land uses. These typically involve creating or disturbing bare soil, thus increasing erosion and sedimentation, storm water runoff, and nonpoint source pollution.

Nutrient enrichment and sedimentation are natural processes that occur as lakes and ponds age over time. However, human activities often accelerate the aging process. Phytoplankton depend on nitrogen and phosphorus for growth. An excess of these nutrients may come from municipal sewage outflows, storm drains, runoff from cropland and suburban lawns, and even air pollution. Excessive nutrients cause uncontrolled growth of plants and algae, which reduces oxygen levels in the water when they die and decompose. The lower levels of oxygen may have harmful effects throughout the lake ecosystem. In extreme cases, dissolved oxygen in the bottom waters of lakes may become completely depleted, leading to “anoxic” conditions that are deadly to fish and other aquatic life. However, if the sources of artificial nutrient enrichment are found and controlled, water quality may be restorable.

Warm-Water Ponds

Found throughout the state, warm-water ponds harbor their own variety of wildlife and plant species. These ponds are typically shallow, with gently sloping sides and thick, organic-rich sediments. They support a mixture of submerged, emergent, and floating plants, including watermilfoil, pickerelweed, waterlilies, cattails, and duckweed. Water temperatures may exceed 73°F during summer—too warm for trout. Fish that can survive include largemouth bass, chain pickerel, brown bullhead, pumpkinseed, bluegill, and golden shiner. Painted and snapping turtles can often be seen on sunny days basking on rocks or floating logs. Green frogs and bullfrogs wait patiently for an insect to fly by, or an aquatic invertebrate to swim along. Algae-eating snails and omnivorous crayfish are found on pond bottoms, along with leeches, segmented worms, and flatworms. Insects such as water boatmen, backswimmers, predaceous diving beetles, and giant water bugs are also common in warm-water ponds and other types of ponds and lakes.

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Now That’s Deep

Native Americans and early settlers believed the vivid green waters of Green and Round lakes in the rolling hills of Onondaga County to be bottomless. In fact, the lakes do have bottoms, though they are surprisingly deep—nearly 200 feet—given the relatively small size of the two lakes (68 and 35 acres at the surface). The lakes’ green color is a result of the great depth and the calcium carbonate dissolved from the surrounding limestone cliffs. Called glacial plunge lakes, they were created by erosion at the base of massive waterfalls that formed as the Ice Age was ending some 14,000 years ago. These are nothing more than very deep examples of the erosion that occurs at the base of any waterfall.

The biological curiosity of Green and Round lakes goes beyond their formation. These lakes are meromictic, which means they never undergo complete mixing. They are unique in New York State in that at least three groups of photosynthetic bacteria inhabit them. Near the surface, photosynthetic bacteria and diatoms form the base of the lake’s food chain. At 55 to 75 feet deep, a three-foot layer of rosy pink water is formed by purple photosynthetic bacteria, plus green sulfur bacteria. These bacteria also occur below this layer, though without the striking colors. But no animals—not even tiny zooplankton—can survive because of the almost complete absence of oxygen at this depth.

Increased sedimentation can change lake water chemistry, as well as bury lake bottom habitats. Any activity in a watershed that bares soil and creates runoff, such as logging, agriculture, and construction, can increase sedimentation. Comprehensive water quality protection efforts must be implemented at the watershed level to preserve lake ecosystems. Effective strategies include upgrading municipal sewage treatment facilities to reduce phosphorus discharges to rivers and lakes; providing assistance to farmers to implement “best management practices” that reduce agricultural runoff; adopting building code ordinances, such as requiring “silt fences” that prevent pollutants from escaping construction sites; and adopting local land-use planning statutes that avoid erosion-causing activities in the immediate watershed of lakes and ponds, particularly on steep slopes.

The introduction of invasive, non-native plants and animals has dramatically changed lake ecosystems. For example, the zebra mussel, a small, filter-feeding freshwater mussel native to Eurasia, first invaded Lakes Ontario and Erie during the 1980s. They have now reached Lake Champlain and Seneca Lake, among other lakes. Zebra mussels reproduce prolifically and lack natural predators. Although tiny in size, because of their large numbers, they can filter huge quantities of water—effectively decimating plankton communities in many water bodies. They settle on any hard surface, encrusting pipes, trash, and virtually anything on the lake bottom—including native freshwater mussels. Since they can threaten economic activity by clogging water intake pipes, people may use chemicals to kill them—further endangering native lake life. Biological controls are being sought, but the feasibility of this approach is not yet apparent.

Non-native aquatic plants such as Eurasian watermilfoil and water chestnut threaten many of New York’s water resources as well. These foreign invaders benefit from having few natural controls. They reduce diversity of other plant species and also make the shoreline and water less attractive for recreational use. Additional resources are needed at the state and regional levels to eradicate or control nuisance aquatic species, and to prevent introduction of new threats yet to arrive in New York waters.

Acid rain is another major threat to many lakes. New York’s rain is 10-100 times more acidic than natural rainwater. The culprits are sulfur and nitrogen oxide emissions from automobiles and coal-burning power plants. Most of the power plants are located in the industrial Midwest, though some are in New York State.

The chain pickerel is an ambush predator often found in shallow, near-shore areas with abundant aquatic vegetation.
Ecological Communities: How We All Live Together

New York's coastal and marine waters teem with life. Oystercatchers, large noisy shorebirds, search mudflats exposed at low tide for clams, mussels, oysters, snails, and other marine invertebrates.

Beaches, Bays, and Ocean

New York's marine environment is best understood as two types of natural systems. The marine system consists of shorelines beyond the barrier islands out to the deeper waters of the Atlantic Ocean (legally defined as “New York” for up to three miles). The estuarine system includes Long Island Sound, the several bays that dent Long Island's north shore, the Peconics between the North and South Forks, the south shore bays from Jamaica Bay through Great South Bay and Mecox, and the Hudson River upstream to Troy.

Taken together, these environments contribute tremendously to the state's biodiversity. They support a wide array of species, including fin whales, mako sharks, and harbor seals off Montauk Point; piping plovers, horseshoe crabs, and surf clams along the sandy beaches of Fire Island; alewife, striped bass, and blue crab in the Hudson River; hard clams, eelgrass, and flounder on the bottom of Great South Bay; and bluefish, blackfish, lobster, and oyster in Long Island Sound.

Ecological Processes

New York's marine and coastal environments and their ecological processes are shaped by wind, waves, ocean currents, tides, temperature, and salinity. Wind on open water creates waves whose rhythms sculpt the state’s beaches and barrier islands. Wave action can erode some coastal areas, while ocean currents, formed by the movement of water particles within waves, may build up other areas as sand is deposited along the shoreline.
Storms rejuvenate beaches and dunes, thus creating nesting and feeding habitat for flowers and terns as well as habitat for beach plant species like sea beach amaranth. Storms also flush the bays and create platforms of sand for establishment of salt marshes and eelgrass. The coastal system is very resilient, able to recover and rebuild after storms.

Each of these physical factors combines in different ways in New York’s coastal environments. The result is a unique mix of species, natural communities, interwoven energy cycles, and other ecological processes. In every case, life has adapted to the challenging conditions of shifting beaches, changing tides, and salinity of the water.

Examples

**Deep Marine Waters**

Deep waters of the marine system are home to an enormous diversity of fish. Albacore tuna, blackfish, black sea bass, bluefish, bonito tuna, codfish, dorado, winter flounder, fluke (summer flounder), kingfish, mackerel, pollock, and sharks such as mako, blue, and thresher abound in New York’s marine waters. These large fish feed on countless smaller creatures.

Two species of jellyfish are common in New York’s marine waters: the lion’s mane jellyfish and the moon jellyfish. The lion’s mane gets its name from the red pigment that runs through its clear center. Its painful sting is familiar to many swimmers. Moon jellies, round and clear, inflict a milder sting.

**Ecological Communities: How We All Live Together**

Each physical factor and the unique species that each supports are interwoven, along with warm southern waters, to New York by mid-August. Jellyfish are simple animals without a brain, heart, gills, or blood. They undulate through the water with help from rudimentary nervous systems. When their poisonous tentacles happen upon their prey—tiny plankton—they release stinging cells that immobilize the prey. The immobile food is then consumed. Stinging cells can also be used as a defense mechanism to fight off predators, however, they don’t work against all predators, such as ocean sunfish and leatherback sea turtles, which are among the species that use jellyfish as a dietary staple.

Stinging cells can also be used as a defense mechanism to fight off predators, however, they don’t work against all predators, such as ocean sunfish and leatherback sea turtles, which are among the species that use jellyfish as a dietary staple.
Summer squid, widely found in New York waters, where they are trapped in trawl nets, are an important commercial species. They also are on the menu of numerous large ocean predators such as marlin and tuna. Even immense sperm whales occasionally come to the New York Bight (the large expanse of shallow ocean between Long Island and the New Jersey coast) in pursuit of summer squid.

The return to Long Island of the seabeach amaranth, a wildflower regarded by the federal government as threatened, is a great conservation success—and a mystery. Seabeach amaranth is a low plant that grows on open beaches above the high tide line, especially around inlets. In 1950 it disappeared from Long Island’s south shore beaches, a loss that was echoed along the eastern seaboard from Massachusetts to Virginia. This absence persisted for 40 years until, to the surprise of botanists, approximately 300 plants reappeared on four separate Long Island barrier islands. Ten years later, nearly 200,000 plants were tallied all along Long Island’s southern barrier beaches. The loss of the seabeach amaranth was the result of human and vehicle traffic, and shoreline manipulation. The recovery appears to be tied to replenishment of sand at eroded beaches, which provided excellent habitat. Efforts to protect nesting areas of two rare birds—piping plovers and least terns—have likely also helped.

The Estuarine System

An estuary is a semi-enclosed body of water formed when freshwater from rivers and streams mixes with saltwater from the sea. Our estuarine system includes bays, sounds, and lagoons near the coast, as well as portions of rivers and streams connected to coastal areas. The estuarine system is made up of deep water and shallow tidal habitats and adjacent tidal wetlands, submerged aquatic vegetation, and beaches with access to open ocean. It may also include tidal freshwaters, where ocean water is diluted by freshwater runoff. The many combinations of water depth, salinity, and tidal range result in a rich array of plant and animal communities.

The Mysterious Recovery of the Seabeach Amaranth

The floors of the Atlantic Ocean and Long Island Sound provide a variety of habitats. Muddy bottoms harbor burrowing animals such as polychaete worms or mud shrimp, which can dig as deep as three feet. Since sand particles do not stick together, burrows are tough to haul. Worms, for example, make burrows by excreting material that glues sand granules together. Winter flounders use fin and body motion to stir up sediment, and then hide beneath the thin layer that settles out. Gravel, rocks, and boulders encourage a more sedentary lifestyle. Kelp, deadman’s finger (a sponge), and frilled anemone reside here.

From top: Green turtle, harbor seals.

Filbers feeding browsers like scallops and oysters play an important role in nutrient cycling and cleansing of estuarine waters. Right: The blue eyes found along the edge of the bay scallop’s shell help it detect movement and avoid predators like the sea star. Below: A scud or “sidewimmer,” a common estuarine invertebrate.

People occasionally spot sea turtles such as Atlantic (Kemp’s) Ridley, leatherback, green, or loggerhead in New York’s marine district. Finback, minke, and humpbacked whales migrate through offshore waters, with a population of finback whales even spending the warmer months in the vicinity of Montauk Point. Gray and harbor seals “haul out” on beaches along the Long Island coast when they are not hunting.

Many birds also use these offshore waters. In addition to shorebirds and waterfowl, a host of true seabirds thrive there. They spend most of their time finding food on or under the ocean waters. Gannets dive headfirst from the air. Shearwaters search continually while gliding just over the wave tops. Murres and dovelies dive from the surface.
Bays

New York's many shallow bays are home to a diversity of sea life and also provide a wealth of seafood. Commercial and recreational fisheries have grown up around bluefish, striped bass, winter flounder, fluke, scup, tautog,weakfish, and others. Oysters named after Blue Point once helped make Great South Bay famous. Today most of our oysters come from Long Island's north shore. Hard clams (called quahogs elsewhere) are still popular, especially the small ones named after Little Neck Bay. And though many associate lobsters with the rocky coast of Maine, they are also New York residents. The young find shelter in eelgrass-covered bottoms of the shallow bays before they move out to deeper marine waters as adults. Scallops and blue crabs also thrive in eelgrass. Blue mussels and whelks, too, make the journey from bay bottom to tabletop.

Eelgrass—the premier plant on bay bottoms—provides food and shelter to many marine animals in the South Shore bays, eastern Long Island Sound and Peconic Bay. Not an alga like true seaweeds, it is actually a flowering plant with roots. The bottoms of the bays, whether muddy, sandy, stony, or covered with eelgrass or sea lettuce, harbor many life forms. Some bottoms never see the light of day. Others—the shoals and flats—emerge when the tide is out. Residents of these bay bottom habitats include the well-known hard clam and its soft cousin, as well as fingernail, duck, and razor clams. Moon and mud snails are hunted by the much larger knobbed whelks. Other snailhunters include crabs, sea urchins, and oyster drills, which bore holes through the shells of their prey.

Deeper waters are patrolled by diving ducks such as greater scaup and goldeneye, which dive to the bottom and root around for shellfish. Shallower waters attract brant and black ducks, which merely tip forward and submerge their front halves to graze on seaweeds, or sift through bottom sediments for worms, snails, and clams. Ospreys plummet from the sky to grab flounder in the shallows. Black skimmers fly along with just their lower bill tips beneath water, ready to snap up any food item, such as Atlantic silversides. Herons, egrets, and ibis wade in the shallows stalking small fish. When the flats are exposed, shorebirds—especially dunlin and least sandpiper—may be found in the hundreds probing sand or mud for worms and other invertebrates.

Tidal Marshes

Tidal marshes are transitional zones between the land and ocean, where daily tidal action moves water in and out of the system. By creating different zones within the marsh system, sun, tides, and salinity all influence which plant and animal species can live in these habitats. The concentration of salts—mostly sodium chloride (common table salt)—dissolved in the open ocean is approximately 35 parts per 1,000. Brackish tidal marshes occur where water salinity ranges from 0.5 to 18 parts per 1,000 and can be found along the Hudson River from New York City to Newburgh. Vegetation is dense and dominated by tall, grasslike plants such as narrowleaf cattail, arrow arum, and pickerelweed. Freshwater tidal marshes occur at the mouths of the Hudson River and Long Island’s largest rivers. Here the water is usually fresh—salinity less than 0.5 parts per 1,000. Vegetation bordering mudflats or open water is dominated by aquatic plants such as spatterdock, arrowhead, burreed, wild rice, and blue flag.

Salt marshes are the most saline of tidal wetlands, sometimes reaching between 20 to 30 parts per 1,000. Salt marshes rival tropical rain forests in the amount of plant material they produce each year. This high productivity comes from three elements of the salt marsh-estuarine ecosystem: mud algae (mostly diatoms and seaweeds), phytoplankton (microscopic plant life suspended in the water), and marsh grasses such as cordgrass, salt hay, and spike grass.

Ideal Fathers

Believe it or not, a species of seahorse—creatures usually found only in warm seas—inhabits New York’s waters. The lined seahorse, which can grow to a height of six inches, can be found in a variety of marine habitats off the coast of Long Island. Seahorses wrap their tails around blades of eelgrass or skim along silty bottoms feeding on small crustaceans, which they suck up through their tubular snouts.

No doubt the most unusual aspect of the seahorses’ life history is that the male is the one that gets pregnant. In a surprising parental role switch, the female deposits her eggs in the male’s brood pouch, which is full of awaiting sperm. After a period of weeks, the male gives birth to as many as 400 baby seahorses.
Intertidal Beaches

Washed by rough, high-energy waves, with their sand or gravel surfaces well-drained at low tide, beaches are subject to extremes of salinity and moisture. The relatively few inhabitants of beaches include tiny but abundant invertebrates such as marine worms and beach fleas. The mass of seaweed that accumulates at each tide is also an important habitat for a variety of invertebrates that in turn provide food for the many migrant shorebirds, including sanderlings and semipalmated plover, and breeding shorebirds such as piping plover. Other species find ample food along the beach by scavenging whatever washes up along the shoreline. Gulls, especially herring and great black-backed, forage for fish and clams deposited by the surf.

Beach Dunes

Sandy beaches above the reach of the highest tides are important feeding, nesting, and resting areas for many coastal species. Beach grass, beach plum, bayberry, and other plants hold the shifting sands in place, providing habitat for small meadow voles and beach tiger beetles that scurry among the dune vegetation. Colonies of least terns, black skimmers, and solitary piping plovers nest on protected areas of the beach. Their simple nest “scrapes” and their pale, speckled eggs blend in well with the sand, making them hard to spot from a distance.

The Intriguing Horseshoe

Horseshoe crabs are more closely related to spiders and scorpions than to other crabs. Recognized by their helmet-shaped brown shell and spiked tail, which helps them turn themselves over if flipped upside-down by a wave, these animals have changed little in appearance in the past 360 million years. Horseshoe crabs spawn in May and June during the highest spring (moon-influenced) tides. Females come to shore and lay thousands of small, round greenish eggs, which become buried in the sand by wave action. The eggs hatch at the next spring tide a couple weeks later, and the young crabs swim out to sea, where they spend the next 9 to 10 years growing to maturity.

Other animals, including migrating shorebirds, depend on horseshoe crab eggs for food. Horseshoe crabs are also important to medicine. Chemicals (clotting factors) in their blood are used to test drug purity. Chitin from their shells speeds healing when incorporated into bandages.
Saltwater intrusion into freshwater systems. Rising seawater temperatures will affect fish movement, spawning behavior, and resistance to disease.

Conservation Challenges

Many conditions that threaten biodiversity throughout New York also imperil biodiversity in the marine environment. Increases in human population during the last century have had enormous consequences for coastal habitats. Changes in land use and development have resulted in habitat loss and degradation of water quality. Shoreline stabilization to support this development, whether by construction of bulkheads, groins, or jetties, has altered coastal processes. Increased recreational use of New York’s beaches, including the use of off-road vehicles, threatens beach-dependent nesting and feeding species like the piping plover, least tern, and black skimmer.

Regulatory efforts have helped reduce losses of tidal wetlands resulting from filling, dredging, and development. However, pollution and habitat loss still pose problems. Another threat is rising sea levels and seawater temperatures. The waters of the Atlantic Ocean have been creeping up at a rate of about 10 inches per century. Some scientists project they are likely to rise an additional 22 inches by 2100 due to climate change. Sea-level rise leads to flooding of low-lying areas, drowning of tidal marshes, erosion of beaches, and saltwater intrusion into freshwater systems. Rising seawater temperatures will affect fish movement, spawning behavior, and resistance to disease.

Shallow marine habitats are threatened by the disruption of sediments—the layers of sands and silts that collect naturally on shoals and in marshes. When these sediments are removed by dredging and changes in tidal dynamics, shoals and marshes slowly starve and wither away. Such sediment disruption has been identified as one of the major causes of coastal habitat loss, although loss of coastal wetlands has been observed over most of the 20th century. Remedies have not yet been found.

To combat these threats, New York State should reinforce its coastal zone protection strategies, making them more comprehensive by incorporating a longer-term view of threats and how to address them. Additional state and local water quality investments are needed to upgrade sewage treatment plants and reduce nonpoint water pollution. The last remaining undeveloped beach and shoreline parcels on Long Island should be acquired as public parkland, and additional resources allocated to restoring salt marshes, eelgrass beds, and other marine environments. Coastal management policies that discourage new development in sensitive coastline areas, and wherever possible allow for the natural movement of beaches, shorelines, and coastal inlets, will help New York’s coastal habitats adapt to future sea-level rise. Taken together, these strategies can help preserve New York’s marine and estuarine biodiversity.
water is simplified—for the worse—when forests are cleared, wetlands drained, and fertilizers applied. Clearing land diminishes the replenishment of groundwater and hastens soil erosion. In an unaltered landscape, a water molecule might help nourish and support a cottonwood tree in Otsego County, for example. Cycling through its leaves, such molecules might be passed along to a leaf beetle, then to a bird, to be deposited as part of a dropping on the soil below. Instead, in a cleared landscape, this molecule is more likely to be sent straight downstream, perhaps all the way through the Susquehanna River and Chesapeake Bay and into the Atlantic Ocean, contributing little to biodiversity along the way. Similarly, soil and nutrients cannot contribute to upland communities when they are swept into surface waters. Once in streams, rivers, lakes, or ponds, these sediments and nutrients disrupt the natural communities there, creating conditions under which fewer species of plants and animals can survive.

Examples

**Agricultural Landscapes**

New York’s original inhabitants took advantage of the state’s tremendous agricultural potential, with its abundant rainfall, productive soil, and moderately long growing season. Most notably, Native Americans raised corn, beans, and squash, supplemented with fish and game, and nuts and berries gathered from the wild. Later, European settlers introduced new crops such as wheat, flax, and domestic varieties of apples; they also raised horses, cattle, hogs, and chickens. Today, more than 30,000 farms contribute to a $10 billion industry in the state. This industry inevitably affects the state’s biodiversity. The net result of most farming activities is a reduction in the diversity of native plants and animals, as humans replace diverse ecosystems with cultivated fields devoted to only one or two plant species. Other major physical changes to natural communities occur when wetlands are drained, or habitats of all kinds are subjected to grazing by livestock. Farming often fragments forest habitats. If the remaining patches of forest are too small, forest interior species such as goshawks and American marten will be left without suitable habitat.
Some farming practices, such as providing grasslands for beef cattle, create habitat for plants and animals that cannot thrive in forests.

Similarly, if improperly applied, pesticides used to control insects or weedy plants can have severe effects on other organisms. Even the safest pesticides often cause unintended harm. The effects of some now banned pesticides such as DDT and chlordane are well known. Not only did they prevent successful reproduction in large animals such as bald eagles and ospreys, but they also have been shown to remain at harmful levels in the environment for many decades. Another risk that pesticides pose to biodiversity is depletion of seeds and soil organisms. Used over a long time, pesticides can reduce the ability of soil to support natural communities.

Overuse of agricultural fertilizers and runoff from animal wastes are a principal source of nutrient pollution in rivers and lakes and other surface waters. Erosion can deplete farm soils. Runoff can dump sediments into aquatic habitats, choking out organisms that require clear waters or rocky and pebbly stream bottoms. For example, brook trout cannot survive when the mayflies and stoneflies upon which trout feed are themselves unable to find clean habitat for feeding and reproducing.

Despite the changes that agriculture brings to the natural landscape, agriculture does benefit some wild species. For example, field margins support edge-loving species such as bobwhite quail and blue-winged warblers. Traditional farms that are smaller and incorporate a variety of activities rather than a large monoculture can provide a surprising amount of such habitat for wild native plants and animals, and thus can play an important role in maintaining the state’s natural biodiversity.

Dominant crops on New York farms are corn, alfalfa, and perennial grasses for hay. These are followed by wheat, oats, barley, and soybeans. Such grains provide food for a wide variety of wildlife. White-tailed deer and wild turkey rely heavily on them, and Canada geese and snow geese have recently changed their wintering and migratory patterns to take of the grain left in fields after harvest. Even manure spread on dairy farms during the winter and early spring provides sustenance—through the undigested seeds and plant parts—for these and other migratory birds such as snow buntings and horned larks.

Fallow fields, pastures, and hay fields fulfill many habitat requirements for wildlife.

The meadow vole is a common inhabitant of hay fields and pastures. It is a small brown animal with a gray underbelly and dark stripes down the back.

Sparrows have special songs that carry well in tall grass. Some, like the aptly named grasshopper sparrow, sound just like insects. Females of each species are striped with the browns, yellows, and tans that blend in well with field grasses, protecting them as they sit tight on their nests.

Grassland nesting birds build their homes in open fields, often on the ground. Our state’s grassland birds include four sparrows (savannah, grasshopper, Henslow’s, and vesper), as well as bobolink, eastern meadowlark, upland sandpiper, northern harrier, and short-eared owl. Sparrows have special songs that carry well in tall grass. Some, like the aptly named grasshopper sparrow, sound just like insects. Females of each species are striped with the browns, yellows, and tans that blend in well with field grasses, protecting them as they sit tight on their nests.

Habitats for such birds were created during the state’s period of European settlement, as forests were cleared and fields became dominant. Today, with reforestation and increasing pressure from development throughout the state, the last strongholds for grassland birds are areas with extensive open fields such as farms, airports, and even military bases. The largest population of the state’s rarest grassland sparrow, the Henslow’s, is found at the U.S. Army’s Fort Drum.

Not just any field will do. Each species of grassland bird has its particular habitat requirements, including grass height and composition, and field size. Since they all nest on or near the ground, they are especially vulnerable to predators. For this reason, grassland nesting birds prefer large open spaces, where they can keep an eye out for predators. For Henslow’s sparrow, this means fields of 75 to 80 acres or more in size. Even a hedgerow or road between two fields that restricts their view may render a farm field unsuitable for nesting.

Since New York’s grassland birds are now largely dependent on agricultural landscapes for their survival, guidelines for compatible agricultural practices have been developed for farmers and others interested in maintaining suitable habitat.
that serves as prey for hawks and owls, including the rough-legged hawk and the short-eared owl in winter. Coyotes, along with red and grey foxes, hunt for voles year round. Weed seeds in fields provide food for wintering tree sparrows and dark-eyed juncos. In summer, vesper sparrows, eastern meadowlarks, and bobolinks may nest in these fields. The largest fields may provide nesting opportunities for northern harriers or upland sandpipers. Wetter fields serve similarly for sedge wrens or Wilson’s snipe.

Orchards and vineyards also provide homes for wildlife. The fruits often serve as important seasonal food sources. In fact, deer, bear, mice, voles, and many birds are so attracted to these crops that they sometimes cause serious losses to farmers.

Though plant diversity suffers when land is farmed, abandonment of farmland allows some species to thrive, at least for brief periods of time. Sun-loving early successional species like asters, goldenrods, raspberries, and shrub dogwoods may enjoy a wider distribution now than they did in the period before European settlement.

Similarly, some plants have a competitive advantage over others when land is grazed by livestock. Rare plants such as the sandplain gerardia, spreading globeflower, and side-oats grama grass do well when pastures are lightly grazed. Grazing arrests the natural succession process of the plant community and allows plants adapted to an early successional stage to flourish.

Most farms have patches that are not actively farmed. These areas offer refuge to a wide variety of plants and animals. Unplowed shores along streams and ponds and woodlots not only provide firewood or lumber to the farmer; they are also suited to woodland animals. Great horned owls nest in larger woodlots, especially if mature white pines are present. Hedgerows provide cover and nesting sites for house wrens, brown thrashers, and gray catbirds. Woodchucks and striped skunks den there. Farm ponds and wetlands can sustain local populations of water birds, fish, and amphibians such as spotted salamanders and gray tree frogs. Natural landscapes also provide refuge for native pollinators, improving crop productivity in insect-pollinated plants and serving as a food source for predators such as hawks and owls, which help keep crop pests in check.

**Cities and Suburbs**

Built of natural materials such as saplings, bark, and thatch, settlements of early Native Americans in New York were truly recyclable. Our modern settlements, by contrast—with their large solid buildings, paved streets, parking lots, and elaborate plumbing and heating systems—have a profound effect on biodiversity.

Although some generalist plants and animals can survive and even flourish around cities, sensitive species cannot. Cities and suburbs are stressed, constantly changing environments. Air, water, and soil in developed areas are often polluted. For this reason, neither lichens nor snails are abundant in urban areas, as they cannot tolerate air pollutants such as sulfur dioxide. Soils are more compacted, making it harder for water to infiltrate and plant roots to grow. In general, cities and suburbs also tend to be warmer than the surrounding countryside, as buildings and pavement absorb the sun’s heat during the day, and slowly release it at night. Buildings—especially tall ones—modify the city environment by affecting where shade and sun will fall, and by creating “wind tunnels” in certain places. Drier, warmer, and windier conditions, in turn, determine which plant and animal species can survive. Those bright city lights so admired on Broadway, along with all the lights on buildings and lining suburban streets and homes, disrupt the movements, migration, and reproduction of many nocturnal species—and can even disturb the growth, germination, and flowering of plants.
Even a comparatively tranquil suburban house and yard can be a hostile environment for most native plants and animals. Some manicured lawns are almost as impervious to water as pavement. Increased water runoff sends lawn and garden chemicals and other household pollutants into nearby waterways.

Often, sensitive species have specialized habitat requirements. Many carnivores such as black bear and bobcat require large expanses of land to meet their needs, and cannot survive in the severely fragmented landscapes of urban and suburban areas. Even very small creatures can be affected. Butterflies (as caterpillars) depend on specific plants for food and many native bees require areas of untrampled soil for nesting, neither of which may be found after development. Salamanders use leaf litter for refuge: they cannot survive in manicured landscapes devoid of fallen logs and branches and a thick, moist layer of leaves.

Other suburban stresses to wildlife include predation by house pets. Domestic cats allowed to roam outdoors are estimated to kill billions of wild animals—birds, small mammals, reptiles, amphibians, and insects—each year in the United States. Roads, along with curbs and storm sewers, cause significant mortality and alter movement patterns, keeping animals from carrying out their daily activities. Given all these stresses, can these seemingly hostile habitats support any life at all? Can biodiversity exist in city and suburb? Of course, the answer is yes. Despite all the modifications people have made, the Earth’s ecological processes continue in urban and suburban areas—although, just as in agricultural systems, they are both changed and simplified by human activity.

Urban areas are usually dominated by non-native species of plants such as tree-of-heaven and mugwort, and animals such as pigeons and house mice. However, native animals and plants can also be abundant in cities and suburbs if they are adaptable, “generalist” species. Weedy plants with rapid growth and wide dispersal, such as black cherry, sumacs, and many grasses, do well. Many animals take advantage of the “subsidies” of food, shelter, and water we unintentionally provide in our suburbanized yards and city streets. These “gifts” include food scraps and garbage, seeds left in bird feeders, and water used for landscaping or found in culverts and foundations. Benefiting from such largesse are mammals such as raccoons, opossums, eastern gray squirrels, big brown and little brown bats, striped skunks, red foxes, coyotes, woodchucks, and cottontail rabbits; and birds such as mockingbirds, American crows, American robins, black-capped chickadees, and grackles.

Two of our more unusual native “city birds” are chimney swifts and nighthawks.

Bats Down There

Another habitat created by humans—abandoned mines—plays a critical role in the life cycle of New York’s bat species. Over the last several decades, biologists have surveyed more than 120 mines and caves in New York for Indiana bats, one of the first animals to be listed by the federal government as endangered. Although during the summer months this species ranges throughout the eastern United States, Indiana bats hibernate in only a few places. In New York, 85 percent of the total known population use just seven caves and mines (called hibernacula) for overwintering. Population numbers appear to be stable at around 13,000 in the fewer than 10 hibernacula that have been found in New York.

Indiana bats are roughly 2 inches long and weigh about 0.3 ounces, the equivalent of nine one-dollar bills. They dine exclusively on flying insects.
Community gardens (below), backyard habitats, and planted wildflower meadows (right) offer much of the same food and shelter that are needed by insects, birds, and other wildlife in more natural communities.

Community gardens and local cemeteries provide habitat for many birds and insects. Golf courses, parks, and other large lawns offer succulent grasses as forage for resident Canada geese and Arctic-nesting brant. Forest patches fragmented by suburban development are highly favored by white-tailed deer. Increases in populations of deer and geese—considered nuisances by many—are due partly to our alterations of habitat. Long Island has scores of former mill ponds that, during the colder months, provide food, water, and resting places for virtually all the waterfowl species that are found on the Atlantic coast. Some of the natural areas and undeveloped parks of New York City, Buffalo, and Syracuse, for example, serve as refuges for native plants and animals still living in the area. These habitat patches can be sources of seeds and animals for restoration of other nearby habitats.

Noisy Flowers

Watch for the rattlesnake wildflower along roadsides and railroad tracks in southeastern New York. Listed by the state as endangered, its yellow pea flowers develop into inflated pods. The seeds inside rattle when shaken. The wildflower is at the northern edge of its range in New York, with only three populations reported in the last 20 years.

Conservation Challenges

Farmlands have been thoroughly studied from a conservation perspective. County soil and water districts provide expertise and funding on “best management practices” that reduce runoff of fertilizers and animal wastes from agricultural lands. The federal Natural Resources Conservation Service administers the Conservation Reserve and Wetlands Reserve Programs, which provide financial incentives to farmers who set aside and protect sensitive habitats. Cornell Cooperative Extension manages the Integrated Pest Management program, which educates landowners on ways to reduce their use of chemical pesticides. Nonprofit land trusts acquire conservation easements that prohibit residential development of farmlands and other rural lands. These are just a few of the many incentive programs designed to protect biodiversity in agricultural landscapes that merit additional funding.

To better conserve biodiversity in settled areas such as cities and suburbs, we need to maintain existing natural habitat patches and restore degraded landscapes where possible. At the same time, we should plan new development in ways that better protect the plants, animals, and natural communities remaining in the larger landscape.

One of the greatest threats to local biodiversity is poorly planned development, whether it occurs as expansion on the fringes of urban areas, or as large-lot development far from urban centers such as hilltop estates in the Taconic Mountains and second homes in the Adirondacks.

Haphazard development—called sprawl—endangers more species and ecosystems than any other human activity. Through conservation, restoration, education, and thoughtful land-use planning at the local and regional levels, we can protect much of New York’s biodiversity. Working with the tools available at all levels of government, we can increase our success rate and limit the destructive effects of sprawl.
Goals and Priorities: The Challenge Ahead

New York has been a leader in conservation for well over a century. In 1836 the state began the Natural History Survey, which led to the establishment of the State Natural History Museum in 1870. In 1885, the Adirondack and Catskill Forest Preserves were created, protecting two of the largest wilderness parks in the eastern United States. Since the early 1970s, state and federal laws and policies have yielded substantial results in habitat protection, restoration, and pollution control. Building on this tradition, new goals and bold actions are needed to continue conserving our irreplaceable natural heritage. Public support is vital. The well-being of current and future generations depends on our success.

Science

New York State should draw on public and private resources to increase scientific knowledge of our biodiversity. Major gaps exist in scientists’ understanding of the biodiversity of New York. If we are to make effective decisions about conservation, land management, and planning, we must have basic knowledge of the rarity, distribution, and health of native plants, animals, and ecosystems, and of the threats to these resources. Scientists also need to know how environmental conditions have changed and are changing over time. Therefore, as a fundamental step, we must increase our commitment to scientific research.

Biodiversity Inventories

New York should expand statewide inventories for plants, animals, and natural communities, including both common and rare species and ecosystems. The New York State Museum has sponsored flora and fauna inventories for over a century and maintains a collection of more than five million plant and animal specimens. New York’s public and private universities, and private museums such as the American Museum of Natural History, also are repositories of huge amounts of biological information.
LEGACY: Conserving New York State’s Biodiversity

Goals and Priorities: The Challenge Ahead

Public Awareness and Information

More ways should be found to increase public understanding of biodiversity, provide biodiversity information to public and private decision makers and land managers, and make biodiversity education an integral part of public education.

Many New Yorkers do not realize the importance of biodiversity, and are not aware of the consequences of its decline and loss. The result is that we are making critical decisions without adequate information and analysis.

A number of effective biodiversity outreach programs, projects, and curricula are currently sponsored by public and private organizations. A Needs Analysis sponsored by the New York State Biodiversity Project identified education and outreach as one of four key components of an effective statewide biodiversity conservation strategy. In part to meet this need, the New York State Biodiversity Research Institute and its partners established the biodiversity clearinghouse: http://www.nybiodiversity.org.

 Nonetheless, broad public understanding of the importance of conserving biological diversity is low. State policy makers, land managers, planners, educators, local officials, and the business community all need improved education and training.

To ensure biodiversity education in the classroom, the subject should be more effectively integrated into required curricula of all public education institutions, and new and updated teaching resources should be provided for finding and using biodiversity information.

In addition, new measures are needed to assist key decision makers and natural resource professionals in securing, interpreting, and applying biodiversity information. Species identification, life history, and habitat management information must be made available in formats understandable to nonscientists. Important audiences include town and county planning boards, environmental permitting and review staff, public and private land managers, environmental consultants, and elected officials at all levels of government.

Public and private land managers must have access to biodiversity information. State policy makers, land managers, planners, educators, local officials, and the business community all need improved education and training.

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Research and Ecological Monitoring

Expanded research efforts are needed to better understand ecological processes, basic biology of species, and their life history requirements, as well as the relationships among organisms and their environments.

Inventories can document where plants and animals exist, but they don’t tell us how species use the landscape, how many there are, how they interact with each other, their roles in ecological processes, and what they require to survive. This knowledge is key to improving land and species management for the long term. In addition, long-term monitoring to determine the status and trends for targeted species and ecosystems is essential to assess threats to biodiversity and gauge the success of conservation efforts.

Several organizations now undertake statewide biodiversity inventory programs. The New York Natural Heritage Program—a joint program of the state Department of Environmental Conservation and The Nature Conservancy—maintains information about rare and imperiled plants, animals, and significant ecological communities at more than 10,000 locations across New York. Information includes detailed inventories of state wildlife management areas and parklands.

However, significant gaps remain in our knowledge of New York’s biodiversity. Comprehensive inventories have not been undertaken in most regions. We still know comparatively little about the aquatic systems, invertebrates, mosses and liverworts, fungi, algae, and microbes that make up the bulk of New York’s biodiversity and that are vital to ecosystem function. Even conspicuous insects like dragonflies, damselflies, and butterflies remain poorly studied.

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Conservation Action

New York State should accelerate efforts to partner with interested landowners in protecting ecologically critical lands and waters, to improve management of biodiversity resources on public and private lands, and to expand consideration of biodiversity information in decisions involving environmental review, land-use planning, and economic development.

All of our biodiversity requires informed consideration and protection. This includes both concentrations of rare species as well as common plants, animals, and ecosystems that are often overlooked. It includes species and communities on private and public lands. Stronger biodiversity conservation action is needed in four areas: protection of important lands and waters; ecologically based land-use planning, resource management; and promotion of economic and ecological sustainability. These actions must be undertaken at both local and regional levels, in collaboration with interested private landowners.

Protection of Important Lands and Waters

Habitat destruction is the number one threat to New York’s plants, wildlife, and ecosystems. Today, less than 20 percent of New York’s lands and waters are permanently protected as parks, wildlife management areas, state forests, and private nature preserves. Ongoing land protection efforts by New York State, federal agencies, local governments, and nonprofit land trusts are urgently needed to acquire special habitats that protect healthy ecosystems and imperiled species. Conservation easements that provide permanent legal protection to privately-owned forests and farmlands are also an essential tool for protecting the integrity of rural landscapes.

Land-Use Planning

Since planning, zoning, and development decisions have such a huge cumulative impact on biodiversity, land-use planners especially need to be targeted by education and outreach programs. In New York State, authority for land-use planning decisions is vested primarily at the town level—in boards appointed by town leaders. Planning boards, made up of volunteers who typically have little or no formal training in biological sciences, are charged with reviewing and passing judgment on construction proposals that shape local and regional development patterns. Boards need access to biodiversity information within their jurisdictions, and assistance in interpreting and incorporating this information in their decision-making processes.

Resource Management

Setting land aside as protected parks and natural areas is not, in and of itself, sufficient to conserve biodiversity. Active resource management programs, based on the best available science, are required. And in many cases, ecological restoration efforts are needed to address environmental degradation from historical threats. In order to restore and maintain healthy ecosystems, resource management initiatives are needed in many areas. Initiatives should: ensure that outdoor recreation activities are planned and overseen in a manner that prevents damage to sensitive habitats; control the introduction of invasive species that displace native plants and animals; undertake controlled burns in fire-dependent ecosystems; restore native vegetation buffers along lakes, streams and wetlands; improve coastal and marine habitats; control excessive populations of deer and other species that overwhelm natural habitats; and restore natural flow regimes to streams that have been altered by dams and reservoirs. These programs must be targeted at both public and private lands.

Promotion of Economic and Ecological Sustainability

A sustainable society is one that satisfies its needs without jeopardizing the prospects of future generations. To accomplish this, human communities must be compatible with natural communities and their ecological processes. This requires thoughtful public policies and investments that encourage land uses, economic activities, transportation systems, and energy generation and use practices that are environmentally sustainable. Such practices will also help to conserve New York’s biodiversity.
Partnerships and Funding

In order to achieve the goals outlined above, public officials, private organizations, and interested citizens must collaborate on two underlying strategies: strengthening public and private partnerships, and securing additional public and private funding.

Partnerships

An enormous number of organizations and institutions representing a wide spectrum of perspectives are engaged in research and conservation of New York’s biological diversity. They include elected officials, state and federal agencies, town and county officials and planning boards, nonprofit environmental groups and land trusts, universities and research institutions, trade associations, private landowners, amateur naturalists, and interested citizens. Given the daunting threats to New York’s natural environment, and the complexity of the state’s human landscape, we will succeed in conserving our biological diversity only if we forge effective public and private partnerships.

Funding

Many public and private funding sources currently exist to support efforts to understand and protect New York’s biodiversity. However, given the complexity and scope of the threats, additional funding is necessary if we are to preserve our natural world for future generations. Elected officials, private organizations, and interested citizens must work together to significantly increase funding for biodiversity research and conservation.

Conclusion

New York harbors a unique wealth of biological diversity that is stunning in its breadth, complexity, and beauty, and that is vital to our existence. However, this irreplaceable natural legacy, which defines the state’s regions and landscapes, faces significant threats and challenges. This book is meant to serve as a rallying point for those interested in biodiversity issues: to motivate efforts by public and private entities to study and to conserve New York’s biological diversity.

New York’s living resources are incredibly diverse. An equally diverse set of strategies—conceived and implemented at the state and local levels by elected officials, public agencies, community leaders, conservation organizations, private landowners, and interested citizens—is needed to protect our biodiversity.

In the end, it’s up to all of us—the citizens of New York—to call for the conservation of both common and imperiled wildlife, habitats, and ecosystems in our local communities and across our great state. Working together, we can protect our natural legacy for ourselves and for future generations.
Appendix One

Sustaining Biodiversity Through Everyday Choices

We all have a role to play in meeting the challenges of the biodiversity crisis—the accelerated loss of animals, plants, and habitats caused primarily by human activities. We encourage you to do what you can, every day, to help conserve New York State’s rich biodiversity—our legacy for generations to come.

• **Protect Natural Areas.** Contact your representatives and let them know that you support decisions that will conserve our biodiversity. Learn about what is going on in your community and get involved in protecting its natural areas.

• **Make Sustainable Food and Resource Choices.** By eating a locally produced diet, you help support New York State’s economy, preserve farmlands, and reduce the pollution generated by transportation and energy costs from shipping food. In addition, organic produce is now widely available. Grown without use of synthetic pesticides, this practice reduces the amount of agricultural chemicals entering waterways. Support other resource conservation efforts by purchasing sustainably harvested, certified forest products such as wood and paper.

• **Reduce, Reuse, Recycle.** All the products we buy use natural resources, and usually end up in expanding landfills that often displace natural areas. Prevent the generation of waste in the first place by purchasing durable, long-lasting goods, and by reusing things or giving them to others. Imagine how many plastic supermarket bags would not have to be produced and disposed of if everyone brought a cloth tote and reused bags! As the old Yankee proverb states, “Use it up, wear it out, make it do, or do without.” It is also important to support markets for recycled products by buying paper and other goods with recycled content, and recycling all that cannot be reused.

• **“Green” Your Landscaping.** Adopt biodiversity-friendly lawn care and encourage your neighbors to do the same. Reduce your use of chemicals and fertilizers, and create backyard habitats (plant native species) that will attract birds, pollinators such as bees and butterflies, and other wildlife; keep cats indoors; and build a bluebird box and/or a bat box (bats will also help reduce mosquitoes in your yard).

• **Choose Efficiency.** Since one of the greatest threats to biodiversity—and to human health—is climate change, one of the most meaningful things to do to protect the Earth, yourself, and future generations is to lower your energy use, especially when making large purchases like a car or a major appliance. When looking for new household appliances, look for the ENERGY STAR label, which means they have met strict energy efficiency guidelines set by the Environmental Protection Agency and U.S. Department of Energy.

• **Use Water Wisely.** Simple habits like turning off the tap when brushing your teeth, washing, or shaving can save 10 or more gallons per day. Installing low-flow toilets and water-saving shower heads can save even more. For drinking water, consider taking it from the tap rather than buying bottled. Bottled water is not necessarily safer than tap water, and comes with an enormous environmental burden in terms of waste and energy use. You can contact your local water department to determine the quality of your water, and if necessary install an appropriate filter.

• **Support Conservation Organizations.** Join one of the many national or local environmental groups, museums, and land trusts striving to protect biodiversity and natural areas. Visit a local nature preserve, go on a guided nature walk, or participate in a volunteer clean-up day.

• **Learn More and Stay Informed.** Awareness of current biodiversity issues is critical if we are to see positive conservation outcomes. Learn about the biodiversity that lives in your neighborhood, and share this information with others.

Additional Resources

For additional information about the biodiversity of our state, visit the New York State Biodiversity Clearinghouse website at: [http://www.nybiodiversity.org](http://www.nybiodiversity.org).

This website was developed by the New York State Biodiversity Project and is maintained by the Biodiversity Research Institute to facilitate the use of biodiversity information by New York’s citizens. In addition to links or references to various sources of biodiversity information, the website also has detailed information on selected groups of New York’s species.
Appendix Two

Current Laws and Policies

A vast array of laws, regulations, and public policies at the local, state, and federal levels affect conservation of New York's biodiversity. Here is a summary of key programs presently at work:

Biodiversity Research, Inventory, and Information

Many federal and state agencies, including the New York State Department of Environmental Conservation (NYSDEC), the Office of Parks, Recreation and Historic Preservation (OPRHP), the U.S. Fish & Wildlife Service (USFWS), and the U.S. Geological Survey (USGS) are charged with collecting natural resource information. In addition, New York has created three programs specifically aimed at conducting research into the status and location of the state's biological diversity.

• **New York State Biodiversity Research Institute.** In 1993, New York enacted legislation that created the Biodiversity Research Institute (Section 235-a of the State Education Law) to help meet challenges associated with preserving the state's biodiversity. The institute is instrumental in identifying priority needs and promoting scientifically sound biodiversity conservation in the state. The institute’s mission includes promoting cooperative scientific and educational efforts to increase our knowledge and awareness of biodiversity, serving as a clearinghouse for biodiversity information, identifying areas that lack adequate biodiversity information and promote research in such areas, and making recommendations to elected officials and government agencies regarding the conservation of New York's biological diversity. The institute is housed within the New York State Museum and includes a number of collaborators from state agencies, state and private universities, nongovernmental organizations, and the general public. Drawing upon annual appropriations from the state's Environmental Protection Fund, the institute's staff initiate, undertake, and fund a variety of biodiversity research, stewardship, and education initiatives. For more information, see the BRI's website: http://www.nysm.nysed.gov/research_collections/.

• **New York Natural Heritage Program.** Established in 1985 as a partnership between the Department of Environmental Conservation and The Nature Conservancy, the New York Natural Heritage Program manages the state's most comprehensive database on New York's rare plants, rare animals, and significant ecological communities. It monitors nearly 200 ecological community types and 1,200 animal and plant species at more than 10,000 locations. This information is used across New York to enable and enhance biodiversity conservation in an objective and non-adversarial context. For more information, including lists of rare species and conservation guides, see the Heritage Program website: http://www.dec.state.ny.us/website/dfwmr/heritage/.

• **New York State Museum, Research and Collections.** Its origins can be traced back to 1836, when the state legislature established the Geological and Natural History Surveys to explore the natural resources of New York. Today, museum researchers inventory plant and animal species in all parts of New York. The State Museum houses the largest collection of specimens and voucher-supported data dealing with New York’s biological resources. Its mission is to advance knowledge of the biological and ecological characteristics that affect the state’s environment, interpret and disseminate information on natural resources, and manage the state's collection of plant and animal specimens. The museum’s Biodiversity Research Group includes a staff of about 20 botanists, zoologists, mycologists, molecular biologists, and ecologists. For more information, see the website: http://www.nysm.nysed.gov/research_collections/.

Protection and Stewardship of Lands and Waters

New York has established many programs to acquire and manage lands and waters that harbor biological diversity.

• **New York State Open Space Plan.** Under state law passed in 1990, New York has developed a comprehensive Open Space Conservation Plan. The plan, updated every three years, sets forth detailed recommendations for enhancing the conservation of lands and waters, including specific consideration of biodiversity concerns, and sets forth priority sites for land protection. The plan is available through the website: http://www.dec.state.ny.us/website/opensp/index.html

• **Environmental Protection Fund.** This permanent, dedicated fund provides more than $200 million annually to support open-space protection, parks, and other environmental activities. Programs include land purchases by the Department of Environmental Conservation and Office of Parks, Recreation and Historic Preservation; support for the Biodiversity Research Institute; stewardship of state lands; and local parks grants and regional initiatives, such as the South Shore Estuary on Long Island and the Albany Pine Bush Preserve. Since its inception in 1993, the fund has supported protection of almost one million acres across New York. Nonetheless, competition for these funds is keen.

• **State Bond Acts.** Historically, New York has relied heavily on voter-approved Environmental Bond Acts to fund open space purchases, water quality projects, and other land management capital needs. The most recent initiative, the 1996 Clean Water, Clean Air Bond Act, is now largely exhausted. In addition, a number of county and town governments (most notably on Long Island and in the Hudson Valley) have adopted local bond acts and other funding methods to protect open space, including lands that harbor important ecological resources.

• **Federal Programs.** The federal government administers many programs that support the conservation of biodiversity. Because federal ownership of land (national parks, forests, and wildlife refuges) is small in New York, most federal support comes in the form of grants to the state Department of Environmental Conservation and other state agencies. These programs include the Land and Water Conservation Fund, the Forest Legacy Program, the Pittman-Robertson Act, and various U.S. Environmental Protection Agency water quality programs. A new federal initiative—the State Wildlife Grants program—provides New York with significant funding for the stewardship of approximately 400 “wildlife...
species of greatest conservation need." For more information on these programs, see New York’s “Comprehensive Wildlife Conservation Strategy,” which is available on the DEC’s website: http://www.dec.state.ny.us.

• Regional Initiatives. Regional initiatives that pull together public and private organizations to protect biodiversity exist in many areas of the state. For example, the Hudson River Estuary Program, led by the state Department of Environmental Conservation, has launched a biodiversity program in the ten-county Hudson Valley region. The program includes field inventories, production of a “biodiversity manual” for local governments, and the services of a field representative to help local governments and organizations find and interpret biodiversity information. Other examples include the Long Island Pine Barrens Commission, the Peconic Estuary Program, the Shawangunks Ridge Biodiversity Partnership, the Adirondack Park Agency, the Susquehanna River Basin Watershed Coalition, and the Watershed Agricultural Commission. Many opportunities exist for strengthening regional initiatives in New York.

Regulatory Programs

State, federal, and local regulatory programs provide many direct and indirect avenues for conserving biological diversity.

• Endangered Species Acts. The federal government and the state of New York have enacted laws protecting endangered species. Pursuant to these laws, the U.S. Fish and Wildlife Service and the state Department of Environmental Conservation have promulgated specific lists of rare, threatened, and endangered plant and animal species. The state list contains 88 threatened and endangered animal species and several hundred plants. Harassing or collecting listed wildlife species, or destroying their habitats, is illegal. Although protections for plants are significantly weaker than those that apply to wildlife, these programs provide important protections for New York’s rarest species.

• Environmental Quality Laws. Many state and federal regulatory programs provide indirect benefits to plants, animals, and ecosystems. For example, state and federal wetlands laws prohibit the filling of designated freshwater and marine wetlands that provide critical plant and wildlife habitats. Similarly, water pollution control laws have significantly enhanced water quality in lakes, streams, and rivers, reducing one of the primary threats to aquatic biodiversity.

• State Environmental Quality Review Act. This state law requires that before undertaking or approving any significant action such as building a highway or approving new residential or commercial development, state and local governments must first fully analyze potential effects on the environment. Among its many elements, the law specifically requires an analysis of potential effects on threatened or endangered species or significant habitats. Although this law does not prohibit projects and developments that impair biodiversity values, it does require that efforts be undertaken to avoid, minimize, and mitigate harmful effects. For more information, see the website http://www.dec.state.ny.us/website/dcs/seqr/index.html.
New York State’s Abundant Natural Heritage

From the rocky summits of the Adirondack High Peaks to the hundreds of miles of shoreline along the Atlantic Ocean and the Great Lakes, New York State’s rich mosaic of wild habitats supports an abundant variety of life. The exact number of species that live in the state is not known, but there are likely tens of thousands—possibly even more.

Scientists and others concerned with the health of the planet refer to the variety of plant and animal life in any environment as its biodiversity. Biodiversity includes the variety of species in all groups of organisms. It also refers to the array of natural communities, ecosystems, and landscapes within which species evolve and coexist. In fact, biodiversity includes all life on Earth, even fungi, and microbes that can’t be seen by the naked eye.

Legacy: Conserving New York State’s Biodiversity offers a remarkable glimpse into this vast array of life and beauty.

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Legacy: Conserving New York State’s Biodiversity is a product of a partnership of the American Museum of Natural History, the New York State Biodiversity Research Institute, the New York State Department of Environmental Conservation, the New York Natural Heritage Program, and The Nature Conservancy.

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