

NATURAL AREAS AND WILDLIFE IN YOUR COMMUNITY



Hudson River Estuary Program

A Habitat Summary Prepared for the Town of Bethlehem

This summary was completed in August 2017 as an update to an earlier 2008 summary, providing information for land-use planning and decision-making as requested by the Town of Bethlehem. It identifies significant ecosystems in the Town, including coastal habitats, streams, forests, wetlands, and other natural areas with important biological values. This summary is based only on existing information available to the New York State Department of Environmental Conservation (DEC) and its partners, and, therefore should not be considered a complete inventory. Additional information about habitats in our region can be found in the *Wildlife and Habitat Conservation Framework* developed by the Hudson River Estuary Program (Penhollow et al. 2006) and in the *Biodiversity Assessment Manual for the Hudson River Estuary Corridor* developed by Hudsonia and published by DEC (Kiviat and Stevens 2001).

Ecosystems of the estuary watershed—wetlands, forests, stream corridors, grasslands, and shrublands—are not only habitat for abundant fish and wildlife, but also support the estuary and provide many vital benefits to human communities. These ecosystems help to keep drinking water and air clean, moderate temperature, filter pollutants, and absorb floodwaters. They also provide opportunity for outdoor recreation and education, and create the scenery and sense of place that is unique to the Hudson Valley. Local land-use planning efforts are instrumental in balancing future development with protection of these resources. By conserving sufficient habitat to support the region's astonishing diversity of plants and animals, communities can ensure that healthy, resilient ecosystems—and the benefits they provide—are available to future generations. For more information on local conservation approaches, see *Conserving Natural Areas and Wildlife in Your Community: Smart Growth Strategies for Protecting the Biological Diversity of New York's Hudson River Valley* (Strong 2008).

The Estuary Program works toward achieving key benefits:

- Clean water
- Resilient communities
- Vital estuary ecosystem
- Fish, wildlife & habitats
- Natural scenery
- Education, access, recreation, and inspiration

This document was created by the New York State Department of Environmental Conservation's Hudson River Estuary Program and Cornell University's Department of Natural Resources. The Estuary Program (<http://www.dec.ny.gov/lands/4920.html>) protects and improves the natural and scenic Hudson River watershed for all its residents. The program was created in 1987 and extends from the Troy dam to upper New York Harbor.

The Estuary Program is funded by the NYS Environmental Protection Fund. The Biodiversity Outreach Program was created in partnership with Cornell University to help Hudson Valley communities learn what plants, animals, and habitats are found locally; understand the value of these resources; and increase their capacity to identify, prioritize, and conserve important natural areas through informed decision-making. Additional information about habitats in the Hudson Valley can be found on DEC's webpages, starting with www.dec.ny.gov/lands/5094.html.

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Introduction

The Hudson River Estuary and its watershed is a region of remarkable beauty, historical and economic significance, and high biological diversity. The region, comprising only 13.5% of the land area in New York, contains nearly 85% of the bird, mammal, reptile, and amphibian species found in the state (Penhollow et al. 2006). Local municipalities can play a key role in conserving this natural heritage and the ecological processes that sustain it. By identifying important areas for habitat and wildlife, municipalities are better equipped to pursue conservation opportunities and make informed land-use decisions. This proactive approach to planning can help municipalities avoid the costs of urban and suburban sprawl, maintain community character and quality of life, and preserve the many benefits, or ecosystem services, that healthy, natural systems provide to present and future generations.

*An **ecosystem** is a community of animals and plants interacting with one another and with their physical environment.*

***Ecosystem services** are life-sustaining benefits we receive from nature, such as food, medicine, water purification, flood control, and pollination. Many of these services are provided for “free,” yet are worth many trillions of dollars.*

- Ecological Society of America

Summary Content

This summary includes complementary text, maps, and tables. The [Habitat Summary text](#) describes what is known about the town's important natural areas and habitats based on information in DEC's databases and a review of local studies available at the time of writing. The text details the information in the maps, including the ecological importance of the data and its sources. There are seven habitat maps for the Town of Bethlehem, which follow the text headings:

[Figure 1: Regional Context](#) of Bethlehem, NY

[Figure 2: Significant Ecological Features](#) in Bethlehem, NY

[Figure 3: Hudson River Coastal Habitats](#) in Bethlehem, NY

[Figure 4: Hudson River Shoreline Status and Tidal Wetland Pathways](#) in Bethlehem, NY

[Figure 5: Streams](#) in Bethlehem, NY

[Figure 6: Wetlands](#) in Bethlehem, NY

[Figure 7: Large Forests](#) in Bethlehem, NY

Descriptions of shrubland and young forest habitats and grasslands are included in the text but not mapped. Following the maps, [Table 1](#) lists known **Species and Ecosystems of Conservation Concern** that have been recorded for New Scotland, including species listed in New York (NY) or federally (US) as [endangered](#), [threatened](#), [special concern](#), [rare](#), a [Species of Greatest Conservation Need](#) (SGCN), or a [Hudson River Valley Priority Bird](#) species. SGCN are species identified in the State Wildlife Action Plan that are experiencing some level of population decline, have identified threats that may put them in jeopardy, and need conservation actions to maintain stable population levels or sustain recovery (NYSDEC 2015). Audubon New York identified the Hudson River Valley priority birds by assessing continental, national, and regional bird planning initiatives in addition to state and federal priority designations.

At the end of the summary, [references](#) identify the sources of information in this document and places to find more information. [General conservation measures](#) for protecting natural areas and wildlife are also provided.

Links in the summary will direct you to websites, publications, and fact sheets for supplemental information. In addition, Adobe Reader will enable you to zoom in and turn off data layers to customize your view of the maps. Most of the GIS layers shown in the habitat summary maps are available for free from the [New York GIS Clearinghouse](#); others are available upon request from the Estuary Program. A complementary online map application, the [Hudson Valley Natural Resource Mapper](#), can be used for more interactive viewing of mapped features in the habitat summary. Attribute information for many of the individual features is available in the mapper, along with links to more information, including GIS data sources.

Please note that some habitats and species identified in this document may be protected by state or federal programs. The [Environmental Resource Mapper](#) on DEC's website can help identify those resources. Please work with DEC's Region 4 Office in Schenectady and other appropriate entities as necessary.

How to use this summary

This summary provides a starting point for recognizing important natural areas in the town and surrounding areas, but is limited to existing information and is not a substitute for on-site survey and assessment. Information provided should be verified for legal purposes, including environmental review. Effective conservation occurs across property and political boundaries and, therefore, necessitates a broader view of natural landscapes. By identifying areas with high-quality resources, this summary will be especially useful for setting priorities to inform municipal planning. Habitat summaries like this have been used by communities for open space plans, comprehensive plans, natural resource inventories, and other conservation and planning actions. One Hudson Valley town used the species lists in its comprehensive plan's generic environmental impact statement, another to designate critical environmental areas. Some communities have incorporated their summaries directly into plans, while others refer to the information when writing their own documents.

Though this summary does not contain adequate detail for site planning purposes, it can be useful for environmental review. First, by identifying high quality habitats on a municipal-wide scale, it helps land-use decision-makers and applicants understand how a proposed site plan might relate to important natural areas on- and off-site. Second, the summary highlights areas that may require more detailed assessment to evaluate potential impacts. Third, the tables identify species of conservation concern that may warrant special

Limitations of Maps in this Summary

Maps included here were created in a geographic information system or GIS. Information on the maps comes from different sources, produced at different times, at different scales, and for different purposes. It is often collected or developed from remote sensing data (i.e., aerial photographs, satellite imagery) or derived from paper maps. For these reasons, GIS data often contain inaccuracies from the original data, plus any errors from converting it. Therefore, maps created in GIS are approximate and best used for planning purposes. They should not be substituted for site surveys. Any resource shown on a map should be verified for legal purposes, including environmental review.

attention during reviews. If it's not already a routine step, the planning board should consider requiring applicants to produce a current letter from the [New York Natural Heritage Program](#) that identifies rare plants, rare animals, and significant ecosystems that are known to be on or near a proposed development site. The planning board and applicants should also work closely with DEC Region 4 Permits staff to ensure regulatory requirements are met.

How to find more information

Most of the GIS data presented in the Habitat Summary maps may be obtained for free from the [New York State GIS Clearinghouse](#) or from other public websites. The summary can be enhanced by local knowledge. Local studies, maps, plans, and knowledgeable residents can provide details and may reveal previously unknown, high-quality ecosystems. It draws upon the 2007 [Normans Kill Riparian Corridor Study](#) as well as the 2008 [Onesquethaw-Coeymans Creek Watershed Study](#) and its description of a 2005 Biodiversity Assessment training study that covered a portion of the town. Biological information in environmental impact statements may also be useful, especially when a municipality has habitat standards for environmental review. For help with incorporating additional information into the summary or questions about obtaining GIS

data used in the maps, please contact Ingrid Haeckel, Hudson River Estuary Conservation and Land Use Specialist.

Guidance and suggestions for developing a more comprehensive natural resources inventory is available in [Creating a Natural Resources Inventory: A Guide for Communities in the Hudson River Estuary Watershed](#) (Haeckel and Heady 2014). This handbook outlines how to inventory valuable natural and cultural assets and strategies for using natural resource information in local land-use and conservation planning. Limited hard copies are available upon request for municipalities.

Conservation

Once important habitats and natural areas are identified, municipalities have numerous options to strengthen their protection, such as incorporating maps and data into comprehensive plans and zoning, developing critical environmental areas or conservation overlay districts, adopting resource protection regulations, and acquiring conservation easements for sensitive habitats, such as floodplains or wetlands and their buffers.

Included with this summary are [General Conservation Measures for Protecting Natural Areas and Wildlife](#) that can help guide Bethlehem's plans and land-use decisions. Additional information on the how and why of local habitat conservation is available in [Conserving Natural Areas in Your Community: Smart Growth Strategies for Protecting the Biological Diversity of New York's Hudson River Valley](#) (Strong 2008). This handbook was published by DEC and details why towns should conserve their biological resources, as well as the tools and techniques local governments can use to conserve natural areas and wildlife. Chapter 5 covers habitat conservation. The document is available on a CD or in hard copy upon request.

Technical assistance is available through the Estuary Program, including help with incorporating natural resource conservation principles and information into municipal land-use planning procedures, plans, and policies. The Estuary Program and its partners also provide training to local leaders to recognize and map ecologically significant habitats and communicate their importance to the community. The [Hudson River Estuary Grants](#) program supports projects that continue to raise the capacity of municipalities, land trusts, and non-profits to identify and assess watershed biodiversity, promote stewardship and conservation of vital habitats, and create local conservation programs. For more information on technical assistance opportunities, please contact Ingrid Haeckel.

Important Habitats in the Town of Bethlehem

Regional Context ([Figure 1](#))

The first step to understanding the natural areas and habitats of Bethlehem is to consider how the town relates to its surrounding area. The town spans approximately 49 square miles including underwater lands in the Hudson River. All land in Bethlehem ultimately drains to the Hudson River Estuary. Almost half of the town lies within the Vroman Kill subwatershed, with smaller areas draining via the Normans Kill and Onesquethaw-Coeymans Creek subwatersheds, or directly to the estuary.

*A **watershed** is the area of land where all of the water that is under it, or drains off of it, goes into the same stream, river, lake, or other waterbody.*

– U.S. Environmental Protection Agency

The tidal Hudson River Estuary forms the Bethlehem’s eastern boundary. Tidal wetlands and shallow water habitats in the estuary encompass some of the town’s most biologically significant habitats. The Upper Hudson River Estuary is identified as a Significant Biodiversity Area (SBA) by the DEC Hudson River Estuary Program and is a globally rare ecosystem that supports many rare species as well as regionally important fisheries (Penhollow et al., 2006):

“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....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.”

***Significant Biodiversity Areas (SBAs)** are locations of high concentration of biological diversity or value for regional biodiversity, described in [The Hudson River Estuary Wildlife and Habitat Conservation Framework](#) (Penhollow et al. 2006).*

The town’s Hudson River shoreline and tidal wetlands are within the SBA and support occurrences of several rare plant species and important habitats for migratory fishes and freshwater mussels. The tidal Normans Kill and Shad and Schermerhorn Islands are also designated Significant Coastal Fish and Wildlife Habitats by the New York State Department of State. These attributes are discussed further in the [Hudson River Coastal and Shoreline Habitat](#) section.

In addition to significant coastal features, the southwest corner of Bethlehem lies in the Hudson Valley Limestone and Shale Ridges SBA, recognized for its diversity of plants, animals, and natural communities, and areas of karst terrain providing winter hibernacula for bats (Penhollow et al. 2006):

“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. ...

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."

The Limestone and Shale Ridges SBA extends from the band of cliffs of the Helderberg Escarpment in Albany County and parallels the New York State Thruway south into Ulster County. The curved ridgeline is approximately 54 miles long and is 5.6 miles wide at its widest point. Several occurrences of significant limestone and shale-associated rare plants in Bethlehem are listed in [Table 1](#).

Geology strongly influences features like soil and groundwater chemistry, and thereby helps shape where different kinds of habitats occur.

Significant Ecological Features ([Figure 2](#))

[Figure 2](#) shows the major ecological features known to occur in Bethlehem, including the Upper Hudson River and Limestone and Shale Ridge SBAs, significant coastal fish and wildlife habitats, areas of known importance for rare animals and rare plants, stream habitat for migratory fishes. [Figure 2](#) and the corresponding descriptions below are based on limited information and more study of the town is needed to better describe Bethlehem's natural features.

Significant Coastal Fish and Wildlife Habitats. The DEC has identified and evaluated coastal habitats throughout the state's coastal regions, providing recommendations to the NYS Department of State so that the most important or "significant" habitats may be designated for protection in accordance with the Waterfront Revitalization and Coastal Resources Act. Within Bethlehem, the [Normans Kill](#) and [Shad and Schermerhorn Islands](#) are designated significant coastal fish and wildlife habitats. They are described under [Hudson River Coastal and Shoreline Habitat](#).

Areas of Known Importance for Rare Plants and Rare Animals. The New York Natural Heritage Program (NYNHP) has identified areas of importance for sustaining populations of rare plants and rare animals based on existing records and the species' habitat requirements. Important Areas include the specific locations where species have been observed, as well as areas critical to maintaining the species' habitat. Proactive planning that considers how species move across the landscape, with careful attention to maintaining connected habitat complexes, will contribute to the long-term survival and persistence of rare species. NYNHP has identified areas of importance in Bethlehem for bald eagle, diadromous fishes, freshwater mussels, a coastal dragonfly, and wood turtle, in addition to areas of importance for rare plants. A complete list of state rare plants and animals known from Bethlehem is shown in [Table 1](#).

NY-Threatened [bald eagle](#) nesting occurs in Bethlehem's coastal habitats. While bald eagle breeding and non-breeding populations are increasing in New York, development pressure and its impacts on habitat remain significant threats. Nesting sites are sensitive to human disturbance.

Diadromous fish refer to species that migrate between the sea and freshwater. NY-Endangered [shortnose sturgeon](#), blueback herring, alewives, and American eel are diadromous fishes of the town's Hudson River coastal habitats and are discussed further in the following sections. Those that return to freshwater habitats to spawn are also referred to as **anadromous** and include sturgeon and herring species. Stream reaches used by American eel are shown in [Stream Habitat for Migratory Fishes](#).

[Alewife floater](#) is a state-rare mussel documented in the Hudson River and mouth of the Normans Kill. Populations of these mussels have declined dramatically since exotic zebra mussels were

introduced to the Hudson River Estuary in the 1990s. These and other freshwater mussels are furthermore threatened by habitat loss and fragmentation, especially from dams; siltation and sedimentation from dams, altered river flows, and surface run-off. Several additional rare mussel species were documented historically in the Normans Kill and are listed in [Table 1](#).

[Russet-tipped clubtail](#) is a state-rare dragonfly documented near the mouth of the Vloman Kill. It may occur elsewhere in the town along the Hudson or its tidal tributaries, and is sensitive to water contamination, hydrological alteration, and other impacts from surrounding upland development.

Wood turtle is a NY-Special Concern species occurring along low gradient perennial streams that also spends time in adjacent forests and grasslands. Wood turtles are threatened by habitat loss, stream degradation, nest predation, and the pet trade.

Note: Rare plants, rare animals, and significant natural communities may occur in more locations than are currently known by NYNHP or DEC. Most areas have never been surveyed by biologists. Several additional species of conservation concern are known to occur in Bethlehem but lack mapped information identifying important habitat areas. [Table 1](#) notes general habitats used by rare species documented in the town. The DEC Region 4 Office in Schenectady should be contacted at (518) 357-2355 with any concerns or questions about the presence of protected species in the Town of Bethlehem.

Stream Habitat for Migratory Fishes. DEC Bureau of Fisheries data and an aquatic habitat connectivity study by NYNHP indicate that the full length of the Normans Kill, Vloman Kill, and Onesquethaw Creek in Bethlehem ([Figure 2](#)) comprise migratory routes for American eel, a fish species that begins life in the Atlantic Ocean and migrates to the headwaters of North American tributary streams as tiny "glass eels" (White et al. 2011). American eel is in decline throughout much of its range, and though eels are able to bypass certain dams, culverts, and other aquatic barriers, they rely on aquatic connectivity along streams to complete their life cycle and return to the sea to spawn. In addition, the tidal portion of the Normans Kill provides spawning habitat for alewife and blueback herring. The Binnen Kill provides spawning and feeding habitat for American shad, blueback herring, and alewife, and has documented use by NY-Endangered shortnose sturgeon.

Hudson River Coastal and Shoreline Habitats ([Figure 3](#) and [Figure 4](#))

Connections to upper watersheds, the Atlantic Ocean, and the changing tides make the coastal and shoreline zones of the Hudson River Estuary a dynamic area. Conditions throughout this reach of the estuary are entirely freshwater, supporting globally rare natural communities such as freshwater tidal marsh and swamp. The Town of Bethlehem's coastal habitats along the tidal Hudson are shown in [Figure 3](#). Tidal shoreline habitat and tidal wetland migration pathways are shown in [Figure 4](#).

Significant Coastal Fish and Wildlife Habitats. Diverse coastal habitats occur in New York that provide critical habitat and feeding areas for animals as well as economic values. As previously mentioned, the DEC has identified and evaluated coastal habitats throughout the state's coastal regions, providing recommendations to the NYS Department of State (DOS) so that the most important or "significant" habitats may be designated for protection in accordance with the Waterfront Revitalization and Coastal Resources Act. The Significant Coastal Fish and Wildlife Habitats are useful for planning at the local level because they describe the highest quality habitats on the Hudson, outlining fish and wildlife values and activities that may have large impacts on the habitats. State and federal law requires that some projects may be reviewed for consistency with coastal policies on significant fish and wildlife habitat. Contact the NYS Department of State Office of Planning & Development for more information on the protection and regulation of these habitats.

There are two designated Significant Coastal Fish and Wildlife Habitat areas in Bethlehem ([Figures 2](#) and [3](#)). Detailed descriptions of the [Normans Kill](#) and [Shad and Schermerhorn Islands](#) sites discuss their value to fish

and wildlife, and information on potential impacts to their habitat values. See [Table 1](#) for more information on the documented rare species associated with Bethlehem's coastal habitats.

The Normans Kill is the largest tributary stream in Albany County, and is one of about 4 major tributaries emptying into the northern portion of the Hudson River estuary, providing important freshwater inflows that help to maintain water quality in the Hudson. The Normans Kill coastal fish and wildlife habitat is an approximately 2-mile stretch of the tributary from its mouth on the Hudson River to a falls which is located just downstream from the New York State Thruway bridge. The [DOS habitat profile](#) describes the Normans Kill as “a relatively large, medium gradient, perennial, warmwater stream, with a drainage area of over 170 square miles, and an average annual discharge volume of approximately 150 cubic feet per second. The first mile of stream below the falls flows through a steep-sided wooded gorge, and is relatively shallow, with a gravelly substrate. The lower mile of the creek (referred to as "Island Creek") is within the tidal range of the Hudson River, and is relatively deep, with a silt and clay substrate. At least part of this segment was channelized in the past and its mouth relocated south in conjunction with nearby commercial and industrial developments. Despite its proximity to the Port of Albany, the Normans Kill and its associated riparian zone remain in a relatively natural condition. ... The length of stream channel accessible to migratory fishes and the lack of significant human disturbance in the upper portion of the creek provide favorable habitat conditions ... for a variety of coastal migratory as well as resident freshwater fish species.” Alewife, blueback herring, and white perch spawn in the creek, and American eel are also present.

The **Shad and Schermerhorn Islands** habitat area is a large, relatively undeveloped floodplain ecosystem spanning 1100 acres from the Vloman Kill in Bethlehem to the mouth of the Binnen Kill in Coeymans. The [significant fish and wildlife habitat](#) includes riverine littoral zones, submerged aquatic vegetation beds, tidal freshwater wetlands, tributary streams, floodplain forest, cliffs, and active agricultural lands. When this area of the Hudson was dredged for navigation, large areas of shallow secondary channel habitat were filled with dredged material behind the historic islands, eventually connecting the islands to the mainland.

Freshwater tidal wetlands, tidal mudflats, and important littoral zone areas along the main stem Hudson River serve as a nursery area for migratory young blueback herring, American shad, and striped bass as well as spawning and feeding areas for resident freshwater species. The Binnen Kill also provides spawning and feeding habitat for American shad, blueback herring, alewife, white perch, and resident freshwater species. NY-Threatened [least bittern](#) and NY-Special Concern American bittern use the area for nesting and northern map turtles and snapping turtles are found here.

Underwater (Subtidal) Habitats. Submerged Aquatic Vegetation (SAV) is plant life that grows under water. SAV improves water quality by trapping fine sediment and organic matter and adding oxygen to the water. It also provides essential habitat for organisms like insects, worms, and snails that feed fish and birds in the estuary. [Figure 3](#) shows areas where SAV has been found since 1997. DEC's most recent survey in 2014 found just 0.8 acre of SAV in Bethlehem, one percent of the town's area documented with SAV since 1997. A dramatic decline in SAV (90% loss) was also seen throughout the Hudson River Estuary following Hurricanes Irene and Lee in 2011. The habitat loss was believed to be due to the large amount of sediment entering the estuary from the storms, which blocked light and prevented plant growth. In 2016, signs of SAV recovery were seen throughout the estuary. Even if SAV is not present today, the areas shown in [Figure 3](#) could support it in the future. Re-mapping of SAV in the Hudson River Estuary is currently underway.

Tidal Hudson River Estuary Wetlands. Tidal wetlands are areas regularly inundated to some degree by tides. There are different types of tidal wetlands depending on plant life present and water depth during high and low tides. Tidal wetlands provide vital habitat in the estuary for rare plants and young fish. In addition, waterfront communities benefit from the ability of tidal wetlands to remove some pollutants from wastewater and protect shorelines from waves and strong storms.

A 2007 inventory by the DEC identified 84 acres of tidal wetlands in the Town of Bethlehem ([Figure 3](#)). The Binnen Kill and Shad and Schermerhorn Islands complex hosts the greatest extent of tidal wetlands in the town (63 acres) and supports a diverse mix of wetland types. A smaller tidal wetlands complex is situated at the mouth of the unnamed tidal creek between the North Albany Terminal and Bethlehem Energy Center. NYSDEC and the New England Interstate Water Pollution Control Commission recently commissioned a detailed natural resources inventory of protected lands in the Binnen Kill complex to identify ecological communities, including the occurrence of rare or endangered species and other natural features. This information will be used to develop future plans for the site, which may include conservation, preservation and restoration.

Several rare plant and invertebrate species are documented from the town's coastal habitats in addition to fish and birds mentioned previously, including NY-Threatened [Davis' sedge](#), rare dragonflies such as the [russet-tipped clubtail](#), and the [alewife floater](#) mussel. See [Table 1](#) for a full list.

Tidal Wetland Pathways. The Hudson River estuary is connected to the Atlantic Ocean and affected by sea level rise (SLR) due to climate change. The Hudson has already risen by one foot since 1900 and is likely to rise an additional 3-6 feet due to SLR by 2100 (Horton et al. 2014). Such a rapid change in water levels threatens waterfront development and infrastructure as well as the future of tidal wetlands. Tidal wetlands along the Hudson River will disappear with SLR unless they can build up in place or move to higher ground. However, wetlands bordered by steep shorelines or existing development may have no place to go. Potential tidal wetland loss threatens the health of the entire estuary. A recent study by Scenic Hudson shows areas along the Hudson most likely to support tidal wetlands in the future as sea level rises (Tabak et al. 2016). The study shows that the location of Bethlehem's tidal wetlands will likely change by 2100.

The **Tidal Wetland Pathways** in [Figure 4](#) show where tidal wetlands are likely to move by 2100 as sea level rises. Tidal wetlands are projected to expand greatly adjacent to the Binnen Kill on Shad and Schermerhorn Island north to the Vloman Kill. The undeveloped floodplain lands of Shad and Schermerhorn Islands are in fact one of the most important opportunity areas in the estuary for new tidal wetlands to be established in the 21st century. Steep shorelines are a barrier to wetland movement in some areas, in others, existing roads, railroads, and development pose a physical barrier. The wetland pathways do not account for all of the barriers that may be present; for example, bulkheads, revetment, and other hard engineered shorelines may be a barrier to inland wetland migration along many stretches of Bethlehem's Hudson River shoreline.

The most effective way for a municipality to conserve tidal wetlands in the face of these changes is to protect and manage the areas where wetlands may move. Minimizing future development in the pathways and designing public waterfronts to allow for these changes will ensure that tidal wetlands have room to adapt to rising sea levels. This strategy will also reduce risks to communities and property owners in the changing Hudson River flood zone. For more information, see [Protecting the Pathways: A Climate Change Adaptation Framework for Hudson River Estuary Tidal Wetlands](#) (Tabak and Spector 2016). Sea level rise projections for the town's waterfront can be viewed using Scenic Hudson's [Sea Level Rise Mapper](#).

Tidal Shoreline Status. Natural shorelines are an important transition zone between water and land and provide habitat for diverse plants, fish and wildlife. Natural shorelines located in the tidal wetland pathways may also allow tidal wetland and shoreline habitats to move to higher ground as sea level rises. Towns can evaluate tidal shoreline status to identify places where natural shorelines could be conserved or where the ecology of engineered shorelines could be enhanced.

Tidal shoreline comprises lands directly on the Hudson River as well as the shorelines of tidal wetlands, tidal tributaries, and coves, including both naturally vegetated and engineered shoreline. Bethlehem has approximately 7.1 miles of shoreline directly along the Hudson River. A 2005 inventory of Hudson River shoreline status by NYSDEC and the Hudson River National Estuarine Research Reserve found over 4.6 miles of hard engineered shoreline in Bethlehem, including bulkhead, rip-rap revetment, and timber cribbing

([Figure 4](#)). The remaining 2.5 miles of natural shoreline include a mix of woody vegetation, graminoid/broadleaf vegetation, and unvegetated sand and gravel.

There are opportunities to conserve, restore, and manage shoreline habitats throughout the Bethlehem waterfront area. Parks, preserves, and regulated wetlands may offer a starting point to conserve or restore natural shorelines that will allow tidal wetlands to move with sea level rise. Even along working waterfronts there are ways to improve the habitat value of bulkheads and rip-rap revetments. The [Hudson River Sustainable Shorelines Project](#) provides information and tools on enhancing the ecology of built shorelines as well as how to conserve natural shorelines.

Streams ([Figure 5](#))

[Streams](#), their floodplains, adjacent wetlands, and other “riparian” or streamside habitats that occur along their channel provide important ecosystem services to communities, including clean water, flood management, and recreational opportunities like fishing and kayaking. In addition, Hudson River tributary streams and their associated shoreline and floodplain areas provide some of the most productive wildlife habitat in the region. The health of the Hudson River Estuary is closely linked to the health of its tributaries and their watersheds (Penhollow et al. 2006).

All of the land in Bethlehem ultimately drains to the Hudson River Estuary ([Figure 5](#)). The Vloman Kill is the largest subwatershed in the town, comprising approximately 22 square miles of land in the center of the town. To the north, 12 square miles drain to the estuary via the Normans Kill, and to the south, 10 square miles drain via the Onesquethaw-Coeymans Creek system. The remaining land area drains directly to the estuary via minor streams and the Binnen Kill.

In addition to watershed boundaries, [Figure 5](#) shows streams, waterbodies, trout status, floodplains, and active river areas. Streams and waterbodies in [Figure 5](#) and other maps in this summary are from the USGS National Hydrography Dataset (NHD) and were digitized from air photos. Note the resulting maps have inherent inaccuracies and will not capture most intermittent streams. Visiting sites and creating more accurate maps are methods to pursue to ensure these important resources are identified and considered during planning processes.

Intermittent streams only flow seasonally or after rain. They can easily be overlooked when dry, but have great impact on larger downstream waters and warrant attention. Many flow directly into the Hudson and its tributaries, wetlands, and other water bodies, influencing water quantity and quality.

Trout status information in [Figure 5](#) is provided from [DEC’s Water Quality Standards and Classifications](#), which identifies trout or trout-spawning presence based on fish survey records. The classifications suggest there is coldwater habitat suitable for trout as well as trout spawning in Onesquethaw Creek. Trout presence has also been documented in the headwaters of the Vloman Kill and in the Krum Kill, a tributary of the Normans Kill at the northern end of the town. Trout require well-shaded, cool to cold, flowing water and are sensitive to warmer temperatures. While all streams benefit from adequate streamside vegetation, it is especially important for maintaining clean, coldwater habitats that support native species like brook trout. See [Figure 2](#) for the location of streams supporting migratory fish. The town also supports important habitat areas for NY-Special Concern wood turtle, a species usually occurring along low gradient perennial streams ([Figure 2](#)).

The [DEC Waterbody Inventory/Priority Waterbodies List](#) (WI/PWL) tracks the degree to which waterbodies are meeting their “best uses” based on their DEC classification. Waterbody impairment is determined for stream or waterbody segments based on DEC’s monitoring and other available information. Impaired waters that do not meet applicable water quality standards are considered for inclusion on the state’s Clean Water

Act Section 303(d) List and reported to Congress. WI/PWL data for tributaries in Bethlehem are available on the DEC website under the [Lower Hudson River Basin WI/PWL](#), and were last updated in 2008. According to the WI/PWL, the [lower Normans Kill and minor tributaries](#) including the lower Krum Kill is thought to experience minor impacts from silt/sediment and nutrient enrichment. The assessment states that “A variety of nonpoint sources contribute to the impacts. Considerable residential and commercial development has occurred in the watershed. Urban runoff and streambank erosion are known, and lawn and golf course runoff are potential sources. The creek runs quite turbid at times.” Although the [Onesquethaw Creek and tributaries](#) are listed in the WI/PWL as having no known impact to listed uses, the assessment states that aquatic life in the stream “is thought to experience minor impacts due to nutrient enrichment, siltation and other pollutants from agricultural and other nonpoint sources.” The [lower Vlooman Kill](#), Phillipin Kill, and Dowers Creek tributaries are suspected to have minor impacts from nutrient pollution, but need further verification.

The [Normans Kill Riparian Corridor Study](#) (2007) produced an inventory and analysis of natural and recreational resources within a 1-km area on both sides of the creek. The study notes that erosion and landslides have been persistent problems along the Normans Kill, particularly where there is stream-side development and/or significant vegetation clearing on slopes. The Bethlehem section of the Normans Kill has had several slope failures, including the 1968 Mahar Road landslide, a 1982 slide behind Del Lanes Bowling Alley, a 2000 landslide on Delaware Avenue, and most recently the 2015 slide at the Normanside Country Club. The study identified steep, erosion prone clay slopes throughout the corridor. The study also compiles existing information on water quality, fish and wildlife, land use, and recreation opportunities throughout the corridor, and establishes recommendations for future recreational use. Fowler’s toad and the umber shadowdragon dragonfly, both Species of Greatest Conservation Need, are known from the Normans Kill corridor. Several rare species of mussels and plants were historically documented in the corridor ([Table 1](#)).

The [Onesquethaw-Coeymans Creek Watershed Study](#) (2008) describes the course of the stream through the town and some possible sources of impairment. The study notes the significance of limestone bedrock underlying much of the watershed to stream flow conditions and habitat – “during periods of low-flow, sections of the creek disappear and flow underground through crevasses, caves and other conduits in the limestone. One result is that the creek is cooled when it flows through the bedrock, helping to provide excellent trout habitat. On the other hand, in areas where the limestone is close to the surface, any polluted surface water can easily enter those same crevasses and flow long distances, unfiltered by soil, to pollute the stream” (pp. 5-6). The study also notes the sensitivity of clay soils found in ravines along the full length of Coeymans Creek. The subsequent 2010 [Onesquethaw-Coeymans Watershed Management Plan](#) lays out recommendations for resource protection and improving water quality.

Effective stream conservation and restoration occurs beyond stream channels and banks. [Figure 5](#) shows Active River Areas (ARAs), which were developed by the Nature Conservancy to identify areas where physical and ecological processes occur that drive and sustain streams. ARAs highlight important near-stream areas influencing stream dynamics and health, including: meander belts—the adjacent areas within which the stream channel migrates over time; floodplains; terraces—former floodplains that may still flood in the largest flood events; riparian wetlands; and material contribution zones, which regularly contribute organic and inorganic (e.g., sediments, water) material to streams. These five components encompass the major processes influencing the stream—hydrology, sediment transport, processing and transport of organic materials, and key biotic interactions (Smith et al. 2008). Note that ARAs were developed through modeling based on coarse elevation data and have not been field verified. Nevertheless, ARAs can provide a starting point to inform land use strategies and stream protection efforts.

Floodplains are a particularly important component of active river areas, especially where forested or undeveloped. Forested floodplains and other forested riparian zones provide organic matter that supports the in-stream food web, shade that controls water temperature, and offer travel corridors for some wildlife (Knab-Vispo and Vispo 2010). In

Floodplains are low-lying areas adjacent to streams and rivers that can become inundated during heavy precipitation or snow melt.

addition to their high ecological value, forested floodplains provide many important functions including preventing erosion and recharging groundwater. They also act as a safety zone between human settlement and the damaging impacts of flood events. The Hudson River Estuary Program’s [“Trees for Tribes”](#) initiative offers free consultation and native trees and shrubs for qualifying streamside buffer planting projects in the estuary watershed.

Floodplain information included in [Figure 5](#) comes from the [Federal Emergency Management Agency](#) (FEMA) Digital Flood Insurance Rate Map (DFIRM) Database. Areas estimated to have a 1% chance or greater probability of being inundated in any given year are often referred to as the 100-year flood zone, including Shad and Schermerhorn Islands and the town’s Hudson River shoreline, floodplains along the Normans Kill, Vloman Kill and tributaries, and Onesquethaw Creek. Some narrow additional areas are mapped by FEMA with a 0.2% chance or greater probability of flooding in any given year (referred to as the “500-year flood”). It is important to note that the FEMA-mapped flood zones and their statistical flooding intervals are estimations based on the data and technology available at the time of mapping. Actual floodplains may extend beyond FEMA-mapped flood zones. Due to many variables including the unpredictable nature of some floods, local drainage problems, and the variable intensity of land development in watersheds, some flood-prone areas may not appear on the maps. FEMA flood zones are included in the Habitat Summary to highlight areas where floodplain habitats may occur, which can provide a starting point for proactive conservation planning and restoration.

Wetlands ([Figure 6](#))

There are many types of wetlands in the Hudson River Estuary watershed, including wet meadows, emergent marsh, forested and shrub swamps, vernal pools, floating and submerged vegetation, and open water, as well as the variety of tidal wetland types in the estuary discussed in the [Coastal and Shoreline Habitat](#) section ([Figure 3](#)).

Each wetland type provides habitats for different groups of plants and animals. Many wildlife species depend upon wetlands for part of their life cycle, including many species of conservation concern in New York State.

In addition to providing critical habitat for many plants and animals, wetlands help to control flooding and reduce damage from storm surge, recharge groundwater, filter and purify surface water, and provide recreation opportunities. The upland area surrounding a wetland is essential to its survival and function; both may diminish when a wetland is surrounded by pavement, buildings, and pollution-generating or other incompatible land uses ([Environmental Law Institute 2008](#)).

Wetlands are areas saturated by surface or groundwater sufficient to support distinctive vegetation adapted for life in saturated soil conditions.

Knowing about local wetlands enables municipalities to proactively plan to conserve this critical part of our life support system. Although several existing maps provide approximate locations and extent of wetlands, they are inherently inaccurate and not a substitute for site visits and on-the-ground delineation. Nonetheless, towns can use these maps as a starting point for inventorying local wetlands and supplement them with more refined data as they become available.

In [Figure 6](#), “known wetlands” are shown from the U.S. Fish and Wildlife Service’s (USFWS) [National Wetlands Inventory \(NWI\)](#). DEC’s [Freshwater Wetlands Program](#) maps (which only include wetlands larger than 12.4 acres, unless designated “of unusual local importance”) are shown as a hatched overlay. Open water habitats including the Hudson River are symbolized in blue as “waterbodies.” NWI data are also available for viewing on the NWI [Wetlands Mapper](#) and NYS freshwater wetland maps can be viewed using the [Environmental Resource Mapper](#). County soil maps are another good source for predicting the location of potential wetlands. In [Figure 6](#), “probable wetland areas” are soil survey units classified as very poorly drained or poorly drained, and “possible wetland areas” are units classified as somewhat poorly drained (after Kiviat and Stevens 2001). Note that the probable and possible wetland areas cover a greater area than NWI and DEC wetland layers. NWI maps often underestimate wetland area and omit smaller and drier wetlands

(Zucker and Lau, unpublished report). In particular, vernal pools, wet meadows, and swamps are often under-represented on maps. Many of DEC's regulatory maps are outdated and have similar inaccuracies (Huffman and Associates 2000). Likewise, note that soil units are only mapped to an approximate area of about two acres, and that soils within the unit may not be homogeneous. Areas shown as supporting probable or possible wetlands should always be verified in the field for the purposes of environmental review.

The town's Hudson River tidal wetlands and other freshwater wetlands in the Hudson River and Binnen Kill corridor are the largest and most biologically significant in the town. Extensive streamside wetlands also occur along the Vroman Kill and Onesquethaw Creek and are especially important wildlife habitats in addition to their role in filtering contaminants from runoff and holding floodwaters. A large wetland complex is also present near Beckers Corners and Maple Ave in Selkirk. NWI maps offer some general information on wetland habitat (e.g., forested, emergent), but in general, existing map resources are not very informative as far as habitat type or importance for biodiversity. Communities can learn more about habitat values by conducting local surveys and studies. The 2005 Biodiversity Assessment Training Study of the Coeymans-Onesquethaw Creek corridor notes large areas of hardwood swamp in the riparian areas along Coeymans Creek and in other low-lying areas subject to frequent flooding. The study also notes an abundance of wet meadow habitats associated with poor drainage conditions on clayey soils. Large "possible wetland areas" mapped in Figure 6 correspond primarily to Rhinebeck silty clay loam soils, which were formed in silt and clay deposits on the glacial lake plains of eastern Albany County. Abandoned agricultural fields on these soils may develop into wet meadows due to the shallow seasonal high water table.

Although no [vernal pools](#) have been mapped in Bethlehem, local wildlife records in the *NY Amphibian and Reptile Atlas* of wood frog, spotted salamander, and NY-Special Concern Jefferson salamander indicate that vernal pools occur in the town. [Vernal pools](#) are small, isolated wetlands that are often dry in summer. They provide habitat for many animals, including forest amphibians like wood frog and several salamander species, which use the pools for breeding. Vernal pools often go undetected in the forest due to their small size and seasonal drawdown. Vernal pools and other small, isolated wetlands are also vulnerable due to limited regulatory protection (see [Conserving Small Wetlands in the Hudson Valley](#) for more information). Knowing there are unmapped vernal pools in Bethlehem, outreach to landowners with potential habitat may help promote stewardship and land-use decisions that protect the pools, surrounding forest habitat, and associated wildlife. Specific management recommendations can be found in [Best Development Practices: Conserving Pool-Breeding Amphibians in Residential and Commercial Development in the Northeastern United States](#) (Calhoun and Klemens 2002) and [Maine Municipal Guide to Mapping and Conserving Vernal Pool Resources](#) (Morgan and Calhoun 2012). Biodiversity assessment may reveal additional wetland habitat types in the town and provide detail on quality and habitat use.

Large Forests ([Figure 7](#))

Large forests provide numerous benefits including wildlife habitat, clean water, climate moderation, and forest products. In general, larger forests provide higher quality habitat and greater benefits than smaller ones. However, the value of each forest is relative to the values of surrounding habitats. For example, a series of forest patches along a stream helps maintain water quality while creating a wildlife travel corridor. Similarly, wooded hedgerows in farm fields often provide a refuge for animals moving through the landscape.

We know little about the on-the-ground habitat quality of individual forests in Bethlehem (e.g., presence of invasive species, lack of understory vegetation, etc.) beyond the few areas that have been mapped and surveyed by NYNHP. However, the "birds-eye view" shows that most of Bethlehem is covered in forests of varying sizes. [Figure 7](#) shows large forest patches in Bethlehem. The map was created from land cover data

developed for the Coastal Change Analysis Program (National Oceanic and Atmospheric Administration 2010). Land cover categories considered 'forest' for this analysis included deciduous forest, evergreen forest, mixed forest, and palustrine forested wetland. Roads were buffered and removed from forest patches to show results of development-related fragmentation. Interstate roads were buffered by a total of 300 feet and state and county roads by 66 feet (Dunn 2008). Forest patch size classifications follow the Orange County Open Space Plan (Orange County Planning Department 2004) as cited in Strong (2008).

Forest fragmentation is the process of breaking large patches of forest into smaller areas, often by clearing it for new roads or development. Fragmentation decreases forest habitat quality and health, disrupts wildlife movement, and facilitates the spread of invasive species. These impacts are greatest at forest edges but can extend for hundreds of feet into forest patches, often displacing sensitive species that depend on interior forest.

Bethlehem's forests are relatively small compared to more rural parts of Albany County and the Hudson Valley; however, there remain sizeable patches of forest habitat in the more undeveloped parts of the town, as well as small patches and street trees that contribute to a better quality of life in suburban areas. Intact forest patches ranging from 200-1,700 acres remain throughout Bethlehem, primarily in the ravines formed by the Normans Kill and Vloman Kill and their tributaries. "Stepping stone" forest patches such as these may provide habitat for some forest interior species as well as relatively broad corridors for wildlife movement and plant dispersal. They enable a large array of species, including wide-ranging and area-sensitive species, to move from one habitat to another across a landscape fragmented by roads and developed areas unsuitable as habitat. Forested stream corridors are particularly favored travel routes for many species of wildlife. The 200-acre threshold is often considered a minimum size for intact forest ecosystems. Smaller forests have limited habitat value for forest interior bird species and suffer greater impacts from development. Forest edge disturbances dominate small forests, such as invasive species, increased predation levels, and micro-climatic differences. Most of the larger forest patches mapped in Bethlehem appear to have considerable edge habitat, and many are in fact divided by local roads, driveways, or small-scale development. These forests nevertheless serve a critical ecological function as buffers to the town's streams and help to protect highly erodible clay slopes, promote groundwater infiltration, and reduce flood damage. Regardless of size or habitat values, all forests and trees in the town help to manage stormwater, moderate temperature, and improve air quality, among other ecosystem benefits.

The largest intact forest patch in the town occurs on a knoll west of Old Quarry Road in South Bethlehem. It continues into the town of New Scotland along the Onesquethaw Creek corridor, measuring over 2600 acres, considered "locally significant." Forest-dependent birds often require a least 2,500 acres of intact interior forest habitat to maintain viable populations. This forest lies within the Limestone and Shale Significant Biodiversity Area and may support rare plant species typical of calcium-rich environments. The 2005 Biodiversity Assessment Training Study of the Coeymans-Onesquethaw Creek corridor notes a unique carbonate crest ledge habitat found in the vicinity of Hollyhock Sanctuary with many species that thrive on the calcium-rich soils. Several rare plants of forested limestone environments have been documented in Bethlehem including [golden-seal](#); see [Table 1](#) for a complete list.

The Biodiversity Assessment also describes the prevalence of forested steep clay bluffs and ravines along the Onesquethaw-Coeymans Creek corridor. Similar forested ravine conditions are also known from the Normans Kill corridor, and likely occur elsewhere in the town. Clay bluff and ravine habitats near the Hudson River are characterized by narrow, steep-sided ravines cut by small streams, with steep bluffs along the river. The clayey soils formed in prehistoric Lake Albany during the melting of the glaciers (Kiviat and Stevens 2001). Maintaining forest along clay bluffs and ravines is especially beneficial to stabilize vulnerable slopes, prevent further erosion, and protect stream habitats.

Wildlife records confirm the availability of high-quality forest habitat in Bethlehem. The [2000-2005 NYS Breeding Bird Atlas](#) documented numerous forest-interior bird species of conservation concern in the town,

including many NY-Species of Greatest Conservation Need such as black-throated blue warbler, scarlet tanager, and wood thrush ([Table 1](#)). Two NY-Special Concern raptors were also documented in Bethlehem: Cooper's hawk and sharp-shinned hawk. Audubon New York's website has specific information on [managing habitat for forest birds](#).

Bethlehem's forests also provide important summer habitat for US-Endangered [Indiana Bat](#) and US-Threatened [Northern Long-eared Bat](#), which hibernate in multiple caves in the neighboring towns of New Scotland and Coeymans. Other hibernating bats and tree bats are also likely present in the town during warmer months. Bats will forage for insects throughout wooded areas and along streams, and female bats will roost in snags and dying trees. The spread of the fungal disease [white-nose syndrome](#) has devastated bat colonies throughout the northeast, resulting in die-offs of up to 99% since 2006. Retaining forest canopy, mature trees, and minimizing fragmentation of mature forest patches may be important for local bat populations. Some restrictions protect threatened bat species from tree-cutting, especially during the period when mothers are birthing and raising pups. The DEC Region 4 Office in Schenectady should be contacted at (518) 357-2355 with any concerns or questions about protected bat species in Bethlehem.

Conserving the town's large intact forested areas and connections between them will help ensure there is enough habitat to sustain forest plants and animals. This strategy will also help to preserve the other benefits that forests provide residents.

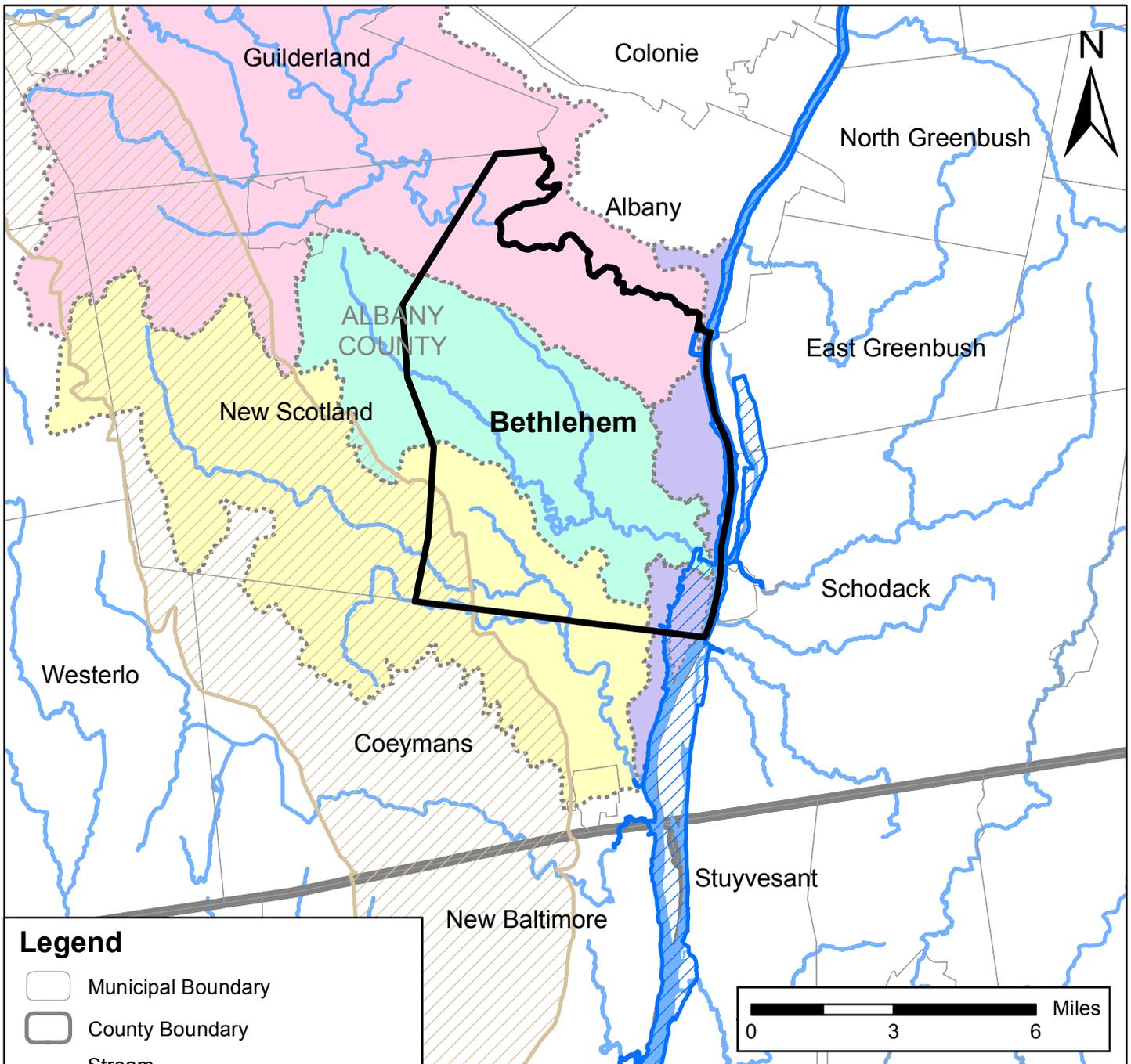
Grasslands, Shrublands, and Young Forests (not mapped)

Recently disturbed sites, such as hayfields, abandoned farm fields, or forest clearings, can provide important habitat for species that require grasslands, shrublands, and young forests. These successional habitat types are transitional and relatively short-lived, and typically require periodic maintenance to avoid becoming more densely vegetated, eventually developing a canopy and becoming forest. We can infer from aerial photography and breeding bird records that valuable grasslands, shrublands, and young forests occur in Bethlehem (see [Table 1](#)).

Grassland or [meadow](#) habitat can support a variety of life, including rare plants, butterflies, reptiles, and birds, in addition to providing agricultural uses and scenic values. The quantity and quality of grasslands for wildlife have rapidly decreased in the Northeast during the last century due to increased human population, changes in agricultural technology, and abandonment of family farms. This continuing trend threatens populations of grassland birds that have adapted to the agricultural landscape. The [2000-2005 NYS Breeding Bird Atlas](#) documented breeding by six grassland bird species of conservation concern in the Bethlehem area, including Species of Greatest Conservation Need such as eastern meadowlark, bobolink, and American kestrel, NY-Special Concern grasshopper sparrow, and NY-Threatened [Henslow's sparrow](#) (see [Table 1](#)). Audubon New York offers guidance on [managing habitat for grassland birds](#). Several rare plants of open, grass-dominated habitats have also been documented in the town, including NY-Threatened [mock-pennyroyal](#) and NY-Endangered [side-oats grama](#).

Shrublands and young forests are transitional habitats characterized by few or no mature trees, with a diverse mix of shrubs and/or tree saplings, along with openings where grasses and wildflowers grow. They can occur in recently cleared areas and abandoned farmland and are sometimes maintained along utility corridors by cutting or herbicides. These habitats are important for many wildlife species declining throughout the region because former agricultural areas have grown into forests, and natural forest disturbances that trigger young forest growth, such as fires, have been suppressed. Records from the *NYS Breeding Bird Atlas* support the presence of 14 species of conservation concern in Bethlehem that prefer young forest and shrubland habitat, including American woodcock, blue-winged warbler, brown thrasher, ruffed grouse, and NY-Special Concern whip-poor-will (see [Table 1](#)). For more information, see the [DEC Young Forest Initiative](#) and Audubon's guidance on [managing habitat for shrubland birds](#).

Figure 1: Regional Context of Bethlehem, NY



Legend

- Municipal Boundary
- County Boundary
- Stream

Watershed

- Normans Kill
- Vloman Kill
- Coeymans-Onesquethaw Creek
- Direct drainage to Hudson River

Significant Biodiversity Areas

- Upper Hudson River Estuary
- Hudson Valley Limestone and Shale Ridge

This map shows the location of the Town of Bethlehem, Albany County, NY in relation to its major watersheds and significant biodiversity areas. This map was produced as part of a Habitat Summary for the town. For more information, please contact NYSDEC's Hudson River Estuary Program Conservation and Land Use Specialist Ingrid Haeckel at (845)256-3829 or ingrid.haeckel@dec.ny.gov. <http://www.dec.ny.gov/lands/5094.html>

Data Sources:

US Geological Survey: watersheds, major streams; New York Natural Heritage Program and NYSDEC: significant biodiversity areas; NYS Office of Information Technology Services: municipal and county boundaries

Map Created 2017



Cornell University

Figure 2: Significant Ecological Features in Bethlehem, NY

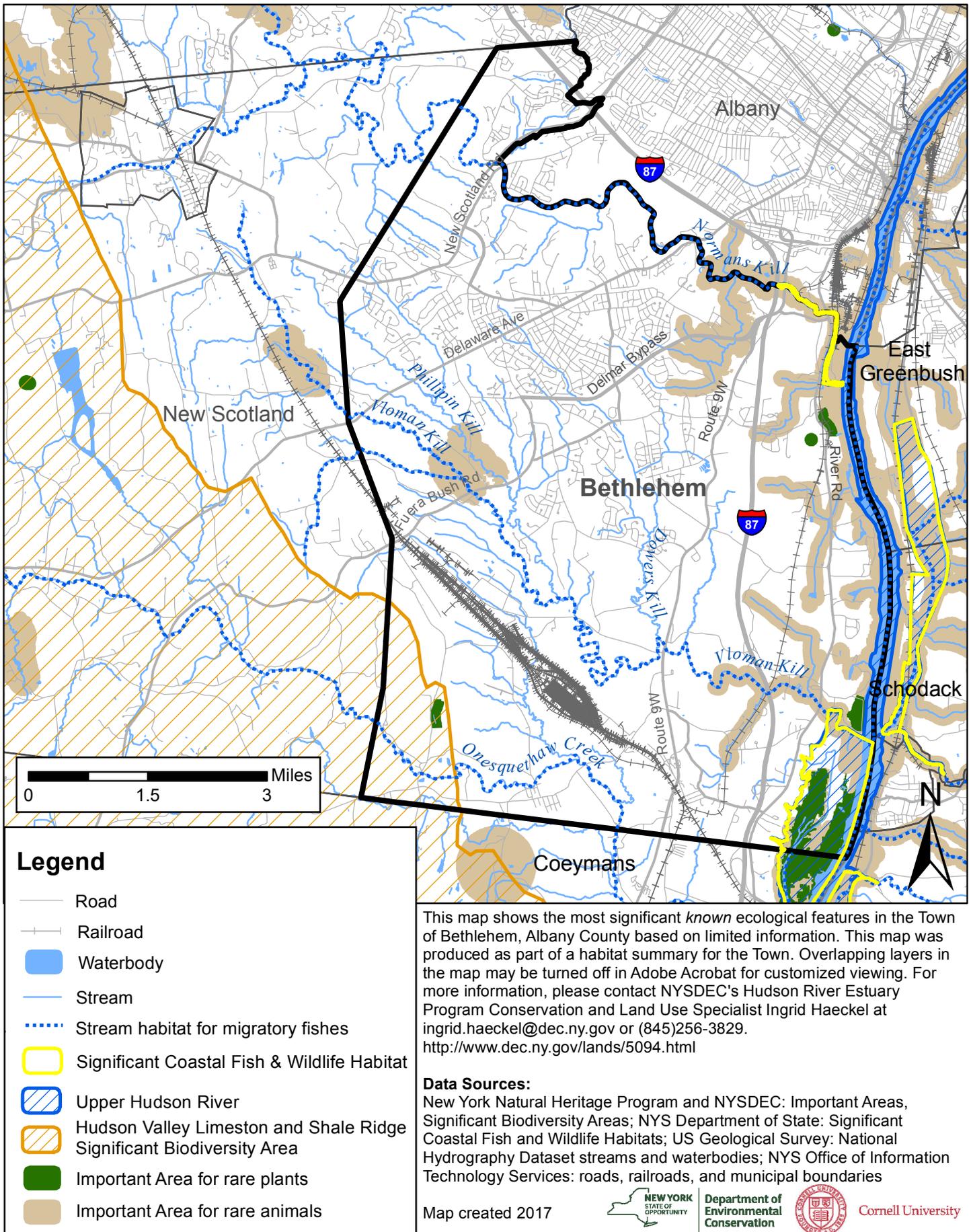


Figure 3: Hudson River Coastal Habitats in the Town of Bethlehem, NY

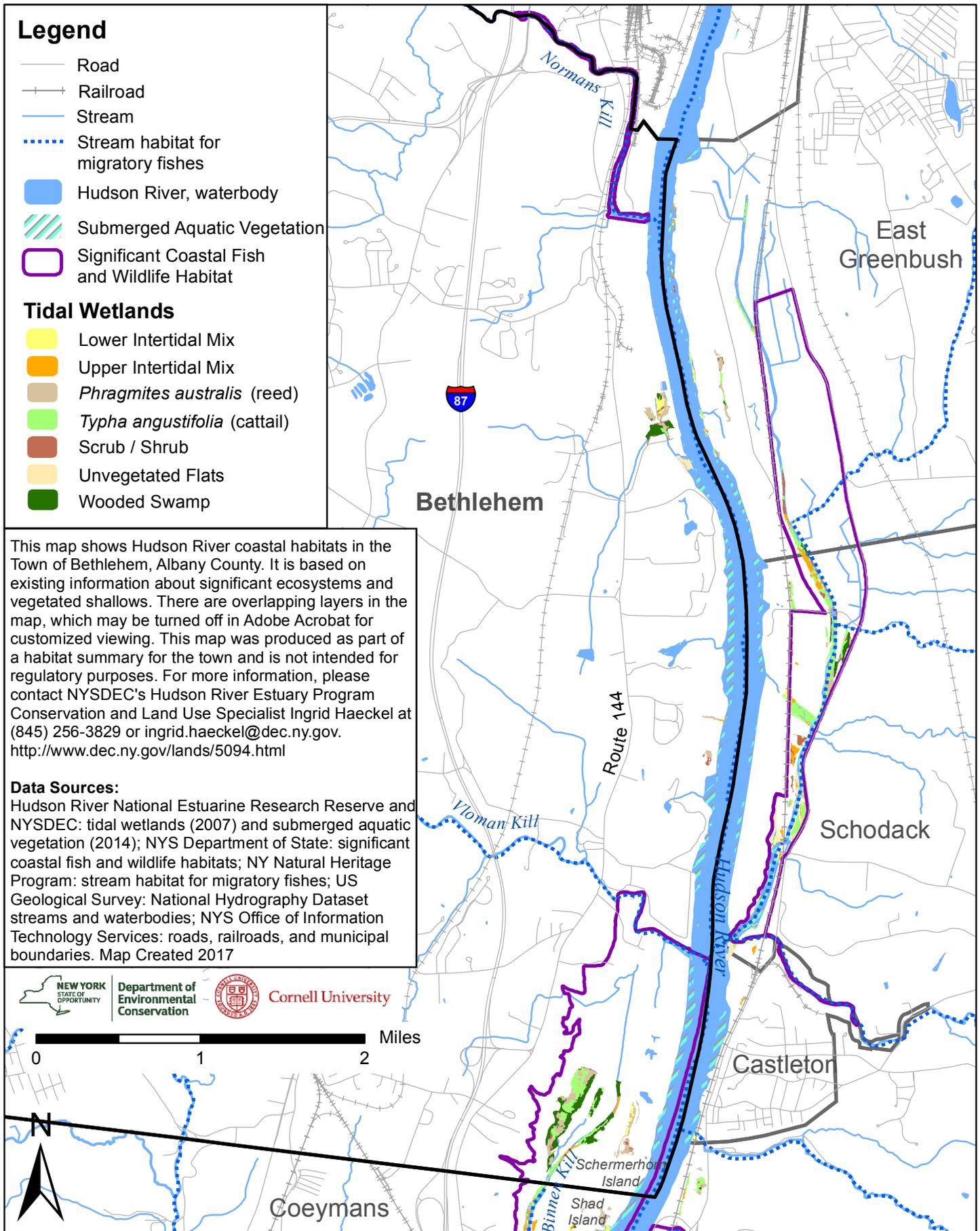


Figure 4: Hudson River Shoreline Status and Tidal Wetland Pathways in the Town of Bethlehem, NY

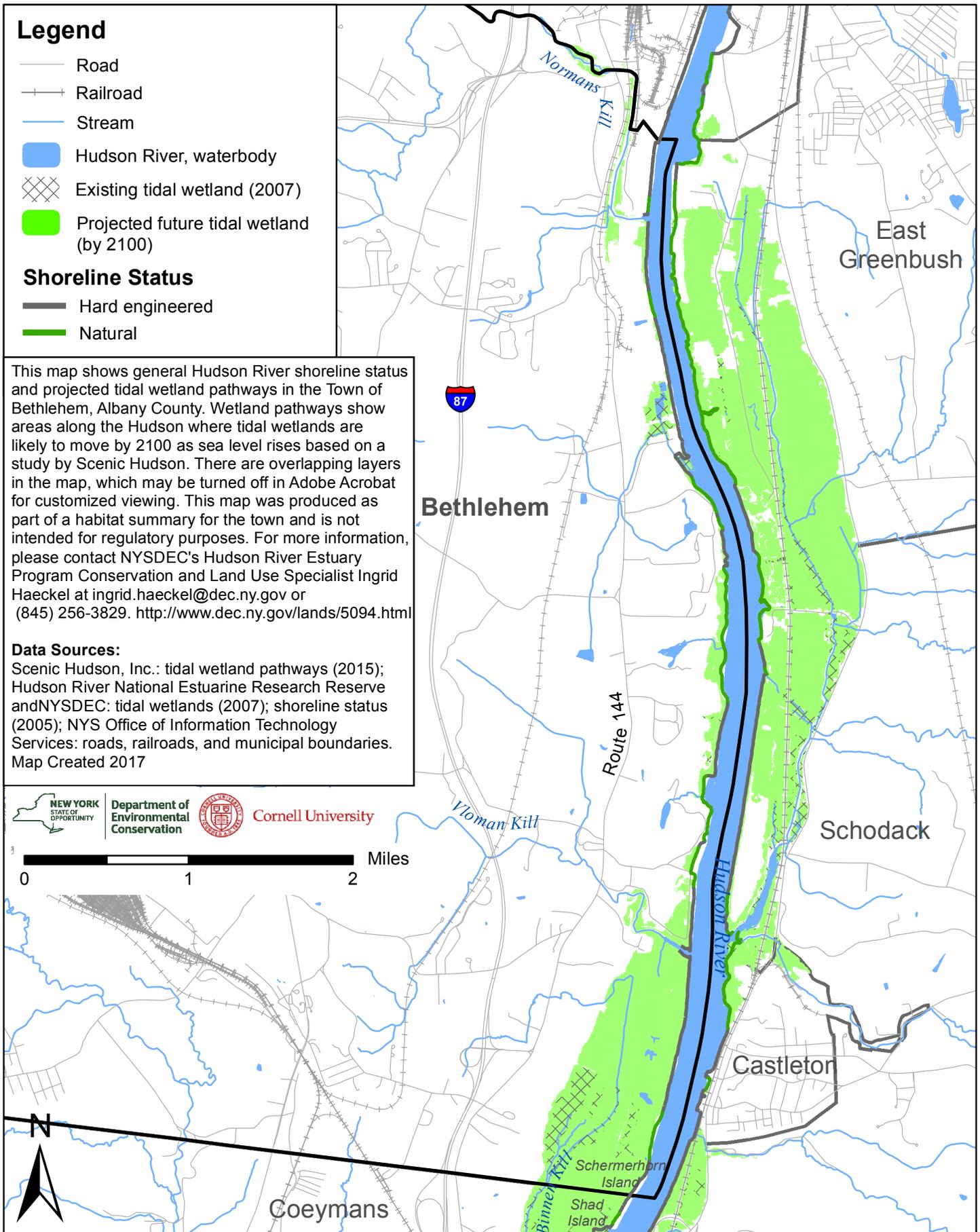
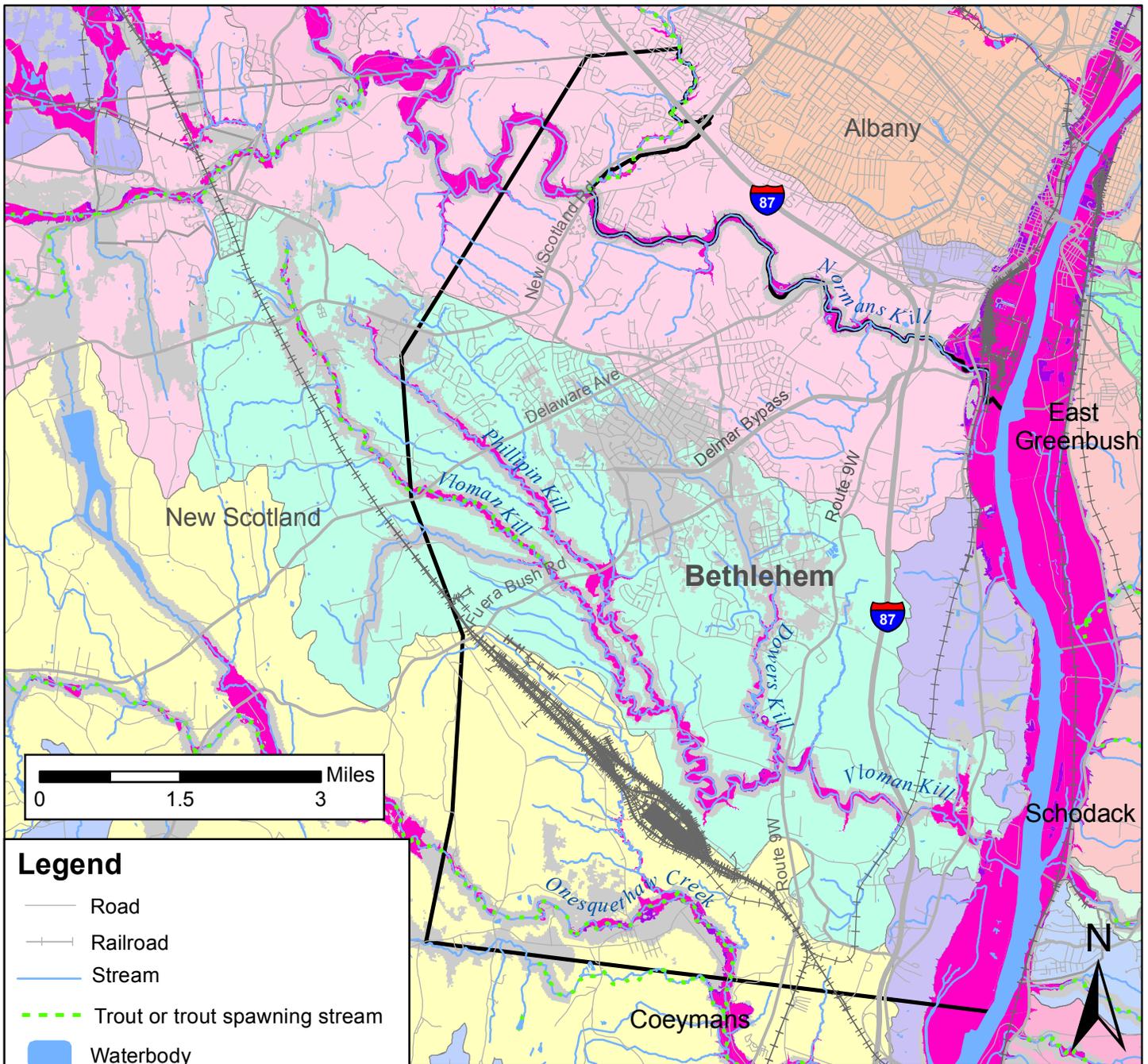


Figure 5: Streams in Bethlehem, NY



Legend

- Road
- +— Railroad
- Stream
- - - Trout or trout spawning stream
- Waterbody
- Active River Area

Floodplain

- 1% Annual Chance (100 year)
- 0.2% Annual Chance (500 year)

Watershed

- Normans Kill
- Vloman Kill
- Coeymans-Onesquethaw Creek
- Direct drainage to Hudson River

This map shows streams, trout or trout spawning status, floodplains, active river areas, waterbodies, and watersheds in the Town of Bethlehem, Albany County. This map was produced as part of a habitat summary for the town and is not intended for regulatory purposes. For more information, please contact NYSDEC's Hudson River Estuary Program Conservation and Land Use Specialist Ingrid Haeckel at (845)256-3829 or ingrid.haeckel@dec.ny.gov. <http://www.dec.ny.gov/lands/5094.html>

Data Sources:

US Geological Survey: streams, waterbodies, watersheds; NYS Department of Environmental Conservation: trout or trout spawning status from Water Quality Classifications and Standards; The Nature Conservancy: active river areas; Federal Emergency Management Agency: Albany County DFIRM and Rensselaer County Q3 flood hazard mapping; NYS Office of Information Technology Services: roads, railroads, municipal boundaries.

Map created 2017

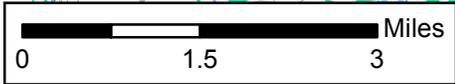
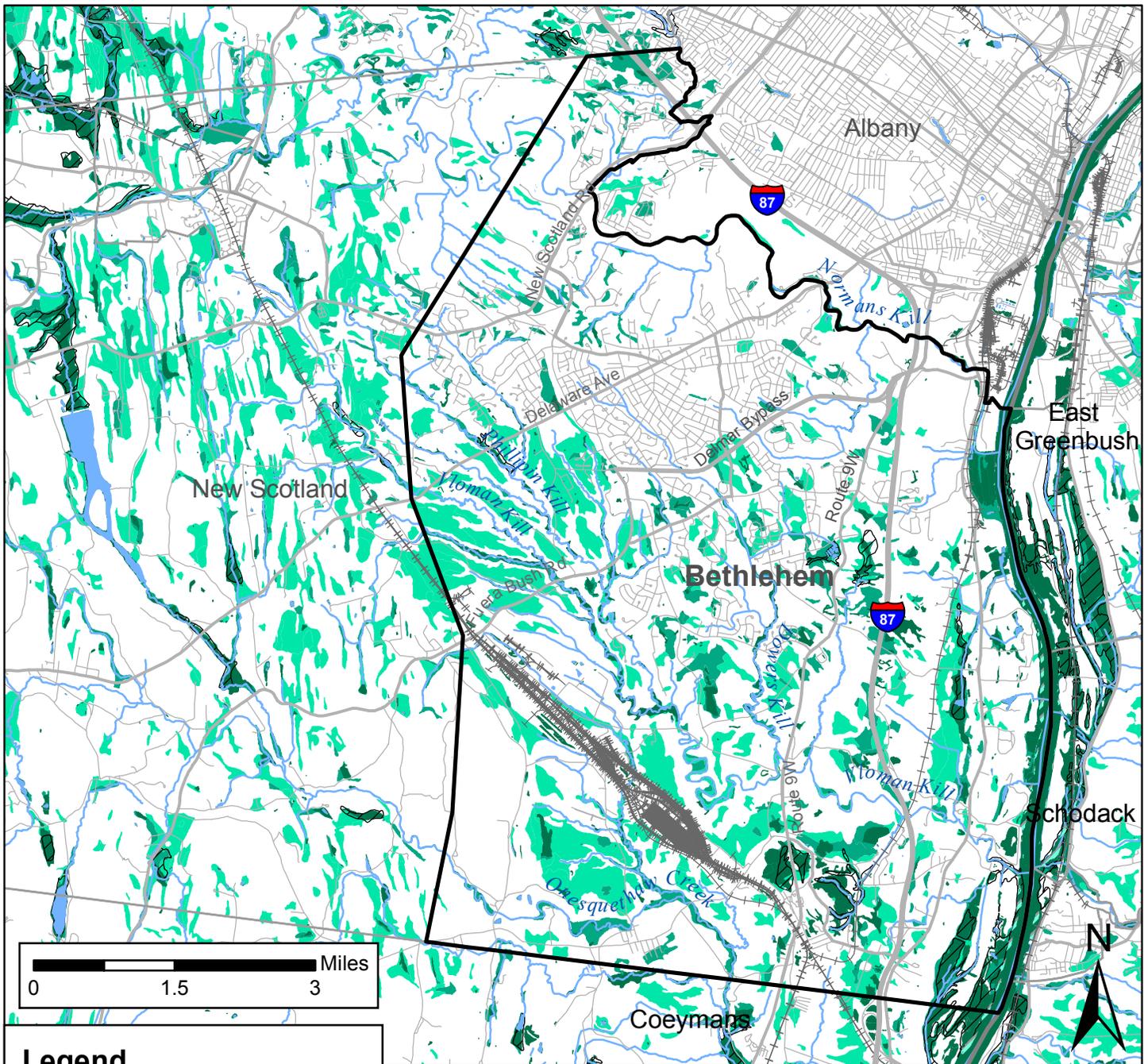


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Figure 6: Wetlands in Bethlehem, NY



Legend

- Road
- +— Railroad
- Stream
- Waterbody
- ▨ Submerged aquatic vegetation
- ▨ NYSDEC Freshwater Wetland
- Known wetland (NW1)
- Probable wetland area
- Possible wetland area

This map shows *known* wetlands from the National Wetlands Inventory (NWI), NYSDEC Freshwater Wetland Map, and NYSDEC tidal wetlands mapping, as well as potential wetlands in the Town of Bethlehem, Albany County, NY. Probable and possible wetland areas were identified based on soil drainage class in the Albany County Soil Survey; see habitat summary text for more details. This map was produced as part of a habitat summary for the town and is not intended for regulatory purposes. For more information, please contact NYSDEC's Hudson River Estuary Program Conservation and Land Use Specialist Ingrid Haeckel at (845)256-3829 or ingrid.haeckel@dec.ny.gov. <http://www.dec.ny.gov/lands/5094.html>

Data Sources: US Fish and Wildlife Service: National Wetlands Inventory; US Geological Survey: National Hydrography Dataset; Natural Resources Conservation Service: county soil survey data; NYS Department of Environmental Conservation and Hudson River National Estuarine Research Reserve: tidal wetlands (2007); NYS Office of Information Technology Services: roads, railroads, municipal boundaries

Map created 2017

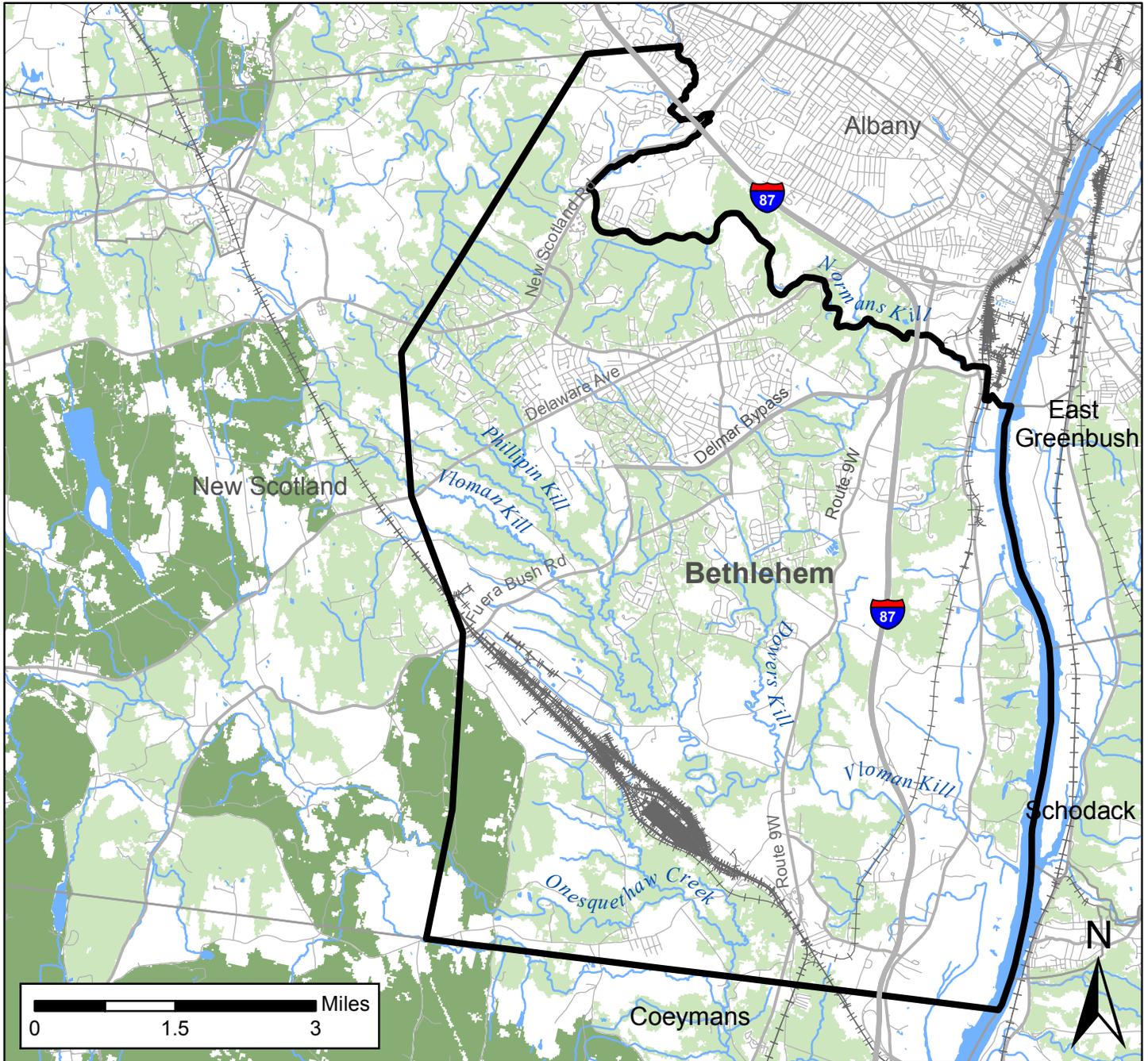


Department of Environmental Conservation



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Figure 7: Large Forests in Bethlehem, NY



Legend

- Road
- +— Railroad
- Stream
- Waterbody

Forest Patch Size (acres)

- Stepping Stone (200-1999)
- Locally Significant (2000-5999)
- Regionally Significant (6000-14999)
- Globally Significant (>15000)

This map shows contiguous forested patches of New York State by acreage for the Town of Bethlehem, Albany County. The patches were developed using 2010 forest cover data from the Coastal Change Analysis Program and buffered roads. This map was produced as part of a habitat summary for the town and is not intended for regulatory purposes. For more information, please contact NYSDEC's Hudson River Estuary Program Conservation and Land Use Specialist Ingrid Haeckel at (845)256-3829 or ingrid.haeckel@dec.ny.gov. <http://www.dec.ny.gov/lands/5094.html>

Data Sources:

NOAA Coastal Change Analysis Program: 2010 land cover
 Cornell University Department of Natural Resources: forest fragmentation analysis
 US Geological Survey: National Hydrography Dataset streams and waterbodies
 NYS Office of Information Technology Services: roads, railroads, and municipal boundaries

Map created 2017



Cornell University

Species and Ecosystems of Conservation Concern in the Town of Bethlehem

Table 1. Species and Ecosystems of Conservation Concern in Bethlehem, NY

The following table lists species of conservation concern that have been recorded in Bethlehem, NY. The information comes from the [New York Natural Heritage Program](#) (NYNHP) biodiversity databases, the [1990-1999 New York Amphibian and Reptile Atlas](#) (NYARA), and the [2000-2005 New York State Breeding Bird Atlas](#) (NYBBA). Species from the NYBBA are included in the table if they were documented in Atlas blocks that are more than 50% in Bethlehem. The table only includes species listed in New York as [endangered](#) (at the state (NYS) and/or federal (US) level), [threatened](#), [special concern](#), [rare](#), [Species of Greatest Conservation Need](#) (SGCN), or a [Hudson River Valley Priority Bird](#) species recognized by Audubon New York. Historical records are provided from the NYNHP biodiversity databases. Generalized primary habitat types are provided for each species, but for conservation and planning purposes, it's important to recognize that many species utilize more than one kind of habitat. More information on rare animals, plants, and ecological communities can be found at <http://guides.nynhp.org>. **Note:** Additional rare species and habitats may occur in the Town of Bethlehem.

Common Name	Scientific Name	General Habitat	NYS Conservation Status					Data Source
			Hudson River Valley Priority Bird	Species of Greatest Conservation Need xx = high priority	Special Concern	Threatened	Endangered	
Mammals								
Indiana Bat	<i>Myotis sodalis</i>	cave, forest		xx			US NY	NYNHP
Northern Long-eared Bat	<i>Myotis septentrionalis</i>	cave, forest		xx		US NY		NYNHP

Birds								
American Bittern	<i>Botaurus lentiginosus</i>	coastal/ wetlands	x	x	x			NYDOS
American Goldfinch	<i>Spinus tristis</i>	shrubland/ young forest	x					NYBBA
American Kestrel	<i>Falco sparverius</i>	grassland	x	x				NYBBA
American Redstart	<i>Setophaga ruticilla</i>	forest	x					NYBBA
American Woodcock	<i>Scolopax minor</i>	shrubland/ young forest	x	x				NYBBA
Bald Eagle	<i>Haliaeetus leucocephalus</i>	coastal	x	x		NY		NYBBA, NYNHP
Baltimore Oriole	<i>Icterus galbula</i>	forest	x					NYBBA
Belted Kingfisher	<i>Megasceryle alcyon</i>	stream	x					NYBBA
Black-and-white Warbler	<i>Mniotilta varia</i>	forest	x					NYBBA
Black-billed Cuckoo	<i>Coccyzus erythrophthalmus</i>	shrubland/ young forest	x	x				NYBBA

Common Name	Scientific Name	General Habitat	NYS Conservation Status					Data Source
			<u>Hudson River Valley Priority Bird</u>	<u>Species of Greatest Conservation Need xx</u> = high priority	<u>Special Concern</u>	<u>Threatened</u>	<u>Endangered</u>	
Blackburnian Warbler	<i>Dendroica fusca</i>	forest	x					NYBBA
Black-throated Blue Warbler	<i>Dendroica caeruleascens</i>	forest	x	x				NYBBA
Blue-Winged Warbler	<i>Vermivora pinus</i>	shrubland/ young forest	x	x				NYBBA
Bobolink	<i>Dolichonyx oryzivorus</i>	grassland	x	xx				NYBBA
Broad-winged Hawk	<i>Buteo platypterus</i>	forest	x					NYBBA
Brown Thrasher	<i>Toxostoma rufum</i>	shrubland/ young forest	x	xx				NYBBA
Chestnut-sided Warbler	<i>Setophaga pennsylvanica</i>	shrubland/ young forest	x					NYBBA
Chimney Swift	<i>Chaetura pelagica</i>	urban	x					NYBBA
Cooper's Hawk	<i>Accipiter cooperii</i>	forest	x		x			NYBBA
Downy Woodpecker	<i>Picoides pubescens</i>	forest	x					NYBBA
Eastern Kingbird	<i>Tyrannus tyrannus</i>	shrubland/ young forest	x					NYBBA
Eastern Meadowlark	<i>Sturnella magna</i>	grassland	x	xx				NYBBA
Eastern Towhee	<i>Pipilo erythrophthalmus</i>	shrubland/ young forest	x					NYBBA
Eastern Wood-Pewee	<i>Contopus virens</i>	forest	x					NYBBA
Field Sparrow	<i>Spizella pusilla</i>	shrubland/ young forest	x					NYBBA
Grasshopper Sparrow	<i>Ammodramus savannarum</i>	grassland	x	xx	x			NYBBA
Henslow's Sparrow	<i>Ammodramus henslowii</i>	grassland	x	xx		NY		NYNHP
Least Bittern	<i>Ixobrychus exilis</i>	coastal/ wetlands	x	x		NY		NYDOS, NYNHP
Least Flycatcher	<i>Empidonax minimus</i>	forest	x					NYBBA
Louisiana Waterthrush	<i>Seiurus motacilla</i>	forest	x	x				NYBBA
Northern Flicker	<i>Colaptes auratus</i>	forest	x					NYBBA
Prairie Warbler	<i>Dendroica discolor</i>	shrubland/ young forest	x	x				NYBBA
Purple Finch	<i>Carpodacus purpureus</i>	forest	x					NYBBA
Rose-breasted Grosbeak	<i>Pheucticus ludovicianus</i>	forest	x					NYBBA

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Ruffed Grouse	<i>Bonasa umbellus</i>	shrubland/ young forest	x	x			NYBBA
Savannah Sparrow	<i>Passerculus sandwichensis</i>	grassland	x				NYBBA
Scarlet Tanager	<i>Piranga olivacea</i>	forest	x	x			NYBBA
Sharp-shinned Hawk	<i>Accipiter striatus</i>	forest	x	x	x		NYBBA
Veery	<i>Catharus fuscescens</i>	forest	x				NYBBA
Whip-poor-will	<i>Caprimulgus vociferus</i>	shrubland/ young forest	x	xx	x		NYBBA
Willow Flycatcher	<i>Empidonax traillii</i>	shrubland/ young forest	x				NYBBA
Wood Thrush	<i>Hylocichla mustelina</i>	forest	x	x			NYBBA
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	shrubland/ young forest	x				NYBBA
Yellow-throated Vireo	<i>Vireo flavifrons</i>	forest	x				NYBBA

Reptiles							
Common Snapping Turtle	<i>Chelydra s. serpentina</i>	wetland		x			NYARA
Northern Black Racer	<i>Coluber c. constrictor</i>	forest		x			NYARA
Northern Map Turtle	<i>Graptemys geographica</i>	coastal		x			NYARA
Wood Turtle	<i>Clemmys insculpta</i>	forest, riparian, grassland		xx	x		NYARA

Amphibians							
Four-toed Salamander	<i>Hemidactylium scutatum</i>	forest, wetland		xx			NYARA
Fowler's Toad	<i>Bufo fowleri</i>	forest, wetland		x			NYARA
Jefferson Salamander	<i>Ambystoma jeffersonianum x laterale</i>	forest, vernal pool			x		NYARA

Fish							
Shortnose Sturgeon	<i>Acipenser brevirostrum</i>	coastal	x			NY US	NYNHP
American eel	<i>Anguilla rostrata</i>	stream		xx			NYNHP

			NYS Conservation Status					
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Freshwater Mussels								
Alewife Floater	<i>Anodonta implicata</i>	coastal		xx			NY US	NYNHP

Butterflies, Dragonflies, and Damselflies								
Karner Blue	<i>Plebejus melissa samuelis</i>	pine bush		xx			NY US	NYNHP
Mottled Duskywing	<i>Erynnis martialis</i>	shrubland		xx	x			NYNHP
Cobra Clubtail	<i>Gomphus vastus</i>	coastal		x				NYNHP
Russet-tipped Clubtail	<i>Stylurus plagiatus</i>	coastal		x				NYNHP
Umber Shadowdragon	<i>Neurocordulia obsoleta</i>	coastal		x				NYNHP

Plants								
Davis' sedge	<i>Carex davisii</i>	coastal					NY	NYNHP
Downy Wood-mint	<i>Blephilia ciliata</i>	limestone outcrop, forest					NY	NYNHP
Golden-seal	<i>Hydrastis canadensis</i>	stream, forest, limestone					NY	NYNHP
Mock-pennyroyal	<i>Hedeoma hispida</i>	grassland/ sandy					NY	NYNHP
Side-oats Grama	<i>Bouteloua curtipendula</i> var. <i>curtipendula</i>	grassland/ rocky					NY	NYNHP
Troublesome Sedge	<i>Carex molesta</i>	grassland, limestone					NY	NYNHP
Violet Wood-sorrel	<i>Oxalis violacea</i>	forest, rocky					NY	NYNHP

Historical Records								
Riverine Clubtail	<i>Stylurus amnicola</i>	coastal						NYNHP
Eastern Pondmussel	<i>Ligumia nasuta</i>	coastal, stream		x				NYNHP
Tidewater Mucket	<i>Leptodea ochracea</i>	coastal		xx				NYNHP
Yellow Lampmussel	<i>Lampsilis cariosa</i>	coastal, stream		x				NYNHP
American Waterwort	<i>Elatine americana</i>	coastal					NY	NYNHP
Carey's Smartweed	<i>Persicaria careyi</i>	wetland					NY	NYNHP

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Cut-leaved Evening-primrose	<i>Oenothera laciniata</i>	sandy open soil				NY	NYNHP
Delmarva Beggar-ticks	<i>Bidens bidentoides</i>	coastal					NYNHP
Dune Sandspur	<i>Cenchrus tribuloides</i>	sand dunes/ pine bush				NY	NYNHP
Estuary Beggar-ticks	<i>Bidens hyperborea</i> <i>var. hyperborea</i>	coastal				NY	NYNHP
Estuary Hatpins (extirpated from NYS)	<i>Eriocaulon parkeri</i>	coastal					NYNHP
Glaucous Sedge	<i>Carex glaucoidea</i>	forest				NY	NYNHP
Great Plains Flatsedge	<i>Cyperus lupulinus</i> <i>ssp. lupulinus</i>	sandy open soil				NY	NYNHP
Green Rock-cress	<i>Boechera missouriensis</i>	forest, rocky				NY	NYNHP
Hooker's Orchid	<i>Platanthera hookeri</i>	forest				NY	NYNHP
Large Twayblade	<i>Liparis liliifolia</i>	forest				NY	NYNHP
Nodding Pogonia	<i>Triphora trianthophora</i>	stream				NY	NYNHP
Northern Bog Violet	<i>Viola nephrophylla</i>	wetland				NY	NYNHP
Puttyroot	<i>Aplectrum hyemale</i>	forest				NY	NYNHP
Small's Knotweed	<i>Polygonum aviculare</i> <i>ssp. buxiforme</i>	sandy open soil				NY	NYNHP
Swamp Lousewort	<i>Pedicularis lanceolata</i>	wetland				NY	NYNHP
Woodland Agrimony	<i>Agrimonia rostellata</i>	forest				NY	NYNHP

General Conservation Measures for Protecting Natural Areas and Wildlife



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- **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, landslides, and wind exposures wherever possible. Discourage development that would interfere with these processes.
- **Restore and maintain broad buffer zones** of natural vegetation along streams, along 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 (such as mined lands), “infill” development, and “adaptive re-use” of existing structures wherever possible, 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**; 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 surfaces) and maximize onsite runoff retention and infiltration to help protect groundwater recharge, and surface water quality and flows.
- **Restore degraded habitats wherever possible**, but do not use restoration projects as a “license” to destroy existing habitats.

Source: Kiviat, E. & G. Stevens. 2001. Biodiversity Assessment Manual for the Hudson River Estuary Corridor. NYS Department of Environmental Conservation, Albany, NY.

References

Audubon NY. 2009. Bird Conservation in the Hudson River Valley [website]. <http://ny.audubon.org/conservation/udson-river-valley-conservation>. Ithaca, NY.

Calhoun, A. and M. Klemens. 2002. Best development practices: Conserving pool-breeding amphibians in residential and commercial developments in the northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, New York. <http://maineaudubon.org/wp-content/uploads/2012/08/Best-Development-Practices-Conserving-Pool-breeding-Amph.pdf>

Ecological Society of America. 1990. Ecosystem Services Fact Sheet. Washington, DC. Available at <http://www.esa.org/ecoservices/comm/body.comm.fact.ecos.html>

Environmental Law Institute. 2008. Planner's Guide to Wetland Buffers for Local Governments. Washington, DC. Available at www.eli.org/sites/default/files/eli-pubs/d18_01.pdf

Haeckel, I. and L. Heady. 2014. Creating a Natural Resources Inventory: A Guide for Communities in the Hudson River Estuary Watershed. Department of Natural Resources, Cornell University, and New York State Department of Environmental Conservation, Hudson River Estuary Program, Ithaca, NY. Available at www.dec.ny.gov/lands/100925.html

Heady, L. and G. Stevens. 2015. Guidebook for Biodiversity Assessment: A Companion to the Biodiversity Assessment Manual for the Hudson River Estuary Corridor. Hudsonia Ltd., Annandale, NY.

Horton, R., D. Bader, C. Rosenzweig, A. DeGaetano, and W. Solecki. 2014. Climate Change in New York State: Updating the 2011 ClimAID Climate Risk Information. New York State Energy Research and Development Authority (NYSERDA), Albany, NY. Available at www.nyserda.ny.gov/climaid

Huffman & Associates, Inc. 2000. Wetlands Status and Trend Analysis of New York State - Mid-1980's to Mid-1990's. Prepared for New York State Department of Environmental Conservation. Larkspur, California. Available at http://www.dec.ny.gov/docs/wildlife_pdf/wetstattrend2.pdf

Kiviat, E. and G. Stevens. 2001. Biodiversity Assessment Manual for the Hudson River Estuary Corridor. NYS Department of Environmental Conservation, Albany, NY.

Knab-Vispo, C. and C. Vispo. 2010. Floodplain Forests of Columbia and Dutchess Counties, NY: Distribution, Biodiversity, Classification, and Conservation. Farmscape Ecology Program, Hawthorne Valley Farm, Ghent, NY. Available at http://hvfarmscape.org/sites/default/files/fep_floodplain_forest_report_nov_2010.pdf

Morgan, D. and A. Calhoun. 2012. The Maine Municipal Guide to Mapping and Conserving Vernal Pools. University of Maine, Sustainability Solutions Initiative, Orono, ME. Available at <http://maineaudubon.org/wp-content/uploads/2012/08/MeAud-ME-Municipal-Guide-to-Mapping-and-Conserving-Vernal-Pool.pdf>

New York Amphibian and Reptile Atlas. 1990-1999. New York State Department of Environmental Conservation, Albany, NY. Website: <http://www.dec.ny.gov/animals/7140.html>

New York State Breeding Bird Atlas 2000. 2000 - 2005. Release 1.0. [updated 2007]. New York State Department of Environmental Conservation, Albany, NY. Available at <http://www.dec.ny.gov/animals/7312.html>

New York State Wildlife Action Plan. 2015. New York State Department of Environmental Conservation, Albany, NY. Available at <http://www.dec.ny.gov/animals/7179.html>

New York State Department of Environmental Conservation and New York Cooperative Fish and Wildlife Research Unit at Cornell University. 2015. Species of Greatest Conservation Need List. Available at: http://www.dec.ny.gov/docs/wildlife_pdf/sgnc2015list.pdf

New York Natural Heritage Program, New York State Department of Environmental Conservation. [data retrieved March 2017]. Biodiversity Databases, Element Occurrence Record Digital Data Set. Albany, NY. www.nynhp.org

New York Natural Heritage Program, New York State Department of Environmental Conservation. Biodiversity Databases, Important Areas Digital Data Set. [2013 update]. Albany, NY. www.nynhp.org

National Oceanic and Atmospheric Administration. 2010. Land Cover data for the Coastal Change Analysis Program. NOAA Coastal Service Center, Charleston, SC. Website: <https://coast.noaa.gov/dataregistry/search/collection/info/ccapregional>

Normans Kill Riparian Corridor Study. 2007. Prepared for Audubon New York by Albany County Department of Economic Development, Conservation and Planning, Albany, NY. Available at <http://www.hudsonwatershed.org/images/WaterShedManagementPlans/Normans-Kill-report.pdf>.

Onesquethaw-Coeymans Creek Watershed Study. 2008. Onesquethaw-Coeymans Creek Watershed Council and Capital District Regional Planning Commission, Albany, NY. Available at <http://www.hudsonwatershed.org/images/WaterShedManagementPlans/onesquethaw.pdf>

Onesquethaw-Coeymans Watershed Management Plan. 2010. Onesquethaw-Coeymans Creek Watershed Council, Albany, NY. Available at <http://www.townofnewscotland.com/DocumentCenter/Home/View/374>

Orange County (NY) Planning Department. 2004. Orange County Open Space Plan. Goshen, NY. Available at http://www.orangecountygov.com/filestorage/124/1362/1460/10182/Supplement_1_Open_Space_Plan.pdf

Penhollow, M., P. Jensen, and L. Zucker. 2006. Wildlife and Habitat Conservation Framework: An Approach for Conserving Biodiversity in the Hudson River Estuary Corridor. New York Cooperative Fish and Wildlife Research Unit, Cornell University and New York State Department of Environmental Conservation, Hudson River Estuary Program, Ithaca, NY. Available at <http://www.dec.ny.gov/lands/5096.html>

Smith, M.P., R. Schiff, A. Olivero, and J. MacBroom. 2008. The active river area: A conservation framework for protection of rivers and streams. The Nature Conservancy, Boston, MA. Available at https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/Documents/ED_freshwater_ARA_NE2008.pdf

Strong, K. 2008. Conserving Natural Areas and Wildlife in Your Community: Smart Growth Strategies for Protecting the Biological Diversity of New York's Hudson River Valley. New York Cooperative Fish and Wildlife Research Unit, Cornell University, and New York State Department of Environmental Conservation, Hudson River Estuary Program, Ithaca, NY. <http://www.dec.ny.gov/lands/50083.html>

Tabak, N. and S. Spector. 2016. Protecting the Pathways: A Climate Change Adaptation Framework for Hudson River Estuary Tidal Wetlands. Scenic Hudson, Poughkeepsie, NY. <http://www.scenichudson.org/sites/default/files/protecting-the-pathways.pdf>

Tabak, N.M., M. Laba, and S. Spector. 2016. Simulating the Effects of Sea Level Rise on the Resilience and Migration of Tidal Wetlands along the Hudson River. PLoS ONE 11(4): e0152437. doi:10.1371/journal.pone.0152437. Available at <http://www.scenichudson.org/sites/default/files/tabak-et-al-2016.pdf>

White, E.L., J.J. Schmid, T.G. Howard, M.D. Schlesinger, and A.L. Feldmann. 2011. New York State freshwater conservation blueprint project, phases I and II: Freshwater systems, species, and viability metrics. New York Natural Heritage Program, The Nature Conservancy, Albany, NY. Available at http://nynhp.org/files/FreshwaterBlueprint2011/NYS_Freshwater_Blueprint_30Dec2011.pdf

Zucker, L. and L. Lau. 2009. An analysis of the size and distribution of geographically isolated, small wetlands in the Hudson River Estuary watershed. Cornell University, Ithaca, NY. Unpublished report.