HUDSON RIVER ESTUARY

WILDLIFE AND HABITAT CONSERVATION FRAMEWORK

An Approach for Conserving Biodiversity
in the Hudson River Estuary Corridor

Hudson River Estuary

New York State Department of Environmental Conservation

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New York State Department of
Environmental Conservation

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Hudson River Valley Greenway

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and Historic Preservation

Hudson River Estuary

Wildlife and Habitat Conservation Framework

An Approach for Conserving Biodiversity in the Hudson River Estuary Corridor

2006

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Hudson River Estuary Program

The Hudson River Estuary Program is a unique regional partnership designed to protect, conserve, restore, and enhance the estuary's productivity and diversity of natural resources to sustain a wide array of present and future human benefits. The Hudson River is a nursery for valuable food and game fish, a water supply, a boater's playground, a landscape of inspiring beauty, a shipping route, and more. Therefore, its management calls for a cooperative effort of broad scope, coordinating public input with the expertise of professionals throughout New York State's Department of Environmental Conservation (NYSDEC) and other agencies.

The *Hudson River Estuary Action Agenda* identifies priority actions to be taken to conserve the natural resources of the estuary and its associated shore lands. One of those priorities is conservation of biodiversity in the Hudson River Valley and the greater Hudson Estuary ecosystem.

This report describes significant habitats of the Hudson River Valley and identifies voluntary, non-regulatory strategies for conserving wildlife and habitat in the region.

For more information on the Hudson River Estuary Program please write or visit the program's web page.

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Northern harrier by Isidor Jeklin (left), brackish tidal marsh along the Hudson River Estuary courtesy of NYSDEC (upper right), and trout-lilies in the Catskill Mountains by Andrew Finton (lower right).

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Several publications were particularly valuable in development of the framework. Descriptions of significant biodiversity areas and habitats were supplemented by extensive surveys, reports, and personal communications from the NY Natural Heritage Program. Characterizations of significant habitats were enriched by high quality habitat profiles included in the Biodiversity Assessment Manual for the Hudson River Estuary Corridor developed by Hudsonia, Limited. Background information on terrestrial habitats and vertebrates, and the status of their conservation was found in the Hudson River Valley Gap Analysis completed by the NY Cooperative Fish and Wildlife Research Unit. Original descriptions of the ecological communities found in the Hudson River Valley were taken from Reschke's Ecological Communities of New York State (1990) published by NYSDEC.

The New York State Department of Environmental Conservation provided support for the development of this document from the Environmental Protection Fund through the Hudson River Estuary Program.

Executive Summary

Purpose

The *Wildlife and Habitat Conservation Framework* describes key plant and animal habitats in the 15 New York State counties bordering the Hudson River Estuary from the Federal Dam at Troy to its confluence with the ocean, an area which contains most of the lower Hudson watershed. It also identifies strategies for the protection of these habitats. The report is intended to assist individuals, non-profit groups, and government officials in developing partnerships to conserve our region's natural heritage, emphasizing voluntary measures and utilizing local home rule. It was developed as part of the *Hudson River Estuary Action Agenda*, led by the New York State Department of Environmental Conservation (NYSDEC).

Plant and Animal Habitat in the Hudson River Estuary Region

The Hudson River begins as a small mountain lake on the side of the state's highest peak, Mt. Marcy, and ends in New York Harbor, one of the world's busiest and most populated metropolitan ports. About halfway along its course it becomes an estuary, an arm of the sea, that provides spawning and nursery grounds for commercially valuable fish, crabs, and shellfish. The River's uplands are covered with forests interspersed with working farms, residential development, and small cities. These lands support a high diversity of species of global and national significance. The Hudson Valley's varied geology creates a tapestry of habitats, such as pine barrens, grasslands, cliffs, mountain ranges, caves, streams, and wetlands, including globally rare freshwater tidal wetlands. This mix of habitats gives the region exceptional importance.

The region, comprising only 13.5% of the land area of the entire state, contains nearly 85% of the bird, mammal, reptile, and amphibian species found in New York State. It is important worldwide for its rich diversity of turtles, and nationwide for its dragonflies and damselflies. It offers opportunities found nowhere else in the state for conservation of amphibian and reptile biodiversity. A number of species use the Hudson Valley as a migration route or as breeding or nursery habitat. This includes migratory fishes such as shad, sturgeon, and striped bass, as well as insects such as the monarch butterfly. Birds as varied as the cerulean warbler, marsh wren, bald eagle, osprey, and ruby-throated hummingbird all spend part of their life cycle in the Valley and part of it in places as far away as Nova Scotia and South America.

The Hudson River Estuary ecosystem is home to a number of species that have their best or only remaining populations in the region. Such species include the northern cricket frog, sable clubtail dragonfly, Kentucky warbler, timber rattlesnake, the bog turtle, Karner blue butterfly, and Indiana bat. Approximately 150 species in the watershed are listed by the NYSDEC as threatened, endangered, or of special concern in New York State. Of the 11 turtle species found in the Hudson Valley, 6 are on state or federal lists of endangered, threatened, or special concern animals, primarily due to habitat loss.

While some species flourish in the Hudson River Valley, others are threatened and some species not now listed as endangered are on the decline. Urbanization and habitat fragmentation are a major concern. Species that require connections between habitat types to complete stages in their life cycles cannot survive if these connections are broken. For example, wood frogs, spotted salamanders, and marbled salamanders require wetlands for breeding and must have adjacent woodlands for their adult stage. Animals that rely on large unbroken tracts of forest, such as the bobcat, wood thrush, cerulean warbler, and red-shouldered hawk can become vulnerable when such forest lands are broken up. Agricultural lands also provide important habitat. Meadows and shrubby fields found on Hudson Valley farms can support species such as the bog turtle, northern harrier, bobolink, meadowlark, and golden-winged warbler. Many of these species are declining in the valley as agricultural land uses decrease.

Pollution and competition with invasive or overabundant species create problems for some species. At least 10 percent of the 3,600 miles of tributary stream habitat in the Hudson Valley are stressed from agricultural and urban runoff, erosion, dams, loss of riparian buffers, and reduced groundwater recharge. Invasive species crowd out native species that serve as food and shelter for many of the regions insects and small animals. Many of these "invasives" take hold where human practices give them an extra boost.

The region is one of the most densely populated areas in the country, and its land is changing fast. According to a report released in 2001 by the Brookings Institution, between 1992 and 1997, urbanized land use in the NYC metropolitan area grew at three times the rate of population growth, and in the Albany Capital District urban land use grew at six times the rate of population growth (Fulton et al. 2001). This rapid land conversion creates an urgent challenge to organizations and agencies faced with finding new ways to include conservation in the region's growth strategy. Protecting habitat does not require that growth stop however, human developments will need to be sensitively placed to maintain important habitats and fit the needs of wildlife species.

Public lands are making an important contribution to biodiversity conservation in the Hudson River Valley, particularly for species that require large forested tracts. A century of open space acquisition has created large intact habitats in the Highlands, the Palisades, the Taconics, and the Catskills. However, 90% or more of the suitable habitat for the region's birds, mammals, amphibians, and reptiles is found on private lands. Furthermore, 23 of these species are not thought to occur at all on public land. While land acquisition will play a role in protecting some of these species, it cannot be the primary strategy. These trends highlight the need for conservation options that can be adopted by interested parties.

Local Conservation Opportunities

Key steps in conserving the richness of the Hudson's heritage can be taken by local planning boards and property owners. Local home rule gives residents the ability to create and maintain the character of their communities and provides great latitude to

communities that want to conserve their natural and biological resources. In order to make informed decisions, communities will need to identify their unique conservation opportunities. Municipalities can then identify critical areas for habitat and natural resource protection and prioritize areas suitable for development. This strategy can increase residential property values, thus providing additional revenue for municipalities. In addition, this approach improves water and air quality and provides a community with space to experience the beauty of nature. By guiding development patterns now, towns can avoid the costs of urban and suburban sprawl and preserve the sensitive wildlife habitat that nurtures the Valley's unique heritage of native plants and animals.

Individual landowners can also take action to protect these important habitats in the Hudson River Valley. Biodiversity conservation can be folded into private land stewardship in order to stem the loss of species and their habitats. With the *Wildlife and Habitat Conservation Framework,* the NYSDEC Hudson River Estuary Program hopes to provide a road map for individuals and communities to make informed decisions about land use and conservation.

The Wildlife and Habitat Conservation Framework

The *Framework* is divided into three parts. Part I provides an overview of the biodiversity issues in the region, discusses the importance of biodiversity in our daily lives, and highlights the major threats to biodiversity. Part II defines significant Hudson Valley habitat types, describes some of the characteristic plants and animals they support, and identifies their unique conservation challenges. Part III proposes various strategies for protecting our resources by working with a variety of partners to meet the needs of both people and of wildlife. It emphasizes approaches that work within New York's long tradition of home rule and property rights.

The information contained in the *Framework* builds upon 10 years of work to catalog the species and habitats of the region that form the ecosystem of the Hudson River Estuary. Since the release of the first *Hudson River Estuary Action Agenda*, NYSDEC has completed a number of wildlife and habitat inventory projects. Many of these studies were conducted in collaboration with state, nonprofit, federal, and academic partners. Collectively, they provide a solid, science-based approach to conservation and a useful source of data for further research and implementation of conservation practices.

On-going inventory projects monitor and predict the distribution of terrestrial vertebrates, breeding birds, amphibians and reptiles, rare plant and animal populations, and exceptional habitat areas. The information collected is used to determine habitats of particular significance in the region. Analyses of the data compiled suggest that the following major habitat types and associated wildlife species are most significant in this region:

- Coastal Habitats

  Coastal habitats include sand beaches, mudflats, coves, salt marshes, tidal wetlands, and tidal creeks. These habitats support waterfowl, colonial wading birds, marine and estuarine fishes, and many species of turtles, molluscs, and raptors, including the nation's symbol of freedom, the bald eagle. Dredge spoil disposal, bulkheads, and construction fill for urban and industrial development have damaged or eliminated large areas of subtidal shallows habitat. In addition, impoundments, dams, and floodplain filling currently block the migration routes for many economically important species that require temporarily flooded riparian wetlands and abandoned channel meanders (oxbows) in order to complete their life cycles. Coastal habitats are also impacted by surrounding land uses, tributary water quality, and recreational activities. Key restoration and preservation strategies should be considered at individual sites to restore native plant communities, restore fish passage and spawning habitat, improve tidal flow, and enhance water quality along our coastlines.

- Wetlands

  The Hudson River Estuary region contains a rich diversity of wetland types, from freshwater tidal swamps and brackish tidal marshes to fens, bogs, and forested wetlands. These habitats are home to a variety of species including the federally-listed black duck, wood frog, the threatened Blanding's turtle, marbled and Jefferson salamanders, muskrat, and beaver. Unfortunately, more than 50% of the wetlands in the region have been lost since European settlement. Wetland conservation strategies should include, where possible, the restoration and protection of wetland hydrology and wetland plant communities, control of invasive species, and management of certain types of wetlands through mowing and grazing. Inland intermittent vernal pools, a common but threatened wetland habitat type, should be identified and conserved along with surrounding critical woodland habitat, and best forest management practices can be used to protect them from pollution and disturbance.

- Tributaries and Riparian Areas

  High quality tributaries, riparian areas, and floodplain forests are important habitat for many species including trout and black bass, salamanders, river otters, beaver, cerulean warbler, and wood turtles. Aquatic animals are highly dependent on riparian areas for shade, leaves (as a source of food), edge-of-channel habitat structure (such as undercut banks), soil stabilization, and woody debris. Removal of riparian areas, modification of stream channels, and increasing impervious surfaces cause some of the changes to watershed hydrology that are putting the water and habitat quality of tributary streams in the Hudson River Valley at risk. Minimizing development in riparian corridors, minimizing the hydrological alteration of stream systems, protecting native floodplain meadows and forests, and restoring natural stream channels will help to protect stream biodiversity. Removal of obsolete dams or the construction of fish passage structures can restore fish migration and sediment and temperature regimes.

- Unfragmented Forest and Habitat Corridors

  Intact forests are summer breeding habitat for migratory songbirds, bobcats, black bear, wood thrush, barred owl, and red-shouldered hawks. Although few examples of "old-growth" lowland forest remain, forests of moderate-sized and moderate-aged trees continue to provide valuable habitat and have the potential to provide mature forest habitat in the future. Many of the biological communities that characterized unfragmented forests are at risk in areas of the Hudson Valley. We can preserve the species that depend on unfragmented forests and habitat corridors by conserving mature lowland forests, concentrating disturbance along the edge of forest blocks, restoring forest fragments in riparian areas, reforesting gaps between disconnected forest tracts, and controlling invasive species while managing for well-developed growth on the forest floor, .

- Open Uplands and Barrens

  This habitat type includes grasslands, shrublands, agricultural lands, and rarer communities such as pitch-pine scrub-oak barrens, and rocky summit grasslands. These areas represent increasingly rare habitat for bobolinks, meadowlarks, grasshopper sparrows, golden-winged warblers, fox, northern harrier (hawks), butterflies, and the state endangered bog turtle. Without management or disturbance, early successional habitats become forest. Many of these animals are now declining due to reforestation or development of lands that were once meadows. Maintenance of early successional habitat should be balanced with the need to conserve stands of unfragmented forest. Control of invasives combined with reintroduction of native species will help to restore degraded sand plains. Conserving large, continuous parcels of open habitat on rocky summits and facilitating infrequent mowing or prescribed fire treatment in lowland areas will help to retain a mix of grasses, woody plants, seedlings, and saplings that provide essential habitat. Outreach to agricultural communities is integral to the preservation of this habitat type.

- Caves and Cliffs

  These habitat types were formed during ancient mountain-building processes or during mining exploration. They are used by rare cliff ferns, bats, peregrine falcons, migrating hawks, and rock-cresses. Approximately 40% of the state occurrences of the eastern small-footed bat and 3 of the 8 federally endangered Indiana bat hibernacula in New York State are found in the Hudson River Valley. Rare cliff plants such as the spleenwort, prickly pear, purple cliffbrake, and three-toothed cinquefoil can be found in the region's mountains. Cliff areas also provide overwintering habitat for many snake species, support the silvery blue and orange tip butterflies, and serve as migration pathways for several hawk species. Cliff and cave inventories should be conducted in the region and conservation measures should be taken to protect sensitive portions of these habitats from land-use practices that can be damaging, such as mining and high volume recreational activities like rock climbing, hiking, and mountain biking.

The *Framework* identifies 23 land areas representing these habitat types in the Hudson Valley that are particularly significant to biodiversity. With almost 89% of the estuary's conservation area in private ownership, landowners, non-profits, sporting clubs, and businesses can play a key role in meeting the goals and targets of the *Hudson River Estuary Action Agenda*. The NYSDEC intends to continue developing a network of partners to improve the overall quality of the Hudson Valley landscape through incentive-based voluntary conservation programs.

Tools are described in this *Framework* that will allow residents to identify habitat areas that provide the highest benefits to the local environmental quality and integrity of the Hudson Valley region. While local residents can best identify the important cultural and environmental features of their communities, there are many partners within the Hudson River Valley that can provide assistance. Grants are available through the Hudson River Estuary Program to carry out habitat assessment, education, and restoration projects. State wildlife biologists are available for consultation, and many non-profit organizations offer technical guidance and services to Hudson River Valley residents, governments, and community groups.

The publication of the *Conservation Framework* is designed to help achieve the objectives of the *Hudson River Estuary Action Agenda* to conserve the rich diversity of plants, animals, and habitats of the Hudson River Estuary region for future generations. Other projects of the Hudson River Estuary Program include technical assistance for local governments in conservation planning and training for local citizens in how to assess biodiversity.

The actions of the Hudson River Estuary Program are wide-ranging — from creating access to clean swimming waters, to upgrading sewage treatment plants, to restoring robust fisheries, and protecting the watershed. Conserving the biodiversity of the Hudson River Valley is a key aspect of this mission.

Overview

Background

The Hudson River Estuary corridor is truly one of the great regions of the world and a special place within the Empire State. It is a region of remarkable beauty, historical and economic significance, and importantly, high biological diversity. From tidal wetlands and coastal ecosystems to high elevation spruce-fir forest, the region boasts a remarkable diversity of habitats, and species that depend on those habitats. Turtles, snakes, bats, frogs, salamanders, birds of prey, songbirds, waterfowl, mollusks, butterflies, old-growth trees, and unique freshwater tidal wetlands are a few examples of an extensive list that describes the biodiversity of the greater Hudson River Estuary ecosystem. Humans are an important part of the environment within the Hudson River ecosystem and are dependent on the region's abundant natural resources. From the rarest to the most common, we must strive to conserve the native plants, wildlife, and ecological communities that make this area so special and at the same time, work with people and communities to ensure that their needs are addressed.

Estuaries are bodies of water, such as rivers or bays, along coasts where the tides carry water inland. In the Hudson River, tides reach as far north as the Federal Dam at Troy and form an estuary. The tidal Hudson River estuary begins as freshwater in Troy, gradually turns brackish near the Hudson Highlands, and becomes noticeable salty at the Tappan Zee Bridge. The Hudson River Estuary corridor, extending from the Troy Dam to the Verrazano Narrows below Manhattan Island, and including the counties bordering the estuary, is the focus of New York State's Hudson River Estuary Program. In order to fully appreciate, understand, and manage the Hudson River Estuary, it is necessary to consider it in the context of its surrounding landscape and watershed. For the Estuary to be healthy, the neighboring lands and forests, and tributary rivers that flow into it must also be healthy.

To date, results from our efforts have revealed that the ecosystems surrounding the Hudson River Estuary support a remarkable array of vegetative cover types. This diversity of land cover is reflected in an abundance of wildlife species, some of which have all or a significant portion of their entire New York range within the Hudson River Estuary corridor. For example, 25 of 31 vegetative cover types identified for all of New York State occur within the 4.2 million acre Hudson River Estuary corridor, an area representing about 13.5% of the land area of New York. For all New York terrestrial vertebrates combined, 86% (308 species) have predicted occurrences from the corridor. Within this total, the Hudson River Estuary corridor provides habitat for 85% (28 species) of New York's amphibian species, 73% (27 species) of New York's reptile species, 87% (199 species) of New York's breeding bird species, and 92% (54 species) of New York's mammal species (Smith et al. 2001).

This remarkable diversity in some instances takes on global significance. In the case of turtles, the Hudson River watershed has a rich diversity of species, many of which are

endangered. The number of species found in the Hudson River watershed is matched in only a few other rivers in the world, including the Suawanee (Florida), Mekong (southeast Asia), and Irrawaddy (Myanmar).

In the last five years, the Biodiversity Program of the Hudson River Estuary Program has completed a number of projects in collaboration with partners to conserve the Hudson River Estuary's rich ecosystem. These collaborative projects include identification and mapping of wildlife habitats from satellite imagery, surveys of rare plant and animal communities and significant ecological communities, monitoring of PCB levels to determine potential affects on nesting eagles, expansion of the Hudson River Valley portion of the NYS Amphibian and Reptile Atlas, initiation of a Hudson River Valley Breeding Bird Atlas to expand and complement the statewide effort, development of a manual and related training for biodiversity assessment, collection and continued analysis of the movement of contaminants in the food chain, grants for conservation and stewardship projects, outreach and technical assistance to Hudson Valley municipalities, surveying bog turtles in the lower Hudson River Watershed, and publication of this conservation framework.

Development of a conservation framework evolved out of the need to provide current information on the biological resources of the area and strategies by which agencies, organizations, and individuals could work collaboratively to achieve realistic conservation goals. This project emphasizes voluntary approaches that can be undertaken in the context of local home rule. No new state regulations are proposed. The conservation of our biological diversity will likely be achieved through a variety of mechanisms, from outreach aimed at land-use planners, to open space protection, to partnerships with landowners to foster conservation practices at home.

Truly effective biodiversity conservation in the Hudson River Estuary corridor will embrace all available conservation tools and will result from empowering people and communities to make informed decisions in their daily lives. Indeed, a conservation program cannot succeed without a high level of public involvement. The Hudson River Estuary Program has initiated a biodiversity outreach and technical assistance program to continue expanding voluntary partnerships with local communities. In addition to training, outreach, and education, biodiversity conservation will be carried forward by projects to develop maps and other informational products that interpret biological survey results; examine the contribution of public lands to biodiversity conservation; continue local training for biodiversity assessment; monitor changes in the region's land use and wildlife communities, and continue to offer grants for conservation and stewardship projects.

Purpose of the Framework

Given the tremendous biological diversity of the region and the complexity of the issues that surround its conservation, a document is needed to identify the biological resources of the Hudson River Estuary corridor and to recommend strategies for the conservation

of those resources. This report should help to coordinate the activities of conservation agencies and organizations in the Hudson River Valley by establishing a framework and approach for biodiversity conservation.

The purpose of the *Wildlife and Habitat Conservation Framework* is to provide a foundation for a coordinated biodiversity conservation program that includes research, management, education, and outreach, and that incorporates conservation considerations into sound land-use planning through the use of a broad range of voluntary measures and conservation tools.

This report establishes a framework that can be applied to:

1) Defining conservation objectives and priorities;

2) Integrating biodiversity conservation considerations into sound land-use planning practices in the context of local home rule;

3) Promoting the use of a broad range of conservation tools, especially measures that can be undertaken voluntarily; and

4) Establishing partnerships among federal, state, and local governments, as well as communities, businesses, private organizations, and individuals.

The *Wildlife and Habitat Conservation Framework* is a product of the Hudson River Estuary Biodiversity Program of the New York State Department of Environmental Conservation (NYSDEC) Hudson River Estuary Program. It was developed under the direction of a steering committee representing more than 20 organizations interested and experienced in biodiversity conservation in the Hudson River Valley (Appendix I).

Intended Audience

We hope that the *Wildlife and Habitat Conservation Framework* is useful for those organizations and individuals working to conserve the biological diversity and uniqueness of the Hudson River Estuary corridor. In particular, it is intended to aide conservationists in establishing coordinated efforts.

While these efforts should evolve at different levels of organization, biodiversity conservation is most effective when it takes place at the local level through a variety of individuals and groups (i.e., citizens, citizens' groups, community organizations, planning boards). Resources are available for these groups as part of the Hudson River Estuary Biodiversity Program.

Overview of the Conservation Framework

This report is organized into three sections, Part I: An Approach to Biodiversity Conservation, Part II: Significant Habitats of the Hudson River Valley, and Part III: Conservation Strategies and Recommendations.

Part I: An Approach to Biodiversity Conservation

Part I provides an overview of the Hudson River Estuary Biodiversity Program and discusses biodiversity conservation within the context of the Hudson River Estuary corridor. The section focuses on the value of biodiversity in our lives, primary threats to biodiversity in the region, and considerations for biodiversity conservation.

Part II: Significant Habitats of the Hudson River Valley

Part II provides an overview of significant habitats in the Hudson River Valley and includes general information on the ecology and conservation of cave and cliff habitats, coastal habitats, open uplands and barrens, tributaries and riparian habitat, unfragmented forests and habitat corridors, and wetlands. Following each description is a list and map of significant biodiversity areas that contain that habitat type. Then, descriptions are provided for each significant biodiversity area in the Hudson River Estuary corridor.

Information presented in Part II is the foundation of a habitat-based approach to biodiversity conservation in the Estuary corridor.

Part III: Conservation Strategies and Recommendations

Part III outlines key program areas and strategies that should be developed or expanded to meet regional conservation goals and address the primary threats to biodiversity in the Hudson River Estuary corridor. The conservation strategies recommended in this document emphasize voluntary measures that can be undertaken in the context of local home rule and individual property rights. Implementation of conservation strategies should occur through a variety of mechanisms involving federal, state, and local governments, as well as private organizations with a common vision for conserving biodiversity.

In general, conservation program areas presented in this document can be grouped into three major categories: biological inventories and ecological research, land management and environmental quality, and education. Some recommendations require a long-term commitment (e.g., ecological monitoring) and may rely substantially on funds provided by state and federal agencies. Other strategies will require broad-based support from a variety of organizations ranging from government agencies to local communities and citizens. Lastly, for some strategies, significant involvement by communities will be required to address issues at the local level.

Periodic Updates

The Hudson River Estuary Biodiversity Program embraces an adaptive approach to biodiversity conservation whereby we learn from both our successes and failures and adjust our approach accordingly, using all available information. It is recommended that the information contained in this report be evaluated every two years and updated as needed.

Conditions in the Hudson River Valley are continually changing. Threats to biodiversity evolve over time; some threats will be resolved through concerted conservation action while new threats could arise. New conservation strategies and actions will need to be undertaken and old strategies discontinued (as appropriate) in response to changing conditions. In addition, available information and knowledge of biodiversity will also grow with time. The databases on which conservation strategies and actions are based are continually updated. Regular updates are essential to maintaining an effective and meaningful conservation program.

Contact Information

For more information on the Hudson River Estuary Biodiversity Program, or this report, please write to:

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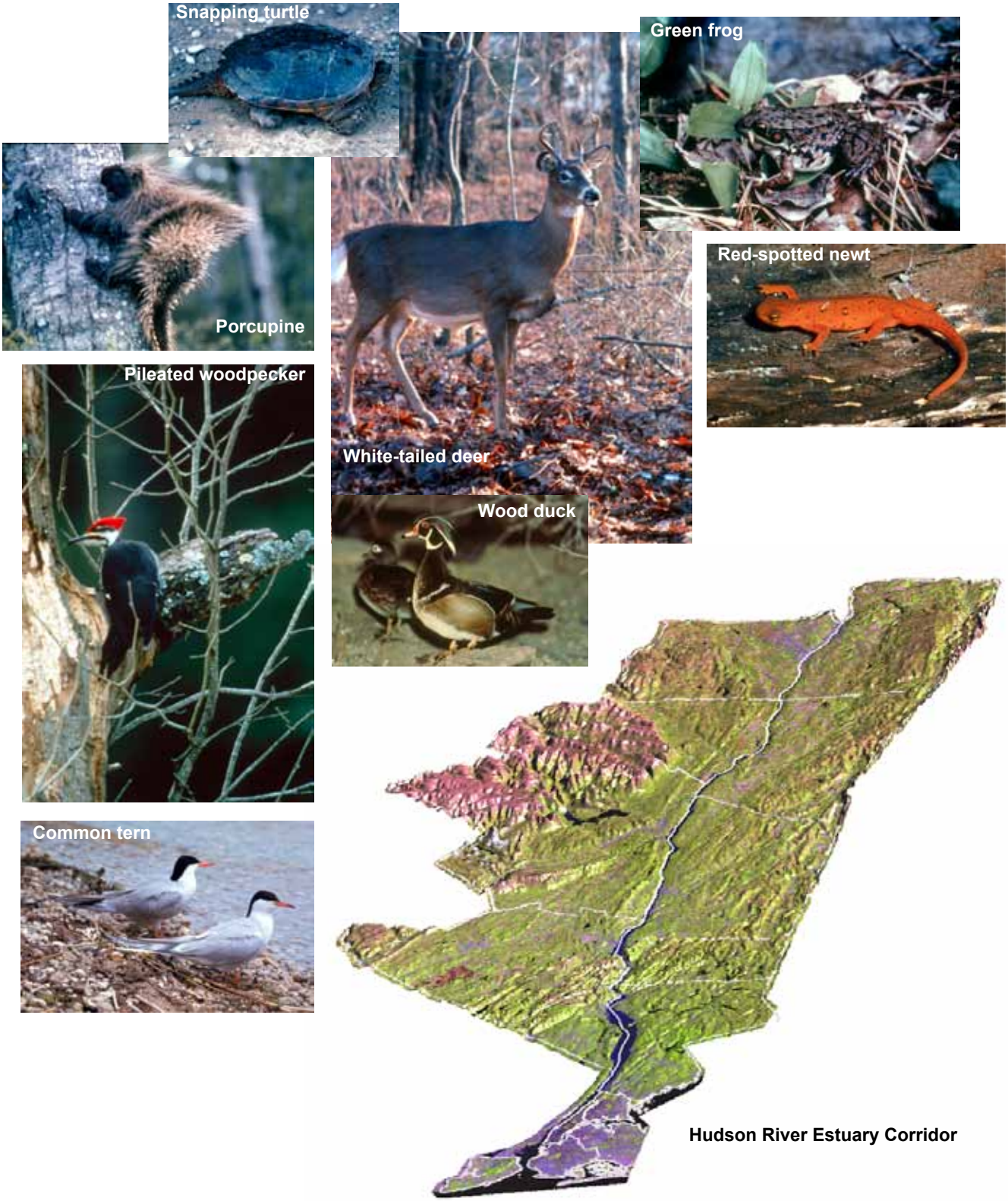


Figure 1. The Hudson River Estuary ecosystem is geologically and biologically diverse. The relief map above shows elevation changes in the 10 counties bordering the Hudson River Estuary from the Troy Dam south to the Verrazano Narrows, and the 5 New York City Boroughs. Also shown are some of the animals and habitats that make the Hudson River Valley an exceptional area of biodiversity. Digital relief map courtesy of the New York Gap Analysis Program (NY Cooperative Fish and Wildlife Research Unit).

PART I: An Approach to Biodiversity Conservation

Introduction

The Hudson River Valley is one of New York State's most impressive regions, rich in history, and cultural, geological, and biological diversity (Figure 1). At the heart of this region is the Hudson River Estuary, which ranges from saline to fresh water, and pulses daily with four-foot ocean tides. The Hudson River Estuary corridor is one of the most densely populated areas of the country and has long been the fastest growing region of the state. Additionally, it is one of the state's primary industrial centers. As a result, tremendous pressures have been placed on the health and sustainability of the region's natural resources. Despite these stresses, it remains highly productive with thousands of species of plants and animals.

Because of the diversity and complexity of both the biological resources and the threats that face these resources, partnerships involving landowners, municipalities, non-profit organizations, government agencies, and others must be developed to effectively conserve biodiversity in the Hudson River Valley. Successful implementation of the strategies and actions presented in this report will require a commitment to both developing and sustaining these partnerships.

The Hudson River Estuary Biodiversity Program

The purpose of the Hudson River Estuary Biodiversity Program is to support the conservation, recovery, and sustainable use of the biodiversity of the Hudson River Estuary corridor, especially as it relates to terrestrial ecosystems. The program emphasizes voluntary approaches to biodiversity conservation in the context of local home rule.

The broad goals of the program are:

1. To maintain biodiversity in the Hudson River Estuary ecosystem by ensuring the health of all native, terrestrial ecological communities, including plant and animal species, and by protecting ecological processes and overall ecosystem function.

2. To assure opportunities for the public to experience, learn about, and enjoy the abundant biodiversity resources of the Hudson River Estuary ecosystem.

Conservation Area

The Hudson River Estuary Biodiversity Program and this report address biodiversity and conservation opportunities for the terrestrial portions of the Hudson River Estuary ecosystem within the Hudson River Valley. The conservation area is the entire upland area (terrestrial habitat and non-tidal and tidal wetlands) of the ten counties bordering the Hudson River Estuary from the Troy Dam south to the Verrazano Narrows. Also included are the 5 New York City Boroughs (New York, Bronx, Queens, Kings, Richmond). The Hudson River Estuary corridor spans approximately 152 miles and covers more than

6,500 square miles, greater than the combined areas of Rhode Island and Connecticut (Figure 2). This definition of the conservation area closely matches the drainage basin boundaries for the Hudson River Estuary, which is tidal as far north as the Federal Dam at Troy.

Areas beyond the Hudson River Estuary Watershed can and do have a profound effect on the estuary and surrounding lands. What happens deep in the neighboring watersheds of the Upper Hudson River in the Adirondacks, the Delaware in the western Catskills, and throughout the Northeast influences biodiversity in and around the Hudson River. Conservation strategies must consider these areas as well, but are not covered in this report.

Biodiversity Defined

Biological diversity, or biodiversity, refers to the abundance and variety of all life on earth. It embodies all of the variety among animals, plants, and microorganisms, their genetic makeup, and the variety of ecosystems in which they live. The definition of biodiversity encompasses three different levels: genetic diversity, species diversity, and ecosystem diversity. Genetic diversity includes genetic variation between species, as well as within and between populations of the same species. Species diversity refers to the variety of different plants, animals, and microorganisms. Ecosystem diversity refers to variability in scale, process, and abiotic factors that define the system. Genetic, species, and ecosystem diversity are all essential to maintaining long-term biodiversity.

Biodiversity Value

Biodiversity has tremendous value to humans and should be protected for many reasons. Humans are interdependent with other organisms on the planet. Our quality of life is inextricably tied to a healthy and diverse environment. We have benefited tremendously from an environment rich in biological variety, from ecological services to aesthetics, recreation, and spiritual benefits.

An investment for the future

One reason we engage in biodiversity conservation is to maintain environmental systems that support quality of life, both for the present and for future generations. Without conservation, future generations may be left with impoverished biological resources. Biodiversity can help ecosystems recover more readily from disturbances resulting from drought, flooding, fire, disease, or human activities. Maintaining biodiversity provides us with options for adapting and responding to changing environmental conditions.

Value for soil, water, oxygen, and ecological balance

Humans derive many benefits from the services provided by intact biological systems. For example, properly maintained natural hydrological cycles, such as those found in unaltered wetlands, stabilize water runoff. Naturally functioning wetlands help prevent flooding or drought and regulate underground water tables while also filtering and purifying water. Sustaining biodiversity also aids in the formation and maintenance of soil.

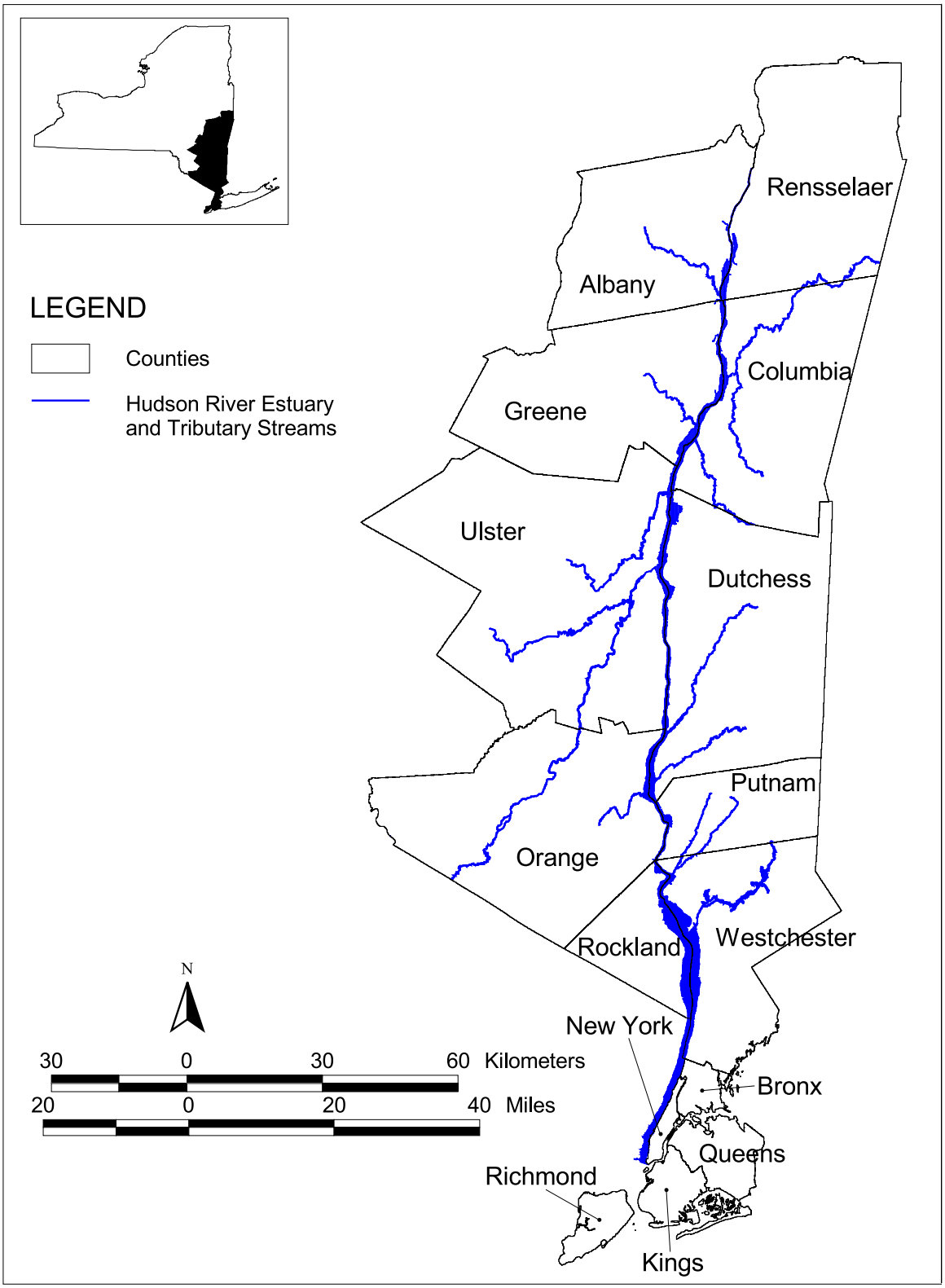


Figure 2. The Hudson River Estuary corridor of New York State is defined to include the counties and New York City boroughs bordering the tidal portions of the Hudson River.

Soil productivity is enhanced by the storing and recycling of nutrients through decomposition and reabsorption. Additionally, ecosystems and ecological processes are essential in the production of oxygen and the recycling of carbon as well as the absorption and decomposition of some pollutants in both air and water.

Services are not only a function of ecological processes but also are provided by species. Breeding populations of predatory birds, mammals, reptiles, amphibians, spiders and insects help control insect and rodent pests in human-inhabited areas. This natural biological control potentially reduces the need for and cost of controlling agricultural pests with chemicals. Also, the maintenance of natural habitats supports the birds and insects that play a key role in crop pollination.

Value for recreation and cultural heritage

The number of people taking part in recreational activities involving biodiversity is growing each year. Biodiversity in the Hudson River Valley provides residents and tourists alike with a great number of choices in recreational activities including fishing, hunting, trapping, hiking, biking, boating, camping, photography, and wildlife observation. The culture, economy, and beauty of the Hudson River Valley is linked to the biodiversity of the region.

Spiritual value

Perhaps the greatest value in biodiversity is the least measurable. Biodiversity helps fulfill the spiritual, aesthetic, and inspirational needs of people and promotes the emotional health of our modern society. Poets, painters, and musicians have been celebrating the spiritual and aesthetic value of biodiversity in the Hudson River Valley for centuries.

Biodiversity also has intrinsic value, independent of what it provides humans or how it serves our needs and desires, and so, we are moved to treasure and protect it.

Biodiversity Conservation Considerations

The focus of biodiversity conservation efforts should reflect regional conservation goals. Biodiversity conservation initiatives that focus solely on individual elements such as a single species or even a small number of species can lead to inefficient and competing management strategies. It is important not to fall into the trap of focusing all conservation efforts and energies on endangered, threatened, and rare species to the detriment of those that are common. A narrow focus may leave some species unprotected or in jeopardy. Some rare species today were once common and some common species may be at risk of becoming rare. Effective biodiversity conservation can only be accomplished through coordinated efforts across spatial scales and taxonomic levels. ***The ultimate purpose of biodiversity conservation is to conserve the entire complement of species, habitats, and processes so that ecological function can be sustained.***

Elements of biodiversity exist at many spatial scales; all of which require consideration in a comprehensive conservation program. At its largest spatial scale, the Hudson River Estuary ecosystem encompasses many smaller, distinct ecosystems. Each nested ecosystem is a complex, interacting collection of biodiversity elements and includes all living and non-living components.

Ecological communities are a primary component in the structure of an ecosystem. Ecological communities are uniquely defined by the plants and animals that compose them and are closely related to soil type, elevation, and other abiotic factors. A mosaic of communities make up the Hudson River Estuary ecosystem, some of which are rare or otherwise exemplary (see Reschke 1990). A community is home to many species of plants and animals. Protecting one community can protect hundreds of species.

A basic, fundamental level and measure of biodiversity is species diversity and includes populations of all species of living organisms. Total species conservation is an inherent goal of biodiversity conservation. Species may be grouped by category indicating their particular contribution to biodiversity and human use. Among these are both vulnerable (rare, threatened, endangered, and species of special concern) and common species, reflecting their relative abundance in the ecosystem. As defined here, vulnerable species include those that are recognized by the federal or state government as being rare (i.e., federal- or state-listed) as well as those species that may not be federally or state-listed, but are rare in the Hudson River Estuary corridor. In addition to vulnerable species, there are some categories of species that may require specific attention. Economically significant species are those species that have an effect on local and/or regional economies. Generally thought of as species that are fished, hunted, trapped, and observed recreationally, these also include pest species. Regionally significant species are those deemed important due to their aesthetic, cultural, or social value to local communities.

Critical to species diversity and species conservation is habitat conservation. Simply stated, habitat is where a wildlife population naturally occurs and obtains support for living (i.e., food, cover, water). Plant and animal species are dependent on their habitat for survival and reproduction, and therefore, the conservation of enough suitable habitat is critical for the effective conservation of overall biodiversity. Setting aside land for habitat is not enough however, if the ecological processes that sustain that habitat are not maintained.

Community Involvement

Biodiversity exists at several scales and comprehensive conservation requires that multiple scales be included. There is no inappropriate scale for conservation. Ultimately, state and federal agencies can provide only a part of the total effort needed to ensure that regional project goals will be achieved. Private lands constitute 90% of the Hudson River Estuary corridor. Therefore, it is essential to work with counties and municipal governments involved in land use planning as well as individual landowners. It follows

that an integral component of biodiversity conservation is an emphasis on developing voluntary approaches and encouraging and assisting voluntary conservation efforts. Only by embracing conservation at all levels through the involvement and cooperation of local communities and landowners will conservation of the Hudson River Estuary ecosystem be successful. If we are to be successful in achieving our goals, it is imperative that people have access to the information necessary to carry out conservation in their local communities.

Partnerships

One of the primary objectives of this report is to create a framework for the coordination of conservation activities and the development of conservation partnerships. It is generally understood that the future of successful conservation lies in our ability to form effective partnerships. Pressures and demands on biodiversity are continually growing and biodiversity is increasingly jeopardized. Even with the dedication of the many individuals and public and private conservation organizations in the Hudson River Estuary corridor, the challenges are too great if each acts independently. Experience has demonstrated that dedicated individuals and organizations working together cooperatively for a common cause can make tremendous accomplishments. Conservation must therefore be a cooperative effort.

There are numerous individuals and organizations involved with biodiversity conservation in the Hudson River Estuary corridor (Appendix I) and conservation partnerships can occur at many levels among several potential partners. Potential partners include, but are not limited to:

- Non-profit Organizations
    - Land Trusts
    - Environmental Organizations
- Federal Agencies
- State Agencies
- County Agencies
    - Soil and Water Conservation Districts
    - Environmental Management Councils
- Local Government Agencies
    - Planning Boards
- Businesses, Corporations
    - Public Utilities
- Educational Institutions (Colleges, Universities, Public Schools)
- Individual Landholders
- Citizens Groups
    - Fish & Game Clubs
    - Watershed Organizations

Threats to Biodiversity in the Hudson River Estuary Corridor

There are numerous important issues facing biodiversity and biodiversity conservation efforts in the Hudson River Estuary corridor. The following are some of the main factors affecting biodiversity and biodiversity conservation across the region. Program areas and specific strategies for addressing these threats are presented in Part III.

- Habitat Change and Fragmentation

  The Hudson River Valley landscape is continually changing as a result of natural and human processes. Habitat change is occurring throughout New York State, including within the Hudson River Estuary corridor. In particular, the state is becoming more forested as agricultural land uses diminish. Early-successional habitats and the species that rely upon these habitats are in decline. The Hudson River Estuary corridor is one of the fastest growing regions of New York State in terms of population and urbanization. As a result, there is considerable clearing of natural areas that leads to habitat fragmentation. Additionally, small-scale losses of wetlands, and in particular vernal pools, continues to be a threat to biodiversity.

  Habitat fragmentation is the breaking up of contiguous areas of habitat into smaller, less connected pieces. When already small parcels of land are further fragmented by development, they might become too small to support the complex interactions required to maintain an ecosystem. Fragmentation can be detrimental to area-sensitive species and advantageous to invasive or generalist species. Forest interior birds and wide-ranging mammals that require large, unbroken tracts of habitat are particularly vulnerable. Patterns of land use development can significantly affect biodiversity. As the region continues to develop, land-use management that considers biodiversity conservation should be encouraged. For example, decisions made by local planning boards on how a subdivision is laid out can have a substantial negative or positive effect on biological resources.

- Invasive and Overabundant Species

  Invasive native and exotic plant and animal species pose a serious threat to biodiversity in the Hudson River Estuary corridor. Generally, invasive and exotic species pose a threat to biodiversity by out-competing and displacing native species and altering ecosystems. The Hudson River Valley is particularly vulnerable to invasion of exotic plants and animals because it is a passageway for commercial goods from other countries as well as other parts of the United States. These invasive species often come as “stowaways” on foreign vessels. Invasive exotic plants are capable of driving out other native plant species in an area and may have reduced value to wildlife in terms of cover, nesting substrate, or as a food source. Invasive native plant and animal species often indicate a disruption in the processes that typically hold native populations in balance.

  The more than 100 invasive plant species in the Hudson Estuary corridor include the exotic purple loosestrife (scientific names of species mentioned throughout this report

are provided in Appendix II) and common reed that have overrun wetlands across the region choking out native wetland plants and possibly harming wildlife populations. Examples of invasive animal species include the exotic European starling, mute swan, and zebra mussel, and the native brown-headed cowbird. Invasive, exotic species are a significant threat to our forests, for example, in the Hudson River Valley the hemlock woolly adelgid is moving northward, beech bark disease is moving southward, and the Asian longhorned beetle is threatening sugar maple in New York City and on Long Island.

Similarly, overabundant native species can lead to direct and indirect displacement of other species. For example, white tailed deer can have a tremendous influence on the distribution and abundance of plant species which in turn affect populations of other species, ultimately affecting overall biodiversity in the area. Lastly, changes in the landscape have caused some animals such as raccoons and skunks to increase in abundance, particularly in urban and suburban areas. Large population increases of these generalists are not only a nuisance to homeowners, but can also result in local reductions in biodiversity as they prey on the eggs and juveniles of many other species.

- Pollution (Air, Water, Soil Quality)

  Air, water, and soil quality profoundly influence biodiversity. Pollution has many sources and impacts biodiversity in a variety of ways. Air pollutants can lead to soil and water pollution through atmospheric fallout (e.g. rain, snow), which can alter soil and water pH, and ultimately habitats and species. Lichens are extremely sensitive to air quality and are unable to live where the air is polluted. Increasingly, non-point source pollution from pesticides and fertilizers carried as water runoff from lawns, agricultural lands, and roads have a negative effect on biodiversity. There is also evidence that pollution can work its way into the food chain as chemical contaminants (e.g., PCBs, pesticides, and heavy metals) in fish and amphibians and ultimately the reptiles, birds, and mammals that prey on them. In the Hudson River Estuary corridor, pollutants of concern include heavy metals, organochlorines such as pesticides, urban runoff, acid rain, endocrine distuptors, and industrial pollutants such as PCBs.

- Management Conflicts on Public Lands

  State and other public lands in the Hudson River Estuary corridor contain significant habitats that are vital to the biodiversity of the region and need to be managed in a manner that directs recreational uses away from ecologically sensitive areas.

  Tourists and residents of the Hudson River Valley take part in numerous recreational activities. Commonly, the demand and timing of recreational pursuits exceeds the availability of natural areas for these activities. As a result, tremendous pressures are placed on open space and natural areas, putting a growing stress on biodiversity. Because recreational activities have the potential to negatively affect biodiversity,

there are times when recreational use of an area may need to be limited in order to protect biodiversity. Conserving additional open space and providing directed opportunities for recreation that consider biodiversity conservation are actions needed to ease this pressure. A great part of the value of biodiversity lies in what it offers to us as a source of recreation, learning, enjoyment, and inspiration. The challenge in the Hudson River Estuary corridor is to balance the need for conservation and the demand for access and recreation.

- Lack of Scientific Knowledge of Biodiversity

  In spite of ongoing, targeted inventory programs, we still lack important knowledge about the abundance and distribution of important elements of biodiversity. We know perhaps even less about how these elements interact to form ecosystem functions. It is necessary to recognize that in some cases, not enough information is available. It is important to collect baseline information on the biodiversity of the region in order to assess changes over time and evaluate success in meeting conservation objectives.

  We need to identify those areas where our knowledge is limited and make a commitment to filling in the gaps. We are limited in our knowledge of the invertebrates, microorganisms, and fungi that account for the majority of species diversity in the region. We are also limited in our knowledge of how to best conserve the entire range of biodiversity. For example, what we have learned about conserving organisms such as vertebrates and vascular plants may not be appropriate for invertebrates or microorganisms.

  The Hudson River Valley has been studied extensively. However, tremendous amounts of data from these studies are largely inaccessible and therefore remain unused. Retrieving this information and making it accessible to researchers and the public alike could contribute greatly to our current understanding of biodiversity in the Hudson River Estuary corridor.

- Lack of Public Awareness and Understanding

  Humans have been and continue to be the principle determinant of the present and future viability of much of the biodiversity in the Hudson River Valley. Commonly, people are unaware of how their everyday decisions affect biodiversity. It is vital that we are adequately informed about both the costs and benefits of our actions on elements of biodiversity. Educating the public and providing the means to make informed decisions will help in the effort to conserve biodiversity. Many people in the Hudson River Valley have a deep concern for the environment and want to do more for conservation, but do not know how.

PART II: Significant Habitats of the Hudson River Valley

Introduction

The Hudson River Estuary corridor contains a rich diversity of habitats, ranging from the highly productive estuarine and coastal habitats and their beaches, mudflats, marshes, swamps, and tributaries; to the mountainous forests of the Highlands, Catskills, Taconics, and Shawangunks. In addition, the Estuary corridor contains exceptional features including the Albany Pine Bush, Shawangunk grasslands, cave complexes, large freshwater wetlands such as the Great Swamp, and globally rare freshwater tidal wetlands.

This diverse assemblage of landforms, cover types, and habitats helps to sustain a multitude of plant and animal species. The lakes, ponds, and wetlands of the region provide a major stopover point for tens of thousands of birds migrating along the Atlantic Flyway and also support resident populations of amphibians, reptiles, and mammals. The remaining unfragmented forests of the Catskills, Highlands, Rensselaer Plateau, and Shawangunks maintain populations of migratory songbirds, black bear, bobcat, fisher, salamanders, snakes and other interesting animals. In the last century, some forested habitats have recovered to the point that they now support species such as coyotes, ravens, fisher and black bear that have been gone from the Hudson River Valley since at least 1850. Meanwhile, farmlands and other open uplands continue to provide early stage successional habitat for populations of grassland songbirds and invertebrate species such as butterflies and dragonflies.

Overall, the Hudson River Estuary region is home to more than 2,000 plant and vertebrate animal species (Smith et al. 2001; Mitchell and Tucker 1997). Additionally, there are numerous less glamorous, but ecologically important species of invertebrates, fungi and bacteria in the region. Although few species have their entire worldwide population within the Hudson River Estuary corridor, a number of species have their only New York State occurrence within the Hudson River Estuary corridor: including the fence lizard, northern cricket frog, and sable clubtail dragonfly. Other species have the majority of their state occurrences or their best remaining populations in the Hudson River Estuary corridor, including the Kentucky warbler, bog turtle, timber rattlesnake and the federally endangered Karner blue butterfly and Indiana bat (Finton et al. 2000).

Terrestrial biodiversity benefits the Hudson River Estuary in important ways. Valuable ecosystem services such as nutrient cycling, water purification, resistance to disease and pest infestations, forest regeneration, and plant pollination are dependent upon biological diversity. Whether these processes operate near the estuary or in the highlands of the Hudson River Watershed, they can affect the quality of the estuary. Upland areas are linked with the estuary through smaller waterways such as creeks, rivers, and ditches that drain the land and empty into the Hudson River. As water flows from the uplands to the estuary, its chemical, physical and biological nature is modified. As a result, the conditions of these tributaries and the lands they drain directly affect the estuarine environment.

While some species flourish in the Hudson River Estuary corridor, others are threatened by habitat loss and fragmentation, pollution, and competition with invasive or overabundant species. Approximately 150 species in the Hudson River Valley are listed by the NYS Department of Environmental Conservation (NYSDEC) as threatened, endangered, or of special concern in New York. A recent Gap Analysis Project (Smith et al. 2001) found that of the terrestrial vertebrate animals, most (272 of 308 species) have only 10% or less of their predicted distribution within public lands, including all of the region's amphibians. Twenty-three species were not predicted to occur at all on public lands. These results highlight the importance of conservation efforts by both public and private landowners and indicate a need for prioritization of conservation efforts.

Significant Habitats and Biodiversity Areas

The entire Hudson River Estuary corridor is a significant biodiversity area within the context of New York State and the New England and mid-Atlantic portions of the U.S. Within the State of New York, it forms a regional matrix that nurtures and sustains the Hudson River Estuary. Areas within the Hudson River Estuary corridor that are representative of biodiversity are shown in Figure 3. Their unique topography, geology, hydrology, and plant and animal communities distinguish them from neighboring areas. These areas contribute a fascinating variety and uniqueness to the region. Often, they contain high concentrations of biological diversity or unusual ecological features that contribute to regional biodiversity.

The areas shown in Figure 3 carry no regulatory designation whatsoever. Instead, it is hoped that recognition of distinct areas will serve as a basis for their voluntary conservation. Recognition of these areas can encourage coordination of conservation partnerships between willing stakeholders. In addition, the identification of different biodiversity areas serves as a mechanism for communicating information on biodiversity to the public. Also, identification of significant areas supports scientific analysis of the patterns and processes that maintain biodiversity at a regional scale.

Biologists analyzed existing data to determine the general locations of significant biodiversity areas within the Hudson River Estuary corridor. The areas were then inventoried and further refined following two years of field study (Howard et al. 2002). Information used to identify biodiversity areas was provided by the U.S. Fish and Wildlife Service (USFWS 1997), New York Natural Heritage Program (Finton et al. 1999, Finton et al. 2000, Howard et al. 2002), the National Audubon Society of New York State (1998), and the New York Cooperative Fish and Wildlife Research Unit at Cornell University (Smith et al. 2001).

These significant biodiversity areas tend to contain uncommon and ancient geologic features, large wetland complexes, unfragmented forests, or sharp changes in elevation. It is important to note that lowland landscapes, whether rural or urban, are as important to the health of the Estuary as mountainous settings. The biodiversity areas range in size from 360 to 361,000 acres. However, over half of the areas are larger than 25,000 acres.

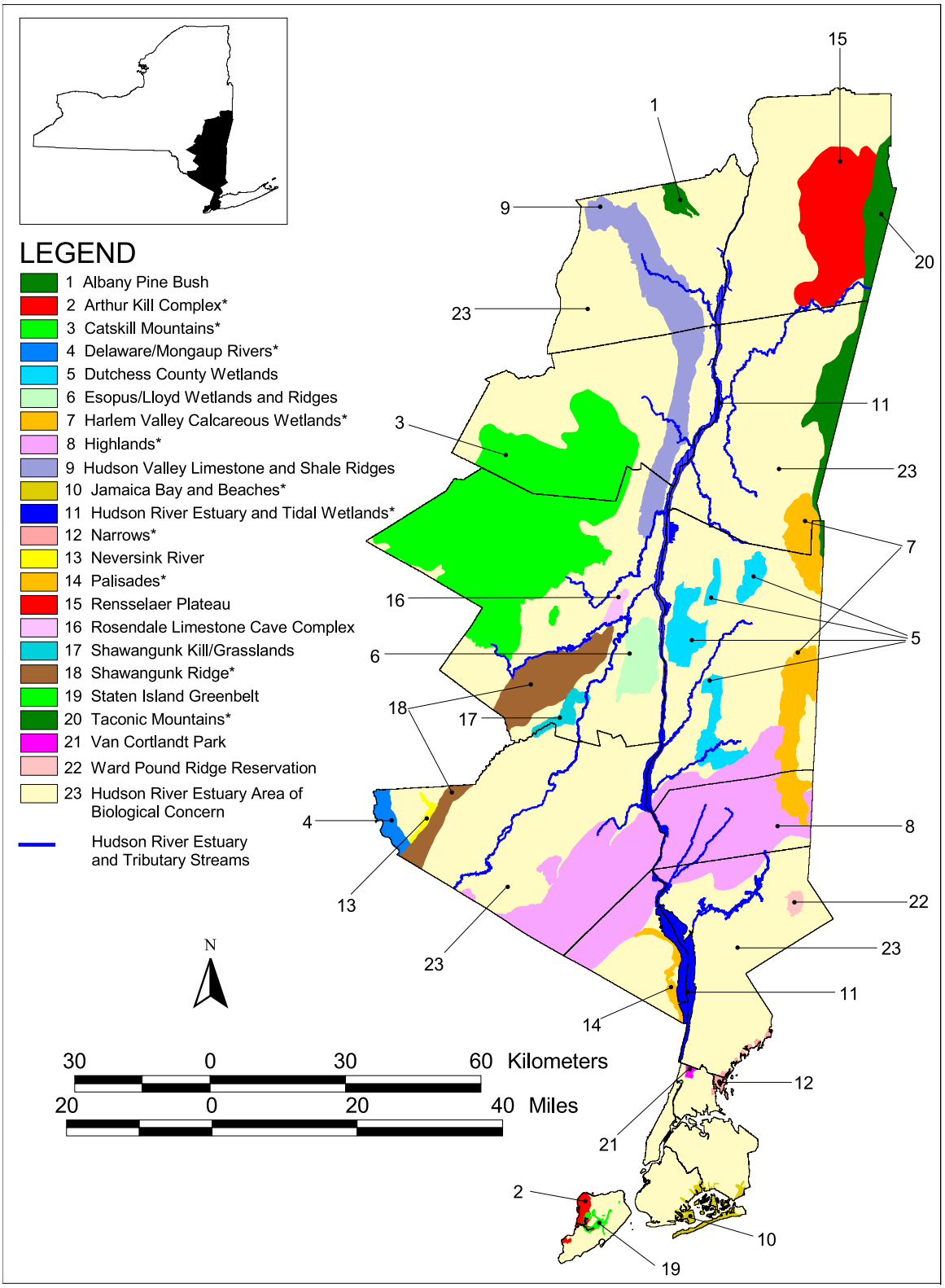


Figure 3. Significant biodiversity areas of the Hudson River Estuary corridor.

* Areas marked with an asterisk extend beyond the political boundaries of the study area.

The highest richness of biodiversity elements occurs in the Highlands West, Shawangunk Ridge, and the Hudson River Estuary in relation to other biodiversity areas their own size (Howard et al. 2002). There are two likely reasons for these areas to rank higher in biodiversity. One is that the overall biodiversity *is* actually higher within the area compared to the other areas. The other reason is that these areas have been more intensively sampled than the others. Almost certainly both of these factors play a role. Biodiversity element occurrences tracked by the NY Natural Heritage Program in Hudson River Estuary corridor and significant biodiversity areas are shown in Figure 4. The NY Natural Heritage Program tracks the distribution and health of viable populations of rare species and significant ecological communities.

The significant biodiversity areas tend to be large in size, but they by no means contain all of the important wildlife, habitat, and ecological elements important to the Hudson River Estuary ecosystem. Significant habitats, some of which are profiled later in this section, may be found throughout the Hudson River Estuary corridor. Ecological processes such as water and nutrient cycling, pollination, and habitat renewal necessary for the maintenance of biodiversity and environmental quality operate throughout the Estuary corridor. Residents of the Hudson River Valley are invited to identify the biological features that make their local area unique and that support environmental quality. The strategy of identifying large areas important to biodiversity must be complimented by local approaches that identify landscape configurations that support biodiversity over the long-term, especially as these landscapes develop and become more populated. Addressing the habitat requirements of common species that are affected by urban sprawl will prevent these species from becoming rare and in need of legislative protection in the future. Significant biodiversity areas are integral parts of landscapes that support stable populations of species and can serve as core habitat areas.

The following sections highlight some of the habitats, species, and significant biodiversity areas that are found in the Hudson River Estuary corridor. First, a general description of the entire Hudson River Estuary Area of Biological Concern is provided. This is followed by information on the contribution of parks and preserves to biodiversity conservation within the area of biological concern. Then, examples and descriptions are provided for the following significant habitat types: cliff and cave habitats, coastal habitats, open uplands and barrens, tributaries and riparian habitat, unfragmented forest and habitat corridors, and wetlands. The descriptions do not provide exhaustive information about the habitats, but they give the reader a general understanding of their ecological importance and offer strategies for their conservation. Additional information on the ecological communities described in this section can be found in Reschke (1990) and Kiviat and Stevens (2001). The habitat descriptions are followed by information on 22 significant biodiversity areas within the Hudson River Estuary Area of Biological Concern. Both significant habitats and significant biodiversity areas are presented in alphabetical order. Information on specific threats to biodiversity and appropriate conservation strategies is provided in Part III of this document.

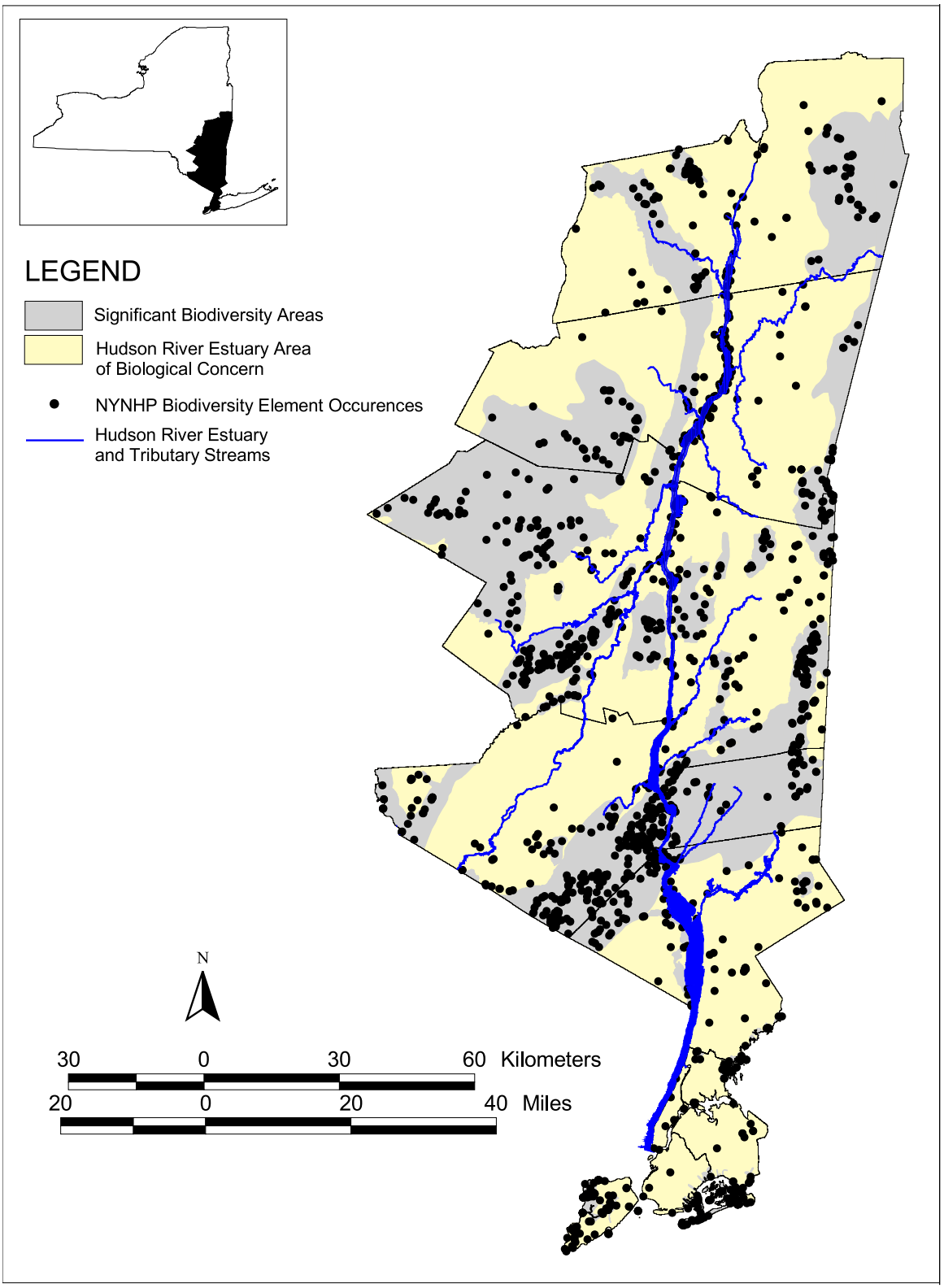


Figure 4. Biodiversity element occurrences tracked by the NY Natural Heritage Program within the Hudson River Estuary corridor. The dots may represent one individual plant or animal occurrence, or a community of organisms.

Hudson River Estuary Area of Biological Concern

Site Description:

The Hudson River Estuary Area of Biological Concern is a region of biological and geological diversity, and has a long and rich human history. A dynamic geologic past has contributed to a great diversity of landscapes, habitats, natural communities, and species. This stunning history includes the workings of continental glaciers, dunes formed when wind carried sand from drained glacial lakes, the movements of great rivers that have eroded mountains, the cliffs that have resisted erosion for eons while softer materials crumbled, and the formation of a mountain chain the size of the Himalayas 450 million years ago in what is now eastern New York.

Sunset over the Hudson River. Photo courtesy of NYSDEC.

The unique geologic setting of the Hudson River Valley is one the reasons the region is so biologically diverse. Although only 13.5% of New York's land area, the counties bordering the estuary from New York City to the Troy dam are home to approximately 86% of the different varieties of terrestrial vertebrate animals that occur in New York State (Smith et al. 2001). The Hudson River Estuary corridor is nationally and globally important for the occurrence of turtles and dragonflies in particular. Residents of the Hudson River Estuary corridor have benefited greatly from the rich biological abundance and clean water this region produces. Many local economies are dependent upon biodiversity, from pollination of important food crops and the production of timber, to recreational opportunities such as boating, fishing and hiking. Increasingly, biodiversity is recognized as a critical component of human and environmental health.

The 150-mile stretch of the Hudson River from the federal lock and dam in Troy to the ocean is tidal and thus defined as an estuary. An estuary includes the entire portion of a river that shows daily influence of ocean tides, and the associated wetlands along the river's edge. There are approximately 60 tributaries of the Hudson River Estuary that transport nutrients, pollutants, organisms, dissolved minerals, and organic and inorganic suspended materials into the Hudson River's main channel. Because the tributaries drain water from the land to the Hudson River, the environmental health of the estuary is closely linked to the condition of tributary watersheds. Some of the Hudson River Estuary's fisheries are negatively impacted by such factors as urban/suburban development, clearing of riparian forests for agricultural and other uses, barriers to fish passage, and contamination by industrial chemicals and pathogens that occur within tributary watersheds. Yet other tributaries in the Hudson River Estuary Watershed provide world-class coldwater fisheries and high quality drinking water. Many wildlife species depend upon tributaries and associated riparian areas for all or a part of their life cycles.

Land ownership in the Hudson River Estuary Area of Biological Concern is classified as mostly private (approximately 89%) while most of the remaining lands are managed by the State (approximately 10%) (Smith et al. 2001). The Hudson River Estuary Area of Biological Concern can be described as predominately forest/woodland (approximately 77%), with important components of crop and pasture lands, urban and suburban areas, and water. Vegetation along the estuary's shores in undeveloped areas is deciduous forest, which includes oak, maple, beech, birch, hemlock, white pine and other trees. Dry rocky slopes, such as the Palisades Ridge and Highlands, support red oak and chestnut oak. Areas with deeper soils, generally located in the mid to upper reaches of the estuary, as well as moist ravines downriver, support oak, sugar maple, tulip tree, black birch, beech, hemlock and flowering dogwood. Major changes in the species composition of hardwood forests have occurred and continue to occur. American chestnut and American elm were lost to fungal diseases of European origin, while other species expanded, including red maple and invasive woody species such as black locust and Norway maple. More recently, beech bark disease ("beech blight"), caused by another introduced fungus, has dramatically affected American beech in the Catskills, and an introduced insect, the hemlock woolly adelgid, is attacking hemlock, especially in the southern region of the Hudson River Valley.

The Hudson River Estuary Area of Biological Concern is one of the most densely populated areas of the country and is one of the state's primary industrial centers. Thus, open spaces are rapidly declining and large unbroken expanses of forest and wetland are becoming fragmented. The heavily populated corridor between Albany and New York City, bordering the Hudson River Estuary, includes more than 50% of New York's population within a land area only 13.5% of the total state land area. There is no significant area of the Hudson River Valley that has not been affected in some way by human activities, though the scale and intensity of those activities have varied over time and space. During the 20th century, the common pattern of landscape change in New York State and in most of the Northeast has been one of increasing forested acreage and urbanization following a decline in agricultural activities. In 1880, nearly 80% of the state land area was in farms. In the wake of clearing for agriculture, grassland species moved into the state and may still be more common today than they were in pre-settlement times.

Much of the information above can be found in reports on the Hudson River Valley Gap Analysis Project (Smith et al. 2001), New York Natural Heritage Program inventory results (Howard et al. 2002), and the Hudson River Estuary Action Agenda 2005-2009.

Site Location:

The following information on distribution of land stewardship was taken from New York State databases and includes estimates current as of 2005:

Towns:	169 towns
Counties:	Albany, Rensselaer, Greene, Columbia, Ulster, Dutchess, Orange, Putnam, Rockland, Westchester, Bronx, New York, Richmond, Kings, Queens
Approximate Size:	6,560 mi^2

Land Stewardship:

Name or Classification	Manager	Area
State Forest Lands	NYSDEC	419 mi^2
State Wildlife Management Areas	NYSDEC	23 mi^2
Public Conservation Easements	NYSDEC	5 mi^2
State Parks	NYSOPRHP	216 mi^2
New York City	NYCDEP	59 mi^2
Municipal/County Parks		62 mi^2
U.S. Military Land	USDOD	29 mi^2
National Park Service	USDOI	23 mi^2
National Wildlife Refuge	USFWS	0.2 mi^2
Other State/Federal Lands		33 mi^2
Private Conservation Land*		107 mi^2

Total Conservation Lands: 976 mi^2

Other Private/Local Government 5,584 mi^2

*Includes most non-governmental conservation lands.

Ecological Significance:

The biodiversity of the Hudson River Estuary Area of Biological Concern is greater than can be expected by chance alone for a land area of similar size within the State of New York. This diversity can be attributed to many factors, including the range in elevation from lowlands to high peaks, a diversity of soils and bedrock geology, and gradients of fresh to salt water.

Among terrestrial vertebrates, 85% (28 species) of New York's total amphibian species, 73% (27 species) of New York's total reptile species, 87% (199 species) of New York's total breeding bird species, and 92% (54 species) of New York's total mammal species can be found in the Hudson River Estuary Area of Biological Concern (Smith et al. 2001). The Hudson River Estuary corridor offers opportunities found nowhere else in the state for conservation of amphibian and reptile biodiversity. In the case of turtles, a 200 million year old group of reptiles, the Hudson River and its tributaries is one of the most important river systems in the world. The number of turtle species found in the Hudson River Valley is matched only by the Suawanee River (Florida), the Mekong River (southeast Asia), and the Irrawaddy River (Myanmar).

Among vegetative communities, the Hudson River Estuary corridor has proportionally more Sugar Maple-Mesic Forest, Oak Forest, and Appalachian Oak-Pine Forest than found elsewhere in New York State, embedded predominately in an urban/suburban matrix.

Grassland habitats of the Hudson River Estuary corridor support several rare or declining bird species, including Henslow's sparrow, vesper and savannah sparrows, sedge wren, northern harrier, meadowlark, and bobolink. Wetlands and coastal areas greatly contribute to the diversity of birds found in the region. Tidal wetlands along the estuary support egrets, least bittern, American bittern, black rail, osprey and many species of waterfowl. Wooded swamps support breeding red-shouldered hawks and concentrations of migrating warblers. Other notable bird habitats in the Hudson River Estuary Area of Biological Concern include the westernmost section of Long Island Sound (the Narrows) and the north shore bays of this area, marshes associated with bays, sand beaches, and the Arthur Kill area of the lower estuary.

Large wetlands scattered across Dutchess, Putnam, Ulster, and Orange counties support the highest diversity of turtles in New York State. These counties contain concentrations of important turtle habitats such as floodplain forest, dwarf shrub bogs, shrub swamps and calcareous fens. Six turtle species found in the Hudson River Estuary corridor (other than sea turtles) are state-listed as endangered, threatened and special concern species including the bog turtle, Blanding's turtle, eastern mud turtle, spotted turtle, wood turtle, and eastern box turtle. Numerous areas throughout the Hudson River Estuary Area of Biological Concern have been documented as containing crucial habitat for salamanders and frogs, including the northern cricket frog, blue spotted salamander, marbled salamander, four-toed salamander, spotted salamander, Jefferson salamander, and longtail salamander.

Hudson River tributaries and their area of confluence with the main stem provide important habitat for migratory fishes, including striped bass, American shad, rainbow smelt, alewife, and blueback herring, as well as resident species, such as white sucker, yellow perch, spottail shiner, white perch, and smallmouth bass. Tributaries with largely intact natural processes have food webs that support diverse plant and animal life. These systems convert carbon and nutrients into biodiversity rather than excessive algae or nutrient exports, which in turn protects the estuary. In addition, streams with intact floodplains soak up and store flood waters, while replenishing ground water, filtering nutrients and chemicals, depositing sediments onto floodplains, and limiting erosion.

Conservation Issues and Recommendations:

While tens of thousand of acres, and numerous species and natural communities are protected by state, local and private landowners, the full range of diversity in the Hudson River Estuary corridor has no legal or management protection. As a result, the voluntary management of private lands for biodiversity, and improved management of public lands, will largely determine the success of biodiversity conservation. Key conservation issues facing private and public land managers within the region include:

- Loss and fragmentation of habitats, particularly those with high ecological significance;
- Loss of old ecosystems such as mature forests or wetlands with deep organic soil;
- Maintaining the natural cycles and processes that support biodiversity (such as predator-prey relationships, hydrologic regimes, land-forming processes, climate regimes, fire regimes, and many kinds of natural disturbance);
- Maintenance of habitat connectivity across the landscape;
- Maintenance of the composition and structure of habitats within natural ranges (replacement of native species by non-native invasive species is a particular concern); and
- Pollution and disruption of habitats that threatens wildlife and human health.

Many of the measures necessary for biodiversity conservation can be addressed by individual landowners, either on their own property or through representation by local governments. Biodiversity protection can be fostered in many small ways, but to stem the ultimate loss of species and habitats in the Hudson River Valley, biodiversity concerns need to be considered in land use planning and land stewardship. The following planning and stewardship measures are recommended for consideration and application where appropriate (Kiviat and Stevens 2001):

- Protect large, contiguous, unaltered tracts wherever possible;
- Preserve links between natural habitats on adjacent properties;
- Preserve natural disturbance processes such as fires, floods, tidal flushing, seasonal drawdowns, and wind exposure, wherever possible;
- Restore and maintain broad buffer zones of natural vegetation along streams, along the shores of other water bodies and wetlands, and at the perimeter of other sensitive habitats;
- In general, encourage development of altered land instead of unaltered land wherever possible;
- Promote redevelopment of brownfields, other post-industrial sites, and other previously altered sites, instead of breaking new ground in unaltered areas;
- Encourage pedestrian-centered developments that enhance existing neighborhoods, instead of isolated developments requiring new roads or expanded vehicle use;
- Concentrate development along existing roads and discourage construction of new roads in undeveloped areas. Promote clustered development wherever appropriate, to maximize extent of unaltered land;
- Direct human uses toward the least sensitive areas, and minimize alteration of natural features, including vegetation, soils, bedrock, and waterways;
- Preserve farmland potential wherever possible;
- Minimize area of impervious surfaces (roads, parking lots, sidewalks, driveways, roof surface) and maximize onsite runoff retention and infiltration to help protect groundwater recharge, and surface water quality and flows; and
- Restore degraded habitats wherever possible, but avoid destruction of existing intact habitats.

Parks and Preserves

Description:

The Hudson River Estuary corridor contains an abundance of parks and preserves (Figure 5). Parks and preserves are protected lands that often have multiple (and sometimes restricted) uses associated with them. Because of their protected status, these lands offer unique opportunities to conserve biodiversity. They include state parks, wildlife management areas, state forests, state reforestation areas, county parks, town and city parks, as well as private conservation lands. The Nature Conservancy, the Open Space Institute, the Audubon Society, and local land trusts are private groups that own conservation lands in the Hudson River Estuary corridor, some of which are open to the public.

State and federal lands comprise about 10% of the Hudson River Estuary corridor, with less than 1% under federal and 9.6% under state stewardship authority (Smith et al. 2001). Federal lands are clustered in the southern third of the Estuary corridor with the largest contiguous block managed by the Department of Defense (West Point Military Reservation). State government agency lands are generally well distributed, but large clusters do occur in the Catskill Mountains in the western portion of the Estuary corridor, and the Highlands and Mohawk/Black River Valley in the south. The Hudson River Estuary corridor is about 77% forested and nearly 12% of these forests are managed by state agencies, while 87% are privately managed (Smith et al. 2001).

Substantial responsibility for biodiversity conservation on public lands within the Hudson River Estuary corridor lies with the NYS Department of Environmental Conservation (DEC) and the New York State Office of Parks, Recreation, and Historic Preservation (OPRHP). These two organizations manage approximately 85% of the total public land area. The distribution of public land stewardship in the Hudson River Estuary corridor is as follows:

Table 1. Distribution of public land stewardship in the Hudson River Estuary corridor.

Public Land Category:	Acres:	% of Public Lands:
State Forest Lands (DEC)	268,262	50
State Parks (OPRHP)	138,227	25
Municipal/County Parks	39,417	7
Reservoir Buffers (NYC)	35,789	7
Other State/Federal Lands	21,070	4
U.S. Military Land	18,374	3
State Wildlife Management Areas (DEC)	14,918	3
Public Conservation Easements (DEC)	3,123	1
Total:	539,180	100

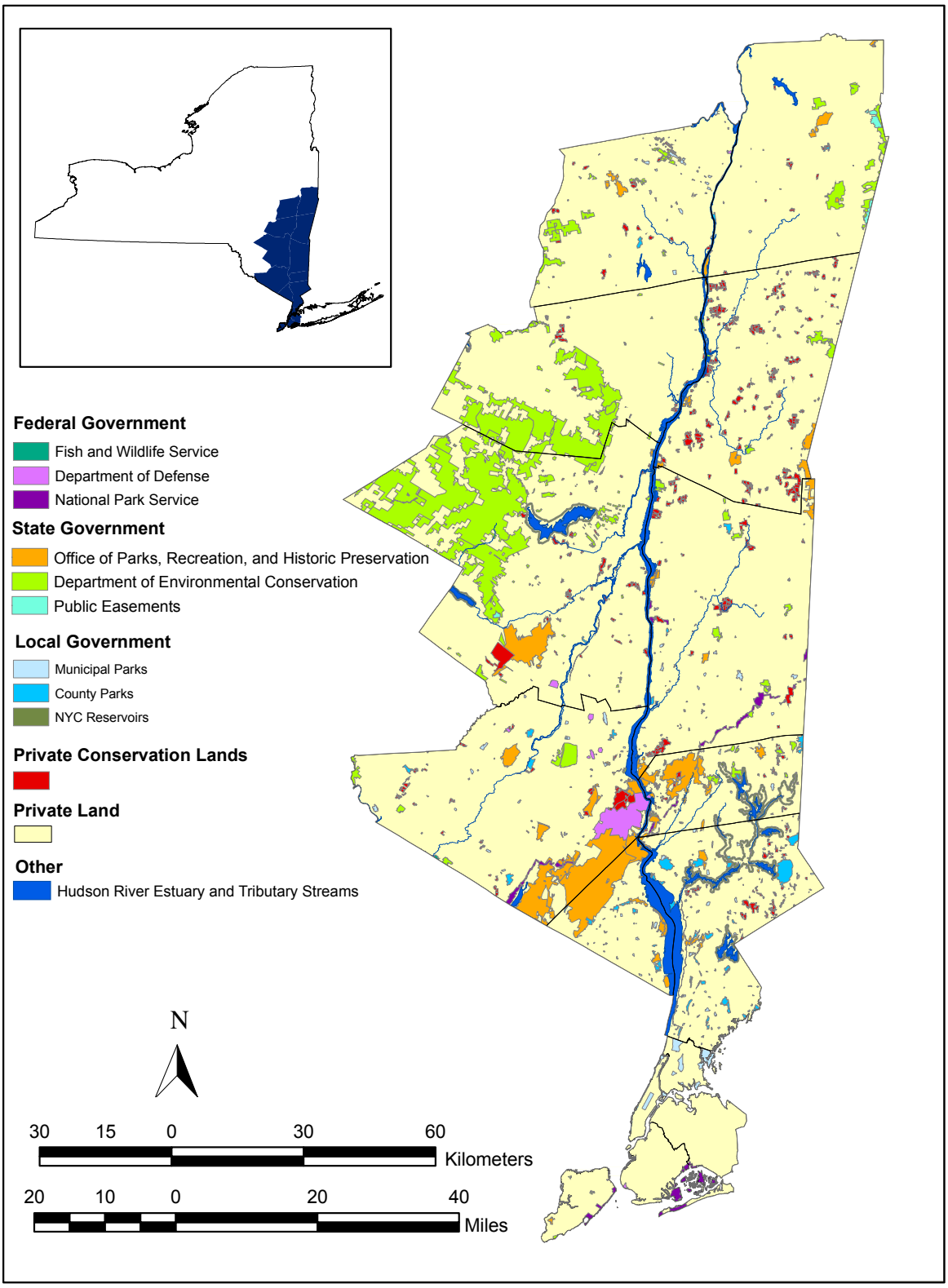


Figure 5. Types and distribution of public lands and private conservation lands in the Hudson River Estuary corridor.

The lands offering the greatest protection of biodiversity have a documented long-term intent, or preferably a written management plan or legal mandate to ensure long term protection of the existing natural habitat. Land stewardship units were assigned to major categories of biodiversity protection for the Hudson River Valley Gap Analysis Project (Smith et al. 2001). Land stewardship units are listed under their various levels of protection, which are roughly described in Table 2.

Table 2. Examples of biodiversity stewardship on conservation lands in the Hudson River Estuary corridor (Smith et al. 2001). For the Hudson River Valley Gap Analysis, each individual land unit was classified by level of stewardship. Some conservation lands appear in more than one category, because individual land units under the same agency were managed differently.

Permanent Protection:
US Military Reservation
The Nature Conservancy Preserves
USFWS National Wildlife Refuges
OPRHP State Park Preserves
NYSDEC Wild Forest, Wilderness, Campgrounds/Ski Areas
NYSDEC Tidal Wetland Areas
NYSDEC Wetland/Unique Areas
NYSDEC Wildlife Management Areas
Private Conservation Land

Majority Protected (but some areas subject to localized, low-intensity uses):
OPRHP State Parks

Mostly Protected (but some areas may receive use that alters existing natural habitat):
US Military Reservation
OPRHP State Parks, Historic Sites
NPS National Recreation Areas
NYSDEC Education Centers
NYSDEC Reforestation Lands
NYSDEC Wild Forest, Wilderness, Campgrounds/Ski Areas
NYSDEC Wildlife Management Areas
NYSDEC Multiple Use Areas
NYSDEC Forest Preserves
NYSDEC Tidal Wetland Areas
NYSDEC Wetland/Unique Areas
State Military Reservations
City of New York Parks and Recreation
NYCDEP Watershed Protection Areas
Private Conservation Land
Private Conservation Easements

Unprotected From Habitat Conversion (most lands subject to intensive use):
NPS National Historic Sites
OPRHP State Parks, Historic Sites, Canal Parks
NYSDEC State Recreation Areas
NYSDEC Multiple Use Areas
NYSDEC Lands Pending Classification
NYSDEC Forest Preserves
Private Conservation Easement

Ecological Importance:

The ecological importance of parks and preserves relates in part to their protected status. However, parks and preserves afford widely differing levels of protection of biodiversity.

The Gap Analysis Project (Smith et al. 2001) mapped the proportion of land cover types under different levels of biodiversity protection. Four forest types accounted for 90% of the land cover in permanent protection: Sugar-Maple Mesic, Evergreen-Northern Hardwood, Oak, and Spruce Fir. Eighty-eight percent of vertebrate species native to the Hudson River Estuary corridor had less than 10% of their predicted habitat in permanent protection. Nearly all (94%) of the listed or ranked species (by NYSDEC, USFWS, or The Nature Conservancy) have less than 10% of their predicted distribution in permanent protection. The low degree of protection afforded to certain land cover types (such as grasslands or water related habitats) may be one reason some species can maintain only small populations with limited distribution in the Hudson River Estuary corridor (Smith et al. 2001).

While some parks and preserves contain nationally and globally rare elements of biodiversity, their larger role may be to support more common ecological communities that are locally rare due to surrounding land uses. For example, Van Cortlandt Park and Ward Pound Ridge Reservation are park lands in close proximity to New York City where some rare species are found and natural vegetation is mostly intact. In a recent analysis (Miller and Klemens 2002), the Ward Pound Ridge Reservation was found to be a “hub” or large core area that is better able to support healthy, viable wildlife populations than smaller areas in eastern Westchester County. The report identified other areas in the region that could act as hubs and also broad swaths of habitat (used by wildlife as migration corridors) that connect the hubs. Based on biological surveys completed within a three-town area, the project identified a biodiversity corridor (Figure 6) that complements preservation of the Ward Pound Ridge Reservation and recommended that the lands be kept in a relatively unfragmented state.

Conservation Strategies:

Conservation strategies for parks and preserves should address maintaining habitats and ecological communities in their natural state. Where appropriate, habitat restoration can be considered. Potential threats to biodiversity (e.g., invasive and overabundant species, potential impacts from permitted land uses) should be evaluated and addressed.

Opportunities to educate the public about biodiversity conservation can be encouraged on these lands through a variety of mechanisms such as interpretive trails, field walks led by naturalists, and educational pamphlets and brochures. The New York State Open Space Plan (draft 2005) suggests that both public land acquisition and private land conservation strategies are necessary to achieve adequate biodiversity protection. Guidelines for acquisition or private conservation should consider the need to buffer parks and protect their ecological communities by strategically acquiring adjacent land or limiting degrading land uses around the park.

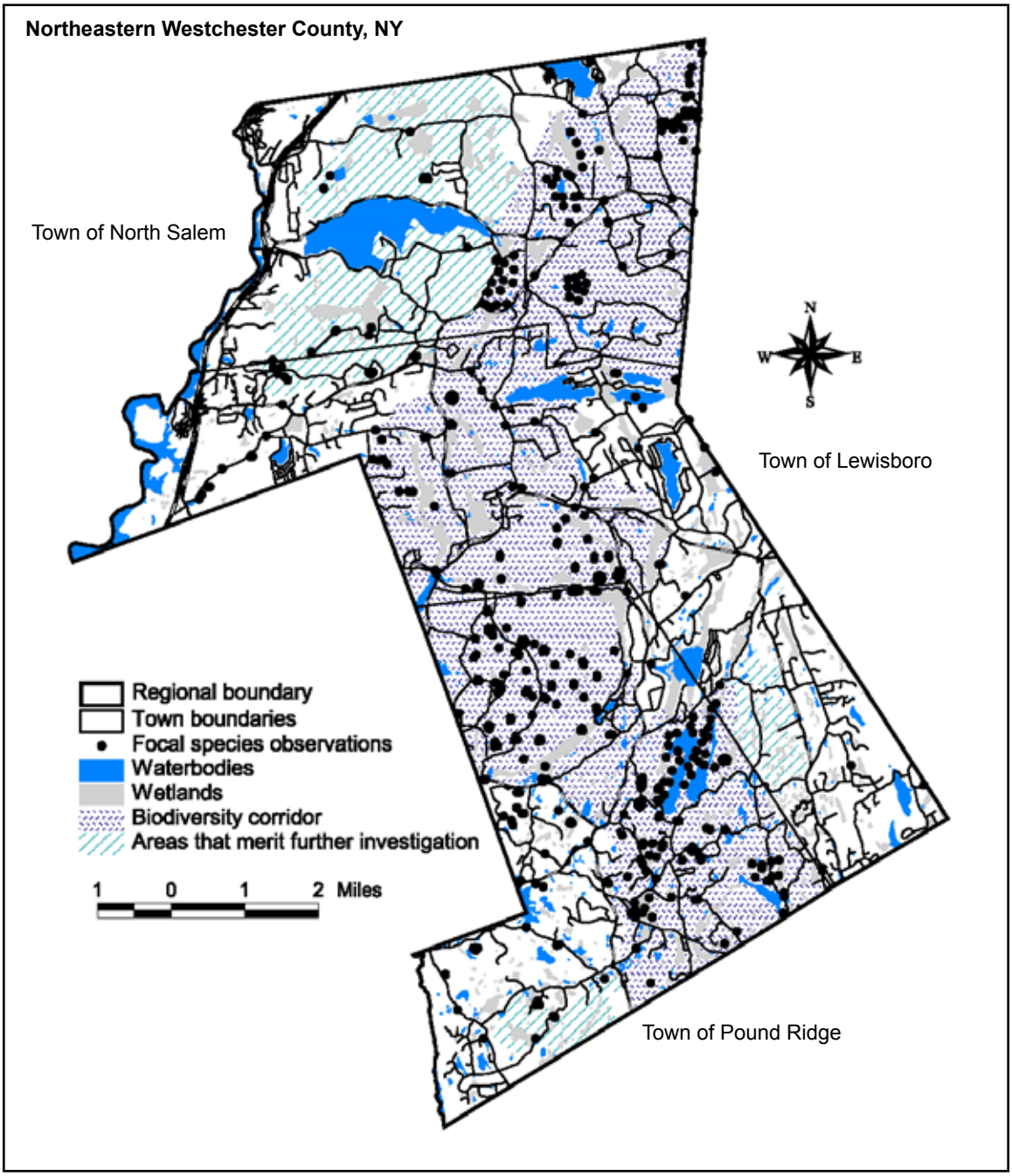


Figure 6. Biodiversity corridor and areas that merit further investigation in three towns of eastern Westchester County (map courtesy of the Wildlife Conservation Society's Metropolitan Conservation Alliance) (Miller and Klemens 2002).

Significant Habitat Descriptions:

Cave & Cliff Habitats

Description:

Caves: Caves in the Hudson River Valley include natural rock formations as well as abandoned mines. Both provide important roosting and wintering habitat for a number of bat species. Ice cave talus communities with unique plant communities also exist on the Shawangunk Ridge.

Calcareous cliff community. Photo by Andrew Finton.

Cliffs: Cliff communities occur on vertical exposures of resistant rock with minimal soil development and vegetation. Cliffs have shallow, droughty soils, are exposed to the brunt of winter and summer weather, and generally are difficult places for plants to grow. These communities range from bare rock, to lichen or moss-covered rock, to grass or forb dominance, to (occasionally) shrub thickets, to tree groves or forest. Bedrock types that predominate along the Hudson River Estuary include diabase, granite, gneiss, schist, quartzite, sandstone, slate, and shale, approximately in order from harder to softer rocks. Cliff communities are also found on rocky hills or ridges underlain by "carbonate" rock: limestone, marble, and similar types of rock composed mainly of calcium carbonate.

The trees growing on cliffs are generally stunted and many dead or damaged trees are often present. Among the most typical trees on harder bedrock are red oak, chestnut oak, red maple, and pitch pine. Typical trees on softer bedrock are basswood, sugar maple, white ash, hackberry, chestnut oak, and American beech. Crevice-using animals (e.g., winter wren, porcupine, small mammals, several species of snakes) are associated with cliff communities.

Ecological Importance:

Caves: Caves in the Hudson River Estuary corridor are critical for a number of bat species, including several that are rare. Bats use these caves as winter hibernacula because temperatures remain stable. Characteristic bats that use caves include little brown bat, Keen's bat, big brown bat, and eastern pipistrelle. Rare species include the eastern small-footed bat and the federally endangered Indiana bat, which hibernates in limestone caves. The Hudson River Estuary corridor is an especially important area for rare bats in New York State, because it contains approximately 40% of the state occurrences of the eastern small-footed bat and three of the eight Indiana bat hibernacula in the state (Finton et al. 2000).

Ice cave talus communities occur on rock and soil at the base of talus slopes and emit cold air where winter ice remains throughout the summer. The vegetation in the immediate area is distinctive because it includes species that occur in much cooler

climates (e.g., black spruce, hemlock, mountain ash, creeping snowberry). Some rare bryophytes have also been found in these communities. Other characteristic wildlife includes timber rattlesnake and certain small mammals (Reschke 1990).

Cliffs: Because of their unique geology, cliffs are important for a number of plant and animal species. Rare plants that may occur in cliff communities include mountain spleenwort, prickly pear, purple cliffbrake, and three-toothed cinquefoil. Cliff areas provide overwintering habitat for a number of snakes. Cliffs and crests constitute many of the important pathways for migrating hawks. The common raven and peregrine falcon nest on cliffs. A characteristic invertebrate of shale cliffs is the silvery blue butterfly. West of the Hudson River the falcate orange tip butterfly occurs where rock-cresses are abundant. An extremely rare earthstar fungus, *Geastrum pectinatus*, has been found on a limestone boulder within the Hudson River Estuary corridor (Kiviat and Stevens 2001).

Conservation Strategies:

Caves: Because of their critical importance as bat hibernacula, inventories of caves in the Hudson River Valley should be continued. All carbonate formations should be inspected for caves. If a cave is located, assistance from an amateur or professional cave specialist should be sought. Cave entrances can be dangerous. Appropriate conservation measures should be taken to protect these communities from land-use practices that would threaten their long-term viability. A buffer is needed around the mouths of caves in order to support the species that use them, particularly bats. Mining activities close to cave habitats can cause physical disturbances that disrupt bat communities. Spelunking can also be disruptive, and should be discouraged in caves known to be used by bats.

Cliffs: Cliff communities in the Hudson River Valley can be negatively impacted by disturbances associated with clearing, heavy pedestrian use, and soil damage by off-road vehicles. All of these activities lead to invasion by weedy introduced plants. Additionally, Reschke (1990) points out that more data on cliff communities are needed. Some of these areas are also extremely popular for rock climbing. Therefore, conservation strategies should address land-uses that threaten the viability of these communities and should include outreach, easements, and balancing recreation with conservation. In some cases, restoration of damaged areas should be considered.

Biodiversity areas notable for cave and cliff habitats (Figure 7):

- Hudson Valley Limestone and Shale Ridges
- Palisades
- Rosendale Limestone Cave Complex

Other biodiversity areas that contain cave and cliff habitats:

- Catskill Mountains
- Harlem Valley Calcareous Wetlands
- Highlands
- Shawangunk Ridge

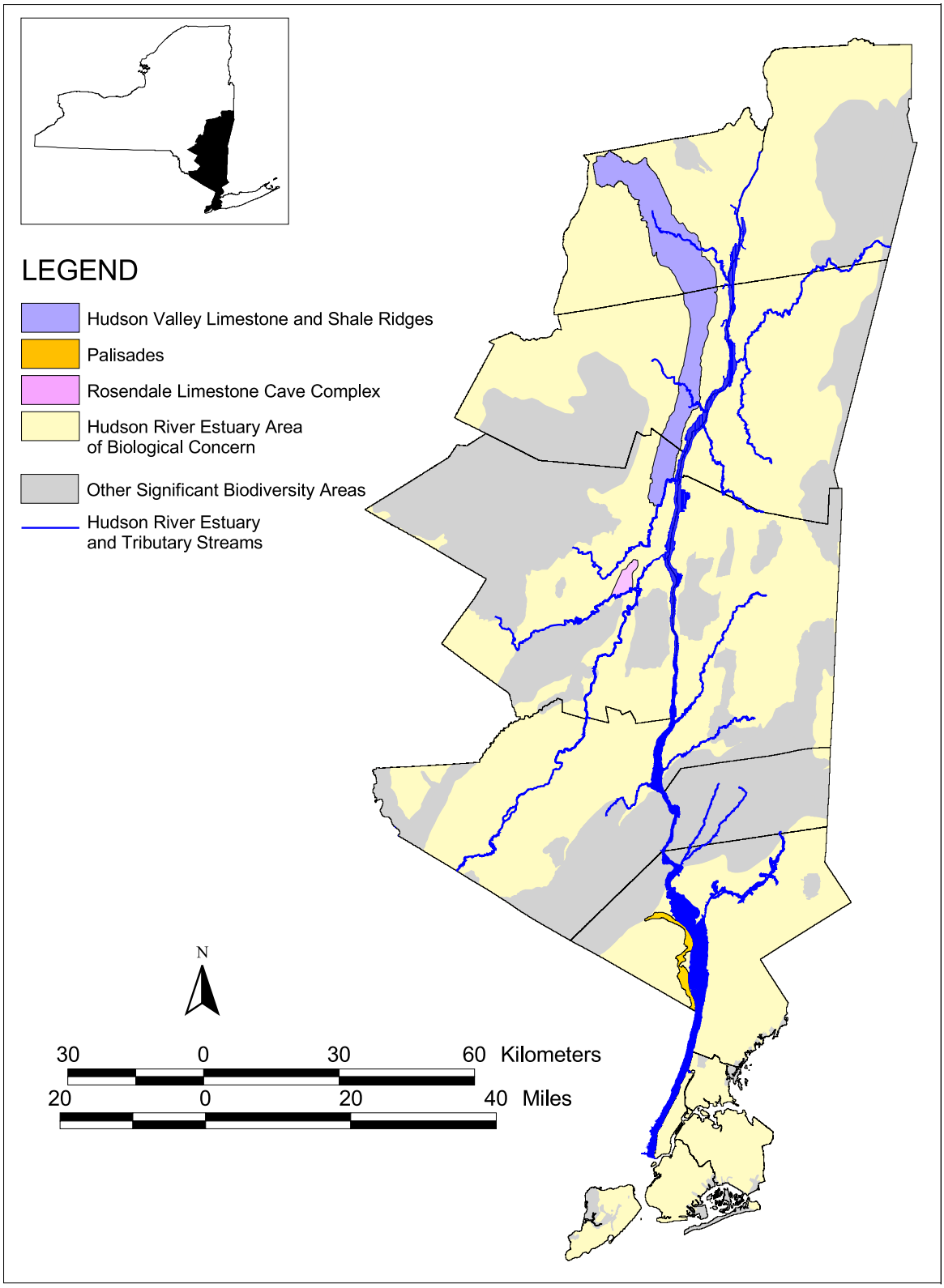


Figure 7. Significant biodiversity areas of the Hudson River Estuary corridor notable for cave and cliff habitats.

Coastal Habitats

Description:

Coastal areas of the Hudson River Valley include a variety of diverse habitats. Examples include sand beaches, dunes, offshore islands, rocky intertidal areas, tidal wetlands, tidal rivers, tidal creeks, salt marshes, mudflats, open-water coves, and coastal grasslands.

Ecological Importance:

Coastal areas within the estuary corridor contain regionally significant fish and wildlife habitat. Waterfowl, colonial wading birds, neotropical migrants, raptors, marine and estuarine fishes, and sea turtles rely upon these diverse habitats for foraging, nesting, and wintering. Coastal habitats support many regionally rare species that are at the northern limits of their geographical range.

Tidal creek. Photo courtesy of Kathryn Schneider.

The narrows. Photo by Rob Pirani.

Conservation Strategies:

Effective conservation of coastal habitats in the Hudson River Estuary corridor will require a coordinated and collaborative effort involving federal, state, and local governments, private organizations, and coastal communities. Because of the diversity of both the habitats and issues surrounding their conservation, specific strategies are not covered here, but rather are presented within the descriptions of the significant biodiversity areas listed below.

Biodiversity areas notable for coastal habitats (Figure 8):

- Arthur Kill
- Jamaica Bay and Beaches
- Narrows
- Hudson River Estuary and Tidal Wetlands

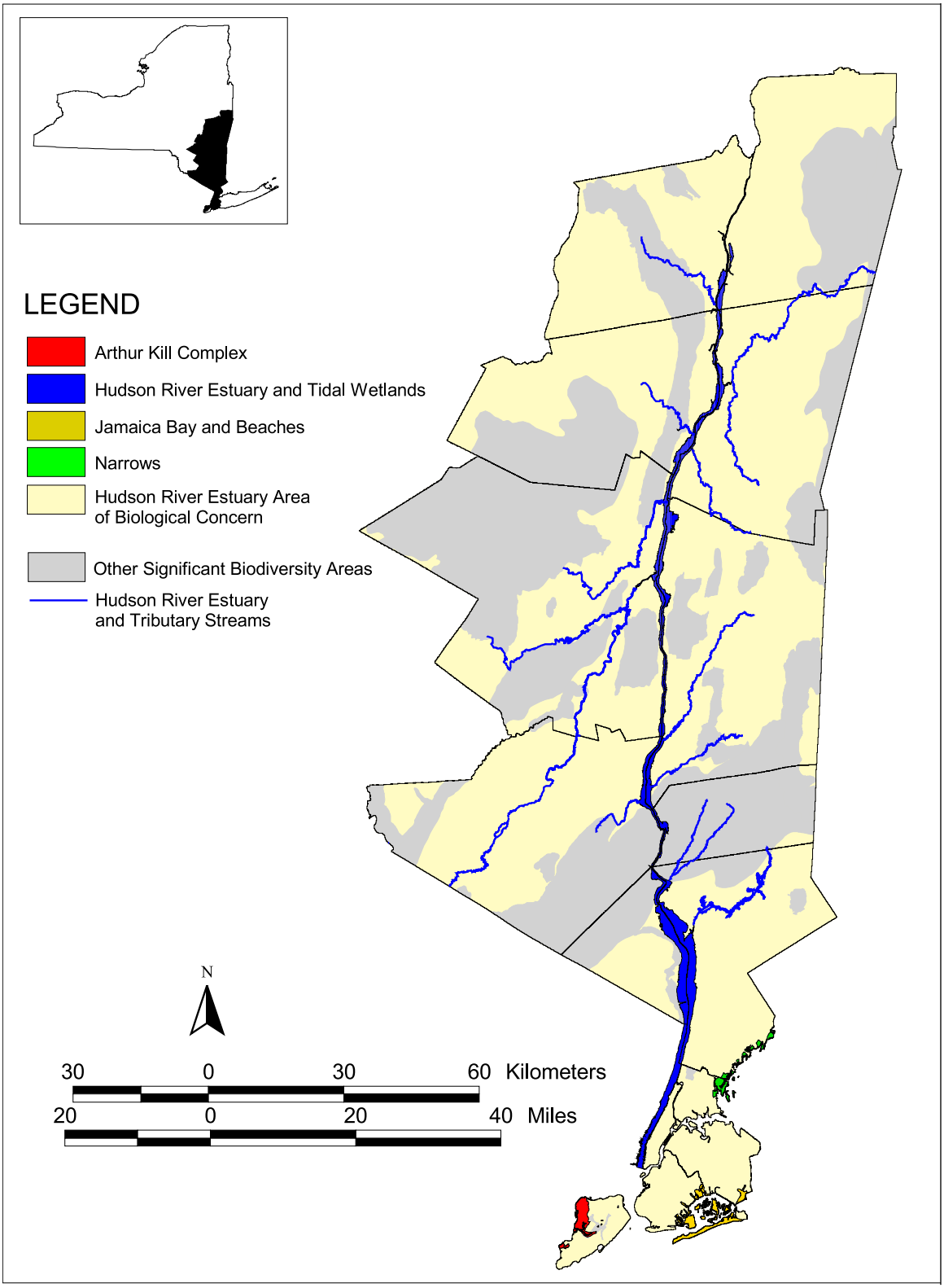


Figure 8. Significant biodiversity areas in the Hudson River Estuary corridor notable for coastal habitats.

Open Uplands & Barrens

Description:

Open uplands and barrens in the Hudson River Valley encompass a variety of ecological communities, including grasslands, pitch pine-scrub oak barrens, serpentine barrens, and rocky summit grasslands. Many of these community types are rare and support threatened, endangered, or special concern species. In general these habitat types are dominated by non-woody plant species. Much of the information on open uplands and barrens presented below is adapted from Kiviat and Stevens (2001).

- Grasslands

  Grassland habitats include a variety of ecological communities, from native grassland communities to successional old fields to agricultural habitats, including cropland and pastureland. Fields abandoned from crops, livestock grazing, mowing, or other management become covered by grasses, forbs, shrubs, saplings or root sprouts of trees. Oldfields often support diverse vegetation with a variety of plant species and may provide habitat for rare birds, plants, and butterflies. Some grasslands in the state are native and were maintained historically by natural and human-induced burning.

  These communities are important for a number of grassland bird species including the field sparrow, grasshopper sparrow, vesper sparrow, Henslow's sparrow, bobolink, mourning dove, upland sandpiper, horned lark, and northern harrier. Grassland communities provide essential habitat for these species for breeding, nesting, foraging, rearing young, and roosting (Sample and Mossman 1997).

- Pitch pine-scrub oak barrens

  This is a shrub-savanna community with pitch pine as the dominant tree. Pitch pine may grow in dense thickets of small trees (dwarf pine plains), or in a more open canopy (as in the Albany Pine Bush). The dominant shrub layer includes scrub oak with a lower shrub layer composed of sweet-fern, blueberries, and black huckleberry. Scrub oak thickets cover 60 to 80% of the community, and contain small patches of grassland. These grasslands are dominated by big bluestem, little bluestem, and Indian grass. Representative forbs include bush-clovers, pinweed, milkwort, goat's-rue, and wild lupine.

  Pitch pine-scrub oak barrens occur on deep, glacial sands (usually derived from the bottoms of drained glacial lakes). The sandy soils are generally nutrient-poor and moderately well drained to somewhat excessively drained, creating poor growing conditions for most plant species. Sand plains, more than any other habitat, are periodically swept by fires, which may kill the tops of woody plants, but not the crowns from which new shoots rapidly grow. Topography may be flat or hilly, the result of former moving dunes now stabilized by the overlying vegetation. Barrens may contain streams, wetlands, vernal pools and patches of mesophytic forests (in moist place

such as stream valleys), grassland, or bare sand with only mosses and lichens. Herbs are few, but include species not found in other habitats.

Characteristic fauna includes frosted elfin, the federally endangered Karner blue butterfly, rufous-sided towhee, common yellowthroat, field sparrow, prairie warbler, brown-headed cowbird, indigo bunting, brown thrasher, and whip-poor-will.

- Rocky summit grasslands

  Rocky summit grasslands are found in the Highlands on rocky summits and exposed slopes of hills. They occur on non-carbonate bedrock (e.g., quartzite, sandstone, schist) and carbonate bedrock (e.g., limestone, dolomite). Many of the community occurrences have originated following fires.

  Characteristic flora includes little and big bluestem, common hairgrass, poverty-grass, and Indian grass. Common forbs include downy and other goldenrods, bristly sarsaparilla, rock-cresses, and rock polypody. Foliose and crustose lichens may be abundant. Mosses are usually present in small patches.

- Serpentine barrens

  Within New York State, this grass-savanna community is known only from Staten Island. A variety of grasses and forbs characterize the community, and trees and shrubs comprise approximately 20-40 and 15-30% of the flora, respectively. The Arogos skipper is a characteristic butterfly of the serpentine barrens.

Grasshopper sparrow. Photo by Mary Tremain.

Ecological Importance:

Open upland and barrens communities provide habitat for a number of rare animal and plant species in the Hudson River Estuary corridor, most notably grassland birds, invertebrates, and timber rattlesnake. Grassland species, particularly grassland-breeding birds that expanded their range into New York following the extensive clearing of forests for agriculture, are now declining in the state due to reforestation. Some grassland species such as grasshopper sparrow are declining throughout their former range, including areas outside of New York State.

Grassland bird species of particular interest include northern harrier, upland sandpiper, sedge wren, bobolink, eastern meadowlark, grasshopper sparrow, Henslow's sparrow, and vesper sparrow. Fields and field edges are important feeding habitats for eastern bluebird. Grasslands are known to support rare plants, especially on calcareous soils. Rare plant species found in wetland areas of the Shawangunk grasslands include Frank's sedge, Bush's sedge, small white aster, swamp agrimony, coontail, and pointed watermeal. More common species in oldfields include goldenrods, asters, Kentucky bluegrass, orchard grass, little bluestem, gray dogwood, multiflora rose, berries, hawthorns, staghorn sumac, eastern red cedar, gray birch, red maple, black locust, oaks, quaking aspen

and white pine. Dry oldfields may support any of several rare butterflies, including the Aphrodite fritillary.

Rocky grasslands provide habitat for the threatened timber rattlesnake. Other reptiles and amphibians that may use these habitats include northern copperhead, eastern hognose snake, black rat snake, worm snake, eastern fence lizard, five-lined skink, eastern box turtle, slimy salamander, and marbled salamander. Rocky summits are important for rare and uncommon mammals, such as bobcat, fisher, porcupine, and boreal redback vole.

Rocky summit grassland. Photo courtesy of Kathryn Schneider.

Sand plain communities are in themselves rare and specialized. The deep, sandy soils support greater biodiversity of non-woody plants and other groups of organisms. Herbs such as wild lupine, sandspur, purple boneset, eyebane, stiff gentian, dotted horsemint and blunt-leaf milkweed do not occur naturally on rock substrates. In the Northeast, buck moth, which in the larval stage feeds on leaves of scrub oak, occurs almost exclusively in sand barrens and rarely in rocky barrens. Over 300 species of vertebrates, over 1,500 species of plants, and over 10,000 species of invertebrates have been reported from the Albany sand plains area (Kiviat and Stevens 2001).

Conservation Strategies:

One threat to these areas in the Hudson River Valley is the conversion of these open canopy habitats into closed canopy forest that do not support the typical plant and animal species. Additionally, invasion by exotic plant species can out-compete native species. Therefore, in addition to land protection, management activities aimed at maintaining these habitats should be implemented. This may involve a combination of techniques (e.g., mowing, burning, brush hog clearing) designed to maintain a specific community or reduce the amount of woody vegetation. However, the timing of these management techniques must be carefully considered in relation to the biology of the species that are present. In some cases, habitat restoration may be warranted (e.g., serpentine barrens on Staten Island).

Grasslands are generally tolerant of human use. However, areas known to support rare plants, rare breeding birds, or rare butterflies should be protected from human disturbance. Rocky summit grasslands may be protected by minimizing habitat fragmentation, soil erosion, and direct and indirect disturbance to wildlife from recreational, extractive, and other land uses. Rocky summit grasslands and other grasslands are threatened by succession, often as a result of fire suppression. Habitats of rare species may require management such as infrequent mowing, selective removal of trees, or prescribed fire to retard development of tree cover.

Land protection may be implemented through a variety of methods including acquisition (on a voluntary, willing seller basis), conservation easements, cooperative land agreements, and outreach. Grassland bird management is an example of how land protection strategies may be used to benefit a variety of species. Areas managed for grassland birds should be at least 250 acres in size, but preferably larger (Vickery et al. 1997). Opportunities to provide adequate habitat for grassland bird species in the Hudson River Valley may come primarily through cooperative land agreements that, collectively, meet minimum habitat requirements. Sample and Mossman (1997) provide detailed recommendations for managing habitat for grassland birds.

Red fox. Photo courtesy of Cornell University.

Within the Hudson River Estuary corridor, cropland, old field/pasture, and barrens comprise approximately 6.5, 1.7, and 0.1% of the land area, respectively (Smith et al. 2001). Because the majority of the Hudson River Valley's open uplands are considered cropland, outreach to the agricultural community may be especially relevant. Developing Best Management Practices for farming activities (e.g., tilling, planting, harvesting, crop and pasture rotation, pesticide and fertilizer use) as they relate to grassland bird conservation should be a priority.

Biodiversity areas notable for open uplands & barrens (Figure 9):

- Albany Pine Bush
- Shawangunk Kill/Shawangunk Grasslands
- Staten Island Greenbelt

Other biodiversity areas that contain open uplands or barrens:

- Delaware/Mongaup Rivers
- Harlem Valley Calcareous Wetlands
- Highlands
- Jamaica Bay and Beaches
- Palisades
- Shawangunk Ridge

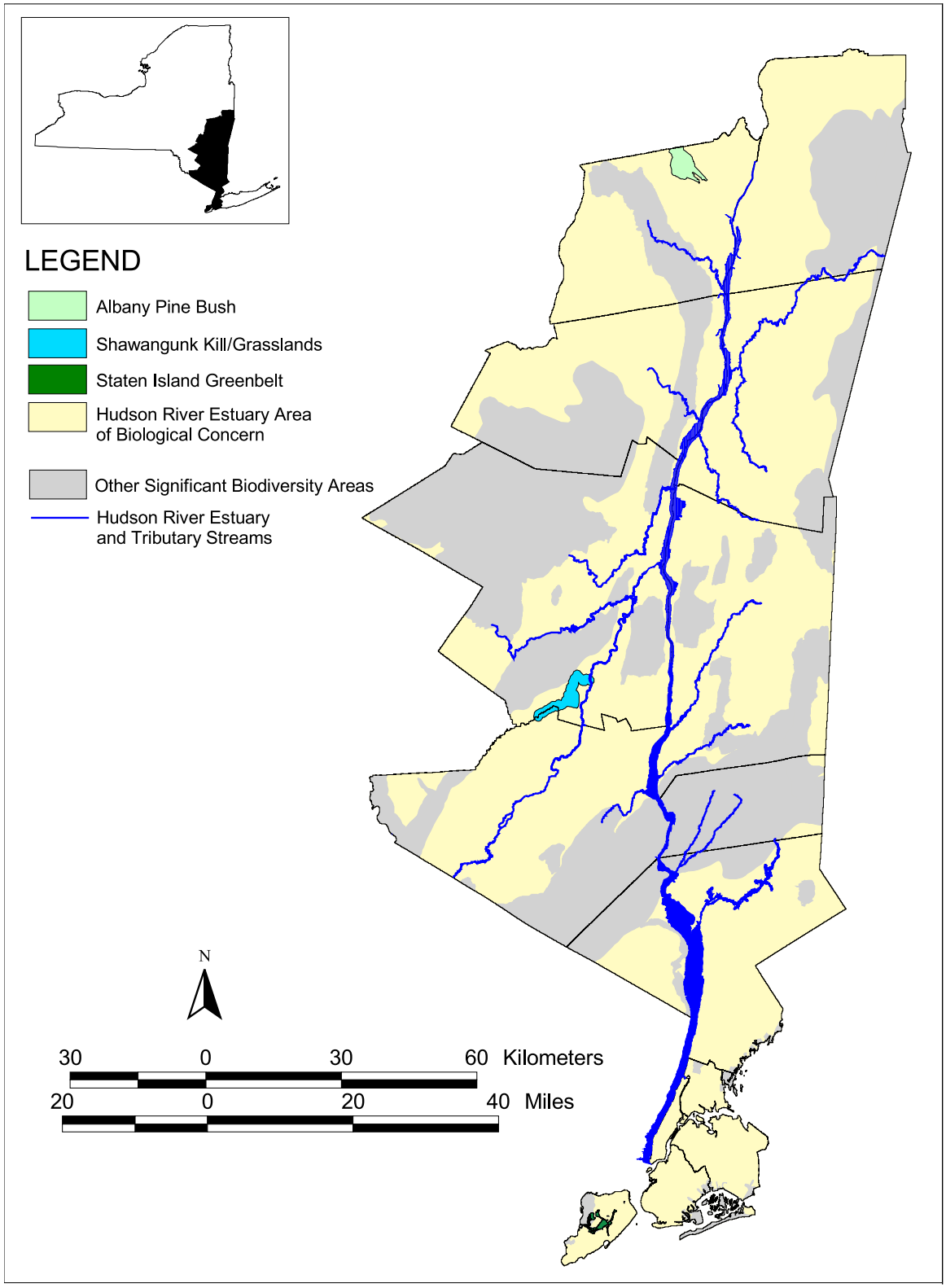


Figure 9. Significant biodiversity areas in the Hudson River Estuary corridor notable for open uplands and barrens.

Tributaries & Riparian Habitat

Description:

The health of the Hudson River Estuary is closely linked to the health of its tributaries and their watersheds. There are roughly 65 major tributaries to the Hudson River Estuary with over 3,600 miles of streams in the estuary watershed. These tributaries and adjacent riparian areas provide important habitat for fish and wildlife. Migratory fish, like herring and eel, and resident species, such as black bass, rely on tributary habitats to complete their life cycles. Blue crabs use the tributaries for nursing and overwintering. In the Hudson River Estuary, the mouths of tributary streams and rivers are influenced by daily tides, and are thus unique communities.

Intertidal swale. Photo courtesy of Kathryn Schneider.

Streams include channel habitat and riparian areas on the tops of the banks, the floodplain, and non-floodplain areas adjoining the stream. A typical stream channel exhibits a sequence of microhabitats in the form of pools, riffles, and runs. Pools and slow runs might support submerged vegetation while channel bars and portions of low banks can support plants such as willows, alder, silky dogwood, spotted jewelweed, stinging nettle, and whitegrass. Streambanks and floodplains are often dominated by plants tolerant of flooding and ice damage. The floodplain is the low-lying area that is flooded by a stream at statistical intervals. The 100-year floodplain for example, is predicted to be flooded once per century. Floodplains contain a variety of habitats, including but not limited to upland meadow, wet meadows, swamps, marshes, and lowland forests. Although once common, floodplain forest is now rare in the Hudson River Estuary corridor.

Riparian habitats represent only a small portion of the landscape, but are a critical source of biodiversity. A riparian zone is an interface between aquatic and terrestrial systems. Riparian ecosystems cover the land bordering a stream, wetland, lake, tidewater, or other body of water. The suitability of these zones for supporting aquatic and terrestrial plants and animals can be altered by agricultural and timber harvesting activities, the creation of physical structures such as buildings, roads, and dams and other human disturbances such as recreation.

Ecological Importance:

Riparian zones serve a variety of functions, including those related to physical and chemical characteristics of streams (e.g., moderating water temperature, controlling stream erosion and sedimentation, controlling non-point source pollution) and they provide habitat for a variety of fish and wildlife species. Many aquatic invertebrates, which are food for predatory fish, use riparian vegetation as habitat and depend upon leaves as a source of food. Leaves fallen from streamside trees are the carbon source that fuels the entire aquatic food chain in small to medium-sized tributary streams. Riparian trees

also help to create critical habitat features, such as cover, undercut banks, and piles of woody debris that trap nutrients. Even a narrow band of woody vegetation contributes to edge of channel habitat structure (such as undercut banks) and temporary bank stabilization. Riparian vegetation is a source of woody debris that helps to create microhabitat within the stream channel. In addition to supporting the aquatic environment, riparian areas are unique ecosystems in themselves, and present optimal conditions for a number of plant and animal species. The soils and microclimate within riparian areas often contain the right conditions for ferns, orchids, and other plants that prefer rich, moist soils and environs.

Riparian zones tend to be biodiverse, because they provide a close juxtaposition of wildlife habitat requirements, an increased number of niches due to increased plant diversity and structural heterogeneity, and high edge-to-area ratios resulting from their linear shape. Riparian corridors are networks that provide potential routes for animal movement, seed dispersal, and gene flow across landscapes, and may serve as a source area for recolonization of nearby disturbed areas. Loss of mature, riparian forest remains an issue of concern in the Hudson River Estuary corridor. Wildlife species that depend upon wide bands of mature riparian forest, riparian wetlands, and silt-free channel beds are the most imperiled.

Belted kingfisher. Photo by Isidor Jeklin.

Terrestrial animals utilize riparian areas for foraging, breeding, migration, hibernation, and refuge. Semi-aquatic mammals that use tributary habitats include mink, muskrat, and river otter. Bats and birds forage on insects above the water. A variety of birds use tributaries and riparian habitat, including waterfowl, woodcock, belted kingfishers, osprey, eagles, herons, and many songbirds. Streams support fish and aquatic macroinvertebrate communities, stream salamanders, green frog, snapping turtle, eastern painted turtle, wood turtle, and northern water snake. A number of invertebrates use these habitats, including damselflies, butterflies, and dragonflies.

Pollutants released in the watershed find their way to the estuary through tributaries. In the Hudson River Estuary corridor, pollutants of concern include excessive sediment and nutrients, toxic chemicals, heavy metals, and pathogens. Other significant causes of water quality impairment in tributary streams include noxious aquatic plants (particularly at tributary mouths), thermal modification, flow alteration and other habitat modifications. Many pollutants readily attach to sediment, which in excess, is also considered a pollutant. Potential pollutants such as pathogens, phosphorus, and some pesticides readily attach to sediments and are resuspended in the water column dur-

ing disturbances, or transported downstream to drinking water reservoirs or the Hudson River Estuary. All stream systems naturally erode and redeposit sediments. However, sediment erosion or deposition beyond natural rates can create conditions that aquatic organisms are unable to tolerate. Common sources of sediment include eroding banks (although some bank erosion is natural), construction sites, agricultural fields, and urban runoff.

The obstruction of fish migration by dams and other structures, and habitat alteration related to activities such as gravel mining or reservoir water releases, can also degrade tributary habitats. Dams alter river continuum and connectivity, disrupt sediment transport, and alter natural fluctuation in water supply. Increasingly, increased impervious surfaces are causing changes to watershed hydrology, particularly in the rapidly urbanizing portions of the Hudson River Estuary corridor. Impervious surfaces such as roads, rooftops, and parking lots direct stormwater to streams as runoff, rather than allowing it to infiltrate the soil and reach the stream as groundwater. Because water is not stored in the soil and released to the stream at slower rates, the result is that low flows are more severe and last longer during summer months, while storm flows may peak at higher and more destructive levels. Both the increased flow rate and amount of water reaching the stream can cause devastating changes in channel and riparian habitats.

Headwater mountain stream. Photo courtesy of Mark Vian.

Conservation Strategies:

The cumulative effects of channelization, point and nonpoint source pollution, gravel mining, dam construction, floodplain filling, and riparian vegetation removal throughout a stream system can lead to dramatic declines in biodiversity. Best Management Practices designed to reduce these disturbances should be developed based on an understanding of how disturbances affect certain species, at what intensities, and during which times during the species' annual life-cycle. Management of stream and riparian habitats may involve the establishment of buffers, limiting livestock and human access during critical time periods, and limiting certain types of activities. Conservation easements, local zoning ordinances, and set-aside of riparian areas, can create a space for natural stream processes to operate.

Minimizing development in the riparian corridor, and minimizing hydrologic alteration of the stream system within the watershed (including intermittent tributaries and wetlands) will help to protect stream biodiversity. Restoration of native riparian meadows and for-

ests, as well as natural channel morphology is essential for the protection of water quality. Stream managers should consider that alterations of floodplain, channel, and riparian habitats in one section of the stream can cause unwanted changes in downstream habitats.

Longtail weasel.
Photo courtesy of Cornell University.

Management approaches to conserving riparian zones must address both the loss and degradation of these habitats and the effects of human disturbance. The USDA Forest Service (Welsch 1991) provides specific guidelines for the conservation and maintenance of riparian zones, including recommendations for the size of forest buffer widths. In general, riparian buffer widths should be at least 300 feet to support wildlife habitat. However, conservation buffers of this size are not always possible. Buffers of at least 50 feet protect some streamside functions, although their long-term effectiveness should be examined for the particular stream and the probability of channel adjustments. Recommended buffer sizes can also be based on particular stream processes and species-specific habitat requirements (Wenger 1999). Riparian buffer recommendations should be incorporated into forestry and agricultural Best Management Practices and communicated to interested landowners.

Biodiversity areas notable for tributaries & riparian habitat (Figure 10):

- Delaware/Mongaup Rivers
- Hudson River Estuary Area of Biological Concern
- Shawangunk Kill/Shawangunk Grasslands
- Neversink River

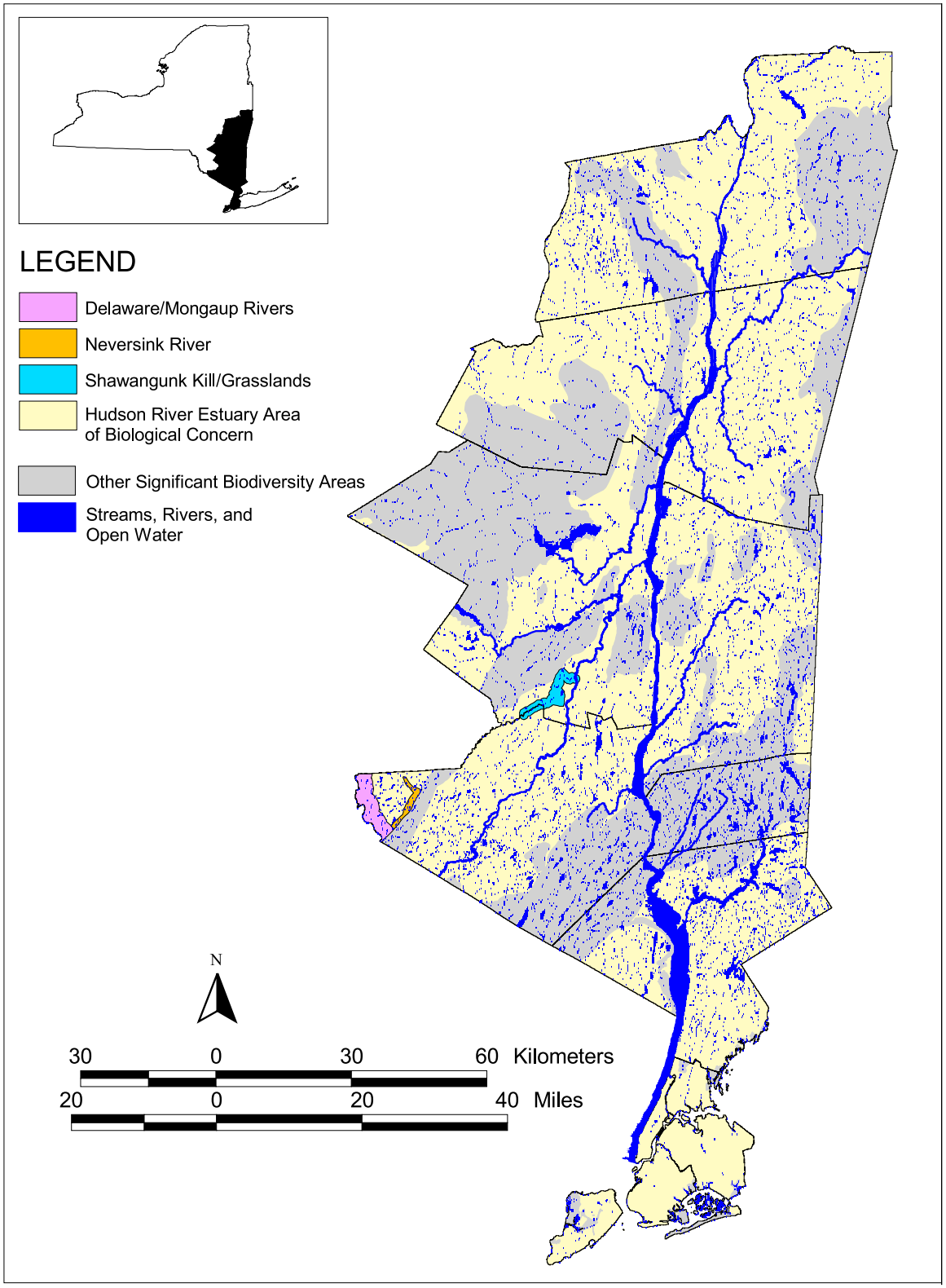


Figure 10. Significant biodiversity areas of the Hudson River Estuary corridor notable for tributaries and riparian habitat.

Unfragmented Forest & Habitat Corridors

Description:

Unfragmented forests are relatively large forest or woodland tracts that are unbroken by major roads or other developments. Some of the forest types found in the Hudson River Estuary corridor include pitch pine-oak forest, Appalachian oak-hickory, chestnut oak forest, beech-maple mesic forest, hemlock-northern hardwood forest, spruce-northern hardwood forest, mountain spruce-fir forest, and mountain fir forest. Some examples of large forested blocks in the Hudson Valley include the Rensselaer Plateau, the Highlands, and the Catskill, Taconic, and Shawangunk mountains. Lowland forest floors that have deep leaf litter and uncompacted soils are rare remnants of features that may once have covered large areas in the Hudson River Valley.

Ecological Importance:

Unfragmented forest blocks are important for a number of species sensitive to disturbance and dependent on large areas to meet their habitat requirements. These species are typically defined as interior or area-sensitive species and include several large mammals (e.g., bobcat, black bear, fisher), raptors (e.g., red-shouldered hawk, Cooper's hawk), and songbirds (e.g, woodland warblers, forest thrushes). Furthermore, some species depend on the clean, cold water provided in headwater streams in forested regions. These streams are critical habitat for trout as well as several species of amphibians.

Sharp-shinned hawk.
Photo by Johann Schumacher.

Habitat corridors that link intact forest blocks are extremely important features in the landscape. Corridors are habitat for dispersing animals, and most importantly connect species populations. In many cases these corridors represent riparian habitat as well.

Although few examples of "old-growth" lowland forest remain, forests of moderate-sized and moderate-aged trees continue to provide valuable habitat and might provide valuable mature forest habitat in the future. Typical trees in a lowland forest include sugar maple, oaks (black, red, chestnut, white), American beech, and hemlock. Other trees that may be present include shagbark hickory, white ash, basswood, tulip tree, and black birch. Characteristic animals of unfragmented forests are red-shouldered hawk, barred owl, pileated woodpecker, ovenbird, wood thrush, cerulean warbler, and Acadian flycatcher. A diverse small mammal community and invertebrate community are usually also present. Rare fungi, lichens and bryophytes (mosses and liverworts) are associated with remaining lowland old-growth forests. The red-shouldered hawk may be rare in part due to fragmentation of this habitat.

Conservation Strategies:

Habitat change and fragmentation are substantial pressures negatively affecting biological diversity in the Hudson River Estuary corridor. Floodplain forest and mesic lowlands are especially at risk of fragmentation, and are under-represented on public lands (A. Finton, NY Natural Heritage Program, pers. comm.). Therefore, it should be stressed that intact, forested habitats should be conserved regardless of size. Within fragmented landscapes, the conservation of habitat corridors that link intact forest blocks is of particular importance. On a local level, this will involve the identification of forest blocks and corridors. Once identified, conservation tools aimed at protecting these areas (e.g., conservation easements, acquisition on a willing seller basis) should be implemented. Forestry plans for these areas should emphasize selective and low-impact harvesting, particularly of mature lowland forest. Forest management practices that reduce the impact of roads and compaction and disturbance by vehicles should be encouraged.

Chestnut oak forest.
Photo by Andrew Finton.

On a regional level, strategies to address habitat change and fragmentation should focus initially on identifying those lands most at risk, assessing the juxtaposition of protected forest blocks and corridors with unprotected land, and identifying critical areas for maintaining or establishing habitat connectivity. Spatial analyses of these features could be conducted using remote-sensing products. Other studies that examine the effects of human demographics on habitat fragmentation could be extremely important for identifying priority areas for conservation efforts and directing development to less sensitive areas.

Biodiversity areas notable for unfragmented forest & habitat corridors (Figure 11):

- Catskill Mountains
- Highlands
- Rensselaer Plateau
- Shawangunk Ridge
- Taconic Ridge

Other biodiversity areas that contain unfragmented forest:

- Palisades

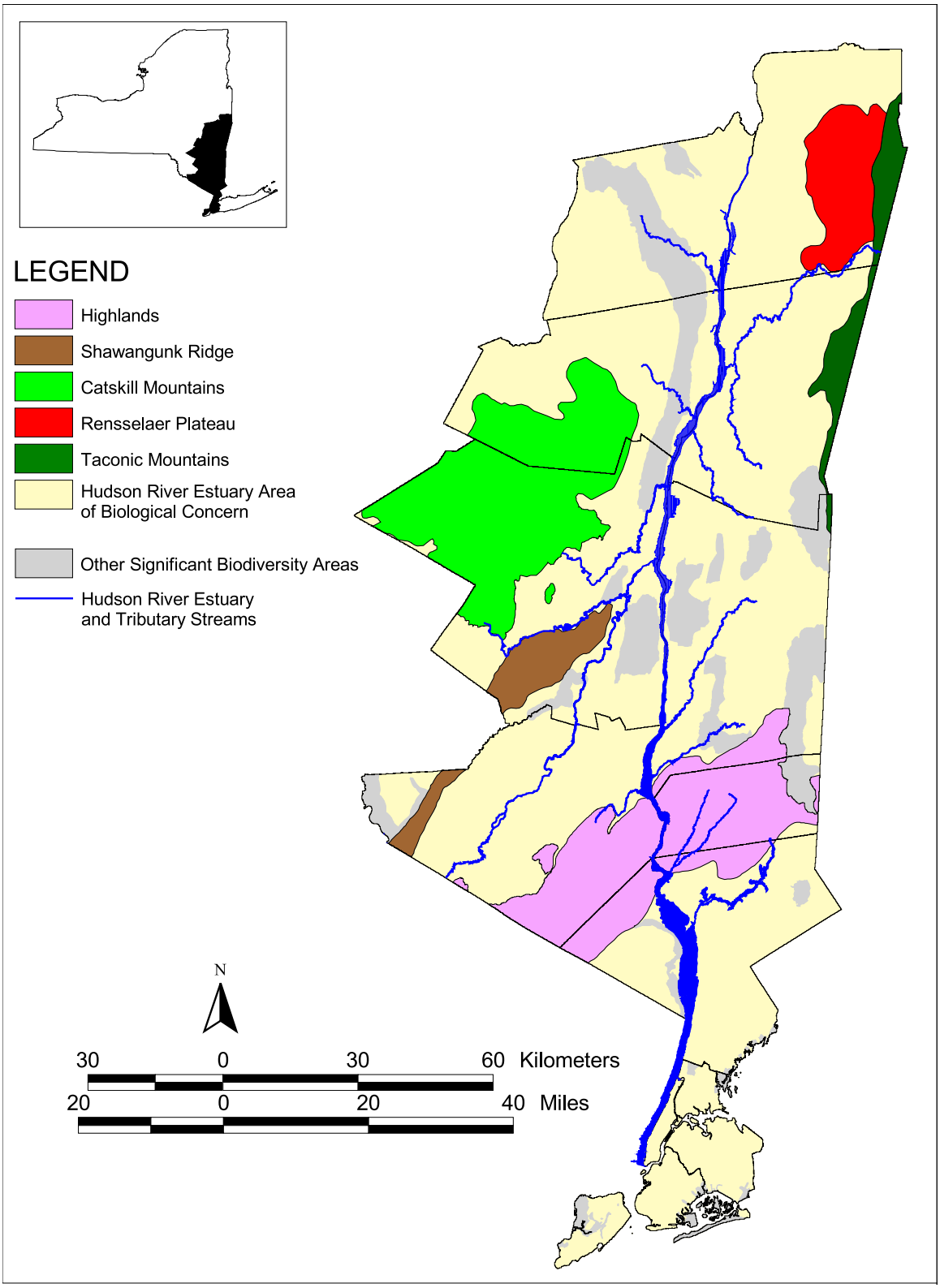


Figure 11. Significant biodiversity areas of the Hudson River Estuary corridor notable for unfragmented forest and habitat corridors.

Wetlands

Description:

Much of the information on wetlands provided below was adapted from Kiviat and Stevens (2001).

- Tidal and Non-Tidal Wetlands

  The Hudson River Estuary corridor contains a rich diversity of wetland types, which in turn supports a variety of plant, wildlife, and fish species. About 29 of the 57 wetland community types occurring in New York have been documented in the Hudson River Estuary corridor (Howard et al. 2002, Edinger et al. 2002). Wetlands represent a transition between aquatic and terrestrial systems and as such, generally support high species diversity. Some wetlands (e.g., bogs) support low species diversity but represent an important component of biodiversity at the landscape scale.

  Tidal wetlands occur along the 152-mile Hudson River estuary and include brackish tidal marsh, brackish intertidal mudflats, freshwater tidal swamp, freshwater tidal marsh, and freshwater intertidal mudflats. The species composition of Hudson River Estuary wetlands change as the water characteristics change from brackish to fresh. Examples of non-tidal wetlands include fens, bogs, scrub-shrub swamp, and forested, floodplain, and headwater wetlands.

  Tidal wetlands of the Hudson River Estuary corridor include (Kiviat and Stevens 2001):

  Fresh and Brackish Subtidal Shallows: The subtidal shallows is the zone between the mean low water elevation and approximately 6.5 ft below mean low water. This zone supports beds of submerged vegetation, which are well-known for their importance to fish and waterfowl. In some areas, the subtidal shallows extend into portions of tidal tributary mouths. This habitat is found throughout the tidal Hudson, but is more extensive in shallower reaches of the river, including the Haverstraw Bay-Tappan Zee and areas north of Saugerties.

  Fresh and Brackish Intertidal and Supratidal Marsh: The intertidal marsh is the herbaceous wetland (i.e., dominated by non-woody plants) and mudflat zone between mean low water and mean high water. A supratidal marsh is a predominately herbaceous wetland occurring at elevations between mean high water and approximately 3.3 ft above mean high water. Possibly the best-studied Hudson River habitat, the marshes attract attention because of their documented importance to fish and birds. These habitats also support many rare plant species, are important for recreation, and appear to play a beneficial role in Hudson River water quality. The combined intertidal and supratidal zones cover approximately 26% of the 58,000 acre high-tide surface area of the tidal Hudson River between the Rip Van Winkle Bridge and the New York-New Jersey state line. The intertidal marhes probably comprise somewhat less than half of the 26%.

Intertidal and Supratidal Swamp: The intertidal swamp is a wooded wetland, dominated by trees or shrubs, occurring in the upper intertidal zone, but below mean high water. A supratidal swamp is a wooded wetland lying between mean high water and approximately 3.3 ft above mean high water. It thus receives tidewater only during spring tides and storm tides. Tidal swamps have been studied little in the Hudson or elsewhere on the Atlantic coast. Hudson River intertidal and supratidal swamps are known to support rich biological communities, including numerous rare plants and a few rare animals. Most tidal swamp is in highly sheltered areas where tidal wetlands predated the Hudson River railroads, on dredge spoil deposits between the railroad and mainland, or at stream mouths, between islands and the mainland, and in protected coves. The largest examples are at Mill Creek, Stockport Flats, Rogers Island, Rams Horn Creek, and Tivoli Bays.

Tidal Tributary Mouth: The mouths of tributaries where nontidal and tidal waters mix, differ in substrate and chemistry from the adjoining aquatic habitats of the tributary and Hudson River. Tidal tributary mouths often have relatively scoured, rocky bottoms, fluctuating turbidity, and a shorter ice season than the adjoining bays or coves. These areas are important foraging habitats for fishes and water birds, and important spawning habitats for ocean and Hudson River fishes. Tidal stream mouths are found throughout the estuary, although in urban areas some streams have been diverted into culverts or artifical channels.

Non-tidal wetlands of the Hudson River Estuary corridor include (Kiviat and Stevens 2001):

Wet Clay Meadow: Wet clay meadows are wet meadow or wet oldfield habitats on clayey soil; most were formerly agricultural fields. Post-agricultural wet meadows may seem unexceptional on first inspection, but some are significant habitats for rare plants. This habitat should be expected wherever level, non-forested expanses of clayey soils occur in the Hudson River Estuary corridor, generally at 100-200 ft elevation.

The threatened spreading globeflower. Photo by Troy Weldy.

Fen and Calcareous Wet Meadow: These are open (i.e., unshaded by trees), herb-dominated (usually sedge-dominated), calcerous, shallow wetlands. Fens are distinguished by groundwater seepage, and a "fen plant community", typically including shrubby cinquefoil. Calcareous wet meadows may have a variety of water sources, and a less specialized plant community. Fens and calcareous wet meadows occur where bedrock is limestone or other carbonate rock, or where the soils contain glacier-transported materials from carbonate rocks. These habitats support many rare

plants and animals, and are sensitive to hydrological changes and pollution. Most fens and calcareous wet meadows are at low elevations.

Blue flag iris. Photo by Paul Jensen.

Non-Calcareous Wet Meadow: These are wetlands with non-calcareous soils and groundwater where the soil is saturated for part or all of the growing season, but only shallowly and briefly inundated, if at all, and which support predominantly herbaceous (non-woody) vegetation. Non-calcareous wet meadows are common in the Hudson River Estuary corridor. They occur where there is seepage, or accumulation of rainwater or runoff, on soils that are moderately to highly acidic. Wet meadows usually occur where there is or was livestock grazing, mowing, hay cutting, recent abandonment of crops, or where woody vegetation has recently been cleared. Wet meadows also occur in beaver meadows (abandoned beaver ponds) and some partially drained marshes. Wet meadows are often associated with the margins of marshes or swamps. Biodiversity values of non-calcareous wet meadows are poorly studied.

Hardwood Swamp: In prevalent usage the term "swamp" refers to a wetland dominated by trees or shrubs. Non-tidal hardwood swamps are fairly common in the study area; conifer swamps are very rare, very different ecologically, and very important for biodiversity. Swamps may be inundated throughout, may contain only small streams or pools, or may border larger streams, ponds, or lakes. Springs or seeps (groundwater discharge) may be present within or at the edges of swamps. Hardwood swamps are more extensive in areas of lower human population and are more common and extensive at lower elevations. Kettle shrub pools are an important type of swamp habitat, particularly to the threatened Blanding's turtle. Kettle shrub pools are deep-flooding, seasonal, shrub-dominated wetlands on glacial outwash, originally formed by the melting of stranded blocks of glacial ice.

Beaver Pond: Beaver ponds are created by beavers building dams across small to medium-sized perennial streams. Beaver ponds flood portions of the riparian area for a few years or sometimes longer. The pond accumulates silt, organic matter, and nutrients. Eventually the beavers die or leave the pond, the dam deteriorates, and the water level of the pond draws down, leaving a beaver meadow — a silty marsh or wet meadow. Beaver ponds and beaver meadows are different from surrounding habitats and are used by many other animals and plants. Beaver ponds are widespread in the Hudson River Estuary corridor, except in areas of high human population density where beaver ponds are usually drained to prevent damage to roads, yards, and ornamental trees.

Circumneutral Pond Lake: These are calcareous spring-fed water bodies with deep, organic substrates, and supporting vegetation of both acidic bogs and

calcareous marshes. Floating peat mats and rafts are often present. Circumneutral bog lakes contain a variety of habitats for rare and uncommon species. Bog lakes are probably widespread near the Hudson River Estuary although many (and the best known) examples occur farther inland.

Acidic Bog: Acidic bogs are perennially wet, very low-nutrient wetlands dominated by low shrubs and peat mosses, with acidic, organic soils. Bogs are rare in the Hudson River Estuary corridor, are strikingly different from other wetlands, and support many uncommon and rare plants.

Marsh: Marshes are wetlands dominated by herbaceous (non-woody) plants, and with standing water through all or much of the growing season. Marshes are very important habtitats for many species of birds. A marsh may be isolated from other surface waters, may adjoin a pond or stream, or may have a stream flowing through it. Nontidal marshes are widespread throughout the Hudson River Estuary corridor, but are mostly at low elevations where more water and nutrients collect.

- Vernal Pools

Vernal pools are seasonal or ephemeral wetlands that form in shallow depressions and alternate on an annual basis between a stage of standing water and extreme drying conditions. They are found in a variety of settings, including depressions in upland forests, in floodplains, in wet meadows, and as part of large wetland complexes. By definition, vernal pools are free of fish and thus can support a rich community of amphibians and invertebrates that would be difficult to sustain if fish were present. Vernal pools are a common, but threatened habitat type that look unassuming, but are critical breeding areas for several species (see below).

Vernal pool at Ward Pound Ridge Reservation. Photo by Dennis DeMello.

Overall, characteristics of vernal pools vary greatly in terms of recharge, discharge, source of water, and geology. Largely fed by precipitation, these small pools may be most readily identified in the spring. Often occurring in small depressions, many dry up in late summer. However, a few have water year round.

Ecological Importance:

- Tidal and Non-Tidal Wetlands

Wetlands are unparalleled in their importance to many fish and wildlife species, providing a variety of habitat components such as breeding grounds, nesting sites, foraging areas, and other critical habitat. Because of historical losses in wetlands across North America, including New York State, these habitats often support endangered, threatened, and special concern plant and animal species. For example,

the Hudson River Valley contains critical wetland habitat for the federally listed bog turtle, Blanding's turtle, and northern cricket frog. Additionally, wetlands along the Hudson River Estuary are especially important for migratory waterfowl in the Atlantic Flyway. Tidal wetlands of the estuary represent some of the state's rarest ecological communities and are important as nursery areas for a number of marine and anadromous fish. Furthermore, wetlands perform a variety of unique physical, chemical, and biological functions that are essential to the health of the environment. Wetlands regulate water flow, protect lake and river shore areas from erosion, and improve water quality.

Quality tidal habitats have low densities of introduced plants such as water-chestnut and Eurasian watermilfoil, and smaller fractions of artificial materials (cinder, demolition debris, railroad ties) in the sediments. Many state-listed rare plants (e.g., Long's bittercress, spongy arrowhead, estuary beggar-ticks, smooth bur-marigold, goldenclub, Fernald's sedge) and other species in the Hudson Estuary corridor that are almost or completely restricted to the Hudson depend upon tidal marsh habitats. Extensive cattail stands, and to some extent mixed cattail stands, support breeding birds that depend to a variable degree on grass-like marsh plants. The mouths of tributaries, where nontidal and tidal waters mix, are important foraging habitats for fishes and water birds, and important spawning habitats for ocean and Hudson River fishes.

Northern cricket frog. Photo by John White.

Common animals of nontidal wetlands include white-footed mouse, raccoon, red-winged blackbird, swamp sparrow, and green frog. Wetlands are used by muskrat, mink, beaver, tree swallow, waterfowl, herons, shorebirds, northern water snake, turtles, frogs, and many invertebrates. Larger live or dead trees often contain cavities used by bats, owls, woodpeckers, eastern bluebird, gray treefrog, and other cavity-using animals. In addition, many species use the buffer areas surrounding wetlands, which may not be protected.

In general, higher quality nontidal wetlands have a large extent, absence or rarity of invasive plants (e.g., purple loosestrife, common reed, reed canary grass), an intact buffer zone with minimal impingement by intensive land uses, absence of landfills or dumps upstream or upgradient, and light or no livestock grazing. Large mats of floating filamentous algae that cover pools for long periods each year indicate overfertilization from external sources. High quality fen and calcareous wet meadows have minimal cover of tall herbs, tall shrubs, or trees. Higher quality wet clay meadows have a greater abundance of sedges (other than tussock sedge). Hardwood swamps of high quality have larger trees and more large downed wood in the swamp.

- Vernal Pools

Vernal pools are a common, but threatened habitat type in the Hudson River Estuary corridor. They are often damaged because they are overlooked or not appreciated by landowners, or in environmental reviews for development. Vernal pools and their surrounding terrestrial areas provide critical habitat for a number of amphibians and invertebrates, some of which breed only in vernal pools. Vernal pools are the only significant breeding areas for Jefferson salamander, spotted salamander, marbled salamander, and wood frog. Other typical users include spring peeper, spadefoot toad, gray treefrog, American toad, and other amphibians that depend on pond habitats for reproduction.

Spotted salamander.
Photo courtesy of Cornell University.

Frogs move from the forest to vernal pools where they mate and lay eggs and then return to the woods after breeding. The deposited eggs hatch into tadpoles, which transform into adults sometime within 6 to 15 weeks. Salamanders spend much of the year underground in tunnels made by small woodland mammals. They emerge from the ground in early spring and migrate up to half a mile on warm, rainy nights to vernal pools. Once they have deposited their eggs, the adult salamanders typically wait for the next rainy night, when they return to the forest. The developing amphibians prey on fairy shrimp, copepods, daphnia, phantom midge larvae, and mosquito larvae. Young adults leave the vernal pools once they have lost all traces of gills and return to breed about two to four years later.

Because these species are largely dependent on vernal pools for breeding success (the risk of predation is high in permanent wetlands), the loss of vernal pools in upland areas will lead to the loss of amphibian species that depend on them, and thus loss of biodiversity. Amphibians in general are declining worldwide, as are many vernal pool dependent amphibians in the Northeast. Jefferson salamander, marbled salamander, and blue-spotted salamander are listed as special concern in New York State. The four-toed salamander, spotted salamander, and wood frog are vernal pool-using species threatened in the Northeast.

Vernal pools are also important habitat for other species, such as wetland dependent turtles (including the state-listed Blanding's turtle and spotted turtle), birds (including the federally listed American black duck), and small mammals. In Dutchess County, kettle shrub pools (a type of vernal pool formed by the melting of stranded blocks of glacial ice) support populations of the threatened Blanding's turtle. Neotropical migrant birds such as the worm-eating warbler, veery, and wood thrush also use vernal pools.

Conservation Strategies:

- Tidal and Non-Tidal Wetlands

Freshwater tidal and non-tidal wetlands in New York State are protected under the Freshwater Wetlands Act, Article 24 and salt-water tidal wetlands in the lower estuary are regulated under theTidal Wetlands Act, Article 25 of the Environmental Conservation Law. However, most small freshwater wetlands less than 12.4 acres are not covered under this legislation. Exceptions are certain smaller wetlands of unusual local importance and wetlands above one acre in size that are regulated within the Adirondack Park. Efforts to identify and protect smaller wetlands should be encouraged. Adequate protection of the uplands buffering wetlands is essential to preserving the integrity of wetland ecosystems and habitat quality for wildlife.

Physical disturbances to tidal wetlands should be avoided or minimized, and tidal flushing should be fully maintained. Dredge spoil disposal in the last century has eliminated large areas of tidal wetlands, especially between Saugerties and Albany. Large areas have also been filled for construction of the railroads and for urban-industrial development, especially in the Westchester and Albany areas. Pervasive chemical pollutants, such as PCB and metals, have contaminated the water and substrates of the Hudson River tidal habitats. Power boating and jet skiing in the shallows can have numerous effects, including pollution and toxic effects on organisms. Motorized craft should be excluded from shallows as much as possible to prevent pollution, and disturbance of animals and plants there. Abandoned and derelict duck blinds should be removed from tidal wetland habitats and duck hunters encouraged to use temporary blinds that are removed each season. The U.S. Army Corps of Engineers and NYSDEC are studying the potential for "restoring" some of the subtidal and intertidal habitat altered by spoil disposal.

Wetland stream. Photo by Paul Jensen.

The mouths of tributaries are degraded by stream channel alteration and water pollution, particularly near urban-industrial areas. Removal of obsolete dams and other structures, and restoration of stream bank plant communities would benefit tributary mouths. In some cases, fish ladders may be needed to provide access for spawning above dams that cannot be removed. Boat traffic in some areas constitutes intense disturbance of tributary mouth and tidal habitats. Finally, restoration of tidal flow should be emphasized and may require the installation of structures that allow flows to bypass obstructions.

Without mowing, burning or grazing, wet meadows are likely to be overgrown by purple loosestrife, shrubs and trees. Common reed is also a potential problem. Invasive species monitoring and control efforts will be particularly effective on sites that currently have

minimal invasive species problems. Recent advances in reducing purple loosestrife are encouraging and may present opportunities for local community involvement in the future.

Non-tidal wetlands, like tidal wetlands, are sensitive to hydrological changes and pollution. Filling, dumping, damming, excavation (to create ponds), siltation, pollution (from road or agricultural runoff), alteration of vegetation, and drainage are destructive to wetlands. Upstream changes in water quantity (changes in hydrology) or quality also impact wetlands. The woody vegetation in communities such as red maple-hardwood swamps and dwarf shrub bogs is often killed by higher water levels caused by downstream dams or road-bed impoundments. Low-intensity grazing or hay cutting may be compatible with biodiversity in some types of wetlands, depending on the kinds of rare or uncommon biota present. Restoration or protection of wetland hydrology, restoration of wetland plant communities, maintenance of buffer zones, control of invasive species, identification and protection of smaller wetlands, and management of certain types of wetlands through mowing, grazing or burning are conservation management actions needed for wetlands. Best Management Practices (BMP's) for timber harvesting (Welsch et al. 1995) and agricultural operations to promote wetland conservation should be encouraged and implemented in the Hudson River Valley.

Great horned owl.
Photo courtesy of Cornell University.

- Vernal Pools

Identification and mapping of vernal pools is a necessary first step in their conservation. Learning how to recognize these pools, even in the dry season, is of critical importance. Vernal pools can be identified through a variety of signs and plant species that may indicate their presence. Some of these identifiers include blackened and compressed leaf litter, buttressed tree trunks, water marked tree trunks, and vegetation such as red maple, highbush blueberry, and buttonbush. Pools should be identified in late winter or early spring when they are most readily recognized. Calhoun and Klemens (2002) recommend Best Development Practices and planning tools for conserving vernal pool wildlife and Welsch et al. (1995) provides Best Management Practices for timber harvesters. Management plans for foresters and local governments (master planning or open space planning) should call for identifying the location of any vernal pools, and the establishment of protective buffer zones around these areas. Reschke (1990) points out that more data on characteristic plants and invertebrates are needed.

Biodiversity areas notable for wetlands (Figure 12):

- Dutchess County Wetlands
- Esopus/Lloyd Wetlands and Ridges
- Harlem Valley Calcareous Wetlands
- Hudson River Estuary and Tidal Wetlands
- Hudson River Estuary Area of Biological Concern

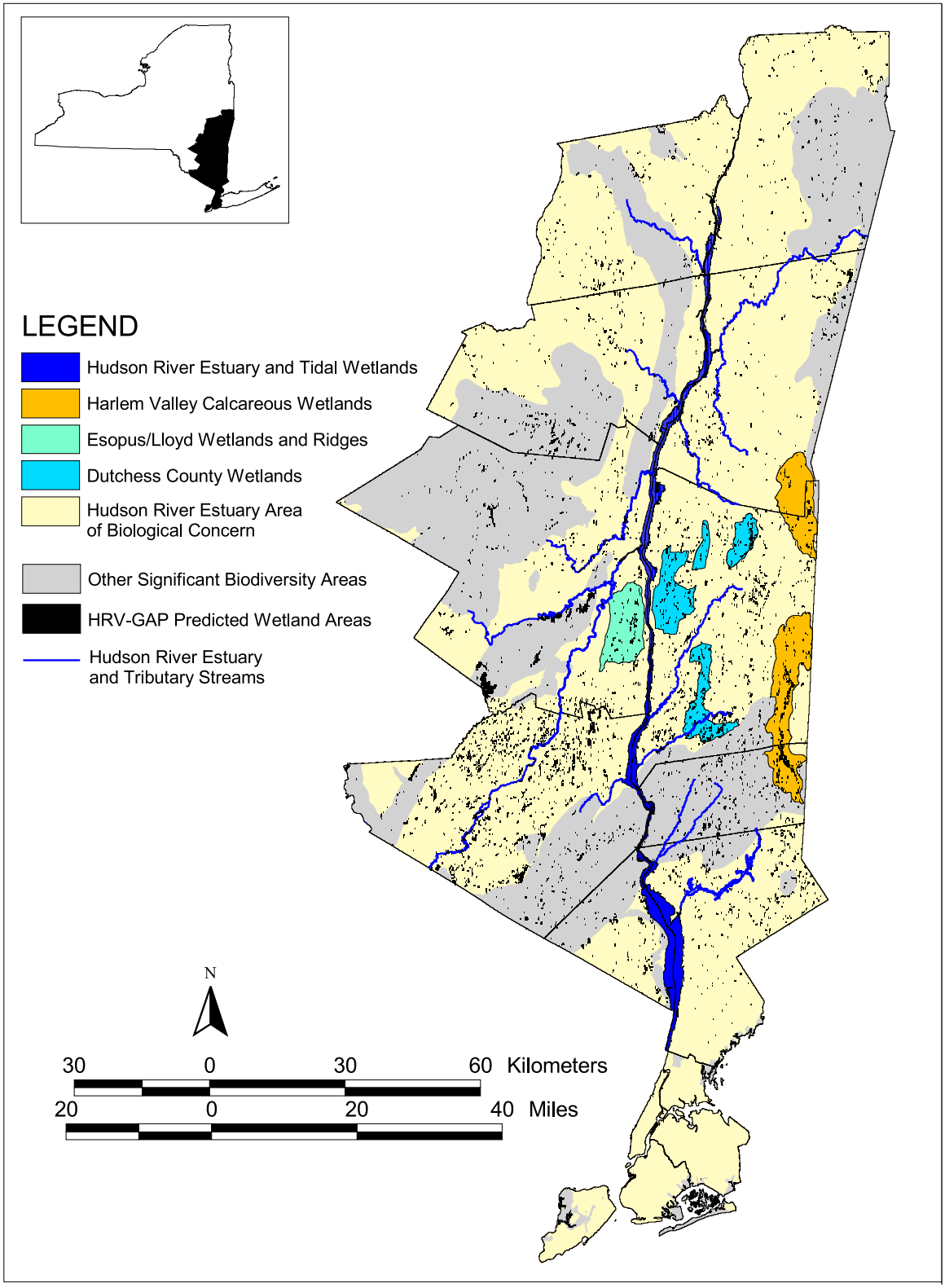


Figure 12. Significant biodiversity areas of the Hudson River Estuary corridor notable for wetlands. The map shows wetland occurrences predicted by the Hudson River Valley Gap Analysis (Smith et al. 2001) as black polygons. This is not a regulatory map.

Significant Biodiversity Area Descriptions:

Albany Pine Bush

Site Description:

The Albany Pine Bush includes the remaining undeveloped sandplain habitat in the Albany Pine Bush, including all parcels of the Albany Pine Bush Preserve, the intervening lands that connect these protected parcels, and some of the surrounding areas adjacent to the Preserve. The area encompasses the regionally rare pine barrens communities and interspersed forest and wetland communities that support rare and highly localized insect species populations as well as rare amphibians, reptiles, and plants. The area is about 6.54 miles long by 3.5 miles wide and covers about 9,000 acres.

Albany Pine Bush. Photo by Steve Young.

The Albany Pine Bush is underlain by shale (Normanskill shale) from the Ordovician period, however the overriding influence on the Pine Bush comes from the surficial deposits of sand. These are dune deposits formed when wind carried sand from drained glacial lakes about 10,000 years ago. The deep, well-drained sand deposits left poor soils that had a large influence on the communities that could establish there.

Site Location:

The Albany Pine Bush is located in eastern New York between the cities of Albany and Schenectady.

Towns:	Albany, Guilderland, Colonie		
Counties:	Albany		
Approximate Size:	14.3 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Albany Pine Bush Preserve	NYSDEC	2.27 mi^2
	Municipal/County Parks		0.81 mi^2
	Private Conservation Land		0.97 mi^2

Ecological Significance:

The Albany Pine Bush is regionally significant as the largest remaining inland pine barrens in the Hudson River Estuary corridor. The Albany Pine Bush contains exemplary occurrences of the globally rare pitch pine scrub oak barrens and several exemplary occurrences of pine-barrens vernal pools. A rare plant associated with pine-barrens vernal pools is the red rooted flatsedge. Other significant plant species in the area include the globally rare and federal species of special concern bog bluegrass, the globally rare orchid, Bayard's malaxis, and the only extant occurrence in the state of the globally rare adder's-mouth. The Albany Pine Bush is nationally recognized for its populations of rare

butterflies and moths (Lepidoptera). There are hundreds of Lepidoptera species found in the Pine Bush, including the federally listed Karner blue butterfly and over 40 noctuid moths (Noctuidae) considered to be pine barrens specialists. The Karner blue depends on dry, open, sandplain communities such as the pitch pine-scrub oak barrens found at the Albany Pine Bush.

Animal species of state special concern and on the NY Natural Heritage "watch list" found in the Albany Pine Bush include Jefferson's salamander, blue-spotted salamander, eastern spadefoot toad (one of only three occurrences known north of Long Island), spotted turtle and eastern hognose snake.

Fire suppression has resulted in the conversion of some of the pine barrens to successional hardwood forest. However, active management and the use of prescribed fire are restoring the area to a more characteristic and functioning pine barrens. The restoration and repeated burning has created a complex of related communities that form a gradient from grassy openings to dense canopy forests. Part of this gradient is pitch pine-oak forest and pitch pine-scrub oak barrens that form a shifting mosaic. Nested within these areas are pine barrens vernal ponds that are important breeding habitat for amphibian species.

Conservation issues and recommendations:

Invasive exotic species, as well as native invasives such as aspens and black locust have altered the composition and structure of the ecological communities and the habitat of many rare species. Plant succession, often as a result of fire suppression, has had similar effects. The Albany Pine Bush Preserve Commission, a multi-agency team, has undertaken efforts for many years to address these concerns, resulting in the protection of many globally rare species and communities in the Pine Bush. The management plan for the Pine Bush developed by the Albany Pine Bush Commission should be supported and implemented. Prescribed burning and other management techniques in the Albany Pine Bush should be carried out to restore the successional forests to pine barrens and to maintain the mosaic of existing pine barrens communities. Ongoing protection efforts are focused on high priority parcels. See the management plan developed for the Albany Pine Bush Preserve Commission for additional information. Additional inventory work is needed.

Location Description:

This area is an expanded representation of the US Fish and Wildlife Service (USFWS) Albany Pine Bush Significant Habitat Complex. The site generally follows the Conrail railroad tracks on the north and the Albany city line on the south as far east as Interstate 87; the western portion of the site is defined by the outer limits of the Preserve and any adjacent natural areas that have the potential to be restored to a pine barren community type.

Arthur Kill

Site Description:

The Arthur Kill includes important nesting and foraging sites for several species of herons, egrets, and ibises as well as for gulls and waterfowl. The freshwater wetland areas and forested buffers are also extremely important as some of the only remaining open space in metropolitan New York suitable as feeding and roosting areas for waterbirds and migratory stopover habitat for songbirds and raptors. This area also contains several plants and natural communities reaching their northeast limit, thus making them rare in New York State.

Site Location:

The Arthur Kill includes the northwestern corner of Staten Island in New York City and adjacent portions of the Arthur Kill and Kill van Kull in both New York and New Jersey. Although not considered part of the Hudson River Estuary Watershed, this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Towns:	Borough of Staten Island (New York City)		
Counties:	Richmond		
Approximate Size:	7.45 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Clay Pit Ponds State Park	NYSOPRHP	0.17 mi^2
	Harbor Herons WMA	NYSDEC	0.06 mi^2
	Old Place Creek Tidal Wetlands Area	NYSDEC	0.09 mi^2
	Other State Tidal Wetlands	NYSDEC	0.04 mi^2
	Greenbelt	City of New York Parks and Recreation	0.05 mi^2

Ecological Significance:

The Arthur Kill is notable for the network of remaining upland and wetland open space within a highly industrialized area. These remaining natural communities support regionally significant fish and wildlife populations, especially wading birds. Of primary significance in this area is the presence of major nesting colonies and foraging areas of herons, egrets, and ibises in a complex of closely associated natural habitats occurring within a major metropolitan area. The three island colonies established in the area represent the largest heronry complex in New York State and support thousands of pairs of a variety of species of colonial wading birds, many of which are of special concern in the region. The Arthur Kill also serves as an important location for nesting waterfowl and many neotropical migrant songbirds. Examples of significant and regionally rare species and communities occurring in this area include red maple sweet gum swamp, southern leopard frog, and the globally rare Nantucket juneberry.

Conservation Issues and Recommendations:

This unique and regionally significant wetlands and heronry complex is within one of the most intensively industrialized and urbanized corridors in the northeastern United States, and is subject to both physical and qualitative losses of habitat due to chemical and nutrient pollution stresses, storm water and sewage discharges, stream channelization, nonpoint source runoff, illegal filling and dumping activities, fragmentation and loss of connecting corridors, loss of upland buffers, invasive species, mammalian predators, uninformed or poorly planned land and waterfront development, human related disturbances, and dredging and other changes in channel flows, among other impacts. Protection of the heronries, wetland foraging areas, and rare plants and communities of this regionally significant habitat complex should be accorded high priority and sought through a multitude of appropriate land protection mechanisms, including cooperative conservation and management agreements with land owners, improved local zoning and land use regulations, easements, land exchanges and, in some cases, acquisition. Additional inventory work is needed.

Great blue heron. Photo by Mary Tremaine.

Location Description:

This area is included in the USFWS Arthur Kill Significant Habitat Complex. The area consists of a contiguous area on the northwest corner of Staten Island, the entire length of the Arthur Kill from its junction with Newark Bay south to the Outerbridge (Route 440) on the south, and several tributary corridors to the Arthur Kill in New Jersey. The contiguous Staten Island area is bounded by the Kill van Kull and Newark Bay on the north, by Fresh Kills and Isle of Meadows on the south, and by several road systems on Staten Island on the east. On the western side of the Arthur Kill, the area includes several New Jersey tributary corridors.

Catskill Mountains

Site Description:

The Catskill Mountains contain major unfragmented forests, including first growth forest, as well as alpine communities, gorges, pristine headwater streams, and reservoirs; the area supports regionally significant populations of forest interior nesting birds, bald eagle, large mammals, coldwater fish, reptiles, and rare communities and plants. The Catskill Mountains significant biodiversity area is roughly circular and about 40 miles across at its widest point. The entire area coves 485,000 acres, of which 361,000 acres fall within the Hudson River Estuary conservation area (435,000 acres are in Greene and Ulster Counties).

Catskills lake. Photo by Elizabeth Hill.

Schoharie Creek runs out of the Catskill Mountains to the north. Esopus Creek drains the majority of the mountain range as it runs through its center and into Ashokan Reservoir at the southeastern edge of the area. Rondout Creek fills Rondout Reservoir at the southwestern border of the area. The Catskill Aqueduct, a major water source for New York City, begins at Ashokan Reservoir.

Two community types occur as matrix forests in the Catskills. Beech-maple mesic forest is common on the valleys and slopes while hemlock-northern hardwood forest is common in cool ravines and steep-sided slopes. The rare Bicknell's thrush breeds in mountain spruce fir and mountain fir communities on Hunter Mountain and its satellite peaks. Large patch communities include chestnut oak forest, mountain spruce-fir forest, red maple-tamarack peat swamp, and spruce-northern hardwood forest. Small patch communities include cliff community, ice cave talus community, hemlock-hardwood swamp, mountain fir forest, mountain spruce-fir forest, spruce-fir rocky summit, pitch pine-oak-heath rocky summit, and sedge meadow. Many of these patch communities occur in relatively stable, bounded geographic regions defined by the mountainous landscape.

The Catskills make up the eastern edge of the Allegheny Plateau in New York. This plateau is of Devonian age (410 to 360 million years ago) and formed when New York was covered in a shallow sea; the Catskill deposits were mainly from the mouths of rivers and the edge of the sea. Surface deposits are shallow and usually classified as rock or til.

Site Location:

The Catskill Mountains are in eastern New York on the west side of the Hudson River Valley.

Towns: Cairo, Catskill, Denning, Halcott, Hardenbergh, Hunter, Hurley, Jewett, Lexington, Middletown, Neversink, Olive, Rochester, Saugerties, Shandaken, Wawarsing, Windham, Woodstock

Counties: Delaware, Greene, Sullivan, Ulster

Approximate Size: 758 mi^2

Land Stewardship:

Name or Classification	Manager	Area
Forest Preserve	NYSDEC	0.55 mi^2
Balsam Lake Mountain	NYSDEC	20.13 mi^2
Belleayre Day Use Area	NYSDEC	0.5 mi^2
Big Indian	NYSDEC	53.0 mi^2
Blackhead Range	NYSDEC	17.72 mi^2
Bluestone	NYSDEC	0.01 mi^2
Colgate Lake	NYSDEC	0.93 mi^2
Devils Tombstone Campground	NYSDEC	0.28 mi^2

Dry Brook Ridge	NYSDEC	0.8 mi^2
Halcott Mountain	NYSDEC	7.33 mi^2
Hunter Mountain	NYSDEC	16.65 mi^2
Kaaterskill	NYSDEC	12.33 mi^2
Kenneth Wilson Campground	NYSDEC	0.93 mi^2
Little Pond Campground	NYSDEC	0.32 mi^2
Middle Mountain	NYSDEC	0.70 mi^2
North Mountain	NYSDEC	5.81 mi^2
North/South Lake Campground	NYSDEC	1.74 mi^2
Overlook	NYSDEC	0.87 mi^2
Peekamoose Valley	NYSDEC	3.16 mi^2
Phoenicia	NYSDEC	11.64 mi^2
Pine Hill	NYSDEC	3.8 mi^2
Plateau Mountain	NYSDEC	26.18 mi^2
Shandaken	NYSDEC	4.36 mi^2
Slide Mountain	NYSDEC	79.08 mi^2
Sundown	NYSDEC	37.28 mi^2
Westkill Mountain	NYSDEC	27.18 mi^2
Willowemoc	NYSDEC	2.39 mi^2
Windham High Peak	NYSDEC	6.11 mi^2
Woodland Valley Campground	NYSDEC	0.18 mi^2
Vinegar Hill WMA	NYSDEC	0.67 mi^2
Ashokan Reservoir	NYCDEP	8.11 mi^2
Rondout Reservoir	NYCDEP	0.65 mi^2
Publicly Owned Water Bodies		15.0 mi^2
Public Easements		0.79 mi^2
Private Conservation Lands		1.26 mi^2

Ecological Significance:

The ecological significance of the Catskill Mountains relates to its large, continuous forest and pristine headwater stream habitats, and the species dependent on these habitats. The Catskill area includes important areas of old-growth forest (areas that were never logged due to their inaccessibility), of which less than 1% remains in the eastern deciduous forest region of eastern North America. The total area of first growth forests in the Catskills is estimated to be between 53,400 and 63,300 acres. The Catskills are home to numerous rare plant species. Examples include the federally listed threatened Northern monk's hood, the globally rare Jacob's ladder, the state-listed endangered roseroot stonecrop, and the state-listed threatened fragrant cliff fern. East of the Mississippi River, muskroot is only known from within refrigerated talus slopes within the Catskills. Some of the world's best populations of the federally protected Northern monk's hood are found within the Catskills. In fact, the only places within the northeast to see this plant in its native landscape are within the Catskill Mountains. Additionally, exemplary occurrences of a number of significant communities can be found in the Catskills. Examples include many ecologically significant cliff and ledge communities associated with steep-sided ravines, and exemplary occurrences of red maple-tamarack peat swamp and hemlock-hardwood swamp.

The Catskills are home to more than 120 species of breeding birds including the rare Bicknell's thrush and several regionally rare raptors such as bald eagle (also a large wintering population), red-shouldered hawk, broad-winged hawk, sharp-shinned hawk, and barred owl. Other important animals that live in the Catskills include regionally rare reptiles and amphibians such as timber rattlesnake, eastern hognose snake, spotted turtle, wood turtle and spotted salamander, and several large mammals such as black bear, bobcat, and fisher. Black bear and bobcat depend on the large tracts of unbroken forest that this region provides.

Recent surveys resulted in the discovery of the White Mountain tiger beetle, a globally rare species that occurs on the vegetated sections of stream cobble bars, along Esopus Creek (Howard et al. 2002). A survey for rare Lepidoptera species (butterflies and moths) resulted in the discovery of West Virginia White in this area (Howard et al. 2002). This species is recorded from only three other locations in the state and this location is the only within the Hudson River Estuary corridor.

Conservation Issues and Recommendations:

Agricultural, residential, and commercial activities and roads are most concentrated in the Catskill valleys. The highest conservation priorities in the Catskills are the protection of riparian and upland habitat in the valleys, old growth forests, and habitats of rare plants and animals. This should be accomplished through cooperative efforts among the state, New York City, local communities, and private landowners. Additional inventory work is also needed.

Location Description:

This area is also identified by the USFWS as the Catskill High Peaks Significant Habitat Complex. The Catskill Mountains significant area is a roughly circular area about 40 miles in diameter that includes the core forested high elevation area of the eastern Catskill Mountains and adjacent reservoirs and reservoir lands. The site follows the break in slope along the escarpment between the Catskills and the Hudson Valley on the east, the southern boundaries of the Ashokan and Rondout Reservoir watersheds on the south, and generally follows the 2,000 foot contour on the west and north. With the exception of the reservoir lands, this area generally corresponds to the Catskill High Peaks Ecozone as defined by the New York State Department of Environmental Conservation.

Delaware/Mongaup Rivers

Site Description:

The Delaware/Mongaup Rivers includes the New York State bald eagle buffer protection zone and the New York State Mongaup Wildlife Management Area (WMA). This area is nationally and regionally significant for its pristine landscape. It contains exemplary populations of state and federally listed plant and animal species and regionally rare ecological communities. Although not considered part of the Hudson River Estuary corridor,

this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Site Location:

Along the border of New York and Pennsylvania, near the tri-state junction of New York, Pennsylvania, and New Jersey.

Towns:	Deerpark, Greenville, Port Jervis		
Counties:	Orange		
Approximate Size:	78.7 mi^2 (including the Pennsylvania portion)		
Land Stewardship:	Name or Classification	Manager	Area
	Mongaup Valley WMA	NYSDEC	2.38 mi^2

Eaglets on the Mongaup River.

Ecological Significance:

The Delaware River is the longest free-flowing river in the northeastern United States. It supports the largest wintering bald eagle concentrations in New York State and one of the largest in the northeastern United States. Other regionally rare animal species in the area include the red-shouldered hawk and the timber rattlesnake. The area also contains exemplary occurrences of significant ecological communities including pitch pine-oak-heath woodland community and riverside ice meadow community.

Conservation Issues and Recommendations:

Encourage landowner practices that protect wildlife habitats in riparian buffer zones. Additional inventory work is needed.

Location Description:

The Delaware/Mongaup River significant area is a 2-mile (radius) buffer that begins at the Shawangunk Ridge significant area boundary and follows the Upper Delaware National Scenic and Recreational River for the length of Orange County and then follows the Mongaup River extending from the Delaware north to the Mongaup Falls Reservoir.

Dutchess County Wetlands

Site Description:

The Dutchess County Wetlands area is a network of four major wetland complexes that provide important habitat for a variety of amphibian, reptile, and bird species. This area contains the highest diversity of turtles in New York State. The significant area encompasses several wetlands and their watersheds, and wetland buffer zones that are biologi-

cally significant for breeding waterfowl, rare turtles, plants, and other species, as well as intervening areas that contain potential habitat for these species. Floodplain forest communities also exist within this area.

The four separate wetland complexes total 66,000 acres. Two of the complexes (Milan Window and Stissing Mountain sites) feed Wappinger Creek, which then flows along the eastern edge of Poughkeepsie and through Wappinger Falls before flowing into the Hudson River. The southernmost complex (La Grange/East Fishkill site) contains wetlands that flow into Fishkill Creek, which flows through Beacon and then directly into the Hudson River about 8 miles after leaving the area. The East Park/Hyde Park site encompasses most of Crum Elbow Creek, from its beginning near Wurtemburg to approximately 0.5 mile of the Hudson River.

The Dutchess County Wetlands fall mostly in the lowlands of the Hudson River Watershed, and consist mainly of soft sedimentary rocks that are easily eroded and with relatively little topography. These lowlands tend to facilitate slow moving water and extensive wetland formation. Some of the Dutchess County Wetland sites, particularly Stissing Mountain, are part of the Taconic ranges more resistant metamorphic rocks. The high variety in rock types helps support a high diversity of flora and fauna.

Site Location:

The wetlands occur east of the Hudson River in western Dutchess County from Interstate 84 north to the Dutchess Columbia county line.

Towns:	Beekman, Clinton, East Fishkill, Fishkill, Hyde Park, La Grange, Milan, Pine Plains, Pleasant Valley, Rhinebeck, Stanford, Wappinger		
Counties:	Dutchess		
Approximate Size:	102.56 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	James Baird State Park	NYSOPRHP	0.93 mi^2
	Reforestation Area	NYSDEC	0.91 mi^2
	Private Conservation Land		1.24 mi^2

Ecological Significance:

Dutchess County is made up of wetland complexes with many habitats that are unusual or scarce in the region. In addition to being valuable in their own right, these wetlands support a number of local populations of the state listed threatened Blanding's turtle, one of the few sites for this species in the northeastern United States. These wetlands also support the state-endangered bog turtle. Other rare reptile and amphibian species in this area include the state listed northern cricket frog (the only known occurrence of this species east of the Hudson River), and the regionally rare blue-spotted salamander, marbled salamander, four toed salamander, spotted turtle, wood turtle, eastern box turtle, red

bellied snake, and eastern ribbon snake. The only documented consistent overwintering by golden eagles in the region occurs in this area. Additionally, pied-billed grebe nesting sites and great blue heron rookeries have been documented in the area. The extensive complex of diverse wetlands and upland forests include rich red maple hardwood swamps containing the state rare swamp cottonwood, floodplain forest, deep emergent marsh, rich sloping fen, and medium fen communities. Other rare plant species include prairie sedge and the state listed rare smartweed dodder.

Conservation Issues and Recommendations:

Swamp cottonwood. Photo by Steve Young.

Suburban expansion, along with runoff from nearby roads, agricultural lands, and developed areas, pose the most serious threats to this wetland ecosystem. Further study of the distribution, population status, habitat use, and movement patterns of the bog and Blanding's turtles, and other species, is needed. Protection of wetlands and their buffer zones, as well as of the movement corridors and road crossings between wetlands, is the highest priority. Additional inventory is greatly needed, especially with respect to amphibians and reptiles, and mapping of habitat complexes for the Blanding's turtle.

Location Description:

This area is similar to the USFWS Dutchess County Wetlands Significant Habitat Complex. The four wetland complexes included within this area are, from south to north: La Grange/East Fishkill, East Park/Hyde Park, Milan Window, and Stissing Mountain.

Esopus/Lloyd Wetlands and Ridges

Site Description:

Esopus/Lloyd Wetlands and Ridges contain wetland and upland habitat that is of particular importance to amphibian species and breeding waterfowl. Upland communities include ridges, ledges, and a mature hemlock-northern hardwood forest. The area has 32,391 acres. The main drainages in this area are the Swarte Kill, which flows into the Wallkill River to the north and Black Creek, which flows into the Hudson River to the east.

Most of this area is underlain by glacial till with large sections of soil underlain by bedrock along the eastern side of the area. Also of continental glacial origin, there are many small kame deposits; these are deposits with similar components of glacial till, but with the fine grains (silts and clays) removed by water action. These fine-grained materials were re-deposited in places such as the lacustrine (lake) silt and clay, lacustrine delta, and lacustrine sand deposits. More recent surficial deposits are the 'swamp deposits' high in organic matter, and the river and stream deposits labeled as 'recent alluvium." The bedrock geology consists of shale (Normanskill shale and Austin Glen formation) in the

western lowland portion of the area and more resistant quartzlike (Quassaic quartzite) in the hills in the eastern section of the area. The quartzlike localities were more resistant to the erosional forces of the glaciers and thus are now elevated above the nearby locales and are not buried in till. Communities on the quartzite deposits consist of more upland and drier community types, while those on the lowland-till-overlaying-shale substrate will be more mixed, with wetland and upland communities.

Site Location:_

Towns:	Esopus, Lloyd, Marlborough, New Paltz, Plattekill		
Counties:	Ulster		
Approximate Size:	51 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Forest Preserve	NYSDEC	0.1 mi^2
	Municipal/County Parks		0.02 mi^2
	Private Conservation Land		1.47 mi^2

Ecological Significance:

Grass pink. Photo by Troy Weldy.

The area encompasses significant wetland communities that serve as critical habitat for threatened amphibian species as well as breeding populations of waterfowl. The state-threatened small flowered crowfoot has been documented in this area. Only 16 sites are known for this species statewide, all of which occur within the Hudson River Estuary corridor. This area provides crucial habitat for the state-listed northern cricket frog. The northern cricket frog prefers shallow vegetated shorelines and bays. It also includes several significant and rare ecological communities including one of the largest dwarf shrub bog occurrences in the Hudson River Valley. The area contains a mature, good condition hemlock northern hardwood forest and good condition red maple hardwood swamp, Appalachian oak-hickory forest, and beech-maple mesic forest. One of the wetlands contains one of the largest populations of the state-rare twayblade (*Liparis lilfolia*) in the Northeast. In general, these wetlands contain many regional rare or uncommon plants with specific habitat requirements (e.g. grass pink, pitcher-plant, rose pogonia). Without proper protection, these plants are likely to be placed on the state rare plant list.

Conservation Issues and Recommendations:

Suburban expansion, along with runoff from nearby roads, agricultural lands, and developed areas, pose the most serious threats to the wetland ecosystem and associated cricket frog populations and other species and communities. Local planning and the reduction of polluted runoff in the vicinity of the wetlands will support the viability of these elements of biodiversity. Additional inventory work is needed.

Location Description:

The Esopus/Lloyd Wetlands and Ridges significant area is bounded by the Thruway on the west, route 9W on the east, Hardenburg, Union Center, and Esopus Avenue on the north and Route 44 to the south.

Harlem Valley Calcareous Wetlands

Site Description:

The Harlem Valley Calcareous Wetlands are composed of the valleys and adjacent ridges in the Taconic Highlands. Wetland communities include red maple-hardwood swamp, floodplain forest, fens, and shallow emergent marsh. These areas contain high quality habitat for a number of wetland-dependent species and some of the best bog turtle habitat in the Hudson River Valley. This area also includes adjacent upland ridge and ledge habitat that is especially important for northern copperhead, timber rattlesnake, and five lined skink.

The area is made up of two separate wetland complexes totaling 94,000 acres. Both complexes occur in the valleys and adjacent ridges of the southern Taconic Highlands. The Northeast-Ancram fen complex occurs in Columbia and Dutchess Counties (the northern complex). The portion within the Hudson River Estuary Watershed includes wetlands drained by Punch Brook Swamp, the Noster Kill, and the Roeliff Jansen Kill. The Great Swamp area (the southern complex) is in Dutchess and Putnam Counties. The portion within the Hudson River Estuary Watershed includes the headwaters of the Croton River and the "South Flow" of the Great Swamp. The portion in the Connecticut River Watershed includes the "North Flow" of the Great Swamp and the headwaters of the Housatonic River.

The majority of the Harlem Valley Calcareous Wetlands biodiversity area consists of Stockbridge Marble, a metamorphic rock composed of the minerals calcite or dolomite. It is formed when limestone is treated to very high temperature and pressure, such as the Taconics mountain forming process. Because of the proximity of this area to the Taconic Mountains, other bedrock components of the area are also mostly metamorphosed rocks (e.g., gneiss, schist, and to a lesser extent, quartzite). These materials are more resistant to erosion than their non-metamorphosed relatives, however their basic (non-acidic) composition maintains wetlands high in pH. Interestingly, because of the nearby Taconic Mountains and the convoluted nature of the bedrock (many layers, wide ranges in metamorphism), water upwellings and springs are common in this region. The result is a preponderance of communities dependent on freshwater upwellings of high pH water, namely fens. Other calcareous regions (Hudson Valley Limestone and Shale Ridges, Dutchess County Wetlands, Esopus Lloyd Wetlands) have much fewer occurrences of fen communities than the Harlem Valley Calcareous Wetlands biodiversity area. Most of the surficial geology deposits are of glacial origin, such as till, kame deposits, and outwash sand and gravel. Other deposits, such as those in the wetlands, consist of more recent alluvium and organic deposits.

Calcareous wetlands. Photo by Paul Jensen.

Wetland matrix communities consist of red maple-hardwood swamp and floodplain forest. The upland matrix community tends to be Appalachian oak-hickory forest. Patch communities include inland Atlantic white cedar swamp, red maple-tamarack peat swamp, rich graminoid fen, rich shrub fen, rich sloping fen, and shallow emergent marsh. Upland patch communities include pitch pine-oak-heath rocky summit, rocky summit grassland, and hemlock-northern hardwood forest.

Site Location:

This area is within easternmost Putnam, Dutchess, and Columbia Counties. Two separate wetland complexes are recognized: the Great Swamp from Brewster, New York north to South Amenia, New York, and the Northeast Ancram fen complex from Sharon, Connecticut, north to Copake Falls, New York. The lowlands occupy a long north south valley west of the Taconic Mountains called the Harlem Valley (after the railroad line) from which this complex takes its name.

Towns:	Amenia, Ancram, Dover, Northeast, Patterson, Pawling, Pine Plains, Southeast, Washington		
Counties:	Putnam, Dutchess, Columbia		
Approximate Size:	117.53 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Taconic State Park	NYSOPRHP	1.0 mi^2
	Bog Brook Unique Area	NYSDEC	0.21 mi^2
	Cranberry Mountain WMA	NYSDEC	0.23 mi^2
	Great Swamp WMA	NYSDEC	0.45 mi^2
	Wassaic MUA	NYSDEC	0.14 mi^2
	Municipal/County Parks		0.3 mi^2
	Private Conservation Land		8.95 mi^2

Ecological Significance:

The site encompasses the calcareous wetlands and uplands and ridgetop habitat that support rare reptiles, waterfowl, and raptors, as well as rare plant habitats and communities.

The mosaic of calcareous wetlands and adjacent uplands in the Harlem Valley supports regionally significant rare reptile populations and rare calcareous communities and plant species. These calcareous wetlands have truly exceptional concentrations of rare elements. The significant area is considered to contain the best bog turtle habitat in this Hud-

son Valley region. Three additional fens within the area were recently found to contain the state endangered (federally listed threatened) bog turtle (Howard et al. 2002). In all, 26 occurrences of bog turtle have been recorded for the Harlem Valley Calcareous Wetlands biodiversity area. This area also contains 11 hibernacula for the state-threatened timber rattlesnake. Other rare animals recorded include Eastern pondmussel and upland sandpiper. Recently, The Nature Conservancy purchased a very significant rich sloping fen with a bog turtle population, increasing protection of the bog turtles, fen communities, and rare plants present there.

Some of the fens and fen like areas of the site also support regionally rare plants. Great Swamp has several rare calcareous communities and plants. In addition to timber rattlesnake populations, the ledges, talus, acidic rocky crest savannas, woodlands, burn areas, and associated habitats also support northern copperhead and five lined skink. The area supports several regionally rare species such as bladderwort, three toothed cinquefoil, and the dogwood thyatirid moth. The deeper marshes and some of the ponds in this area are important habitats for waterfowl and marsh birds. The extensive wooded swamps support breeding red shouldered hawk and concentrations of migrating warblers. Also notable in the region is an extensive, old growth, hardwoods floodplain savanna with huge ashes and maples, unlike anything else in the region.

Ledge habitat. Photo by Paul Jensen.

Conservation Issues and Recommendations:

Suburban expansion and invasive species are the two central conservation issues in this area. Further study and field surveys of the distribution, population status, habitat use, and movement patterns of the bog turtle, in particular, and other species are needed throughout the entire complex of calcareous wetlands in the tri state region. Protection of wetlands, their buffer zones, and movement corridors connecting wetlands, is a high priority. These efforts should help direct suburban development to less sensitive areas.

Location Description:

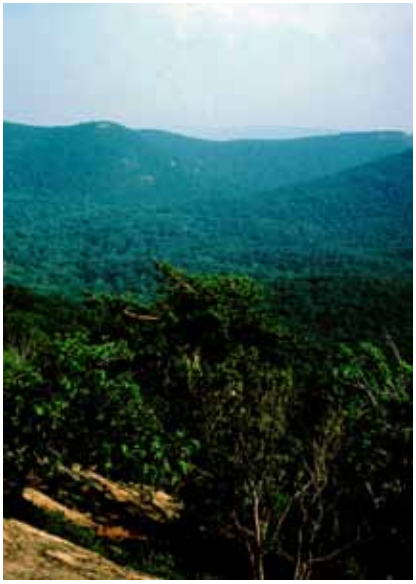
This area is similar to the USFWS Harlem Valley Calcareous Wetlands Significant Habitat Complex. The Great Swamp follows the ridgetops that form the immediate watershed of the wetlands. Great Swamp habitat area includes the wetlands of the Harlem Valley adjacent and proximate to the East Branch of the Croton River, Swamp River, and Ten Mile River; marble hills emerging from the floor of the Harlem Valley; and mountainous slopes on the east and west sides of the Harlem Valley. There is a drainage divide between the Hudson River and the Housatonic River Watersheds at the village of Pawling where the East Branch of the Croton River flows to the south into the Hudson and the Swamp River flows to the north into the Housatonic Watershed. Although the watersheds are separate, the swamp itself is continuous over both watersheds.

The Northeast Ancram fen complex follows the ridgetop of the Taconic Mountain range (Washburn, Alander, Brace, and Thorpe Mountains) from Copake, New York, southward to State Line, Connecticut. Included is the wetland complex at State Line and the ridges just west of Indian Lake south to Sharon Station Road. This site includes the wetlands and immediate watershed of the Drowned Lands Swamp, Punch Brook, and Bashbish Brook on the western half of this complex, and the chain of wetlands along the Noster Kill and Webatuck Creek on the eastern half of this complex; it includes the Panhandle or Oblong of the northeastern corner of Dutchess County southward towards Millerton, and the western escarpment of the Taconic Mountains. The southern portion of the Panhandle wetlands and the wetlands south of Millerton drain southeastward to the Housatonic Watershed. The northern portion of the Panhandle wetlands and the Drowned Lands area drain into the Roeliff Jansen Kill, which is part of the Hudson River Watershed.

Highlands

Site Description:

The Highlands are noteworthy as a relatively undeveloped corridor of forests, wetlands, and grasslands of regional importance to breeding and migratory birds, resident amphibians and reptiles, and rare plants and communities close to the New York City metropolitan area. It is significant for its high concentration of species and communities of special regional emphasis dependent on large, unfragmented forest and wetland habitats.



The Highlands. Photo by Paul Jensen.

The portion of the Highlands west of the Hudson River includes 190,243 acres within the State of New York and continues west to cross the entire State of New Jersey. The portion of the Highlands east of the Hudson River totals 215,137 acres in Dutchess, Putnam, and Westchester counties extending from the Hudson River to the Connecticut border. Ridgelines and valleys, including stream courses and wetlands and lakes are generally in a northeast to southwest alignment. Streams run directly into the Hudson River Estuary, otherwise they generally run into the Ramapo River, which flows south through the center of the Highlands west of the Hudson River. Major streams east of the Hudson River include Canopus Creek, Peekskill Hollow Creek, and the Croton River. The Delaware Aqueduct, a major water source for New York City, begins at the West Branch Reservoir within the Highlands.

There is a large diversity of bedrock types in the Highlands. These rocks are the oldest in the Hudson River Estuary corridor at 1.3 billion years old; they were formed during the same process that formed the Adirondack Mountains in northern New York. The high complexity indicates that these layers have been compressed, bent, twisted, and otherwise metamorphosed into erosion-resistant bedrock that form the mountains of southeastern

New York. The folds and faults in the bedrock are generally parallel to each other and generally determine the positions of the ridges and valleys. A large fault, the Ramapo Fault, coincides with the path of the Hudson River and separates the Highlands East from the Highlands West. The complexity of the Highlands bedrock acts to increase the diversity of the communities and taxa (animal and plant species and subspecies) present by increasing the types and range of minerals and nutrients available. Areas on the surface that are not bedrock outcrops usually consist of glacial till or more recent riverine or lake deposits.

Acidic talus slope woodland.

The matrix communities of the Highlands include Appalachian oak-hickory forest, chestnut oak forest, and oak-tulip tree forest. Recently, a 5,681-acre chestnut oak forest was documented, along with a 2,071-acre Appalachian oak-hickory forest. A large matrix chestnut oak forest of 45,000 acres links the West Point Military Academy with the occurrence of this community in Black Rock Forest and Harriman and Bear Mountain State Parks. Hemlock-northern hardwood forest acts as a large patch community here, in comparison to the more northern Catskill Mountains where it may be matrix forest as well. Dispersed among the matrix forests are patch communities such as pitch pine-oak-heath rocky summit, rocky summit grassland, and acidic talus slope woodland, which may be either large patch or small patch, and red cedar rocky summit, inland white cedar swamp, rich graminoid fen, dwarf shrub bog, highbush blueberry bog thicket, and cliff community, which tend to be small patch communities.

Site Location:

In southeastern New York State, within the Highlands physiographic region.

Towns:	Beacon, Beekman, Blooming Grove, Carmel, Chester, Cornwall, Cortlandt, East Fishkill, Fishkill, Haverstraw, Highlands, Kent, Monroe, North Salem, Patterson, Pawling, Peekskill, Philipstown, Putnam Valley, Ramapo, Somers, Southeast, Stony Point, Tuxedo, Warwick, Woodbury, Yorktown		
Counties:	Dutchess, Orange, Putnam, Rockland, Westchester		
Approximate Size:	619.14 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Clarence Fahnestock State Park	NYSOPRHP	16.86 mi^2
	Franklin D. Roosevelt State Park	NYSOPRHP	0.47 mi^2
	Hudson Highlands State Park	NYSOPRHP	5.95 mi^2

Wonder Lake State Park	NYSOPRHP	1.49 mi^2
Donald Trump State Park	NYSOPRHP	0.44 mi^2
Bear Mountain State Park	NYSOPRHP	7.16 mi^2
Goose Pond Mountain State Park	NYSOPRHP	7.16 mi^2
Harriman State Park	NYSOPRHP	74.09 mi^2
Sterling Forest State Park	NYSOPRHP	22.44 mi^2
Storm King State Park	NYSOPRHP	2.84 mi^2
Big Buck MUA	NYSDEC	0.23 mi^2
California Hill MUA	NYSDEC	0.47 mi^2
Depot Hill MUA	NYSDEC	0.42 mi^2
Ninham Mountain MUA	NYSDEC	2.56 mi^2
Pudding Street MUA	NYSDEC	0.11 mi^2
White Pond MUA	NYSDEC	0.45 mi^2
Castle Rock Unique Area	NYSDEC	0.24 mi^2
Black Rock Forest Preserve		6.0 mi^2
Camp Smith State Military Reservation	Division of Military and Naval Affairs	3.0 mi^2
West Point Military Academy	U.S. Department of Defense	25.22 mi^2
NYC Watershed Protection	NYCDEP	8.55 mi^2
Municipal/County Parks		5.02 mi^2
Publicly Owned Water Bodies		7.37 mi^2
Private Conservation Land		20.31 mi^2

Ecological Significance:

This significant area represents one of the largest unfragmented landscape blocks in New York State that creates an important landscape corridor that links the mid-Atlantic states (New Jersey and Pennsylvania) with New England. Along with the continuous and relatively unfragmented forests, the area contains higher elevation ridges and several networks of relatively undisturbed wetlands in the valleys. The ecological significance of this area relates to its large, contiguous forest and wetland habitats and the disturbance sensitive species dependent on these habitats, as well as the diversity of plants, communities, and animals unique to this region.

Species populations in the Highlands are indicative of large contiguous areas of undisturbed forest and wetland habitats and include wood turtle, timber rattlesnake, red shouldered hawk, barred owl, warblers and thrushes, black bear, and bobcat. The rare cerulean warbler, a forest-interior specialist, has a thriving population in the deciduous forests of the Highlands, one of the few concentrations of this species in the state.

Timber rattlesnake.

There are numerous abandoned mines in the Highlands, many of which are currently being used as winter bat hibernacula. The federally listed endangered Indiana bat and the state special concern eastern small-footed bat are known to occur in the Highlands. Regionally rare ridge top communities include rocky summit grasslands and pitch pine-oak-heath rocky summit community. The great species diversity that is supported throughout the region is an indication of the high ecological value of the area's habitat.

Conservation Issues and Recommendations:

The most significant threat to the Highlands is the continued conversion and fragmentation of the area's forests and wetlands. Conservation efforts should focus on maintaining the unfragmented forest core from the glacial moraine north to the Hudson and across the Hudson to the Connecticut border with linkages on forested ridges to the Delaware River to the south. Additional inventory work is needed.

Location Description:

This area is similar to the USFWS New York-New Jersey Highlands Significant Habitat Complex. The physiographic region of the Highlands follows the boundary between the Highlands and Piedmont physiographic provinces on the southeast, and between the Highlands and the Appalachian Ridge and Valley provinces on the northwest. Though the physiographic region proper extends from the Delaware River in New Jersey northeast across the Hudson River to Candlewood Lake in southwestern Connecticut, the extent of the Highlands biodiversity area described in this document is confined to the study area. The Highlands province is distinguishable from the adjoining provinces by differences in geology, topography, and geomorphology (landforms).

Hudson River Estuary and Tidal Wetlands

Site Description:

The Hudson River Estuary contains significant freshwater and brackish tidal wetlands, as well as other riverine and estuarine habitats, islands, riparian zones, and important tributaries. These habitats support a high diversity of fish, birds, and mammals. Tidal wetlands exist along the entire reach of the estuary and include some of the rarest ecological communities in the state. Some of the islands contain significant upland communities, including pitch pine-oak-heath rocky summit and hemlock-northern hardwood forest.

The Hudson River extends 152 miles from the mouth of the river to the Federal Dam near Troy, New York. The width of the river ranges from 1/6 mile to 2.5 miles and the surface area at high tide is 82,000 acres. Intertidal wetlands and subtidal shallows consist of 26% or 21,200 acres of this surface area.

The Hudson River Estuary has a four-foot tidal pulse that extends all the way to Troy. In years with average amounts of precipitation falling in typical seasonal patterns, the leading edge of salt water is held downriver between the Tappan Zee and Yonkers during spring runoff. As runoff slackens during the summer, the salt front pushes northward to Newburgh Bay, and during droughts to Poughkeepsie and beyond. Because of the changing levels of salinity and tidal nature of the Hudson River, species assemblages vary by locality and overall diversity is high. In addition to the tidal riverine community, brackish intertidal mud-flats, brackish tidal marsh, freshwater intertidal mudlflats, freshwater intertidal shore, freshwater tidal marsh, and freshwater tidal swamp all together form a matrix down the shoreline of the river. Brackish, or lower salinity, tidal wetlands are regularly flooded by ocean water that has been diluted by freshwater from upstream. These wetlands are found south of the Highlands down to Manhattan. Freshwater tidal swamps found along the Hudson are globally rare. Saltwater marshes are now rare in New York Harbor, although they once extended for thousands of acres around Manhattan. Patch communities within the tidal portion of the Hudson River include calcareous shoreline outcrop, cliff community, and tidal creek.

Osprey. Photo by O.S. Pettingill.

The Hudson River Valley is broad and gently rolling with a bedrock of shale, siltstone, sandstone, limestone, and dolostone. Most of these are relatively soft sedimentary rocks and easily eroded. These bedrock formations have been eroded away to low plains with the Hudson River flowing through them. Most of the surficial deposits near and within the river are modern river channel deposits. River margins are made nutrient rich as the river carries fresh sediment from the uplands and deposits them along the river's banks.

Site Location:

The Hudson River Estuary is the portion of the Hudson River extending from the Battery at the southern tip of Manhattan north to the Federal Dam in Troy, New York.

Towns:	Albany, Athens, Bethlehem, Bronx, Brunswick, Catskill, Clarkstown, Clermont, Coeymans, Colonie, Cornwall, Cortlandt, Coxsackie, Esopus, Fishkill, Greenburgh, Greenbush, Greenport, Haverstraw, Highland, Hyde Park, Livingston, Lloyd, Marlborough, Mount Pleasant, New Baltimore, New Windsor, Newburgh, North Greenbush, Nyack, Orangetown, Ossining, Peekskill, Philipstown, Poughkeepsie, Red Hook, Rhinebeck, Saugerties, Schodack, Stockport, Stony Point, Stuyvesant, Ulster, Wappinger, Yonkers
Counties:	Albany, Bronx, Columbia, Dutchess, Greene, New York, Orange, Putnam, Rensselaer, Rockland, Ulster, Westchester
Approximate Size:	110.66 mi^2

Land Stewardship:	Name or Classification	Manager	Area
	Storm King State Park	NYSOPRHP	2.97 mi^2
	Bear Mountain State Park	NYSOPRHP	7.48 mi^2
	Hook Mountain State Park	NYSOPRHP	1.31 mi^2
	Nyack Beach State Park	NYSOPRHP	0.17 mi^2
	Tallman Mountain State Park	NYSOPRHP	1.06 mi^2
	Palisades State Park	NYSOPRHP	0.004 mi^2
	Hudson Highlands State Park	NYSOPRHP	9.38 mi^2
	Rockefeller State Park	NYSOPRHP	0.07 mi^2
	Bristol Beach State Park	NYSOPRHP	0.004 mi^2
	Hudson River Islands State Park	NYSOPRHP	0.36 mi^2
	Schodack Island Sate Park	NYSOPRHP	1.83 mi^2
	Mills-Norrie State Park	NYSOPRHP	1.54 mi^2
	Quiet Cove State Park	NYSOPRHP	0.05 mi^2
	Riverbank State Park	NYSOPRHP	0.04 mi^2
	Hudson River State Park	NYSOPRHP	0.53 mi^2
	Moodna Creek Unique Area	NYSDEC	0.09 mi^2
	Kowawese Unique Area	NYSDEC	0.16 mi^2
	Rogers Island WMA	NYSDEC	0.49 mi^2
	Turkey Point State Forest	NYSDEC	
	Montrose Point State Forest	NYSDEC	
	Tivoli Bays WMA[1]	NYSDEC	2.69 mi^2
	Nutten Hook Unique Area	NYSDEC	0.05 mi^2
	Piermont Marsh[1]	NYSDEC	0.1 mi^2
	Stockport Flats[1]	See Below	2.41 mi^2
	Iona Island[1]	See Below	0.87 mi^2
	Public Easements	NYSDEC	0.24 mi^2
	Municipal/County Parks		3.26 mi^2
	Private Conservation Land		6.16 mi^2

[1]One of four tidal wetlands that make up the Hudson River National Estuarine Research Reserve, a collaborative effort involving the National Oceanic and Atmospheric Administration (NOAA), the Palisades Interstate Park Commission, NYSDEC, NYS Office of General Services, and NYSOPRHP (NYSDEC & NOAA 1993). An additional 1.5 mi^2 is included in Piermont Marsh and includes part of Tallman Mountain State Park.

Ecological Significance:

The Hudson River is one of the most extensive freshwater tidal river systems in the northeastern United States. The tidal communities found here are regionally and globally rare. Wetland habitats are the cornerstone of the Hudson River Estuary ecosystem because they play a critical role as nursery grounds for fish and shellfish species, nesting sites and migration stops for birds, and sources of nutrients to the food chain. The marshes and tidal flats of the Hudson River Estuary contribute essential nutrients to aquatic and ter-

restrial food webs that extend throughout the river system and far into the Atlantic Ocean. Besides serving as important habitats, the wetlands that border the Hudson River Estuary perform other valuable services. Pollutants are filtered from water that flows through fresh and saltwater marshes, and these same wetlands buffer valuable real estate from floodwaters and storm surges. Estuarine plants also help to prevent erosion and stabilize the shoreline.

Estuaries are transition zones from inland freshwater ecosystems to saltwater ecosystems found in coastal environments. Estuarine environments are among the most productive on Earth, creating more organic matter each year than comparably sized areas of forest, grassland or agricultural land. Several measures of the importance of estuaries are that more than half of the commercial fish species caught globally and more than 75% of America's commercial fish catch spend part of their lives in an estuary. Key commercial and recreational species such as striped bass, bluefish, and blue crab depend on nursery habitat in the Hudson River Estuary.

During recent field surveys, populations of the state-endangered plant Hudson River water nymph were rediscovered in a freshwater intertidal mudflats community. The entire global range of this plant is limited to the Hudson River Valley; therefore, it is considered endemic. This is the only endemic plant to all of New York State. Other globally rare plants still found in the Hudson Rive Estuary include estuary begger-ticks, Long's bittercress, and salt-meadow grass. Rare animals of the Estuary include shortnose sturgeon, Atlantic sturgeon and Atlantic needlefish. Harbor seal are periodically reported and the Northern diamondback terrapin is present in some of the lower Hudson River Estuary tidal marshes.

The Hudson River Estuary ecosystem has been stressed by multiple activities such as the discharge of raw sewage that leads to high bacterial counts and low dissolved oxygen levels, landfilling that has destroyed valuable wetlands, cooling water intakes that kill millions of fish, and food webs contaminated by toxic chemicals. Among fish of commercial, recreational and ecological importance, the American shad, Atlantic sturgeon, river herring (blueback herring and alewife), American eel, and largemouth bass are in decline. Little is known of the status of blue crab, smallmouth bass, and other species. Striped bass have increased over the last few decades, but fishing pressure in the Estuary and along the Atlantic coast must be carefully managed or it could lower current population levels. Although tidal wetlands have been protected by state and federal law since the 1970s, erosion, sea level rise, changes in salinity, introductions of nonnative species and other factors have caused changes in wetland plant and animal communities over time.

Further description of the Hudson River Estuary is divided below into general salinity habitat zones based on average annual salinities.

- <u>Lower Hudson River Estuary</u>

  The lower Hudson River Estuary zone from Manhattan to Stony Point is an area that approaches marine habitat characteristics, having very strong semi diurnal (twice

daily) tidal currents and moderate salinities. This section of the Hudson is generally the zone of greatest mixing of river water and ocean water. The lower Hudson is rich in benthic resources and provides a significant nursery for fish populations. It is an important source of food resources for populations of wintering and migratory birds. This stretch of the river has significant concentrations of wintering waterfowl, especially canvasback. Other important animal species living in this area include osprey, fiddler crabs, blue crab, and diamondback terrapin. There are several regionally significant plants that occur in the Lower Hudson including the state endangered cylindrical headed bulrush. Piermont Marsh is a sizeable intertidal brackish marsh community and one of the largest undeveloped wetland complexes on the Hudson. It includes the northernmost occurrence of salt marsh species on the Hudson. Because it represents an exemplary ecological community type, Piermont Marsh has been designated as one of four sites that make up the Hudson River National Estuarine Research Reserve.

- Mid-Hudson River Estuary

  The productive and regionally significant Mid-Hudson River estuary is generally fresh water in winter and has low salinity in summer. This section encompasses regionally significant spawning migratory and nursery habitat for anadromous, estuarine, and freshwater fish, important winter feeding and roosting areas for the federally listed threatened bald eagle, and globally and regionally rare brackish and freshwater tidal communities and plants. The open water and tidal wetlands in this reach are spawning and nursery habitats and a migratory pathway between the upper and lower estuary for anadromous and resident fish.

  The habitat contains many unusual features, including deep tidal river habitat that is a rare ecosystem type in the eastern United States, and an important winter foraging area for the bald eagle. The numerous creeks and tidal brackish and freshwater marshes in this stretch serve as breeding, nursery, and migration corridors for fish and wildlife. Iona Island supports important winter roost sites for bald eagles that feed in the adjacent deepwater segment of the river. Iona island also has several rare plants including Bush's sedge, slender knotweed, and pinweed. Con Hook Marsh is a small, brackish tidal marsh with several rare plants, including cylindrical headed bulrush, spongy arrowhead, necklace sedge, and pinweed. Con Hook Marsh is also an important wintering area for waterfowl, especially mergansers. Constitution Marsh is a freshwater to brackish tidal marsh and is the largest undeveloped brackish tidal wetland on the Hudson River. It is a prime breeding and feeding area for marsh nesting birds.

Muskrat. Photo by John Kanter.

- Upper Hudson River Estuary

  The open water, tidal wetlands, and tributaries in the upper reach of the Hudson are regionally important fish spawning habitats for anadromous fish, especially American shad, striped bass, Atlantic sturgeon and shortnose sturgeon, and provide habitat for all life stages of resident freshwater species. The numerous creeks and tidal

freshwater marshes in this stretch serve as breeding, nursery, and migration corridors supporting waterfowl, shorebirds, herons, raptors, and passerine birds. Regionally and globally rare tidal communities include freshwater tidal swamp, freshwater tidal marsh, freshwater intertidal mudflats, and freshwater intertidal shore. The Hudson River water nymph, a state-endangered endemic plant, was recently rediscovered in a freshwater intertidal mudflats community from the Upper Hudson River (Howard et al. 2002).

Conservation Issues and Recommendations:

All activities that degrade water quality in the Hudson River Estuary adversely affect the fish and wildlife that use this habitat for various life functions. Water pollution by chemical or oil spills; excessive turbidity; sedimentation; and other point and nonpoint source pollution degrade the quality and function of the estuarine habitat. Toxic contamination has long term effects on the safety of food and the health of consumers due to bioaccumulation and biomagnification. Water quality improvement efforts are needed throughout the estuary. Upgrades to sewage treatment facilities, control of point and nonpoint source pollution, and contaminant trackdown and clean-up should continue to be major goals throughout the watershed. Full restoration of the hydrologic continuum (wetlands and the river), especially hydrologic connections under the existing railroad beds, and restoration of riparian corridors along the tributaries to the Hudson, will increase available upland habitat, improve the quality of aquatic habitat in the tributaries, and reduce sediment and nutrient input into the Hudson. Improvement of habitat complexes for animals requiring both wetlands and uplands should be encouraged. Additionally, measures to conserve and educate the public about submerged aquatic vegetation (SAV) beds located throughout the estuary should be continued and expanded.

Location Description:

- Lower Hudson River Estuary

  This area is also identified by the USFWS as the Lower Hudson River Estuary Significant Habitat Complex. The area for the lower Hudson River follows the shores of the Hudson River from the tip of Battery Park, Manhattan, generally referred to as river mile 0, north to the Stony Point area river mile 41. The area includes all riverine and estuarine habitats, including open water and tidal wetlands in this stretch of the river.

- Mid-Hudson River Estuary

  This area is identified by the USFWS as the Mid-Hudson River Estuary Significant Habitat Complex. The mid Hudson River estuary follows the shores of the Hudson River from Stony Point, river mile 41, to Poughkeepsie, river mile 75. The significant area includes all riverine and estuarine, open water and tidal wetland habitat in this stretch of the Hudson.

- Upper Hudson River Estuary

  This area is identified by the USFWS as the Upper Hudson River Estuary Significant Habitat Complex. The upper Hudson River estuary follows the shores of the Hudson River from Poughkeepsie at river mile 75 to the northern inland extent of the tidal Hudson River at Troy Lock and Dam, river mile 152. The significant area includes the tidal freshwater portion of the Hudson River, including all riverine, open water, and tidal wetlands in this stretch of the river as well as supratidal wetlands and some adjoining uplands and nontidal wetlands. The significant area also includes the lower portion of major and minor tributaries feeding into this part of the Hudson, up to the first impediment to fish passage in each tributary.

Hudson Valley Limestone and Shale Ridges

Site Description:

The Hudson Valley Limestone and Shale Ridges consist of the limestone areas that parallel the New York State Thruway, mainly to the east of the Thruway, and the parallel shale ridge west of the Thruway. This area is a regionally significant geologic feature that contains habitats that support several rare mammal, amphibian, reptile, bird, and plant species. The area covers about 127,000 acres in a curved line about 54 miles long and 5.6 miles wide at its widest point. The northern section consists of the band of cliffs known as the Helderberg Escarpment and the southern section extends along the Potic Mountain ridge.

Hudson Valley shale ridges. Photo by Elizabeth Hill.

Significant natural communities in this area include red maple-black-gum swamp, vernal pool, chestnut oak forest, Appalachian oak hickory forest, and pitch pine-oak-heath -rocky summit. In addition, small patch communities in the Potic range to the south include shale cliff and talus community and shale talus slope woodland. In other areas, calcareous cliff community, calcareous talus slope woodland, red cedar rocky summit, and rocky summit grassland communities have been documented in the upland and bedrock outcrop localities. In the lowlands, floodplain forest, limestone woodland, maple-basswood rich mesic forest, red maple-hardwood swamp, and silver maple-ash swamp have been documented.

The bedrock of the Hudson Valley Limestone and Shale Ridges mainly consists of limestone from the early to mid Devonian Period (approximately 400 million years ago). These rocks were produced when the area was covered by shallow seas and fossils are not uncommon. The limestone acts as a buffer to neutralize the increased acid precipita-

tion in the region, a helpful characteristic to the local flora and fauna. The boundaries of this area also include Ordovician (450 million years ago) deposits of shale, sandstone, siltstone, and limestone. The surficial deposits consist mainly of till and river and lake bottom deposits in the lowlands, with bedrock in the uplands.

Site Location:

The Hudson Valley Limestone and Shale Ridges are about 11 miles west/southwest of Albany.

Towns:	Athens, Berne, Bethlehem, Coeymans, Knox, Guilderland, New Baltimore, New Scotland, Athens, Catskill, Coxsackie, Saugerties, Westerlo		
Counties:	Albany, Greene, Ulster		
Approximate Size:	199 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	John B. Thacher State Park	NYSOPRHP	2.0 mi^2
	Thompson's Lake State Park	NYSOPRHP	0.24 mi^2
	Forest Preserve	NYSDEC	0.14 mi^2
	Black Creek Marsh WMA	NYSDEC	0.12 mi^2
	Great Vly WMA	NYSDEC	0.30 mi^2
	Louise E. Keir WMA	NYSDEC	0.18 mi^2
	Margaret Burke (Knox)	NYSDEC	0.22 mi^2
	Municipal/County Parks		0.99 mi^2
	Private Conservation Land		2.31 mi^2

Ecological Significance:

The limestone bedrock supports a wide variety of diverse communities, many of which are rare in New York State and the Hudson River Estuary corridor. These include calcareous cliffs, calcareous talus-slope woodlands, and red cedar rocky summits. The shale ridge contains what may be the best examples of shale cliffs and talus slopes in the region. Several sizable limestone caves occur on the Helderberg Escarpment where eight species of bats are known to occur including the federally endangered Indiana bat. The limestone cliffs are one of only two areas in the Hudson River Estuary corridor to support a winter hibernaculum for the Indiana bat (the other is the Rosendale Limestone Cave Complex) and also includes three sites for the state special-concern eastern small-footed bat. Other rare animal residents include Henslow's sparrow, upland sandpiper, sedge wren, and least bittern. One waterfowl concentration area is present within this area.

Wood turtle. Photo courtesy of Cornell University.

Numerous species of amphibians and reptiles are commonly found within the Hudson Valley Limestone and Shale Ridges, including the spotted salamander and several other rare species such as Jefferson salamander, blue spotted salamander, and wood turtle. Numerous rare plants occur in the area, including the smooth cliff brake, ram's head lady's slipper, and American ginseng. More rare plant species are found throughout the rich uplands and lowlands.

Conservation issues and recommendations:

Habitat conversion as a result of suburban expansion is of greatest concern in the largely unprotected lands of this significant area. Exploring opportunities for conservation agreements (easements or acquisition) that ensure the continued existence of the least disturbed and unfragmented examples of the state-rare communities listed above is recommended. Exotic species including garlic mustard and tree-of-heaven are common throughout the area. Management efforts to reduce and prevent the spread of these exotic species in the highest quality areas are recommended. Implementing the Helderberg Escarpment Planning Guide will help to protect the unusual resources found here. More complete surveys of the karst areas, escarpment wetlands, and other significant habitats are needed.

Location Description:

This area is a modification and extension of the USFWS Helderberg Escarpment Significant Habitat Complex. The northern portion of the habitat area consists of the Helderberg Escarpment itself and the land both above and below the escarpment within approximately 3 miles of the escarpment face from Dormansville north to the Albany Schenectady County line. South of the Helderberg Escarpment, the site extends along the Potic Mountain ridge and extends as far south as Marion Mountain. From the Potic Mountain Ridge, the site follows south along the limestone escarpment to the Schoharie Turnpike. It proceeds east and then south on Hans Vosenkill Road until just north of Catskill and then east on Huckleberry Hill Road a short distance to Route 9W. It proceeds south on 9W until Saugerties and continues south to Esopus Creek. It follows Esopus Creek west and south to Plattekill Creek, west on Plattekill Creek to the shale escarpment. It follows the western shale escarpment line north to the Helderberg Escarpment.

Jamaica Bay and Beaches

Site Description:

Jamaica Bay and Beaches encompass important breeding and juvenile nursery habitat for fisheries as well as year round foraging areas for waterfowl, shorebirds, and colonial nesting waterbirds. The extensive salt marsh and upland islands in the bay provide nesting habitat for gulls, terns, waterfowl, and herons; foraging and roosting habitat for shorebirds and waterbirds; upland sites for grassland bird nesting and foraging areas; and butterfly concentration areas. This is an extremely valuable area for resident and migratory fish and birds and for other wildlife and plant populations.

Site Location:

Jamaica Bay is located on the southwestern tip of Long Island in the boroughs of Brooklyn and Queens, New York City and the town of Hempstead, Nassau County. The bay connects with Lower New York Bay to the west through Rockaway Inlet and is the westernmost of the coastal lagoons on the south shore of Long Island. Although not considered part of the Hudson River Estuary Watershed, this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Towns:	Boroughs of Brooklyn and Queens, New York City, Town of Hempstead		
Counties:	Kings, Nassau, Queens		
Approximate Size:	17.52 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Gateway National Recreation Area	U.S. DOI	10.28 mi^2
	Bayswater Point State Park	NYSOPRHP	0.02 mi^2
	Healy Avenue Tidal Wetlands Area	NYSDEC	0.02 mi^2

Ecological Significance:

The location of Jamaica Bay and the rich food resources found there make it a regionally important area for fish, wildlife, and plants. This area contains species dependent on coastal and beach habitats found nowhere else within the Hudson Estuary corridor conservation area. Its geographic location acts to concentrate marine and estuarine species migrating between the New York Bight portion of the North Atlantic and the Hudson Raritan Estuary. Shorebirds, raptors, waterfowl, landbirds, and various migratory insects are concentrated by the coastlines in both directions. These migratory species are further concentrated by the surrounding urban developed land into the remaining open space and open water of Jamaica Bay. The waters and sediments of Jamaica Bay are a highly productive and regionally significant habitat for finfish, shellfish, and wildlife. The rare Northern diamondback terrapin uses habitats throughout the bay for nesting and feeding. Jamaica Bay is also one of the most important migratory shorebird stopover sites in the region, especially during fall migration (July to November).

Conservation issues and recommendations:

Land-use conflicts in this area result from the high-density human population. Recreational overcrowding, shoreline hardening, extensive dredging and dredge soil deposition, and invasive species are all a result. The bay continues to be threatened by poor water quality, loss of upland and wetland buffer, and disturbance of habitat areas. Virtually the entire watershed of Jamaica Bay is urban, developed land and the bay receives substantial pollution from a variety of point and nonpoint sources. Recommendations include directing recreational use away from areas determined to be most biologically sensitive,

Jamaica Bay. Photo courtesy of Kathryn Schneider.

developing monitoring programs to study the impacts of recreation and invasive species on biodiversity, and exploring opportunities to mediate the impacts of recreation and other activities. Additionally, efforts to improve the water quality in the bay and throughout the watershed should be strongly encouraged. Recommendations for restoring the water quality, habitat quality and quantity, and species diversity are detailed in the Jamaica Bay Watershed Management Plan published by the New York City Department of Environmental Protection. Additional inventory work is needed.

Location Description:

This area was also identified by the USFWS as the Jamaica Bay and Breezy Point Significant Habitat Complex. This significant area includes the entire Jamaica Bay estuarine lagoon, part of Rockaway Inlet, and the western part of the Rockaway barrier beach. The area generally follows the shoreline of Jamaica Bay and includes most of the tidal creeks and undeveloped upland areas adjacent to the bay; these serve as buffers for the bay, as upland habitat, and as existing and potential restoration sites. This complex also contains the western end of the Rockaway barrier beach and the Marine Park/Plumb Beach area just to the west of the main body of Jamaica Bay to include beach and dune habitat for nesting bird and rare plant species.

Narrows

Site Description:

The Narrows is notable for its wading colonial bird rookeries, island heronries, and significant coastal habitats.

Site Location:

The Narrows constitutes the westernmost section of Long Island Sound between Hell Gate, at the convergence of the Harlem and East Rivers, and the Hempstead Sill, a major shoal area extending north and south across the Sound from Matinecock Point on Long Island, near Glen Cove, Nassau County, to the New York Connecticut line. This significant area also includes a small area of southwestern coastal Connecticut in the vicinity of Greenwich. Although not considered part of the Hudson River Estuary Watershed, this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Towns:	Bronx, New Rochelle, North Hempstead, Mamaroneck, Queens, Rye		
Counties:	Bronx, Nassau, Queens, Westchester		
Approximate Size:	65.62 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Fort Totten	U.S. DOD	0.15 mi^2
	Udall's Wetland	NYSDEC	0.06 mi^2
	Municipal/County Parks		4.34 mi^2
	Private Conservation Land		0.05 mi^2

Ecological Significance:

The principal habitat types of significance in this area are offshore islands with colonial wading bird rookeries; rocky intertidal areas; and tidal wetland areas consisting of various combinations of associated salt and brackish marshes, mudflats, tidal creeks, and protected open water coves. The wetlands systems in this area are diverse and relatively undeveloped, with tidal rivers and creeks, salt marshes, mudflats, freshwater marshes and shallow water areas occurring over the general area. The three north shore bays, Little Neck Bay, Manhasset Bay, and Hempstead Harbor, are collectively among the most important waterfowl wintering concentration areas in the surrounding region. Sand beaches in this area provide essential nesting habitat for piping plover, a federally listed threatened species, least tern, and Northern diamondback terrapin. Marshlands associated with the bays are valuable feeding and nesting areas for green backed heron, clapper rail, American black duck, and are feeding areas for several species of wading birds. North and South Brother Islands are the site of the largest black crowned night heron colony in New York State. The wetlands along the mainland in this area provide important nesting habitat for several species of special emphasis in the region, including green backed heron, yellow crowned night heron, American bittern, Canada goose, American black duck, and clapper rail. Several regionally rare plants occur at Pelham Bay Park, including purple milkweed, persimmon, Bush's sedge, globose flatsedge, slender blue flag, short fruited rush, yellow giant hyssop , and woodland lettuce.

Conservation Issues and Recommendations:

Industrial, commercial, and residential expansion in the extremely urbanized environment of the Narrows continues to influence existing natural ecosystems and fish and wildlife populations. In spite of this, many important and regionally significant areas persist, although their future appears uncertain without intensive and coordinated protection, management, and environmental safeguard programs in place. Protective measures should be taken, whether by regulation, zoning, planning, cooperative agreements, or initiatives such as the National Estuary Program, to restore, maintain, enhance, and protect the aquatic, terrestrial, insular, and benthic habitats of the Narrows, the major bays, and the lesser embayments and coves along the mainland. Protective measures will ensure that these areas continue to support the regionally significant populations of waterfowl, fish, and colonial breeding birds that utilize and depend upon these habitats. Additional inventory work is needed.

Location Description:

This area was also identified by the USFWS as the Narrows Significant Habitat Complex. The site corresponds approximately with that of the Narrows proper, and includes most of the mainland wetlands and nearshore waters and islands of western Long Island Sound and portions of the East River within this area. Specifically included in this area are the three major bays on the north shore of western Long Island, in Nassau and Queens Counties: Little Neck Bay, Manhasset Bay, and Hempstead Harbor, which are recognized here as an interrelated complex of regionally significant fish and wildlife aquatic habitats. Although the overall area of this complex is considerably more extensive than the individual significant habitat areas identified in the East River section and the Westchester/Bronx and Connecticut shorelines of the Narrows, these habitats were felt to be linked, or potentially so, and thus were included together.

Neversink River

Site Description:

The Neversink River flows into the Delaware River and contains globally significant populations of the dwarf wedgemussel, as well as other rare mussels including the brook floater and alewife floater.

Neversink River. Photo by William Rudge.

Site Location:

The Neversink River runs along the west side of the Shawangunk Mountains joining the Delaware River near the tri-state junction of New York, Pennsylvania, and New Jersey. Although not considered part of the Hudson River Estuary Watershed, this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Towns:	Deerpark
Counties:	Orange
Approximate Size:	0.46 mi^2

Ecological Significance:

The Neversink River is most notable for its exemplary occurrences of the globally rare dwarf wedgemussel. It also contains several significant communities including floodplain forest, and shale cliff and talus community. Regionally rare animal species in this area include the bald eagle and timber rattlesnake.

Conservation Issues and Recommendations:

Changes in water level, flow, or chemistry in the Neversink River would likely impact the rare mussel populations found there. A management plan for the lower Neversink River

involving federal, state, county, and local agencies and organizations focused on protecting the habitat and water quality for mussels would be beneficial. The lower Neversink River, floodplain, and adjacent uplands need to be protected through a variety of mechanisms, including acquisition and easements, to prevent impacts to the globally significant mussel population. The water quality, water flow, and water chemistry must be maintained, and appropriate flows from the Neversink Reservoir must be maintained. Research should be conducted to determine host fish and other life history requirements of all the rare mussel species in the lower Neversink River. Additional inventory work is needed.

Location Description:

The Neversink River significant area follows the Shawangunk Ridge significant area boundary on the east down to the boundary for the Delaware/Moungaup rivers significant area. The Neversink River significant area conservatively follows route 209 on the west and extends up the western reach of the Neversink for approximately 3.3 miles.

Palisades

Site Description:

The Palisades include regionally rare talus slope and traprock communities, and is an important open space within the urbanized zone along the Hudson River Estuary. It is used by migratory and resident raptors and songbirds. The entire Palisades area consists of a 12,000-acre region in Rockland County and adjacent New Jersey and of this, 8,600 acres fall within New York State. In New York, the Palisades biodiversity area is about 18 miles long and 1.5 miles wide at its widest point.

The Palisades is a narrow ridge along the western shoreline of the Hudson River consisting mainly of upland, outcrop, cliff, and talus slope communities. The matrix communities consist of Appalachian oak-hickory forest and chestnut oak forest. Good quality rocky summit grassland patch communities have been documented.

View of the Hudson River Estuary from the Palisades. Photo by Steve Stanne.

About 195 million years ago, liquid magma pushed into a large fracture somewhat near the surface of the earth. The magma cooled to form a very resistant rock called diabase. Because the magma filled a relatively horizontal fracture at the current ground surface, this “intrusion” is termed a sill. The Palisades Sill forms an east-facing cliff 120-130 meters thick. The diabase appears with column-like structures formed when the magma cooled, contracted and subsequently cracked in the regular column-like

pattern. On both sides of the Palisades Sill are reddish brown mudstones and sandstone that formed about 200 million years ago, when dinosaurs roamed the land. For today's plants, animals, and communities, the diabase offers a very different rock type than most in the region to grow on. This igneous rock offers cliff habitats and the potential for communities quite different from the standard, calcareous substrate common in the region.

Site Location:

The Palisades is a narrow ridge located along the western shoreline of the Hudson River Estuary in southeastern New York, at the northern end of the metropolitan New York City region.

Towns:	Clarkstown, Haverstraw, Orangetown, Ramapo		
Counties:	Rockland		
Approximate Size:	13.96 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Blauvelt State Park	NYSOPRHP	0.89 mi^2
	Haverstraw Beach State Park	NYSOPRHP	0.04 mi^2
	High Tor State Park	NYSOPRHP	1.05 mi^2
	Hook Mountain State Park	NYSOPRHP	1.31 mi^2
	Rockland Lake State Park	NYSOPRHP	0.35 mi^2
	Nyack Beach State Park	NYSOPRHP	0.17 mi^2
	Tallman Mountain State Park	NYSOPRHP	1.06 mi^2
	Palisades State Park	NYSOPRHP	0.03 mi^2
	Municipal/County Parks		1.55 mi^2

Ecological Significance:

The Palisades biodiversity area supports several significant ecological community types and numerous regionally significant species including several federally and state listed species. One of the highlights of this area includes the 1998 discovery of the globally rare basil mountain mint as well as seven other rare plants. Fewer than 25 populations are known worldwide for the basil mountain mint and Torrey's mountain mint and two of the largest remaining populations exist within this area of the Hudson River Estuary corridor. Prior to this find, basil mountain mint was last seen in New York in the late 1800s.

Talus slope communities and rocky summit grassland communities occur in only a few locations in the region. The talus slope community provides dens and basking areas for regionally rare reptiles including the northern copperhead and five lined skink. The only known remaining occurrence for the Allegheny woodrat in the region occurs in the Palisades. The Allegheny woodrat was thought to be extirpated from New York, until a survey and trapping effort in 2001 found the only known extant woodrat population in the state (Howard et al. 2002). The Palisades Ridge is also important as a migratory corridor and nesting area for raptors and songbirds. The hawk watch each fall at Hook Mountain

Box turtle. Photo courtesy of Cornell University.

counts about 25,000 hawks, as well as other landbirds and waterfowl, and constitutes the largest fall counts of any hawk watch in New York State. The relatively unfragmented forest habitats on the Palisades also support populations of two declining turtle species, the wood turtle and the eastern box turtle.

Conservation issues and recommendations:

Several management issues on the public lands of this area could be improved to reduce threats to many of the rare plant occurrences. Invasive exotic species and natural successional processes threaten to crowd and overtop rare species populations. Misplaced bike trails and hiking trails can threaten to trample and erode sensitive populations. Trail re-routing, exotic species removal, and brush clearing activities should be designed to benefit rare species' populations. The Allegheny woodrat population is also threatened, probably by parasitic roundworm. Active protection of the Allegheny woodrat may be necessary, including trapping and removing raccoons, inoculating rats against roundworm, and reintroducing them to historically occupied habitats. Additional inventory work is needed.

Location Description:

This area was also identified by the USFWS as the Palisades Significant Habitat Complex. The eastern portion of the Palisades significant area follows the west shore of the Hudson River from just south of the George Washington Bridge in Fort Lee, New Jersey, north about 22 miles to Haverstraw, New York, and then west another 4 miles. The inland (western) portion of the site parallels the river boundary; the two encompass the open space on the Palisades Ridge. The significant area ranges from about 0.6 mile to 1.5 miles in width.

Rensselaer Plateau

Site Description:

The Rensselaer Plateau contains a diverse mix of wetland and upland communities that are more common in northern New York and New England, including spruce-fir swamp, shallow emergent marsh, sedge meadow, hemlock-northern hardwood forest and spruce flats. The large, contiguous nature of this area provides habitat for a number of large-ranging mammals and forest-interior bird species.

The Rensselaer Plateau is an expansive plateau of contiguous high elevation northern forests. In comparison with the nearby more mountainous Taconic range, the topography

is rolling and contains many swamps and lakes among the forests. The area is 121,236 acres. The Little Hoosic River drains the northeast side of the Rensselaer Plateau, while the Poesten Kill, Quacken Kill, and tributaries to Kinderhook Creek (Black Brook, Roaring Brook, Black River, West Brook) flow from the west and southern portions.

Matrix forest in the Rensselaer Plateau contains hemlock-northern hardwood forest communities (including two large blocks of 2,400 and 2,500 acres) and spruce flats community. Many patches of other community types exist within the matrix forests, such as hemlock-hardwood swamp, spruce-fir swamp, shallow emergent marsh, and sedge meadow. Other patch communities include talus cave community, calcareous talus slope woodland, oligotrophic dimictic lake, inland poor fen, dwarf shrub bog, black spruce-tamarack bog, and maple-basswood rich mesic forest.

The majority of the Rensselaer Plateau is covered by glacial till from the last glaciation. Till usually consists of a mixture of material ranging in size from large boulder-sized rocks to very fine silt and clay. Nearly the entire area (including all the bedrock outcrops) consists of a bedrock of Rensselaer Graywacke, a dark gray, clay-rich sandstone or fine-grained conglomerate. This one region is the only remnant of this rock type, and was originally formed about 540 million years ago, during the early Cambrian Period. This ancient sedimentary rock is more resistant to erosion than other rocks to the west, resulting in the higher elevations on the Plateau. Other major bedrock components include shale and quartzite.

From a biological perspective, all of the bedrock components tend to have good buffering capabilities against acid deposition. The extensive surficial deposits of till produce rocky soils that are difficult to farm, likely one of the main reasons the forests remain so extensive on the Rennselaer Plateau. However, the mix of silts, clays and sands in till deposits result in good quality soils for the natural communities.

Site Location:

Ten miles east of Albany, NY.

Towns:	Berlin, Brunswick, Grafton, Hoosick, Nassau, Petersburg, Pittstown, Poestenkill, Sandlake, Stephentown,		
Counties:	Rensselaer		
Approximate Size:	189.5 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Cherry Plain State Park	NYSOPRHP	0.25 mi^2
	Grafton Lakes State Park	NYSOPRHP	3.60 mi^2
	Pittstown State Forest	NYSDEC	1.86 mi^2
	Capitol District WMA	NYSDEC	6.32 mi^2
	Municipal/County Parks		0.24 mi^2
	Private Conservation Land		1.06 mi^2

Ecological Significance:

Rensselaer Plateau represents one of the larger unfragmented forested areas of high quality in the region. The ecological significance of this area relates to its large, contiguous forest and wetland habitats and the species dependent on these habitats, as well as the diversity of plants, communities, and animals unique to this region. Area-sensitive animals found in this area include a variety of forest interior songbirds as well as large mammals that occur in low densities such as moose, black bear, bobcat, fisher, and river otter. In addition to the continuous and relatively unfragmented northern forests, the area contains regionally significant boreal wetland communities that occur within the forests. Examples include dwarf shrub bog, sedge meadow, spruce-fir swamp, and inland poor fen. The acidic ponds within the Rensselaer Plateau contain some of the best populations of Farwell's water milfoil, a state-threatened aquatic plant, and algae-like pondweed, an aquatic plant recently moved to the NY Heritage Program watch-list.

Rensselaer Plateau meadow. Photo by Andy Finton.

Conservation Issues and Recommendations:

The conservation of habitat corridors that link intact forest blocks is of particular importance. Additional inventory work is needed.

Location Description:

The Rensselaer Plateau significant area is similar to the Rensselaer Hills ecozone (Will et. al 1982). This area encompasses the expansive plateau of contiguous and largely roadless high elevation forests (approximately 180 square miles). Elevations start at 700 feet, however, most of the area is above 1,000 feet.

Rosendale Limestone Cave Complex

Site Description:

This area encompasses a series of extensive abandoned limestone mines that serve as critical habitat for several native bat species. Wetlands within the area provide habitat for a number of animal species, including the state-listed endangered northern cricket frog. The state-rare plant species goldenseal occurs in this significant area.

The Rosendale Limestone Cave Complex occurs right over a lower Devonian limestone formation called the Rondout Formation. This formation contains a very high quality limestone once used in extensive production of an early type of cement and was mined extensively. The resulting mine shafts and rooms are the 'caves' the bats use as hibernacula. The surficial geology consists mostly of limestone outcrops (e.g., bedrock), but

some areas also have deposits of glacial till, outwash sand and gravel, and one small kame deposit. These glacial deposits facilitate the wetland communities where cricket frogs occur.

Site Location:

Towns:	Rosendale, Hurley		
Counties:	Ulster		
Approximate Size:	9.13 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Rosendale Bat Cave WMA	NYSDEC	0.02 mi^2
	Private Conservation Land		1.79 mi^2

Ecological Significance:

The Rosendale Limestone Cave Complex is most noted for providing critical winter hibernacula for several bat species including the federally listed endangered Indiana bat and a state species of special concern, the eastern small-footed bat. The caves in this area are among the top 15 sites in the world for hibernating populations of both Indiana bat and small-footed bat. In 2000, a new bat hibernaculum was discovered that contained more than 10,000 Indiana bats as well as eastern small-footed bats. The population estimate makes this hibernaculum one of the top 10 sites in the U.S. for Indiana bats (Howard et al. 2001). These caves also serve as regionally significant hibernaculum for several other bat species including long-eared myotis, little brown bat, eastern pipistrelle, and big brown bat. All species combined, this area has the second largest total number of hibernating bats of any site in New York State.

Limestone cave. Photo by Ted Kerpez.

The wetland communities in this area are also notable for supporting regionally significant animal species. Principle among them is the state listed endangered northern cricket frog. The northern cricket frog was discovered during 2000 surveys at two locations and was until then thought to be extirpated from the wetlands (Howard et al. 2002). Another rare animal reported from the area is pied-billed grebe. A population of goldenseal, a plant often collected and used within herbal medicinal products, was also recently found. This plant is usually located within a forested landscape on top of calcareous soils and near wet seeps or adjacent to wetlands. Discovery of the population raises speculation that additional rare plants of calcareous bedrock might exist within the area.

Significant natural communities of the area include calcareous talus slope woodland, hemlock-hardwood swamp, limestone woodland, red maple-hardwood swamp, and hemlock-northern hardwood forest.

Conservation Issues and Recommendations:

Land protection may be implemented through a variety of methods including acquisition (on a voluntary, willing seller basis), conservation easements, cooperative land agreements, and outreach. Additional inventory work is needed, particularly for winter bat hibernacula.

Location Description:

The Rosendale Limestone Cave significant area is defined by the limestone physiographic belt. It is bounded by the Thruway (I-87) to the east, the Rosendale town line to the west, Route 28 to the north and Rondout Creek to the south.

Shawangunk Kill/Shawangunk Grasslands

Site Description:

The Shawangunk Kill is a relatively undisturbed Hudson River Estuary tributary. It flows to the northeast between the Shawangunk Ridge and Wallkill River, which drains into the Hudson River. Its relatively low nutrient levels, cool water, and lack of a major water control structure allow the lower Shawangunk Kill to support a regionally rare biological community. This site includes Shawangunk grasslands, immediately adjacent to the Shawangunk Kill, that are important for a number of grassland bird species. Additionally, wetlands within this area support a number of rare plant species. This biodiversity area covers 11,470 acres and encompasses approximately 14 miles of the lower Shawangunk Kill with a 0.62 mile buffer on either side of the river and an enlargement near the middle to include the Shawangunk grasslands (formerly the Galeville Military Airport).

Shawangunk Kill. Photo by Paul Jensen.

The bedrock underlying the area easily erodes (Normanskill shale and Austin Glen formation), explaining the relatively low elevation and general lack of topography. In accordance, surficial deposits cover all the bedrock. In addition to glacial till, deposits of fine sediments (silt and clay) from proglacial lakes and variable sediments from the current river channel are present.

Site Location:

The Shawangunk Kill is a tributary of the Wallkill River and its headwaters originate on the east slope of the Shawangunk Ridge. It is located in the Wallkill River valley and runs

along the base of the east slope of the Shawangunk Ridge about 12.4 miles west of the Hudson River, and about 62 miles northwest of New York City.

Towns:	Crawford, Gardiner, Shawangunk		
Counties:	Orange, Ulster		
Approximate Size:	17.44 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Shawangunk Grasslands NWR	U.S. DOI	0.90 mi^2
	Municipal/County Parks		0.08 mi^2
	Private Conservation Land		0.11 mi^2

Ecological Significance:

The Shawangunk Kill supports high diversities of fish and mussels, unusual for the Hudson River Estuary corridor. Six species of freshwater mussels have been identified in this stretch of the river, including the globally rare swollen wedge mussel. Populations of the brook floater which were previously found in several areas are likely in decline (Howard et al. 2002). Wood turtle occurs in riparian habitat of the Shawangunk Kill and its tributaries. The Shawangunk Kill supports a number of rare plants including the largest known populations of beakgrass east of the Mississippi.

Henslow's sparrow.

The Shawangunk grasslands support several rare or declining grassland bird species, including Henslow's sparrow, northern harrier, upland sandpiper, short eared owl, long eared owl, and rough legged hawk. Other grassland nesting birds likely use this site as well. The grasslands are an important raptor concentration area in the Hudson River Valley. Rare plants found in wetlands of the area include Frank's sedge.

Conservation Issues and Recommendations:

Excessive water withdrawals could have significant impacts on flow and water quality. Water withdrawals from the Shawangunk Kill would be detrimental to the rare species found there. Longer low flow periods would result in increased warming of the water, reduced dissolved oxygen, increased concentration of nutrients and silt, and changes in the patterns of sediment deposition. As much as possible, further development or agricultural use should be directed at least 1,000 feet from the river. Agencies and conservation organizations should work with farmers and landowners to improve stream bank buffering through fencing, plantings of native shrubs and trees, and other methods. The local communities along this stretch of the river are encouraged to develop a regional plan to reduce impacts on the Shawangunk Kill. Additional studies of the flora and fauna of this stretch of the river, as well as of other locations in the upper Shawangunk Kill and other locations in the Wallkill River Valley, are needed.

Agreements and easements should be developed with willing farmers to delay the first cutting of hay to avoid impacts on grassland nesting birds. Agricultural BMPs that minimize negative impacts on grassland birds should be developed cooperatively with producers. Educational and outreach programs that promote the coexistence of sound farming practices and grassland bird conservation should be provided to the agricultural community. This biodiversity area may provide an opportunity for state, federal and local conservation partners to coordinate their efforts. The US Fish and Wildlife Service is developing a management plan for the Shawangunk Grasslands National Wildlife Refuge which will include strategies for preserving wildlife habitat values, protecting rare, threatened and endangered species, and providing priority public uses on refuge lands.

Location Description:

The biodiversity area was also identified by the USFWS as the Shawangunk Kill Significant Habitat Complex. The Shawangunk Kill includes the lower 18 river miles segment from the village of Pine Bush downstream to its junction with the Wallkill River and a buffer 0.62 mile (1 kilometer) on both sides of the river. The site also includes the Dwaar Kill from the village of Dwaarkill downstream to its junction with the Shawangunk Kill. This area is intended to encompass the regionally rare animal and plant populations associated with the river and a buffer zone to protect the river corridor.

Shawangunk Ridge

Site Description:

The Shawangunk Ridge contains an unusual diversity of plant communities and a high diversity of associated plant and animal species. The high diversity in the area is due in part to the wide range of topography and substrate. The area contains communities that range from wetland to ridgetop, slope, and cliff. The forest habitats are important as a migration corridor for raptors, other migratory birds, and wide-ranging mammals. An adjacent portion of the lower Neversink River just west of the Shawangunk Ridge is included in this biodiversity area, because of the importance of the ridge in maintaining high water quality and the presence of globally significant mussel populations (see the Neversink River description).

Shawangunk ridge habitat. Photo by Steve Young.

The entire boundary of the Shawangunk Ridge extends into New Jersey and encompasses more than 205,000 acres. The portion within the Hudson River Estuary Watershed is over 87,000 acres in area and 44 miles long and 7 miles wide in its widest part. Streams within the area drain into Rondout Creek to the north and Shawangunk Kill and the Wallkill River to the south. The southern portion of the Shawangunk Ridge drains away

from the Hudson River Estuary Watershed to the Neversink River to the north, which in turn flows into the Delaware River.

The forest matrix for the majority of the Shawangunk Ridge is chestnut oak forest. This community covers more than 38,000 acres. Here, the most abundant tree species are chestnut oak and red oak and the most abundant shrub species are huckleberry and mountain laurel. Large patch communities include hemlock-northern hardwood forest, and pitch pine-oak-heath rocky summit. Hemlock-northern hardwood forest communities tend to occur in the cool, moist ravines and depressions in the uplands of the Shawangunk Ridge. The most abundant tree species tend to be hemlock and chestnut oak, with hemlock also dominating in the understory. In contrast, the pitch pine-oak-heath rocky summit communities occur in dry, well-drained uplands and rock outcroppings of the ridge. The largest patch of this community covers 4,000 acres. Pitch pine is the most abundant tree species, while scrub oak is the common tall shrub.

The Shawangunk ridge consists mainly of a bedrock type called the Shawangunk Conglomerate. This is made of quartz sand and pebbles held together strongly by a quartz cement. Because of the high percentage of quartz, this sedimentary rock is very resistant to erosion. Thus, as the other, less resistant, nearby formations were eroded away, this formation remained as a striking, very steep-sided ridge. Deposits on top of the bedrock are generally thin layered or even nonexistent. As a result, much of the surficial geology is simply considered bedrock. Glacial deposits, such as till and kame deposits are also present.

Site Location:

The Shawangunk Ridge is located in the Ridge and Valley physiographic province of southeastern New York, about 56 miles northwest of New York City.

Towns:	Deerpark, Gardiner, Greenville, Mamakating, Marbletown, Mount Hope, New Paltz, Rochester, Rosendale, Shawangunk, Wawarsing		
Counties:	Orange, Sullivan, Ulster		
Approximate Size:	134.34 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Minnewaska State Park	NYSOPRHP	24.6 mi^2
	Forest Preserve	NYSDEC	0.40 mi^2
	Bashakill WMA	NYSDEC	0.03 mi^2
	Shawangunk MUA	NYSDEC	0.09 mi^2
	Shawangunk Ridge State Forest	NYSDEC	1.49 mi^2
	Huckleberry Ridge State Forest	NYSDEC	0.79 mi^2
	Private Conservation Land*		21.2 mi^2

*Includes the 6.78 mi^2 Sams Point Dwarf Pine Ridge Preserve managed by The Nature Conservancy and the private 13.1 mi^2 Mohonk Preserve.

Ecological Significance:

The Shawangunk Ridge is the northernmost ridge in the Appalachian Ridge and Valley physiographic province. There is a high diversity of vegetative communities on the ridge containing species and communities typically found north of this region alongside species and communities typically found to the south or restricted to the Coastal Plain. This results in an unusual area where many regionally rare plants and animals are found at or near the limits of their ranges. Other rare species found in the habitat area are those adapted to the harsh conditions on the ridge.

Regionally significant upland communities in this area include chestnut oak and mixed oak forest, pine barrens including globally and state rare dwarf pine ridges, hemlock northern hardwood forest, state rare pitch pine-oak-heath rocky summit and cliff and talus slope and cave communities. A variety of wetlands, small lakes, streams, and bogs occur in the area and contain regionally significant communities including state rare pitch pine blueberry peat swamps, globally rare inland Atlantic white cedar swamp, and red maple swamps. Numerous vernal pools are found on the ridge as well. These pools and their surrounding habitats support a variety of amphibian species, including regionally rare salamanders such as the spotted salamander, Jefferson salamander, and longtail salamander.

Timber rattlesnake, northern copperhead, and eastern hognose snake occur at several locations, as does five-lined skink. Turtles inhabiting the ridge include spotted turtles in the ponds and wetlands, and wood turtles in wooded riparian habitat all along the ridge. The diversity of relatively unfragmented, undisturbed, deciduous and coniferous forests and wetlands on the ridge support a variety of nesting bird species and also serves as an important corridor for many migrating species. There are several area-sensitive, large mammal species in the area including black bear, bobcat, and fisher.

Bobcat. Photo courtesy of Cornell University.

Rare species found in the area include state-rare dragonflies and arrowhead spiketail, which are found in the wetland communities. Other unusual animals include rare moths, peregrine falcon, and a bat hibernaculum. Recent findings include a new site for the state-threatened fern, mountain spleenwort, and two sites for the

state-threatened Appalachian sandwort (Howard et al. 2002). Within New York, known populations of the mountain spleenwort are restricted to the cliff faces of the Shawangunk Ridge. The arctic rush is also located on these cliff faces. The beautiful flowering shrub rhodora is fairly common between Lake Awosting and Sam's Point and these are the best areas in the state to see rhodora.

Conservation Issues and Recommendations:

Habitat conversion of land on the ridgetops would fragment both the forest and wetland habitats and reduce the suitability of the ridge to support its rare plant and animal populations. Deer grazing of rare plants such as the small whorled pogonia and broom crowberry could be a threat if the density of the deer population increases. Radio towers could present a hazard to migratory raptors and other landbirds. Hemlock wooly adelgid threatens the hemlock forests on the ridge. Although much of the land on the top of the ridges is protected, ways to prevent habitat fragmentation on the remaining areas should be explored. Significant habitat areas along the periphery of the publicly owned lands in the northern Shawangunks should be identified and considered for inclusion into adjacent protected areas. Additional inventory work is needed.

Location Description:

This area is similar to the USFWS Shawangunk-Kittatinny Ridge Significant Habitat Complex. The Shawangunk Ridge significant area includes the entire section of the ridge from its northernmost extent at the junction of Rondout Creek and the Wallkill River in the town of Rosendale, Ulster County, New York. The area includes only the portion of the ridge within New York; the ridge continues south via the Kittatiny ridge through New Jersey across the Delaware River at the southern end of the Delaware Water Gap into Pennsylvania and along the Appalachian Mountains, but that part of the ridge is beyond the geographic scope of this study. The boundaries of the significant area on either side of the ridge are generally based on the break in slope between the ridge and the adjacent valleys.

Staten Island Greenbelt

Site Description:

The Staten Island Greenbelt contains 4 of the 5 occurrences of the globally rare serpentine barrens community on Staten Island and is an important area for rare plant species. Additionally, the area contains a large forest block.

Site Location:

Located on Staten Island in the far southeastern corner of New York State. Although not considered part of the Hudson River Estuary Watershed, this site is included in this report due to its presence in the conservation area, which is defined as the counties bordering the Hudson River Estuary.

Towns:	Staten Island		
Counties:	Richmond		
Approximate Size:	3.53 mi^2		
Land Stewardship:	Name or Classification	Manager	Area
	Kaufman Camp Unique Area	NYSDEC	0.02 mi^2
	St. Francis Unique Area	NYSDEC	0.004 mi^2
	Greenbelt	City of New York Parks and Recreation	2.95 mi^2

Ecological Significance:

Although the majority of Staten Island is densely populated, there are numerous locations that contain rare species and rare communities, including the Staten Island Greenbelt. Staten Island is the southernmost land in New York State and contains many species and communities that are found nowhere else in the state, but are more common in the mid-Atlantic states to the south. The geology and coastal position of Staten Island add to its unique properties. Staten Island contains the only occurrence of serpentine bedrock in New York State, and the island occurs at the southern terminus of the most recent glaciation. This significant area includes four of Staten Island's five occurrences of the globally rare serpentine barrens community. This area also possesses the largest, more or less contiguous forested area on the Island. Found here is a large and diverse example of the southern variant of oak-tulip tree forest. This area has historic records for the globally rare adder's-mouth, as well as 13 other occurrences of 9 rare plant species.

Serpentine barrens. Photo courtesy of Kathryn Schneider.

Conservation issues and recommendations:

The growth of woody vegetation and the resulting succession of serpentine barrens to closed canopy communities, threatens their viability and the rare plants that utilize this habitat. Management plans for this area should include fire management or other means (cutting, brush hog, etc.) to keep woody vegetation from developing and to maintain the native grasses and forbs. Development of unprotected open space threatens the occurrences at this site, as do clearing or tree cutting operations, alterations in the hydrology of wetland areas, and invasive exotic species.

Additionally, management plans should allow the remaining native forest areas to mature without cutting and should include monitoring and removal activities of exotic species in high priority sites. Open space on Staten Island receives intense development pressure. While some forested tracts have recently been acquired by the state, additional forested lands, as well as wetlands, need further protection based on NY Heritage Program inventories and information from local biologists. Additional inventory work is needed.

Location Description:

The Staten Island Greenbelt significant area is similar to the New York City Parks and Recreation boundary. The area encompasses a relatively contiguous forest in a suburban/urban environment.

Taconic Ridge

Site Description:

The Taconic Ridge encompasses large areas of contiguous, high quality, northern hardwood forest underlain by complex metamorphic bedrock. It serves as a principle watershed and recharge area for numerous rich fens and associated rare plant and animal species. The Taconic Ridge extends nearly 60 miles along the eastern edge of New York State and is about 12 miles wide at its widest point. Within New York, it covers approximately 78,700 acres. Running along the divide between the Hudson and Connecticut River Watersheds, 53,600 acres of this area fall within the Hudson River Watershed.

Hemlock-northern hardwood forest and Appalachian oak-hickory forest are the most common matrix forest types. Patch communities include pitch pine-oak-heath rocky summit, acidic talus slope wetland, and rocky summit grassland.

The Taconics contain high topographic variability that enhances diversity of community types and associated species. About 450 million years ago (the Ordovician Period), colliding continents caused the formation of a mountain chain the size of the Himalayas in eastern New York and western New England. These mountains have eroded to what is now the Taconic Range. The bedrock geology consists of various types of metamorphic rocks; mainly deformed sedimentary rocks that were pushed up from the ocean floor from the advancing continent. These bedrock formations have less buffering capabilities against acid rain and other pollutants than the limestone-rich areas of the Hudson River Estuary corridor. Communities in the Taconics are likely to be more sensitive to chemical changes in atmospheric deposition. In the upper elevations of the Taconics, the surficial geology is mapped as bedrock, the lower elevations are generally considered to be glacial till. Although till is very rocky, the range of particle sizes (clay and silt all the way to boulders) and the recent exposure/creation of these particles increases the quality of the soil for the plant communities.

Site Location:

The Taconic Ridge is east/southeast of Albany and runs along the border between New York and Massachusetts.

Towns:	Ancram, Austerlitz, Berlin, Canaan, Copake, Hillsdale, New Lebanon, Northeast, Petersburg, Stephentown
Counties:	Columbia, Dutchess, Rensselaer
Approximate Size:	115.37 mi^2

Land Stewardship:	Name or Classification	Manager	Area
	Taconic State Park	NYSOPRHP	8.92 mi^2
	Taconic Ridge State Forest	NYSDEC	2.49 mi^2
	Berlin State Forest	NYSDEC	4.6 mi^2
	Beebe Hill State Forest	NYSDEC	6.1 mi^2
	Public Easement	NYSDEC	3.82 mi^2
	Municipal/County Parks		0.04 mi^2
	Private Conservation Land		0.91 mi^2

Ecological Significance:

The Taconic Ridge is notable for its large, contiguous northern hardwood forests. It is one of the best occurrences of northern hardwood forest communities in the region. It serves a diverse population of resident and migratory bird species as wintering and breeding habitat and as a migratory corridor. The area also supports regionally rare plant and animal species. Examples include bog turtle and timber rattlesnake, and the globally and state rare Ogden's pondweed and Hill's pondweed.

During recent biological surveys, a spruce-northern hardwood forest community, which is uncommon in these mountains, was documented on the summit of Berlin Mountain, and a relatively large beech-maple mesic forest was documented at The Knob in New Lebanon and Canaan (Howard et al. 2002).

Taconic Ridge migratory corridor. Photo by Andy Finton.

Conservation Issues and Recommendations:

Habitat fragmentation, especially on ridge tops, has been increasing in recent years. Protective measures for these ridge tops need to be explored. This area also needs additional inventory work.

Location Description:

The Taconic Ridge significant area is similar to the Taconic Mountains ecozone (Will et. al. 1982).

Van Cortlandt Park

Site Description:

Van Cortlandt Park is one of the largest parks within metropolitan New York City and supports relatively large areas of intact natural vegetation in an urban setting.

Site Location:

Metropolitan New York City.

Towns:	Borough of Bronx (New York City)
Counties:	Bronx
Approximate Size:	1.82 mi^2
Land Stewardship:	City of New York Parks and Recreation

Ecological Significance:

This site is one of the largest parks within metropolitan New York City having large areas of intact natural vegetation. The area has a mature to old-growth oak-tulip tree forest and 10-15 rare plant occurrences.

Conservation issues and recommendations:

Mowing activities and woody plant growth threaten rare plant occurrences. Mowing outside of flowering and fruiting season and preventing tree growth from shading plants will maintain rare plant occurrences. Invasive exotic species including garlic mustard, tree-of-heaven, purple loosestrife, and common reed threaten communities and rare species and should be reduced and/or removed where feasible. Additional inventory work is needed.

Location Description:

The Van Cortlandt Park significant area corresponds to the New York City Parks and Recreation boundary.

Ward Pound Ridge Reservation

Site Description:

Ward Pound Ridge Reservation supports exemplary populations of a variety of amphibians, reptiles, and insects (in particular butterflies and moths). This area consists of a 3,900-acre region in eastern Westchester County. Just east of the Cross River Reservoir, the Cross River flows through the northern section of the area.

Ward Pound Ridge is part of the geologic region called the Manhattan Prong. The rocks of the Manhattan Prong were tightly folded and metamorphosed during the Taconian mountain forming process about 450 million years ago. An especially weather-resistant bedrock formation, called poundridge gneiss, forms the backbone of this significant area's

hill. Other resistant rock, Fordham gneiss, occurs in the remainder of the area, with less-resistant Inwood marble occurring right along the edge. Because the Ward Pound Ridge mainly consists of upland, hilly terrain, the main surficial bedrock features are glacial till and rock outcrop.

Site

Location:

Largest county park in Westchester County, NY; approximately 30 miles north of New York City.

Towns:	Lewisboro, Pound Ridge
Counties:	Westchester
Approximate Size:	6.15 mi^2
Land Stewardship:	Westchester CountyParks

Ecological Significance:

Ward Pound Ridge is a critical area in the region supporting a diverse community of moths, butterflies, and other insects. A notable example is the tiger spiketail dragonfly, which occurs in fewer than ten sites across New York State. Ward Pound Ridge also contains regionally significant community occurrences including chestnut oak forest and a rich variant of red maple-hardwood swamp. Rare plant occurrences include spotted pondweed, featherfoil, and rattlebox.

This area is a known breeding site for the state-protected Kentucky warbler. Watch list species that have been documented include the northern copperhead and four state-listed special concern species: marbled salamander, worm snake, hognose snake, and the eastern box turtle. Natural communities are relatively disturbed in the area, mainly from deer overbrowse. However, some of the wetlands are of good quality and one upland community, an acidic talus slope woodland, was recently discovered and transcribed as a significant community (Howard et al. 2002).

Conservation Issues and Recommendations:

A burgeoning deer population is a major threat to rare plant species and communities and wildlife species associated with these communities. Invasive plant species in this area are also a significant threat to native, rare plant species and subsequent insect populations. A management program is needed to effectively control the deer population and control invasive plant species. Additional inventory work is needed.

Location Description:

The Ward Pound Ridge Reservation significant area corresponds to the Westchester County Parks boundary for the Ward Pound Ridge Reservation.

PART III: Conservation Strategies and Recommendations

Introduction

The strategies and recommendations presented in this section are intended to provide a long-term direction for the conservation of biological diversity in the Hudson River Estuary corridor. This section outlines general conservation program areas (biological inventories and ecological research, land management and environmental quality, and education) and strategies. Program areas and specific strategies are designed to address the primary threats to biodiversity in the Hudson River Estuary corridor.

The Hudson River Estuary Biodiversity Program recommends an approach that utilizes a broad range of conservation tools. No new regulatory programs are recommended in this report. Instead, partnerships and outreach to landowners, local governments, and public land managers are the basis of the conservation strategy.

As conservation strategies are implemented, continued ecological research and biological inventories will help to support science-based land management and improvements in environmental quality. Efforts to prevent future degradation are a particular emphasis of the program. Biodiversity outreach projects can utilize the program's biodiversity data and information to provide educational and training opportunities for citizens, local communities, land trusts, and other conservation organizations.

This report provides a foundation for coordinating actions and developing partnerships, a critical element influencing the future success of conservation efforts in the Hudson River Estuary corridor. It creates a mechanism for individual, community, organization, and government involvement and identifies and directs attention to biodiversity, and threats to biodiversity. In this respect, recommended conservation strategies and actions encompass multiple scales from local to regional.

Addressing Threats to Biodiversity

Addressing threats to biodiversity was considered a critical priority as conservation strategies were developed. Threats were identified through a series of meetings involving the program's steering committee. From this process, key conservation program areas and specific strategies and actions were developed to address these threats (Table 3).

Deriving conservation strategies that target primary threats to biodiversity ensures that conservation effort is directed where it is most needed and where it will have the greatest benefit. Many actions can be developed from these conservation strategies, and organizations are encouraged to work cooperatively to develop and implement specific actions. Importantly, most strategies can be applied to significant habitats and biodiversity areas, and to both public and private lands.

Table 3. Threats to biodiversity in the Hudson River Estuary corridor and program areas designed to address each threat.

Threat	Program Area
Lack of Scientific Knowledge of Biodiversity	• Biological Inventories & Ecological Research
Pollution (Air, Water, Soil Quality)	• Biological Inventories & Ecological Research • Land Management & Environmental Quality • Education
Invasive and Overabundant Species	• Biological Inventories & Ecological Research • Land Management & Environmental Quality
Management Conflicts on Public Lands	• Land Management & Environmental Quality • Education
Habitat Change and Fragmentation	• Biological Inventories & Ecological Research • Land Management & Environmental Quality • Education
Lack of Public Awareness and Understanding	• Education

Conservation Program Areas & Strategies

The section below is organized from general to specific. Broad conservation program areas (biological inventories and ecological research, land management and environmental quality, and education) are described, followed by specific activities within those program areas that address threats to biodiversity. Recommended strategies are provided at the end of each section.

Program Area: Biological Inventories & Ecological Research

In a broad sense, strategies addressing the need to increase our overall knowledge about biodiversity and how to manage for it include identifying key areas where information is lacking, promoting research opportunities, and seeking new sources of funding. It is important that conservation practices are based on current information.

Continuing applied research efforts and inventories that update our knowledge of the occurrence of species and habitats will provide an objective basis for biodiversity conservation. Research and inventories provide data and information necessary for developing techniques that will improve land management and environmental quality, and the information base for education and outreach activities. Scientific information is also needed to develop conservation and management priorities that maximize the effectiveness of limited funds.

- **Biological Inventories**

Inventories of common and rare plants, animals, and ecological communities (habitats) within the uplands and wetlands of the region should be continued and expanded. Biological inventories provide the foundation for other program areas and allow us to establish baseline information and monitor trends and accomplishments. Adequate knowledge of the abundance and distribution of elements of biodiversity is the foundation of a successful conservation program. The Gap Analysis Project and the New York Natural Heritage Program have been integral to the early success of the Hudson River Estuary Biodiversity Program. Using different methodologies, each program has inventoried the presence and distribution of species and ecological communities. In addition, the Natural Heritage Program tracks the quality of biodiversity element occurrences. Two large atlas projects have provided additional inventories. The NYS Amphibian and Reptile Atlas Project collected data for all species of amphibians and reptiles occurring in the wild in New York for the period 1990 - 1999. The information has been mapped at the county, town and USGS topographic quadrangle scale and in the future more specific location data might be available. The Breeding Bird Atlas is a comprehensive, statewide survey of breeding birds that reveals the current distribution of breeding birds in New York. The Breeding Bird Atlas was expanded and refined in the Hudson River Estuary corridor. The Atlas 2000 Project began in January 2000 and completed in 2005. The first Breeding Bird Atlas was conducted from 1980 to 1985. These research and inventory programs allow us to assess the extent and quality of biodiversity occurrences and illustrate where conservation is most needed and would be most effective.

While the inventory programs above operate within the entire Hudson River Estuary corridor, intensive inventories at the local scale have also been completed and are underway. Examples include a town-wide assessment of biodiversity resources completed for the Town of East Fishkill (Dutchess County) by Hudsonia, Limited (Figure 13); and the identification of landscape components important for biodiversity conservation within selected towns of the lower estuary corridor by the Metropolitan Conservation Alliance (a program of the Wildlife Conservation Society). Both of these projects support municipalities and towns in carrying out biodiversity conservation planning.

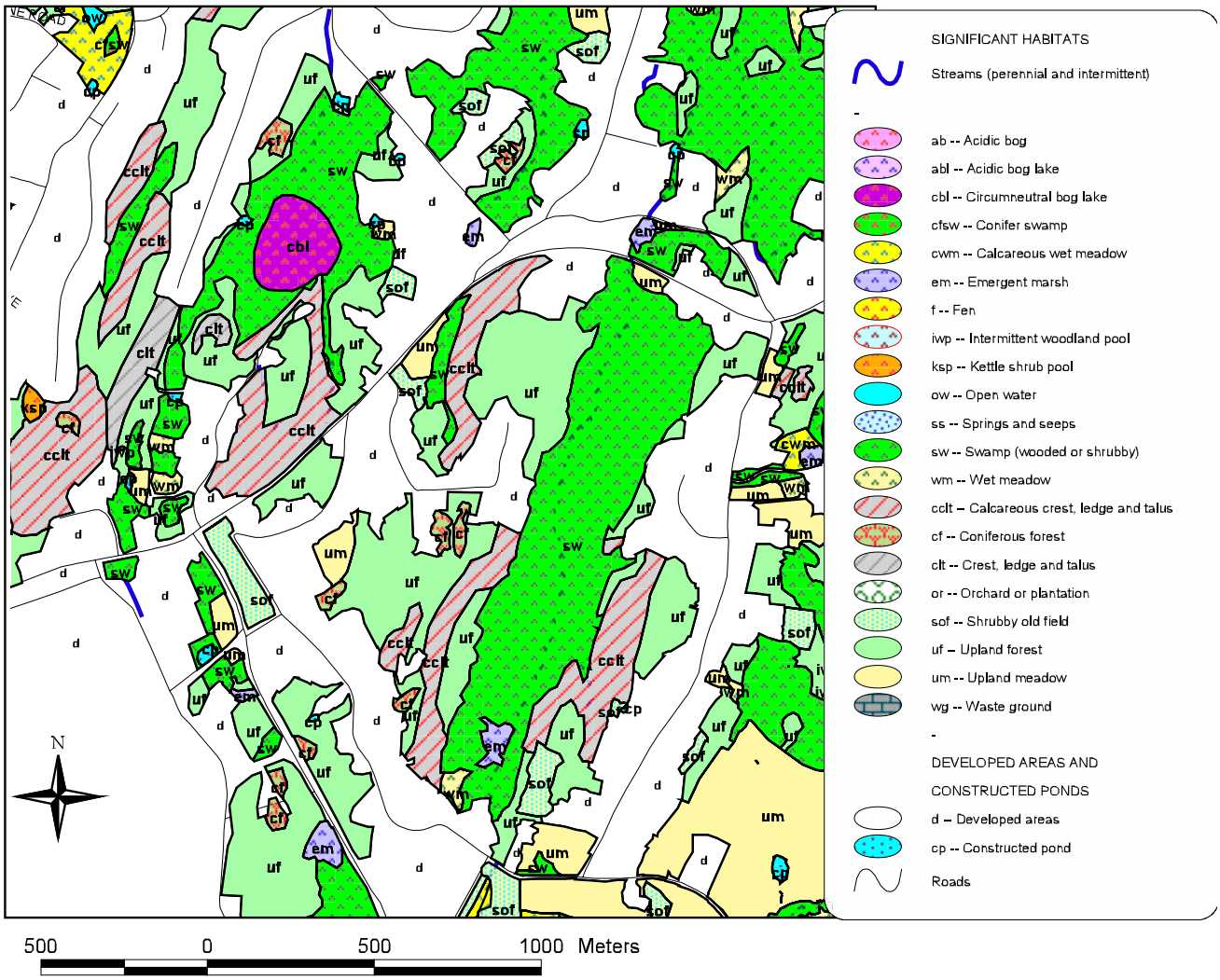


Figure 13. Sample portion of the East Fishkill habitat map, Hudsonia Ltd. 2002. See Stevens and Broadbent (2002) for descriptions of habitats. The habitat mapping project was funded by the Marilyn Milton Simpson Charitable Trusts.

Accurate and current inventory data establishes a baseline for monitoring and evaluation programs, supports local planning for economic growth and biodiversity, facilitates scientific management of public lands, and provides the information base upon which outreach and educational programs should be developed. To date, inventory data have been used for the identification of significant biodiversity areas within the Hudson River Estuary corridor, which in turn have been used for providing recommendations for New York State's Open Space Plan. At another level, inventory efforts have been used to provide baseline data for town planning processes.

Two primary sources of existing inventory data, the New York Natural Heritage Program and the New York Gap Analysis Project, are described next.

New York Natural Heritage Program Approach

The New York Natural Heritage Program is a cooperative effort between The Nature Conservancy and NYS Department of Environmental Conservation (NYSDEC). Its purpose is to facilitate conservation of New York's distinctive biodiversity by identifying, documenting, and mapping the presence and distribution of rare and exemplary elements of biodiversity. The Heritage Program also provides information to the public about rare species and habitat conservation strategies in New York.

The NY Natural Heritage Program considers all plant and animal species as well as ecological communities to be elements of biodiversity. It therefore takes both a species-focused and natural community approach to identifying the presence and distribution of rare and common elements of biodiversity. Inventory efforts begin by compiling lists of all vulnerable native species and classifying all ecological communities in New York State. Sources used to develop the species lists and the community classification include scientific and popular literature, museum collections, state records, and the advice of knowledgeable professionals. The Heritage Prgram conducts focused field surveys to discover new rare species populations and significant ecological communities, and to verify and update existing information on known occurrences.

The NY Natural Heritage Program maintains an "Active Inventory List" of plant and animal species that it monitors in New York State. This list contains most species that have fewer than 50 populations in the state or that are considered highly vulnerable to extirpation. It also contains species for which only historical collections are known and species thought to be extirpated from the state. For ecological communities, The Heritage Program actively inventories all rare natural community occurrences as well as common natural communities that are of exceptional quality.

Each surveyed element (i.e., species or ecological community) is ranked on state and global rarity scales. State rarity ranks describe the abundance and distribution of a species and are a measure of its risk of extirpation from New York. The global rarity rank is an indication of the vulnerability of a species or community throughout its entire range and is more or less a measure of an element's risk of extinction. These ranks help land-use decision makers understand just how rare and imperiled a given species or ecological community is. In addition, each rare species population and exemplary ecological community occurrence is ranked for its quality. Quality ranks consider size, condition, and landscape context and are an indication of the viability of a given species or community occurrence.

All rare species and significant ecological community occurrences are delineated using a Geographic Information System (GIS) and entered into the Heritage Program biodiversity database. This database, and the methods used to populate it, are consistent with similar databases maintained by Natural Heritage Programs throughout the United States, Canada, and Central and South America. This collaborative network of

databases is coordinated by NatureServe (formerly the Association for Biodiversity Information), and allows for rapid analysis and interpretation of rare species patterns throughout the Hudson River Watershed, New York State, and North America.

The NY Natural Heritage Program recently completed inventory and analysis of biodiversity element occurrences within 18 biodiversity areas (Figure 4) of the 10 counties bordering the estuary north of New York City (Howard et al. 2002). Previous inventories covered selected areas within the towns (Finton et al. 1999) and counties (Finton et al. 2000) bordering the Hudson River Estuary. The inventory results demonstrate the importance of the Hudson River Valley to the overall biodiversity of New York State. The surveyed 18 biodiversity areas contained 36% of the rare animal taxa, 27% of the rare plant taxa, and 54% of terrestrial and palustrine (wetland) communities known in the state. The results also indicate the importance of the significant biodiversity areas within the Hudson River Estuary corridor. The surveyed biodiversity areas contained at least one locality for 85% of rare animal taxa, 76% of rare plant taxa, and almost all of the ecological communities known to occur in the Estuary corridor. Several of the notable survey results include rediscovery of the Allegheny woodrat (Neotoma magister) in the Palisades (previously thought to be extirpated from the state) and rediscovery of two plants that have not been observed in New York State for over 50 years: the Hudson River water-nymph (Najas guadalupensis var. muenscheri), and basil mountain mint (Pycnanthemum clinopodioides). These surveys expand and refine our knowledge and understanding of rare species and all natural communities and make the Heritage Program database a more powerful information and conservation tool for all New York State citizens.

In the future, priority areas of the Hudson River Estuary corridor will continue to be surveyed by the Heritage Program. The Heritage Program has developed informational products that will help to interpret their extensive survey information for local and regional decisionmakers.

New York Gap Analysis Project Approach

The New York Gap Analysis Project (Smith et al. 2001) is part of a national effort to inventory and digitize into a computer-based, geographical information system (GIS) the distribution of plant and animal species and plant assemblages that are an integral component of national biodiversity. The gap analysis approach compliments that of the Heritage Program inventory by expanding the community focused approach to the entire landscape. In New York, a statewide vegetation map was produced delineating the distribution of native ecological communities. This map was developed from satellite images showing the distribution of distinct vegetation assemblages. The assemblages were classified using a system unique to the Hudson Valley and adapted to conform to the National Vegetation Classification Standard (Federal Geographic Data Committee 1997) organizational hierarchy. The classification system was developed

using multiple field data sources and then cross-referenced with Ecological Communities of New York State (Reschke 1990). The resulting land cover map offers the advantage of being able to identify and predict native ecological communities across New York State where field data are lacking. The land cover classification was then combined with wildlife-habitat relationship models to predict the distribution of animal species. Unprotected areas of biodiversity were identified by digitally overlaying maps of public and private conserved lands with maps of predicted species richness. The gap analysis methodology should be useful for guiding future research, biological inventories, and land-use planning at the regional scale.

f the terrestrial vertebrate animals, 272 of 308 species were predicted to have 10% or less of their distribution within protected lands, including all of the region's amphibians. Twenty-three species were not predicted to occur at all on protected lands, including the Eastern mud turtle and 22 bird species. Most of these bird species nest in grassland or water related habitats. The gap analysis results show that a large portion of the higher elevation lands in the Hudson River Estuary corridor are in public ownership (68% of land above 2,297 ft or 700 m), while the lower elevation lands (areas below 1,641 ft or 500 m) are predominantly in private ownership with no known plans for permanent biodiversity protection. At least 12% of the Hudson River Estuary corridor is public land. Habitat types poorly represented in protected areas (areas managed to stay in a primarily natural condition) include evergreen wetlands, deciduous wetlands, emergent wetlands (wet meadows), shrub swamp, successional hardwoods, successional shrub, Appalachian oak-pine forest and open water (lakes and streams).

The products created by the Gap Analysis Project can be used to further analyze land use patterns and biodiversity distribution. Using data generated by the gap analysis, human population growth models were developed to predict where areas of biodiversity are at risk from encroachment in the Hudson River Estuary corridor (Smith et al. 2004). Gap results are also helping to analyze the contribution of public lands to biodiversity conservation in the Estuary corridor.

Other Approaches

Other groups use different approaches to assess biodiversity in the Hudson River Valley. For example, the Wildlife Conservation Society's Metropolitan Conservation Alliance tracks focal taxa, groups of organisms that are not necessarily rare or endangered, but that provide data on ecosystem health, conditions, and environmental change.

Through use of the Biodiversity Assessment Manual for the Hudson River Estuary Corridor, Hudsonia, Ltd. encourages landowners and decision makers to conduct large-scale and site-specific biodiversity assessments to identify ecologically significant habitats, natural communities, and species of plants and animals of particular conservation concern.

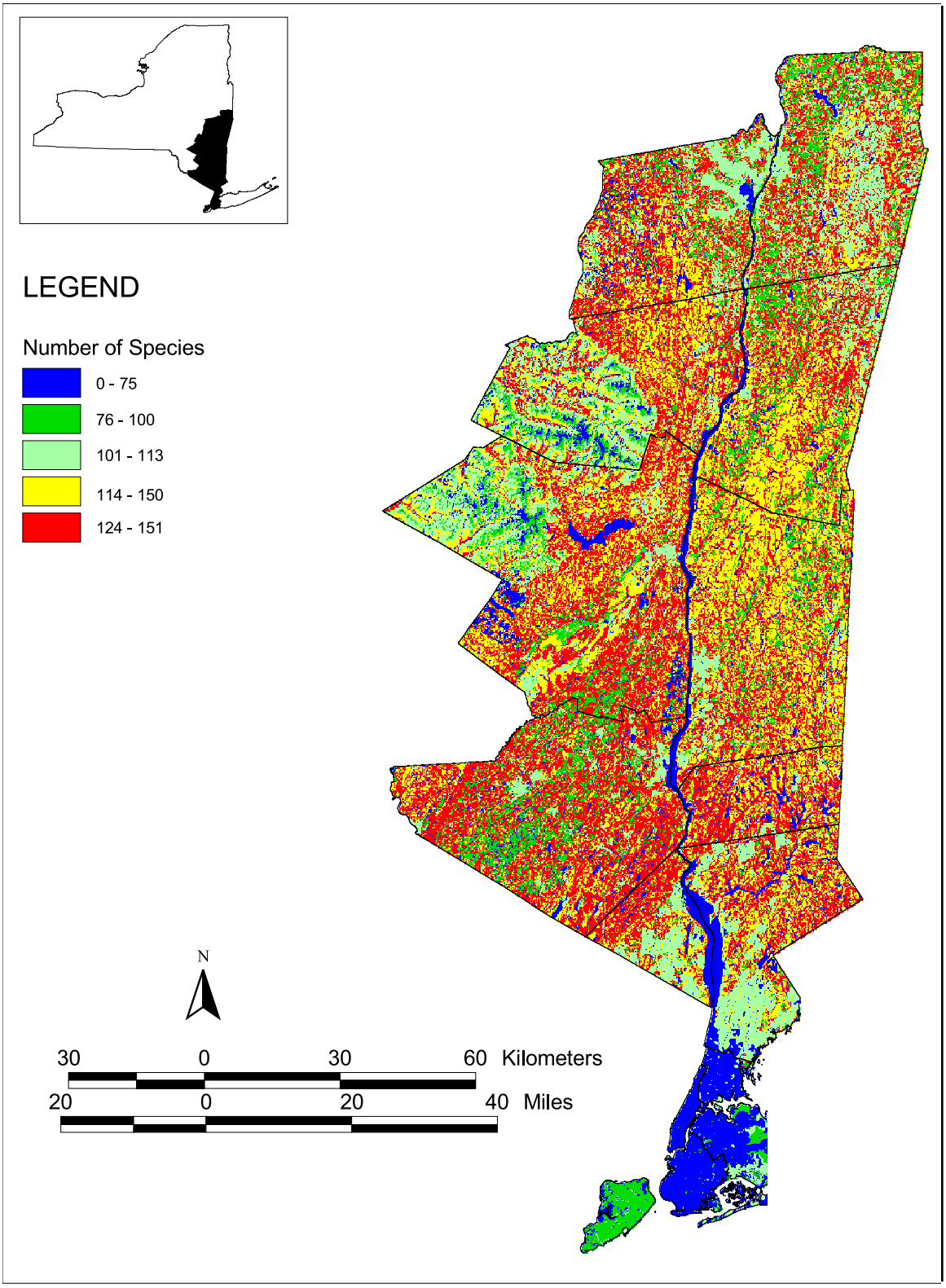


Figure 14. Predicted species richness in the Hudson River Estuary corridor (Smith et al. 2001).

In summary, employing a variety of scientific approaches to inventorying and monitoring biodiversity at multiple scales will produce the most useful and reliable information.

Strategies for biological inventory:

- Address key areas where data are lacking;
- Expand understanding of less known taxonomic groups;
- Conduct biological inventories that improve our understanding of both common and rare species and habitats, environmental health, and responses to environmental change;
- Develop and implement methods for establishing conservation priorities;
- Combine data sets collected at multiple scales.

- **Ecological Research & Monitoring**

An important component of conserving biodiversity in the Hudson River Valley is development of an ecological research and monitoring program. Ecological research helps us to understand how wildlife populations and habitats are maintained and how humans can interact with both to maintain environmental quality. Ecological research and monitoring will help to alert scientists and citizens to regional and site-specific threats affecting the health of the environment in the Hudson River Estuary corridor. Because the principal threats to biodiversity have been identified, a program designed around evaluating and monitoring the impact of these threats and the effectiveness of management strategies should be implemented.

Ideally, this program would also help to identify plants, animals, and ecological communities that are at risk before they become threatened or endangered. As mentioned previously, the NY Natural Heritage Program, NY Gap Analysis Program, NYS Amphibian and Reptile Atlas Project, and the NYS Breeding Bird Atlas Project and other programs have established baseline data that could be extremely useful for future ecological research and monitoring. Monitoring programs are also an excellent opportunity to foster community and volunteer group participation.

Ecological research directly feeds into the development of land management strategies. Land managers and planners require an understanding of the cumulative effects of human activities and natural processes and the possible consequences of planning and management activities. Researchers could examine how various land management activities affect the health of wildlife populations, humans, and ecosystems and use the findings to develop conservation strategies.

An important aspect of biodiversity that is often overlooked is the maintenance of ecological processes that provide environmental quality, such as clean water, groundwater recharge, or the breakdown and processing of potentially toxic substances by natural systems. The results of research on these subjects can help planning agencies and managers work proactively to prevent degradation of environmental quality and

the loss of biodiversity. Ecological research should be carried out at multiple scales in the Hudson River Estuary corridor, from individual sites to the landscape level. It is important to understand how the entire Hudson River Estuary ecosystem, which includes both terrestrial and aquatic components, supports and is supported by biodiversity.

Ecological research and monitoring in the Hudson River Estuary corridor should focus on 4 priority areas, including:

1. The status of endangered, threatened, and special concern species

The New York Natural Heritage Program has conducted intensive biodiversity inventories in the Hudson River Valley since 1998, collecting data on rare plants, animals, and ecological communities and documenting threats to these resources. These inventories have provided important baseline data that might be used to assess changes in the populations and habitats of rare species and communities over time.

Monitoring of rare species and communities should occur on a regular schedule that is defined during the planning stages. As a companion to this effort, ecological research could be conducted to study the effects of land-use change on populations and communities of interest. The effects of habitat management on rare species should be monitored (for example, the use of prescribed burning at the Shawangunk Grasslands National Wildlife Refuge for rare grassland birds) and the relationships between landscape configuration and population sustainability explored.

2. Ecosystem health and integrity

Complex linkages exist between biodiversity, ecosystem health, and human health. Monitoring of vertebrate and invertebrate indicator species can be useful for assessing ecosystem health (the functioning and performance of ecosystems). Studies of species health can also provide early indications of threats to human health. Common indicator organisms include amphibians, butterflies, and dragonflies. In general, choosing the appropriate indicator species involves balancing the dual requirements of practicality and accuracy. An indicator must, by definition, be relatively well known or at least easy to study, but it also must be informative, accurate, and reliable. Indicator species should be correlated through research with their associated endpoint.

Indicators that are linked to many other parts of the ecosystem are valuable to track since their decline can result in the declines of numerous species. Indicators of ecosystem stress should respond rapidly to the stress if they are to be used as early warnings. Other stress indicators may not respond as quickly, but may be useful if they accurately and clearly indicate the particular impact. A wider range of criteria can be met using multiple indicators.

An exploratory study should be initiated to assess the feasibility of monitoring indicator species in the Hudson River Estuary corridor. Such a study should investigate which threats to biodiversity can be monitored through the use of indicator species,

the most appropriate species to monitor, cost, duration, methods, and long-term funding opportunities.

Several large-scale efforts have been made to document the occurrence of ecological communities, both common and rare, in the Hudson River Estuary corridor. However, knowing where a species occurs is not the same as knowing why it occurs there. To be effective, ecological communities (i.e., habitats) must be conserved at their natural size scale and in adequate condition and configuration to insure that they contain all their associated species. For conservation purposes, it is critical that the ecological processes and disturbances that sustain a particular ecological community are operating within their natural range of variation. Ecological systems with high biological integrity are able to absorb small perturbations and to prevent them from amplifying into larger disruptions in ecosystem function. They are also better able to return to an original level of productivity and species composition following disturbance. A natural community with high integrity exhibits resistance, resilience, and persistence over centuries. Continued research and consideration of landscape function and ecological integrity are necessary to ensure the sustainability of biodiversity and environmental quality.

3. Species potentially impacted by contaminants

Bioaccumulation of contaminants through the aquatic food chain affects a number of wildlife species in the Hudson River Estuary corridor. Particularly vulnerable are a number of bird (bald eagle, heron) and mammal species (otter, mink) that prey upon fish and shellfish in the estuary.

A sampling program should be established that measures contaminant levels in a selected suite of wildlife species at regular time intervals. Research in this area for a Natural Resource Damage Assessment has been initiated, however, additional research that links contaminant levels to the health and reproduction of these species is also needed.

4. Invasive, exotic, and overabundant species and their impacts on native flora and fauna

There are over 115 exotic species in the Hudson River Valley, and more enter the region each year. Research focused on the use of remotely-sensed satellite imagery could be useful for collecting baseline information on the abundance and distribution of some invasive, exotic, and overabundant plants in the Hudson River Estuary corridor. This research could be used in evaluating control of invasive species over time. Initial progress has been made on developing techniques for monitoring and prediction of purple loosestrife distribution. Coupled with this effort is the development of a management plan for purple loosestrife in the Hudson River Estuary corridor. The research on purple loosestrife may serve as a model for other invasive exotic plants.

Program Area:
Land Management & Environmental Quality

Land management has a large affect on environmental quality in the Hudson River Estuary corridor. Land management strategies can address a variety of threats to biodiversity and can be implemented at multiple levels. In particular, the federal, state, and local governments are important landholders and strategies to conserve biodiversity on public lands can be implemented. The management of public and private lands should be actively coordinated, if adjoining landowners/managers are willing to conserve habitats across their boundaries.

Land management deals directly with habitat conservation measures that can be implemented at all levels, including acquiring land for conservation and public use on a willing-seller, willing-buyer basis, negotiating conservation easements, and providing land stewardship incentives to landowners. Conservation easements and land stewardship incentives are a cost-effective way of promoting biodiversity conservation while maintaining private land ownership. Examples of land stewardship incentives may include monetary compensation (e.g. USDA Conservation Reserve Program (CRP), Wildlife Habitat Incentives Program (WHIP)), tax breaks, or public recognition for stewardship. Land management strategies can be developed for larger landholders in particular. For example, in the Hudson River Valley, agricultural land represents a primary source of open space and can be an important source of biodiversity potential. Agricultural and forestry best management practices can both benefit these operations and support biodiversity conservation.

Specific areas that address land management should include:

- **Management Recommendations for Public Lands:**

  The state and federal government own a substantial amount of land in the Hudson River Valley (Figure 5) and make many important land-use decisions influencing wildlife and habitat diversity. These public lands protect significant habitats and currently contain some of the best remaining intact landscapes in the Hudson River Estuary corridor. Municipal parks and non-profit conservation lands are also vital for biodiversity, providing not only locally important habitat, but also stopovers for migrating birds and butterflies. In suburbanizing areas such as the Hudson River Valley, parks and preserves can be crucial for biodiversity conservation.

  Some of the larger areas under state ownership include State Forests and Preserves and Wildlife Management Areas managed by the NYSDEC and State Parks and Historic Sites managed by the New York State Office of Parks, Recreation, and Historic Preservation (OPRHP) (Table 4). These areas are particularly important because, in part, they serve to provide a mechanism for some level of protection (though variable) for plants and animals and their habitat. The New York State Department of Transportation and Office of General Services also own and manage a significant amount

of land in the Hudson River Estuary corridor, and offer various levels of biodiversity protection. Additionally, the United States Federal Government manages approximately 5% of the total public lands in the Hudson River Valley. Coordination of management activities among state, federal, and private landowners to meet regional conservation goals should be a high priority.

Table 4. Distribution of land ownership in the Hudson River Valley (Smith et al. 2001). Multiply square kilometers by 0.386 to obtain square miles.

Land Stewardship	Total (km^2)	% HRV
US Fish and Wildlife Service	1	<0.01
US Forest Service	0	0.0
Dept. of Defense – US Military Reservation	66	0.4
National Park Service (NPS)	35	0.2
Federal Government Total	**102**	**0.6**
OPRHP – State Parks, Preserves, and Historic Sites	490	0.3
NYSDEC – Div. of Public Affairs and Education	5	0.0
NYSDEC – Div. of Lands and Forests	994	6.0
NYSDEC – Div. of Fish, Wildlife, and Marine Res.	90	0.5
Division of Military and Naval Affairs	8	<0.1
State Government Total	**1,586**	**9.6**
City of New York Parks and Recreation	14	0.1
New York City Dept. of Environmental Protection	80	0.5
The Nature Conservancy Preserves	24	0.1
Remaining Local and Non-Governmental	13	0.1
Local and Non-Governmental Total	**118**	**0.8**
Private Total	**14,668**	**89**
Total	**16,474**	**100**

State public lands fall under a variety of different types or categories, each with a different mandate and capacity for protecting sensitive plant and animal species and critical habitats. These variable mandates generally relate to differences in priorities given to public use and access. Because of this, conservation priorities and subsequent policies are different for State Forests, State Parks, State Wildlife Management Areas, Multiple-Use Areas, transportation rights-of-way, and other public lands. In spite of these differences, however, some broad-based recommendations can be made that transcend different public use and natural resource management mandates.

Informed land management will assure that biodiversity conservation is considered in decisions affecting the future use of public and non-profit conservation lands. The following recommendations promote the conservation of biodiversity in the Hudson River Estuary corridor while recognizing the importance of public access to biodiversity.

Strategies for public land management:

- Identify opportunities to conserve biodiversity on public lands and incorporate them into site management plans;
- Tailor policies and programs to consider the protection and conservation of biological diversity. State agencies should make efforts to incorporate conservation considerations into their planning, particularly where it has never been a consideration. State agencies that have traditionally considered some level of conservation should re-evaluate and re-examine conservation policy and actions to include and emphasize biodiversity conservation;
- State and Federal lands should serve as a model for private land owners, demonstrating the value of biodiversity and providing examples of sound conservation approaches;
- Actively coordinate the management of public and private lands, concentrating on those lands that are adjacent to each other or lie across political boundaries;
- Allow or mimic natural processes including natural disturbance regimes such as fire and flooding;
- Retain natural land cover. When possible and compatible with management objectives, maintain lands in a natural state, minimizing human disturbance;
- Manage state lands to protect all native elements of biodiversity rather than a single or few species;
- Minimize habitat fragmentation;
- Develop a management plan for each state land holding that outlines conservation strategies that address principle threats to biodiversity;
- Promote wise recreational use on state lands compatible with regional biodiversity conservation goals and reduce existing conflicts between recreation and biodiversity conservation;
- Target, monitor, and evaluate road and highway construction and other infrastructure projects to ensure that sensitive areas and species are avoided and protected on state lands. Promote the use of NY Natural Heritage Program and other biological data by state agencies overseeing proposed projects and activities to direct growth and development away from critical areas of biodiversity on state lands;
- Incorporate habitat considerations into right-of-way management programs. Use native plant species in plantings on public lands (e.g. highway medians and shoulders). Schedule maintenance on state lands to avoid negative effects on nesting or migratory species (e.g., delayed mowing);
- Upgrade conservation status (e.g. stewardship rank as outlined in Table 2) of state lands that have important elements or areas of biodiversity;
- Retrofit roadways, culverts, drains, and fences to allow for the natural migration of reptiles and amphibians;
- Facilitate public understanding of the role of public lands in conserving biodiversity; and

- Support programs that help municipal parks and non-profit preserves to identify habitats and manage them in a regional context, including conservation of sensitive areas, removal of invasive and exotic species, restoration of native plant communities, and management where appropriate.

- **Control of Invasive & Overabundant Species:**

Several invasive exotic plant species have become established in the Hudson River Estuary corridor, including purple loosestrife, common reed, and water chestnut. When these plants form monotypic stands the result can be an overall decrease in the biodiversity of an area, most often in biodiversity rich wetlands.

To date, the Hudson River Estuary Biodiversity Program has focused on efforts to control purple loosestrife in the Hudson River Valley. Biological control of purple loosestrife appears promising, however the control effort is still undergoing evaluation by NYSDEC and Cornell University. The biological control agents being tested include a root-boring weevil and two leaf-eating beetles. A spectral fingerprint was developed for purple loosestrife, cattail, and common reed (using remote sensing and GIS analysis) and will be used to map stands of loosestrife in the Lower Hudson River Valley (Richmond et al. 2002).

The development of management plans for other invasive species in the Hudson River Valley should be a priority. Additionally, research on ecological relationships and impacts of invasive species is needed to provide a sound basis for management decisions. Research and management activities could be directed at invasive plant and animal species such as water chestnut, common reed, mute swan, hemlock woolly adelgid, and the zebra mussel. Initial research efforts should focus on understanding the abundance and distribution of invasive species and their interaction with and effects on native plants and animals. Using this information, species-specific management plans can be developed and implemented.

Overabundant wildlife species can have a profound influence on local and regional biodiversity. White-tailed deer are perhaps the best example of a species that can dramatically alter its habitat. Deer over-browsing changes the composition, diversity, and abundance of plant communities and associated wildlife species. Furthermore, deer over-browsing can negatively affect rare plant species.

Current deer densities in the Hudson River Valley are generally high. In areas where deer densities are negatively affecting tree regeneration or threatening a rare plant or community, management plans should be developed on a site-specific basis. Management plans should stem from a monitoring program designed to track changes in the composition, diversity, and abundance of native plant communities. The use of deer exclosures can be a useful tool to monitor and demonstrate the effects of over-browsing at various deer densities. Because the NYSDEC has the authority to manage white-tailed deer in the state, efforts to promote management on a site-specific basis

(incorporating biodiversity concerns) should be encouraged. Areas that have medium to high deer densities and that contain rare plant communities should be prioritized for a monitoring and management program.

Strategies for control of invasive & overabundant species:

- Continue applied research to develop invasive species control methods;
- Manually remove invasive species and replace with native species;
- Develop management plans for invasive and overabundant species;
- Monitor trends in invasive and overabundant species;
- Encourage natural landscaping.

- **Reducing Habitat Loss and Fragmentation:**

Habitat loss and fragmentation on public and private lands is probably the most significant threat to biodiversity in the Hudson River Estuary corridor. Fragmentation of large habitat areas into smaller sections can lead to the local extirpation of area-dependent species. Fragmentation might also interrupt species migrations. Newly created habitat types can form a barrier to species that are not adapted to survive in that type. In particular, roads form a barrier that raises mortality and blocks migration for some species. Reptile and amphibian species are especially susceptible to being killed while crossing roads.

Many types of disturbance can lead to the loss or degradation of habitats. Activities such as residential, commercial, industrial and municipal development; road building; gravel pit mining; agricultural clearing; logging; and power line cutting can threaten natural communities and populations by eliminating and fragmenting habitat, and by disrupting crucial ecological processes and functions. These activities provide entry points for invasive, exotic species. Alterations to and manipulations of existing hydrologic regimes and water levels can adversely affect wetland communities and species requiring wetland habitat. Hydrologic disturbances include damming, removal of man-made or beaver dams, ditch draining, irrigation pumping, dredging, and filling.

Many plant, animal, and natural community occurrences on protected lands are threatened by trampling and erosion caused by off-road vehicles, motorcycles, boat ramp activities, dirt bikes, horses, rock climbers, hikers, birdwatchers, and photographers. Invasion by exotic species often follows these activities. Those seeking to experience natural areas can inadvertently disturb sensitive species and rare plant populations and their habitat along scenic trails and mountain summits.

Other issues facing land managers include fire suppression, which affects communities and associated species dependent on open canopy habitats, collecting of commercially valuable plant and animal species, illegal killing of feared or unwanted wildlife, protection of old-growth forests, and grass mowing and other clearing activities that threaten species in cemeteries, airports, parks, golf courses, abandoned farm fields, and along streams. In some cases, mowing can benefit species, but the timing of such activities and the size of the open area are crucial to the success of the species.

The vulnerability of habitats to disruption in the Hudson River Estuary corridor was assessed using a model of projected residential development (Smith et al. 2004). This model is based on physical constraints and the stage of a housing neighborhood in its "life-cycle" (i.e., single-family subdivisions, multi-family dwellings, or areas under renewal) within a census blockgroup area. The results of the model's predictions are shown in Figure 15. The areas identified as possessing a high probability of future residential development represent 59% of the total land area in the Hudson River Estuary corridor. These areas include, or are adjacent to, 48% of the land area currently under some form of public or private conservation management (much of the public land areas are not actually available to residential development). Over 86% percent of the land areas within the highly vulnerable to development (high-ranking) category have no long-term conservation mechanism (governmental or legal). These high-ranking areas have total species richness values (measured by total species count) ranging from 86 to 147. The highest species richness reported for any area in the Hudson River Estuary corridor is 151 out of a potential 308 (Smith et al. 2001). The average species count of 130 for the high-ranking areas highlights the conflict between maintaining wildlife habitat and providing for human habitat expansion.

Given the tremendous pressures on the biological diversity of the Hudson River Valley, the full range of conservation tools will be required to effectively address the loss and fragmentation of the significant habitats presented in Part II. Conservation strategies and actions described in this section include land acquisition (on a voluntary, willing-seller basis), conservation easements, outreach, education, legislation, cooperative land agreements, and tax incentives.

Strategies for reducing habitat loss and fragmentation:

- Identify unfragmented core habitat areas and habitat corridors at scales appropriate for the presentation of species and processes;
- Reclaim the best possible minimum thresholds of habitat connectivity through restoration efforts where fragmentation has already occurred;
- Provide land stewardship incentives to landowners, non-profits, sporting clubs, and others and advise them on desirable management practices (e.g., provide greater tax incentives for owners to keep property in forest management);
- Acquire land and conservation easements for protection and public use on a willing-seller, willing-buyer basis;
- Advance opportunities for wildlife-related recreation (e.g., hunting, birdwatching, and other pursuits);
- Support the viability of forestry and agriculture compatible with biodiversity conservation;
- Provide information and support to local planning boards to incorporate biodiversity considerations into land use decisions consistent with local home rule;
- Promote the conservation and restoration of habitats considered most significant for biodiversity conservation in the region (e.g., restore tidal

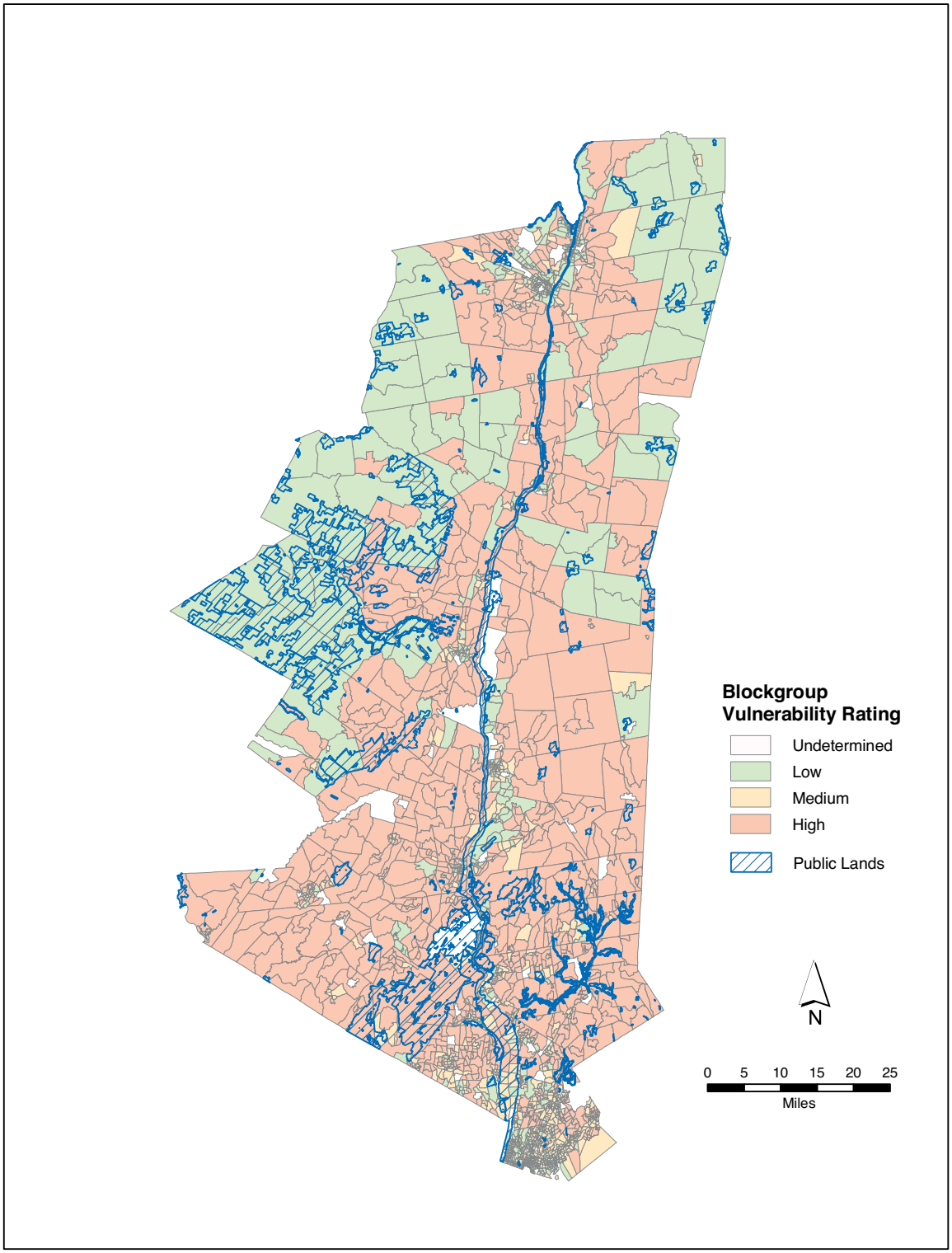


Figure 15. Census block groups within the Hudson River Estuary corridor ranked according to their likelihood of residential development (Smith et al. 2004). The blue-hatched areas are public or private lands in conservation stewardship. Within the "high vulnerability" areas, about 14% of the lands are considered to be in conservation or public stewardship.

and non-tidal wetland hydrology; remove obsolete dams and other structures; conduct controlled burning or mowing on early successional habitats; identify and buffer vernal pools and freshwater wetlands; reduce livestock use of riparian areas; and restore native plant communities);
    - Develop site-specific strategies for significant habitats and biodiversity areas.

- **Pollution Control:**

  Sources of pollutants include permitted or illegal point sources, such as failing municipal and industrial wastewater systems, toxic dumps, and leaking landfills; and nonpoint sources such as petrochemicals, pathogens, and lawn chemicals transported with urban and suburban runoff, agricultural runoff, construction-site runoff, and acid or nitrogen-enriched precipitation.

  Strategies for pollution control:

    - Support continued reduction in air and water pollution in the region;
    - Develop and promote farming and forestry Best Management Practices (BMPs);
    - Educate homeowners, landowners, and the agricultural community about the impacts of pesticides, herbicides, and fertilizers on wildlife species.

Program Area:
Education

Education strategies address a variety of threats to biodiversity and can be implemented at a variety of levels. Many education strategies address the desire to raise public awareness and understanding about biodiversity issues and the need for conservation. A general educational goal is to increase understanding of biodiversity conservation in the Hudson River Estuary corridor and promote the utilization of conservation tools in local land-use planning and land stewardship by property owners, communities, local governments, and land trusts.

Many local governments (county, town, city, and village), land trusts, and communities desire more information and assistance with biodiversity conservation. The Hudson River Estuary Biodiversity Program has partnered with other organizations to develop several tools for biodiversity conservation, including a New York Natural Heritage Program database, maps, and conservation guides for biodiversity element occurrences in the Hudson River Estuary corridor, Hudson River Valley Gap Analysis land cover and species distribution maps, GIS trainings, and a Biodiversity Assessment Manual for the Hudson River Estuary Corridor (Kiviat and Stevens 2001) and related training programs. These tools can be useful to local governments and land trusts for biodiversity conservation planning.

As part of the educational process we should promote the interaction between state conservation agencies, their partners, and the public. A positive relationship fosters

cooperation and the coordination of conservation actions. These efforts could involve working with:

- local government (village, town, county) decision makers to incorporate biodiversity conservation considerations in open space planning, comprehensive planning, and SEQRA reviews;
- land trusts and land conservation organizations to incorporate biodiversity conservation considerations into land acquisition and land management planning;
- Hudson River Valley citizens and communities to value biodiversity and support local efforts to conserve biodiversity during open space planning, master planning, and SEQRA reviews;
- Cornell Cooperative Extension and other outreach specialists to increase participation in biodiversity outreach efforts; and
- agricultural and forestry operation managers, owners, and workers to implement Best Management Practices (BMPs) that promote biodiversity conservation.

Educational programs can improve understanding of biodiversity and its importance, provide training on the use of conservation tools, assist in the identification of priority sites for conservation, provide educational opportunities on public lands, increase the availability of biodiversity information, improve understanding of how cooperative land agreements can be used to benefit wildlife and wildlife habitat, and promote individual and community involvement in biodiversity conservation.

Strategies for biodiversity education:

- Educate the public on biodiversity issues and the need for conservation;
- Encourage and facilitate community involvement in biodiversity conservation, inventory, and monitoring;
- Make biodiversity information available to citizens, local officials, and county and town planning boards;
- Encourage biodiversity sensitivity in land-use decision making;
- Partner with schools to raise awareness and understanding;
- Provide training on and assistance with conservation tools to communities, local governments, and land trusts;
- Promote opportunities for children to experience the outdoors and explore the region's natural resources.

- **Biodiversity Outreach and Technical Assistance Program:**

  A biodiversity outreach and technical assistance program was established to increase understanding of biodiversity conservation in the Hudson River Estuary corridor and the utilization of conservation tools in local land-use planning and land stewardship. The program provides a critical link between NYSDEC staff and its partners and local governments and land trusts. The early successes of this program have illustrated the importance of working on an individual basis with partnering communities.

Initial outreach efforts have been with towns that are updating their comprehensive planning process, and county agencies that are involved in land management (e.g., parks departments) and those working on open space plans, and land trusts. Towns are best able to integrate biodiversity considerations during the land use planning process because it lays the groundwork for zoning and local law changes. Assistance to towns and counties includes biodiversity seminars, information and data gathering, assistance with grant applications, and promoting effective land use tools to protect natural resources. As the Outreach and Technical Assistance Program expands, efforts will likely include audiences such as businesses, educators, and special interest groups (e.g., environmental organizations, farm and forestry associations, and sportsmen's federations).

Objectives of the biodiversity outreach and technical assistance program include:

1. Define information and technical assistance needs of land trusts, communities, landowners, and local governments engaged in open space and comprehensive planning;
2. Assist local governments, land trusts, and landowners with incorporating biodiversity conservation considerations into decision making;
3. Assist and train local governments, land trusts, and landowners in the use and application of available data, information, and tools for biodiversity conservation;
4. Provide biodiversity information for communities and local decision-makers; and
5. Work with other outreach specialists to promote Best Management Practices (BMPs) for biodiversity.

Outreach to local governments in the Hudson Valley began in 2001 as a partnership between DEC, Cornell University, Hudsonia, Ltd., and the Metropolitan Conservation Alliance (a program of the Wildlife Conservation Society). These entities coordinate closely with each other to provide integrated outreach and technical assistance to intended audiences. By working collaboratively, the Biodiversity Program is able to increase the breadth and depth of the outreach program.

Hudsonia's outreach efforts promote use of the Biodiversity Assessment Manual for the Hudson River Estuary Corridor (Kiviat and Stevens 2001). Community groups (including town planning board and conservation advisory council members) are trained to use the Biodiversity Assessment Manual to identify and map habitats in their area of jurisdiction. Each group develops new information on ecologically significant habitats that can help municipal governments with land use planning and SEQR reviews.

A project by the Metropolitan Conservation Alliance includes biological surveys for indicator species, as well as developing and promoting the use of land-use tools to conserve functioning ecological systems. Initial efforts are focusing on 18 towns in

Westchester, Putnam, Orange and Ulster Counties. Outreach to towns includes slide presentations; presentation and interpretation of field survey data; and assistance with planning tools such as master plans, open space studies, ordinances, overlay districts, and zoning changes. Outreach also includes interaction with landowners who have granted permission to access their property for biological surveys.

The Hudson River Estuary Biodiversity Program is also partnering with Cornell Extension in development of a community-based Biodiversity Program Work Team for the Hudson River Valley. An Extension biodiversity workshop and mini-grants program supports local biodiversity conservation efforts in collaboration with County Cooperative Extension offices.

More information on current outreach and technical assistance efforts can be obtained by contacting the Hudson River Estuary Program Biodiversity Outreach Coordinator at the Hudson River Estuary Program office address provided in the Overview of this document.

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Appendix I

Steering committee members of the NYSDEC[1] Hudson River Estuary Biodiversity Program (1997-2002).

Name	Organization
Dave Adams	NYSDEC, Bureau of Habitat
Richard Anderson	National Audubon Society
Kris Alberga	NYSDEC, Division of Lands and Forests
Carina Bandle	Hudsonia Ltd.
Andy Beers	The Nature Conservancy
Betsy Blair	NYSDEC, Bureau of Marine Resources
Chris Bowser	Hudson River Sloop Clearwater, Inc.
Al Breisch	NYSDEC, Bureau of Wildlife
William Conners	Federation of Dutchess County Fish & Game Clubs
Glen Cole	NYSDEC, Bureau of Wildlife
Nick Conrad	NY Natural Heritage Program
Jim Colqhoun	NYSDEC, Bureau of Habitat
Scott Cuppett	NYSDEC, Hudson River Estuary Program[2]
Frank Dunstan	NYSDEC, Division of Lands and Forests
Frances Dunwell	NYSDEC, Hudson River Estuary Program
Melissa Everett	Hudsonia Ltd.
Stuart Findlay	Institute of Ecosystem Studies
Andy Finton	New York Natural Heritage Program
Laura Flynn	The Nature Conservancy
Karen Frolich	NYSDEC, Hudson River Estuary Program[3]
Jean Gawalt	NYSDEC, Bureau of Wildlife
Fred Gerty	NYSDEC, Land Services
Gary Goff	Cornell Cooperative Extension
Colleen Hatfield	Rutgers University
Bob Herberger	NYSDEC – Land Services
Libby Herland	United States Fish & Wildlife Service
Michael Hodge	Wildlife Habitat Council
Nordica Holochuck	NY Sea Grant Extension
Timothy Howard	NY Natural Heritage Program
Leah Hurtgen	NY Farm Bureau
Paul Huth	Mohonk Preserve, Inc.
Paul Jensen	NYSDEC, Hudson River Estuary Program[3]
Arthur Johnsen	NYSDEC, Bureau of Wildlife
Elizabeth Johnson	American Museum of Natural History
Steve Kahl	U.S. Fish & Wildlife Service
Chuck Keene	Museum of the Hudson Highlands
Ted Kerpez	NYSDEC, Bureau of Wildlife
Walt Keller	NYSDEC, Bureau of Fisheries
Erik Kiviat	Hudsonia Ltd.
Michael Klemens	Wildlife Conservation Society
Gary Kleppel	State University of New York, Albany
Vince Knoll	Outdoor Coalition of New York
Fred Koontz	Wildlife Trust
Paul Kupchok	Green Chimney School
Tom Lake	Hudson River Almanac
Don LaValley	NYS Conservation Council

Name	Organization
Cara Lee	The Nature Conservancy
Eric Lind	National Audubon Society
Thomas Lyons	NYS Office of Parks, Recreation, and Historic Preservation
Jim McDougal	Wildlife Conservation Society
Dave Miller	National Audubon Society
Nick Miller	Wildlife Conservation Society
Andrew Millliken	U.S. Fish & Wildlife Service
Kathryn Moser	The Nature Conservancy
Paul Novak	NY Natural Heritage Program
Peter Nye	NYSDEC, Bureau of Wildlife
Ralph Odell	NYS Office of Parks, Recreation, and Historic Preservation
Peg Olsen	The Nature Conservancy
Mark Penhollow	NYSDEC, Hudson River Estuary Program[3]
Jenna Spear-O'Mara	NYSDEC, Division of Lands and Forests
Marcus Phelps	U.S. Forest Service
Rob Pirani	Regional Plan Association
Gerald Rasmussen	NYSDEC, Bureau of Habitat
Frank Regerro	Orange County Federation of Sportsmen
Milo Richmond	New York Cooperative Fish & Wildlife Research Unit, Cornell University
Jack Robbins	Westchester County Parks Department
Mark Russo	Cornell Cooperative Extension/Rockland County
Kathryn Schneider	New York Natural Heritage Program
Eric Scherer	American Heritage Rivers
Karen Schneller-McDonald	Wildlife Conservation Society
Joshua Schwartz	Pace University
Charles Smith	Cornell University
Randy Smith	Dutchess County Parks
Stephen Smith	Cornell University
Steve Stanne	NYSDEC, Hudson River Estuary Program[2]
Margaret Stewart	State University of New York, Albany
Kristi Sullivan	Cornell University
Dennis Suszkowski	Hudson River Foundation
Tim Tear	The Nature Conservancy
Maria Trabka	The Nature Conservancy
Maynard Vance	NYSDEC, Bureau of Wildlife
David VanLuven	NY Natural Heritage Program
Bethia Waterman	NYSDEC, Hudson River Estuary Program
Troy Weldy	NY Natural Heritage Program
Jeff Williams	New York Farm Bureau
Jeff Zappieri	Department of State, Coastal Management Program
Leslie Zucker	NYSDEC, Hudson River Estuary Program[3]

[1]New York State Department of Environmental Conservation
[2]In partnership with the New York State Water Resources Institute, Cornell University
[3]In partnership with the New York Cooperative Fish & Wildlife Research Unit, Cornell University

Appendix II

Common and scientific names for plant and animal species mentioned in this report.

Common Name	Scientific Name
Plants	
adder's-mouth	*Malaxis* spp.
algae-like pondweed	*Potamogeton confervoides*
American ginseng	*Panax quinquefolius*
Appalachian sandwort	*Minuartia glabra*
arctic rush	*Juncus trifidus*
ash	*Fraxinus* spp.
aspen	*Populus tremuloides*
Atlantic white-cedar	*Chamaecyparis thyoides*
balsam fir	*Abies balsamea*
basil mountain mint	*Pycnanthemum clinopodioides*
Bayard's malaxis	*Malaxis bayardii*
beakgrass	*Diarrhena obovata*
big bluestem	*Andropogon gerardii*
black huckleberry	*Gaylussacia baccata*
black locust	*Robinia pseudoacacia*
black spruce	*Picea mariana*
bladderwort	*Utricularia* spp.
blue flag iris	*Iris versicolor*
blueberry	*Vaccinium* spp.
bog bluegrass	*Poa paludigena*
broom crowberry	*Corema conradii*
Bush's sedge	*Carex bushii*
bush clover	*Lespedeza capitata*
buttonbush	*Cephalanthus occidentalis*
cattail	*Typha augustifolia*
chestnut oak	*Quercus montana*
common hairgrass	*Deschampsia flexuosa*
common hairgrass	*Deschampsia flexuosa*
common reed	*Phragmites australis*
coontail	*Ceratophyllum* spp.
creeping snowberry	*Gaultheria hispidula*
cylindrical-headed bulrush	*Scirpus cylindricus*
Eastern hemlock	*Tsuga canadensis*
eastern redcedar	*Juniperus virginiana*
estuary beggar-ticks	*Bidens bidentoides*
Farwell's water milfoil	*Myriophyllum farwellii*
featherfoil	*Hottonia inflata*
fragrant cliff fern	*Dryopteris fragrans*
Frank's sedge	*Carex frankii*

garlic mustard	*Alliaria petiolata*
globose flatsedge	*Cyperus echinatus*
goat's rue	*Tephrosia virginiana*
goldenseal	*Hydrastis canadensis*
grass pink	*Calopogon pulchellus*
hardstem bulrush	*Scirpus acutus*
hemlock	*Tsuga canadensis*
highbush blueberry	*Vaccinium corymbosum*
Hill's pondweed	*Potamogeton hillii*
huckleberry	*Gaylussacia* spp.
Hudson River water nymph	*Najas guadalupensis* var *muenscheri*
Indian grass	*Sorghastrum nutans*
Jacob's ladder	*Smilax pulverulenta*
little bluestem	*Schizachyrium scoparium*
Long's bittercress	*Cardamine longii*
maple	*Acer* spp.
marginal wood fern	*Dryopteris marginalis*
milkwort	*Polygala* spp.
mountain spleenwort	*Asplenium montanum*
mountain ash	*Sorbus Americana*
mountain laurel	*Kalmia latifolia*
muskroot	*Adoxa moschatellina*
Nantucket juneberry	*Amelanchier x nantucketensis*
necklace sedge	*Carex projecta*
Northern monk's hood	*Aconitum noveboracense*
oak	*Quercus* spp.
Ogden's pondweed	*Potamogeton odgenii*
persimmon	*Diospyros virginiana*
pinweed	*Lechea pulchella* var. *moniliformis*
pitch pine	*Pinus rigida*
pitcher plant	*Sarracenia purpurea*
pointed watermeal	*Wolffia braziliensis*
poverty-grass	*Danthonia spicata*
prairie sedge	*Carex prairea*
purple loosestrife	*Lythrum salicaria*
purple milkweed	*Asclepias purpurascens*
ram's-head lady's slipper	*Cypripedium arietinum*
rattlebox	*Crotalaria sagittalis*
red maple	*Acer rubrum*
red oak	*Quercus rubra*
red rooted flatsedge	*Cyperus erythrorhizos*
rhodora	*Rhododendron canadense*
rock polypody	*Polypodium virginianum*
rose pogonia	*Pogonia ophioglossoides*
roseroot stonecrop	*Sedum rosea*

Common Name	Scientific Name
salt-meadow grass	*Diplachne maritima*
scrub oak	*Quercus ilicifolia*
short-fruited rush	*Juncus brachycarpus*
slender blue flag iris	*Iris prismatica*
slender knotweed	*Polygonum tenue*
small white aster	*Aster vimineus*
small whorled pogonia	*Isotria medeoloides*
small-flowered crowfoot	*Ranunculus abortivus*
smartweed dodder	*Cuscuta polygonorum*
smooth cliff-brake	*Pellaea glabella*
softstem bulrush	*Scirpus validus*
spongy arrowhead	*Sagittaria calycina* var *spongiosa*
spotted pondweed	*Potamogeton pulcher*
spreading globeflower	*Trollius laxus*
spruce	*Picea* spp.
swamp agrimony	*Agrimonia parviflora*
swamp cottonwood	*Populus heterophylla*
sweet fern	*Comptonia peregrina*
sweetgum	*Liquidambar styraciflua*
tamarack	*Larix laricina*
Torrey's mountain mint	*Pycnanthemum torreyi*
three-toothed cinquefoil	*Potentilla tridentata*
tree-of-heaven	*Ailanthus altissima*
trout lilly	*Erythronium americanum*
tuliptree	*Liriodendron tulipifera*
twayblade	*Liparis lilifolia*
water chestnut	*Trapa natans*
wild lupine	*Lupinus perennis*
woodland lettuce	*Lactuca floridana*
yellow giant hyssop	*Agastache nepetoides*

Invertebrates

alewife floater	*Anodonta implicata*
Arogos skipper	*Atrytone arogos*
arrowhead spiketail	*Cordulegaster obliqua*
blue crab	*Callinectes sapidus*
brook floater	*Alasmidonta varicosa*
daphnia	*Daphnia* spp.
dwarf wedgemussel	*Alasmidonta heterodon*
Eastern pondmussel	*Ligumia nasuta*
fairy shrimp	*Branchinecta* spp.
fiddler crab	*Uca pugnax*
frosted elfin	*Callophrys henrici*
hemlock woolly adelgid	*Adelges tsugae*

Karner blue butterfly	*Lycaeides melissa samuelis*
sable clubtail dragonfly	*Gomphus rogersi*
silvery blue butterfly	*Glaucopsyche lygdamus lygdamus*
swollen wedge mussel	*Alasmidonta varicosa*
tiger spiketail dragonfly	*Cordulegaster erronea*
zebra mussel	*Dreissena polymorpha*

Amphibians

American toad	*Bufo americanus*
blue-spotted salamander	*Ambystoma laterale*
Eastern spadefoot toad	*Scaphiopus holbrooki holbrooki*
four-toed salamander	*Hemidactylium scutatum*
gray treefrog	*Hyla versicolor*
Jefferson salamander	*Ambystoma jeffersonianum*
long-tailed salamander	*Eurycea longicauda longicauda*
marbled salamander	*Ambystoma opacum*
Northern cricket frog	*Acris crepitans crepitans*
southern leopard frog	*Rana utricularia*
spotted salamander	*Ambystoma maculatum*
spring peeper	*Hyla crucifer*
wood frog	*Rana sylvatica*

Reptiles

blanding's turtle	*Emydoidea blandingi*
bog turtle	*Clemmys muhlenbergi*
Eastern box turtle	*Terrapene carolina carolina*
Eastern hognose snake	*Heterodon platyrhinos*
Eastern mud turtle	*Kinosternon s. subrubrum*
Eastern ribbon snake	*Thamnophis sauritus sauritus*
five-lined skink	*Eumeces fasciatus*
Northern copperhead	*Agkistrodon contortrix mokasen*
Northern diamondback terrapin	*Malaclemys terrapin terrapin*
Northern fence lizard	*Sceloporus undulatus hyacinthinus*
red-bellied snake	*Storeria occipitomaculata*
spotted turtle	*Clemmys guttata*
timber rattlesnake	*Crotalus horridus horridus*
wood turtle	*Clemmys insculpta*
worm snake	*Carphophis amoenus*

Birds

American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*
bald eagle	*Haliaeetus leucocephalus*

Common Name	Scientific Name
barred owl	*Strix varia*
belted kingfisher	*Ceryle alcyon*
Bicknell's thrush	*Catharus bicknelli*
black-crowned night heron	*Nycticorax nycticorax*
bobolink	*Dolichonyx oryzivirus*
broad-winged hawk	*Buteo platypterus*
brown thrasher	*Toxostoma rufum*
brown-headed cowbird	*Molothrus ater*
Canada goose	*Branta canadensis*
cerulean warbler	*Dendroica cerulea*
clapper rail	*Rallus longirostris*
common raven	*Corvus corax*
common yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Accipiter cooperii*
field sparrow	*Spizella pusilla*
golden eagle	*Aquila chrysaetos*
grasshopper sparrow	*Ammodramus savannarum*
great blue heron	*Ardea herodias*
great horned owl	*Bubo virginianus*
green heron	*Butorides virescens*
gull	*Larus* spp.
Henslow's sparrow	*Ammodramus henslowii*
horned lark	*Eremophila alpestris*
indigo bunting	*Passerina cyanea*
Kentucky warbler	*Oporornis formosus*
least tern	*Sterna antillarum*
long-eared owl	*Asio otus*
mourning dove	*Zenaida macroura*
mute swan	*Cygnus olor*
Northern harrier	*Circus cyaneus*
osprey	*Pandion haliaetus*
peregrine falcon	*Falco peregrinus*
pied-billed grebe	*Podilymbus podiceps*
piping plover	*Charadrius melodus*
prairie warbler	*Dendroica discolor*
red-shouldered hawk	*Buteo lineatus*
rough-legged hawk	*Buteo lagopus*
rufous-sided towhee	*Pipilo erythrophthalmus*
sedge wren	*Cistothorus platensis*
sharp-shinned hawk	*Accipiter striatus*
short-eared owl	*Asio flammeus*
tern	*Sterna* spp.
upland sandpiper	*Bartramia longicauda*
veery	*Catharus fuscescens*
vesper sparrow	*Pooecetes gramineus*

whip-poor-will	*Caprimulgus vociferus*
wood thrush	*Hylocichla mustelina*
woodcock	*Scolopax minor*
worm eating warbler	*Helmitheros vermivorus*
yellow-crowned night heron	*Nyctanassa violacea*

Mammals

Allegheny woodrat	*Neotoma magister*
beaver	*Castor canadensis*
big brown bat	*Eptesicus fuscus*
black bear	*Ursus americanus*
bobcat	*Lynx rufus*
Eastern pipistrelle	*Pipistrellus subflavus*
Eastern small-footed bat	*Myotis leibii*
fisher	*Martes pennanti*
harbor seal	*Phoca vitulina*
Indiana bat	*Myotis sodalis*
Keen's bat	*Myotis keenii*
little brown bat	*Myotis lucifugus*
long-eared myotis	*Myotis evotis*
longtail weasel	*Mustela frenata*
mink	*Mustela vison*
moose	*Alces alces*
muskrat	*Ondatra zibethica*
raccoon	*Procyon lotor*
red fox	*Vulpes fulva*
river otter	*Lutra canadensis*
white-tailed deer	*Odocoileus virginanus*

Fish

alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
Atlantic needlefish	*Strongylura marina*
Atlantic sturgeon	*Acipenser oxyrhynchus*
blueback herring	*Alosa aestivalis*
largemouth bass	*Micropterus salmoides*
shortnose sturgeon	*Acipenser brevirostrum*
smallmouth bass	*Micropterus dolomieui*
striped bass	*Morone saxatilis*