Natural Resources Inventory for Greene County, New York

2019

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This *Natural Resources Inventory* (*NRI*) illustrates and describes the geology, landforms, streams, lakes, groundwater, habitats, soils, plants, wildlife, and places of scenic and recreational value to the people of the county. It also describes threats to resources of concern, discusses general conservation measures, and offers ways to identify conservation priorities, specific conservation tools and strategies, and other ideas for the best uses, conservation, or restoration of important resources.

The *NRI* is intended as a practical reference for Greene County residents, landowners, developers, municipal agencies, conservation NGOs, and others interested in understanding, using, and caring for the land and water of the county.

The bedrock and glacial histories of the county are reflected in the habitats and water resources, and in our past and present-day uses of the land. Distinctive landscapes span the tidal habitats along the Hudson River, the expanses of farmland of the Lake Albany plain, the limestone and shale habitats of the Kalkberg, the rolling forested hills and picturesque valleys of the Batavia Kill, Catskill Creek, and Schoharie Creek, and the large, unfragmented forests, spectacular falls and gorges, and high rocky summits of the Catskill Mountains.

Two hundred years ago large parts of the county's forests had been cleared for rowcrops, pastures, and hayfields, even high into the hills where some pastures extended above 2000 feet elevation. Large forest areas were also cut or cleared for charcoal production and leather tanning. Streams were harnessed for the water power that drove lumber mills, grist mills, foundries, tanneries, textile mills, and industrial operations of all kinds. Bluestone was quarried for flagging, and limestone for soil conditioning, cement, and structural uses; clay was mined for brickmaking; and ice was harvested from the Hudson River and inland waterbodies for refrigeration. Through the 20th and 21st centuries, however, these intensive uses of the county's natural resources have declined, forests have retaken much of the landscape and, with the decay and breaching of old dams, many stream segments have regained their former unobstructed flow. Today, although farming, mining, and logging are still part of the Greene County economy, most residents and businesses no longer depend directly on uses of local natural resources for their livelihoods. The tourism and recreation industries are a huge exception, however. The resorts at Hunter and Windham mountains bring year-round visitors to the region, and the scenic beauty and abundant recreational opportunities in the Catskill Mountains and in the Hudson River corridor are major draws for many of the hotels, motels, inns, bed-and-breakfasts, restaurants, and other businesses that serve vacationers and recreationists.

Because Greene is a rural county characterized by small population centers, small businesses, little heavy industry, and large areas of open, undeveloped land, it has retained many cool, clear streams, large forests, and many species of plants and wildlife that tend to disappear from more heavily settled regions.

In recognition of high concentrations of important, unusual, and vulnerable biological features, the NYS Department of Environmental Conservation (NYSDEC) has designated three Significant Biodiversity Areas (SBAs) in the county:

- The **Catskill Mountains SBA**—recognized for its large, unfragmented forests, alpine communities and other unusual and exemplary forest communities, deep ravines, and rocky headwater streams; its support of plants and animals of conservation concern; and contributions to the drinking water reservoirs of the New York City system. (This SBA covers parts of Cairo, Catskill, Halcott, Hunter, Lexington, Jewett, and Windham.)
- The **Hudson Valley Limestone and Shale Ridges SBA**—recognized for the regionally significant limestone bedrock that supports unusual and high quality forest, cliff, and rocky slope communities and rare plants and animals. (This SBA covers parts of Athens, Catskill, Coxsackie, and New Baltimore.)
- The **Upper Hudson River SBA**—recognized for the regionally- and globally-rare freshwater tidal communities that support numerous rare species of plants and animals; serve as nursery habitat for Hudson River fish and shellfish, nesting and foraging sites and migration stopovers for birds, and important sources of nutrients for the Hudson River food web; and buffer the shoreline from storm surges. (This SBA covers parts of Athens, Catskill, Coxsackie, and New Baltimore.)

In addition, the New York Natural Heritage Program has identified more localized "Areas of Known Importance" for biodiversity throughout the county due to the presence of rare plants, rare animals, or significant natural communities. These include, among other places, the open lands of the Route 9W corridor that support grassland breeding birds and raptor hunting areas; the spruce-fir forests on the highest Catskills summits that support rare songbirds; the exposed Catskills ledges and nearby forests that support rare snake species; limestone woodland and cliff communities; high-quality coolwater streams with wild-reproducing brook trout and other sensitive aquatic animals, and the freshwater tidal communities of Hudson River.

The county has large areas of Prime Farmland Soils and Farmland Soils of Statewide Importance and, although agriculture does not hold the place that it did 150 years ago in the life of the county, it is still prominent in the lake-plain corridor in the eastern zone and in the Basic Creek/upper Catskill Creek region of the county; farming also occurs elsewhere in less-concentrated areas. Over 34,900 acres were in agricultural parcels in 2017 (the most recent census year). Farm products with the highest value of sales were poultry and eggs (eighth highest of all counties in the state as of 2017), vegetables, hay, and nursery/greenhouse crops. Farming and associated businesses are still a significant part of the county's economy, and farmers are among the most important stewards of land and resources.

The array of natural resources in the county gives us local food from domestic and wild sources, clean drinking water, pollinators for agricultural crops, climate moderation provided by large forests, and countless other goods and services. The extraordinary beauty of the landscape and abundant opportunities for public recreation benefit residents and visitors alike, and have long drawn vacationers, weekenders, artists, and writers that have helped to build the Greene County community, culture, and economy.

Human activities on the land, however, pose multiple threats to natural resources through loss, fragmentation, and other degradation of habitats; over-harvesting; introduction of non-natives pests and diseases; alteration of water movement over the land and through the soil; and contamination of soils, streams, and ponds, to name a few. NYSDEC stream sampling, for example, has found that some streams and lakes are contaminated with mercury, nutrients, or pathogens from agriculture, sewage discharges, septic leachate, and other sources, so there is much still to do to improve the habitat quality and water quality of Greene County watercourses.

Climate change poses over-arching and wide-ranging threats to water supplies, agriculture, wildlife, and human health, but local actions by landowners, municipalities, and conservation organizations can maintain and improve the resiliency of natural landscapes and infrastructure to the effects of global warming. Using green infrastructure approaches to stormwater management, eliminating aquatic barriers along streams, and maintaining and restoring broad landscape connections between intact habitat areas may be among the most effective ways to keep people and property safe and maintain native biological diversity in the face of climate change. Reducing or eliminating non-climate stressors such as pollution and habitat fragmentation will help maintain ecosystem functions even as biological communities change in response to the warming climate.

Most of the natural resources important to local communities are unprotected by federal, state, or local laws and regulations—including all kinds of upland habitats, as well as small wetlands, small streams, and floodplains. While landowners have much autonomy in the uses and care of their own land, municipalities have authority to adopt local policies and enact legislation to protect resources deemed important to the public welfare. Here are some examples of ways that landowners, developers, and town agencies can use the *NRI* for these purposes:

- **Landowners** can use the *NRI* to discover new aspects of their land, learn about the relationship of their property to the larger landscape, and consider land management that takes advantage of natural assets while protecting sensitive areas.
- **Developers** can use the *NRI* to understand some of the natural features of local concern, and then locate and design new development projects to accommodate those features.
- **Municipal comprehensive plan committees** can use the *NRI* to identify important natural resources in the community, identify priority areas for particular land uses or for conservation, and develop policy recommendations for stewardship and protection of resources of concern.
- **Other municipal committees** can use information in the *NRI* to incorporate protection of sensitive resources into the open space plan, zoning ordinance and subdivision regulations,

or to delineate Critical Environmental Areas or Conservation Overlay Districts for places of special concern.

- **Municipal planning boards**, **zoning boards of appeal**, and **conservation advisory councils** who are reviewing land development proposals can use the *NRI* to see if there are known features of conservation concern on or near the development parcel. (The *NRI* is not a substitute for onsite observations but can alert users to some of the features that deserve special attention in the project review.)
- **Municipal planning boards** can adopt environmental review procedures that require applicants to provide site-specific information from the *NRI* in their application materials, so that potential impacts on features such as aquifers, Prime Farmland Soils, unusual habitats, Significant Biodiversity Areas, or trout streams are fully considered when new land uses are contemplated.
- **Land trusts** can use the *NRI* information to help identify conservation priorities for their own strategic planning and in their work with landowners to design conservation easements.

For Greene County communities that are concerned about flood protection and mitigation, maintaining clean and ample supplies of drinking water, protecting scenic resources, promoting successful agriculture, preserving native biological diversity, or tackling any of a host of other issues related to natural resources, this *NRI* can be a useful first reference for learning about the resources of interest. It describes and illustrates where they occur, their status in the county, their significance to people, the threats (if any) to those resources, and strategies, tools, and partners for best uses, stewardship, and conservation.

Northern dusky salamander at the Mountain Top Arboretum, Tannersville.
Photo: Erik Kiviat © 2019

INTRODUCTION

This *Natural Resource Inventory* (*NRI*) describes important natural resources throughout Greene County, New York, describes their distribution and conservation significance, and discusses some of the implications for uses of land and resources. The purpose of the inventory is to inform citizens, municipal and county agencies, and conservation organizations about the land and water that supports the people, farms, businesses, and natural areas of the county.

Municipal agencies need good information about natural resources for land use planning, and for environmental reviews and decisions about land development projects. Farmers, other landowners, and developers make plans and decisions every day about management or new uses of the land; the planning boards of towns and villages routinely review land development proposals; and town and village boards periodically undertake revisions to municipal comprehensive plans and zoning ordinances. This document can inform all of those efforts so that valuable natural resources can be put to their best uses, and resources of conservation concern can be better protected.

An understanding of the array of local resources, their vulnerabilities to human activities, their potential vulnerability or resilience to the effects of climate change and other stresses, and their importance to the human community will help the people of Greene County consider which areas are best suited for land development or other uses, and which are best left alone. Promoting and maintaining clean air to breathe; ample and clean groundwater to feed our drinking water wells; abundant, clean water in our streams and lakes; high-quality farmland; wild lands for wildlife habitats, scenic beauty, and recreation; and the historic places and landscapes that bind us to our natural and cultural heritage will help to preserve the parts of the county that make this a wonderful place to live and work.

The *NRI* is designed to be used by county and municipal agencies and committees—such as town boards, planning boards, and zoning boards of appeal, highway departments, comprehensive plan committees, and zoning revision committees—as well as landowners, developers, conservation organizations, and others concerned with land use planning, land management, policy-making, and resource use and conservation.

While much of the information depicted in the *NRI* maps is at a fairly coarse scale, it can nonetheless inform town-specific or even site-specific planning as long as the user understands the limitations of the data. For example, the bedrock geology map shows the most prominent bedrock types in different parts of the county, but does not show the more detailed local variation in bedrock types. The federal wetland maps depict many but not all the wetlands in the landscape, so site-specific field observations are necessary for detailed site planning.

The data used to prepare the *NRI* map figures are available to everyone through the Greene Land Trust (GLT) website, enabling planning boards and others with Geographic Information System (GIS) capability to overlay the map layers with other data relevant to local concerns. For those without GIS software, the GLT website also has a "layered pdf" that enables any user to view map layers selectively (https://www.greenelandtrust.org/projects/natural-resource-maps).

The *Greene County Agriculture and Farmland Protection Plan* (GCAFPB et al. 2002) describes the kinds and status of farming in the county, some of the threats, and some recommendations for promoting successful agriculture. The *Greene County Grassland Habitat Management Plan* (Strong et al. 2014) examines the eastern corridor of active, fallow, and abandoned farmland that has been recognized for its importance for grassland birds, and provides guidelines for land use planning with an eye to habitat protection. The *Greene County Open Space and Recreation Plan* (Greene County Planning Department 2002) provides much information on natural resources and serves some of the purposes of an *NRI*. The *Schoharie Creek Watershed Assessment* (Shirer et al. 2018) provides maps and descriptions of natural features and identifies areas of special importance for conservation within the Schoharie Creek watershed. This *NRI* builds on those documents and provides updated information, describes additional resources, and presents additional ideas for uses and conservation of natural resources.

This *NRI* also fulfills action item 4.11 in the *Greene County Comprehensive Economic Development Plan* (Greene County Planning Department 2007) to "create and maintain a natural resource inventory for Greene County." The natural resource maps, descriptions, and conservation recommendations can help the county fulfill action item 4.21, "to develop open space strategies and conservation standards to be met by new development projects."

The *NRI* was prepared by Hudsonia Ltd. in collaboration with the Greene Land Trust and the Cornell Cooperative Extension-Columbia and Greene Counties. The *NRI* project was funded in two phases by the New York State Environmental Protection Fund through grants to the GLT from the Land Trust Alliance, the Hudson River Estuary Program of the New York State Department of Environmental Conservation (NYSDEC), and the Hudson River Valley Greenway.

Three Conventions in this *NRI*

Terms that are included in the Glossary (Appendix A) are in **red type**.

In-text references to other sections of the *NRI* are in **bold** type

Species of plants or animals with statewide rarity ranks are denoted by a dagger (†) superscript.

Terms in red type are defined in the Glossary (Appendix A). Plants and animals that are listed in the New York State Environmental Conservation Law as Endangered, Threatened, Rare, or Special Concern, or listed by the New York Natural Heritage Program as S1, S2, or S3, or listed by NYSDEC as Species of Greatest Conservation Need are given a dagger (†) superscript. The ranks of each are given in Appendix C. The text uses common names for plants and animals, but Appendix Table C-1 gives the scientific names for all species mentioned.

HOW TO USE THE *NRI*

This *NRI* gathers into a single document much existing information about natural resources, their uses, their status and condition, and their significance to the people of Greene County. It is intended for use by county planners, municipal officials, community and watershed groups, landowners, developers, residents, and visitors who wish to better understand the natural resources that support our communities.

Below are some specific ways that the *NRI* can be used; see the **Achieving Conservation Goals** section for more detail on some of these topics.

Comprehensive Planning
A municipal *Comprehensive Plan* is the document that sets forth the community's vision for its future along with the land use policies to help achieve that vision. The *Plan* is typically based on consideration of land development trends, natural resources, and community needs for transportation, public safety, recreation, housing, and economic sustainability. Many citizens of Greene County value natural resources and open spaces for their beauty, their ecological services to the human community, their importance for agriculture, forestry, and recreation, and their contributions to the rural sense-of-place. This *NRI* illustrates locations of aquifers, good farmland soils, streams, large forests, large meadows, wetlands, rare species habitat areas, and scenic and recreation resources—features that contribute immeasurably to the public well-being, and can serve as a basis for preparing or revising a comprehensive plan.

> This *NRI* illustrates locations of aquifers, good farmland soils, streams, large forests, large meadows, wetlands, rare species habitat areas, and scenic and recreation resources.

For example, the section on **Identifying Local Conservation Priorities** can help a comprehensive plan committee find the places in their community that may be most appropriate for certain uses or for new development, or are most deserving of special stewardship or conservation, and many of the *NRI* maps can be directly incorporated into the plan to illustrate important natural and cultural features.

Zoning and Subdivision Regulations
Many Greene County municipalities have a zoning ordinance, and most also have subdivision and site plan review regulations. The *NRI* can be used to identify priorities for new or amended zoning and subdivision regulations to better protect resources of concern, and to help evaluate other proposed changes to the regulations. For example, some of the *NRI* maps can be used to conceptualize and delineate Conservation Overlay Districts to protect resources of special importance such as aquifers, stream corridors, farmland soils, or scenic vistas. The *NRI* itself can be referenced in new regulations, and can be used as a reference for applying local laws. See the

Achieving Conservation Goals section for types of zoning and other regulations that can help ensure adequate protections for natural resources.

Critical Environmental Areas (CEAs)
A municipality may designate specific areas as CEAs under the State Environmental Quality Review Act (SEQR). A CEA is an area with exceptional habitat, open space, scenic, agricultural, social, cultural, historic, archaeological, recreational, or educational value; or special sensitivities; or that provides a benefit or poses a threat to human health (see **Achieving Conservation Goals** sections for more information). The CEA designation carries no specific protections, but creates a heightened awareness of the importance of an area during SEQR reviews. Any development proposal in a CEA that requires SEQR review will have additional scrutiny during the review process with regard to the potential impacts on the features for which the CEA was identified. The natural resource information and maps in the *NRI* can provide the basis for conceiving and delineating CEAs.

Map Data
Most of the GIS data used to prepare the natural resource maps in this *NRI* is available online from the Greene Land Trust. Viewing the data with GIS software allows the user to zoom in to the town-wide scale or closer, and make some of the map details more discernible than they are at the county-wide scale.

Environmental Reviews and SEQR
Most land development projects proposed by a state agency or a municipality and many approvals from a state agency or unit of local government require an environmental impact assessment according to the State Environmental Quality Review (SEQR) Act. The SEQR process has the potential to greatly reduce potential adverse impacts to natural resources of concern if conducted thoroughly. This *NRI* is a good starting point for assessing important natural resources and their specific sensitivities. Although *NRI* maps are not an adequate substitute for onsite surveys during project review, they will alert users to many features of interest and concern, and can help identify areas where more site-specific assessments may be needed in the SEQR process.

Site Plan Review
The *NRI* can be used in site plan review in the same way described for the SEQR process, indicating which resources on or near the site may be important, and showing how the parcel fits into the larger landscape. A municipality can even <u>require</u> that the *NRI* be consulted by an applicant and the planning board in the site plan review process to ensure that resources of concern are not overlooked. An onsite assessment of natural resources is also essential, and some sites warrant further assessment by an expert (for example, if habitat for a rare species may be present). Consulting the *NRI* at the earliest stage of the review of a new project can help the reviewing agency and the applicant direct new uses to the least-sensitive areas of a development site.

Site-Specific Land Use Planning
For developers planning new projects, farmers who own or lease land, or landowners considering new land uses and land management on their properties, the *NRI* can help identify some of the

important resources on and near the site, and how the site contributes to and benefits from the larger landscape. Your own knowledge of the land along with information from the *NRI* can help with designing land uses in ways that better accommodate sensitive natural areas. For example, preserving open space that is adjacent to other open space on neighboring properties will enhance the habitat values of both. Protecting an undisturbed buffer zone along a stream will benefit the fish and water quality of the stream and can help mitigate downstream flooding. Maintaining or restoring intact habitats that support native pollinators and other insects beneficial to agricultural crops can benefit farm productivity. In the vicinities of streams, ponds, and sensitive aquifers, proper siting and design of septic systems, judicious use of fertilizers, and minimized use of pesticides and other agricultural chemicals will help protect the water quality of those water resources. Users should remember, however, that the *NRI* maps are drawn from existing map data at a countywide scale, and should not be used as a substitute for more detailed information obtained onsite.

Uses of the *NRI*

For municipal or county planners, officials, and community groups:

- Identifying local conservation priorities
- Updating a municipal comprehensive plan
- Developing a municipal or regional open space plan
- Designating Critical Environmental Areas
- Improving zoning and subdivision regulations
- Informing the State Environmental Quality Review (SEQR) of proposed development projects
- Reviewing site plans and subdivision plats for other proposed development
- Providing information for watershed assessment and planning

For landowners, residents, farmers, and developers:

- Recognizing some of the special natural resources on their land
- Understanding the role of their land in the larger landscape
- Planning for land management or land uses with natural resource conservation in mind

PHYSICAL SETTING

Greene is a rural county of 658 square miles (420,844 acres) in southeastern New York. It is bordered on the east by the Hudson River and Columbia County, and on the north, west, and south by Albany, Schoharie, Delaware, and Ulster counties. Greene County has 14 towns, 5 incorporated villages, and numerous hamlets (Figure 1). The main population centers are the towns and villages of Catskill and Coxsackie and the Town of Cairo, but 42% of the population resides in the other villages and hamlets and along rural roads throughout the county. As of the 2010 US Census, the population of full-time residents in the county was 49,221 (Table 1). The American Community Survey of the US Census Bureau estimates that the 2018 population of the county was 47,491 (https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml).

Greene County lies within two physiographic regions—the Hudson-Mohawk Lowlands and the Catskill Mountains. The Catskills and the Hudson River are the dominating physical features. Elevations range from sea level at the Hudson River shore to 4040 feet above sea level (asl) at the summit of Hunter Mountain.

Most of the county drains ultimately to the Hudson River. Much of the western half of the county drains to Schoharie Creek and the Schoharie Reservoir, one of the drinking water reservoirs in the New York City system. The reservoir drains both north to the Mohawk River, the largest tributary to the Hudson, and south—via the Shandaken Tunnel—to the Esopus Creek, which feeds the Ashokan Reservoir and is another significant Hudson tributary. Most of the Town of Halcott, however, is in the Delaware River watershed, draining via Vly Creek and other streams to the Upper East Branch of the Delaware.

Common milkweed is an important nectar plant for bees, moths, and butterflies, and is the larval host for the monarch butterfly. Photo: Jill Knapp © 2019

1 Municipalities of Greene County, NY

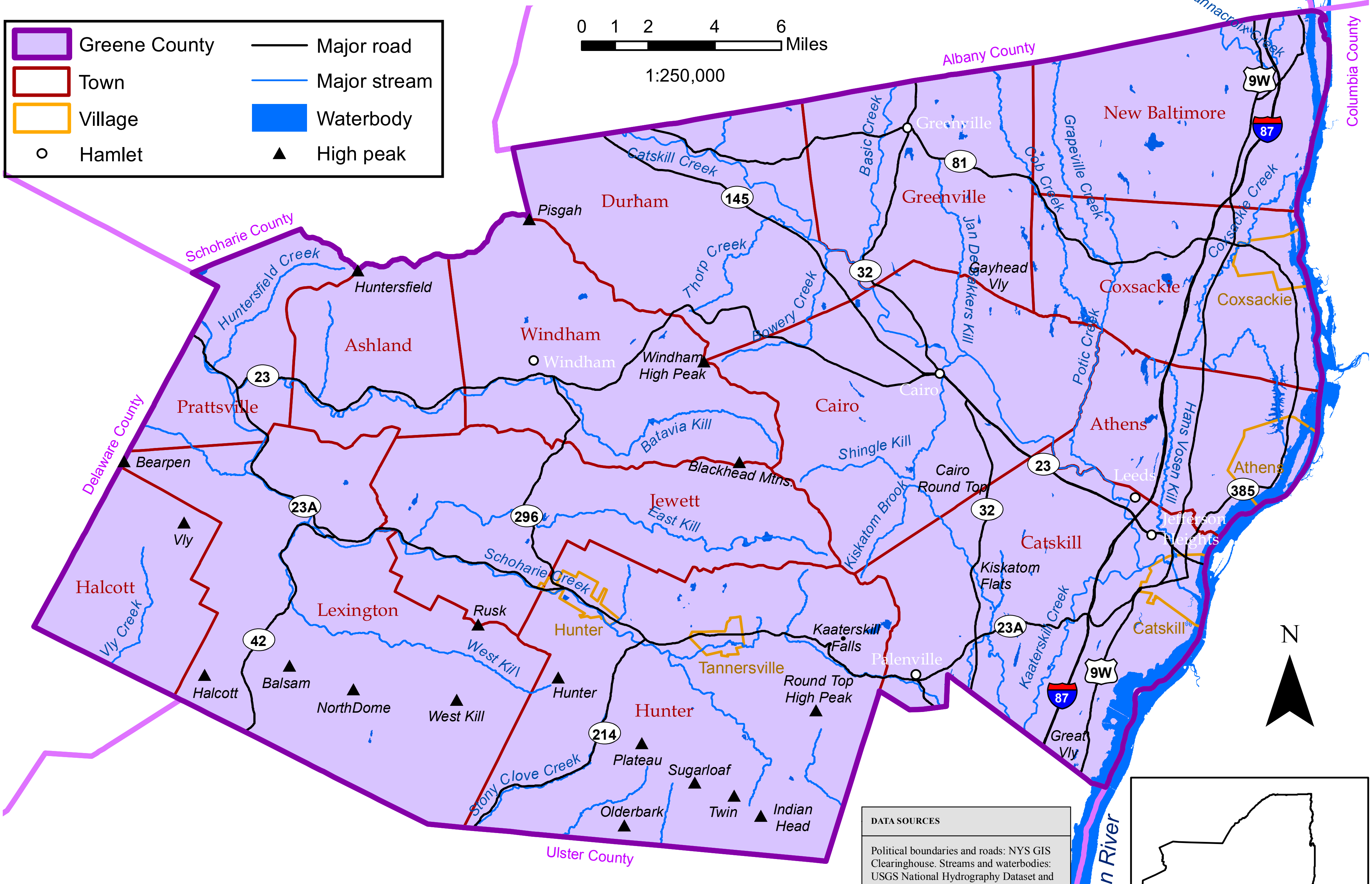


Figure 1. Municipalities of Greene County, New York. Greene County Natural Resources Inventory, 2019.

Table 1. Greene County municipalities and populations (from the US Census 2010).

			Population[1]		**Population density**
Municipality	**Area (acres)**	**Area (sq mi)**	**2000 census**	**2010 census**	**(people/sq mi)**
Town of Ashland	16,614	26.0	752	784	30
Town of Athens	18,477	28.9	3,991	4,089	141
Village of Athens	2,944	4.6	1,695	1,668	363
Town of Cairo	38,451	60.1	6,355	6,670	111
Town of Catskill	41,062	64.2	11,849	11,775	183
Village of Catskill	1,830	2.9	4,392	4,081	1407
Town of Coxsackie	24,582	38.4	8,884	8,918	232
Village of Coxsackie	1,658	2.6	2,895	2,813	1082
Town of Durham	31,590	49.4	2,592	2,725	55
Town of Greenville	25,011	39.1	3,316	3,739	96
Town of Halcott	14,746	23.0	193	258	11
Town of Hunter	58,074	90.7	2,721	2,732	30
Village of Hunter	1,133	1.8	490	502	279
Town of Jewett	32,333	50.5	970	953	19
Town of Lexington	51,021	79.7	830	805	10
Town of New Baltimore	27,546	43.0	3,417	3,370	78
Town of Prattsville	12,627	19.7	665	700	35
Village of Tannersville	768	1.2	448	539	449
Town of Windham	29,018	45.3	1,660	1,703	38

[1] Census population data are based on the number of people who reside full time in the county. While the county has many homes used seasonally or part-time, there are no accurate counts of part-time residents.

Caterpillar of the Io moth (a giant silk moth) on black swallow-wort. Photo: Kelsey West © 2019

Climate

The climate of Greene County and the northeastern US in general is classified as "humid continental" (NCDCa no date). Nearly all storm and frontal systems moving eastward across the continent pass through or close to this region. The county receives cold, dry air in winter from central Canada or the Hudson Bay; warm, humid air from the Gulf of Mexico and adjacent subtropical areas in summer; and cool, cloudy, and damp weather conditions from the North Atlantic Ocean from time to time. Our weather and climate are also affected by storm systems moving northward along the Atlantic coast. The prevailing wind is generally from the west in this region, southwesterly during the warmer months and northwesterly in the colder half of the year (NCDCa no date). Within the county, differences in latitude, elevation, aspect, and proximity to the Hudson River make for large differences in the local climate in different parts of the county.

Summer daytime temperatures usually range in the 70s and 80s°F over much of New York, although for a few days from late May to mid-September, highs are only in the 60s°F or reach into the 90s°F. The Catskill Mountains tend to be cooler and wetter than the nearby lowlands. Temperatures decrease by approximately 2-3°F per thousand feet of elevation; those temperature differences are greater in summer than in winter (Thaler 1996).

> Differences in latitude, elevation, aspect, and proximity to the Hudson River make for large differences in the local climate in different parts of the county.

The first frost usually arrives in late September or early- to mid-October, and the last frost typically occurs in mid-April to mid-May, but actual dates vary greatly from year-to-year and from one location to another within the county. The average length of the frost-free season can vary by a month or more between different parts of the county; areas near the Hudson River are likely to have at least 20 frost-free weeks, while areas far to the west may have only 13 weeks in some years (NCDCb no date). Many ponds and lakes have frozen over by mid-December of a typical year (Thaler 1996). Most of Greene County is in the USDA Hardiness Zone 5b (minimum temperatures -15 to 10°F), but higher elevations and western parts are in Zone 5a (minimum temperatures -20 to -15°F) (https://planthardiness.ars.usda.gov/).

Precipitation is fairly uniformly distributed throughout the year—there are no distinctly dry or wet seasons on a regular annual basis. Average monthly precipitation in summer is circa (ca.) four inches, but the amount can vary widely from one place to another, and generally increases west to east (Thaler 1996, NCDCa no date, NCDC 2018).

The Catskill Mountains receive more snow and experience more frequent snowfall events than nearby lowland areas. In fact, the Catskill Mountains receive more total precipitation annually than any other part of New York State (DeGaetano and Costallano 2013), with average annual precipitation over 45 inches in Greene and Ulster counties. The high peaks region receives the highest annual precipitation in the Catskills, with averages at Elka Park and Tannersville of 54-60 in (Thaler 1996).

Greene County rainfall is usually adequate during the growing season for commercial crops, lawns, gardens, and natural habitats. Severe droughts are rare, but minor droughts are common and can deplete well water supplies, cause moisture stress for livestock, crops, and natural vegetation, and increase the possibility of wildfires.

Greene County has never experienced a hurricane (Thaler 1996, Greene County Emergency Services 2016). The storms that reach the Atlantic coast as hurricanes have all downgraded to tropical storms by the time they have travelled the 100+ miles inland to Greene County. Nonetheless, the high winds, large rainfall volumes, and flooding of tropical storms, such as Irene, Lee, and Sandy in 2011 and 2012, have caused severe damage to structures, roads, and farmland in the county.

Major floods can happen in any season. The greatest potential and frequency for floods is typically in the early spring when substan-
tial rains combine with rapid snowmelt to produce large volumes of runoff, but a thaw in mid-winter when there is significant snow cover can also produce large floods, sometimes exacerbated by ice jams. Recent large storms (Irene, Lee, and Sandy), however, have produced record-setting floods in the late summer and fall.

Common whitetail is often seen along the shores of lakes, ponds, and streams. Photo: Larry Federman © 2019

In the past, New York State and Greene County have had abundant snowfall, with more-or-less continuous snow cover from about mid-December through mid-March, and maximum depths usually occurring in February. Snowfall patterns have been changing noticeably over the last 20 years, however, when many winters have seen limited snow cover and prolonged periods of bare ground. Topography, elevation, and proximity to the Hudson River result in great variations of snowfall from one location to another. Areas near the Hudson River typically receive less snow than areas distant from the Hudson and at higher elevation. Nor'easter storms occur October through April, and snow yields of 12-24 inches or more from such storms are not uncommon (NCDCb no date).

Table 2. Climate normals (30-year averages) for Greene County, 1981-2010.

Data are from the NOAA National Centers for Environmental Information weather stations at Platte Clove, East Jewett, and Cairo. Note that these are monthly averages over a 30-year period and do not show the extremes that occur in most years at these locations.

	Precipitation (inches)			**Minimum Temperature (°F)**			**Average Temperature (°F)**			**Maximum Temperature (°F)**		
Month	Platte Clove	East Jewett	Cairo	Platte Clove	East Jewett	Cairo	Platte Clove	East Jewett	Cairo	Platte Clove	East Jewett	Cairo
Jan	4.55	4.36	3.18	11.6	9.5	13.4	21.1	20.2	22.9	30.7	30.9	32.4
Feb	3.92	2.96	2.59	13.2	10.8	15.5	23.5	22.4	25.9	33.7	34.1	36.3
Mar	5.57	4.29	3.63	19.8	17.8	24.1	31.0	29.6	34.6	42.2	41.4	45.1
Apr	4.80	4.41	3.77	30.9	29.1	35.0	42.4	41.4	46.6	54.0	53.7	58.1
May	4.50	4.26	3.35	41.4	39.2	45.0	53.2	52.3	57.3	64.9	65.4	69.6
Jun	5.42	4.43	3.97	50.8	48.2	54.5	62.0	61.0	66.2	73.2	73.8	77.8
Jul	5.41	4.43	3.49	54.5	52.3	59.1	66.3	65.0	70.8	78.2	77.8	82.6
Aug	5.65	3.92	3.37	53.8	50.6	57.3	65.2	63.4	69.1	76.7	76.3	81.0
Sep	5.97	4.61	3.80	47.2	43.2	49.2	58.4	56.2	61	69.5	69.2	72.9
Oct	6.09	5.14	4.28	36.0	33.4	37.7	46.7	45.7	49.3	57.4	58.1	60.9
Nov	4.74	4.41	3.74	27.9	26.4	30.2	37.2	36.7	39.7	46.5	46.9	49.3
Dec	6.07	3.92	3.41	17.7	16.1	20.2	26.3	25.5	28.9	34.9	34.8	37.7
Total annual precip	62.69	51.14	42.58									

Elevations and Topography

Elevations in Greene County are low in the east along the Hudson River and high in the west, especially west of the towns of Durham, Cairo, and Catskill, whose western boundaries are defined by the Catskill escarpment, the distinct boundary of the Catskill Mountains (Figure 2). The terrain is generally gently sloped east of the escarpment and in the major valleys, and steep in the Catskill Mountains (Figure 3).

The Hudson River, at sea level, is bordered by a broad plain ca. 1-5 miles wide, the approximate lateral extent of an ancient lake—glacial Lake Albany—that covered this area ca. 13,200 – 18,000 years ago (Dineen et al. 1988).

The Hudson River is bordered by a broad plain marking the approximate lateral extent of an ancient lake—glacial Lake Albany—that covered this area ca. 13,200 – 18,000 years ago.

Westward is the north-south ridge up to 500 ft elevation called the "Kalkberg" (Dutch for "limestone mountains"), underlain by limestone, shale and sandstone. West of the Kalkberg is another series of low hills—the Hoogeberg (Dutch for "high mountain")—with elevations up to 1000 ft (Broad 1993). West of the Hoogeberg in southern Greene County is the Kiskatom Flats, a broad, flat area ca. one mile wide and four miles long that is the legacy of another glacial lake (Titus 2017). In northern Greene County the Hoogeberg extends to the Catskill Creek valley (Berdan 1954), beyond which other low hills roll up to the Catskills escarpment. These hilly areas between the Kalkberg and the escarpment are cut by the broad valleys of Catskill Creek, Kaaterskill Creek, Potic Creek, Vly Brook, and Kiskatom Brook.

The Catskill Mountains were originally named the "Katsberg" by the Dutch, but the origin of the name is now obscure. It may have been for Jacob Kats (or "Cats"), a prominent Dutch poet (1577-1660), or for the abundant wildcats in those hills—presumably bobcats and mountain lions—or perhaps for some other local feature such as the Native American fortifications along the Hudson, called "kasteel" by Dutch sailors (Iliari 2017).

The mountains rise steeply along the eastern escarpment to high elevations at Windham High Peak (3424 ft), the Blackhead Mountains (3980 ft), Stoppel Point (3417 ft), and Kaaterskill High Peak (3655 ft). The highest elevations in Greene County are Hunter Mountain (4040 ft), Blackdome (3980 ft), Thomas Cole (3940 ft), and West Kill (3880 ft). These four mountains, along with Slide Mountain in Shandaken (4180 ft) (Ulster County) are the highest in the Catskills. The only significant break in the escarpment in Greene County is where Kaaterskill Creek tumbles steeply down the slope from Haines Falls to Palenville at the foot of the escarpment. The major valleys in the county are associated with Catskill Creek, Kaaterskill Creek, Potic Creek, Batavia Kill, Schoharie Creek, West Kill, and East Kill; many other valleys are along smaller streams.

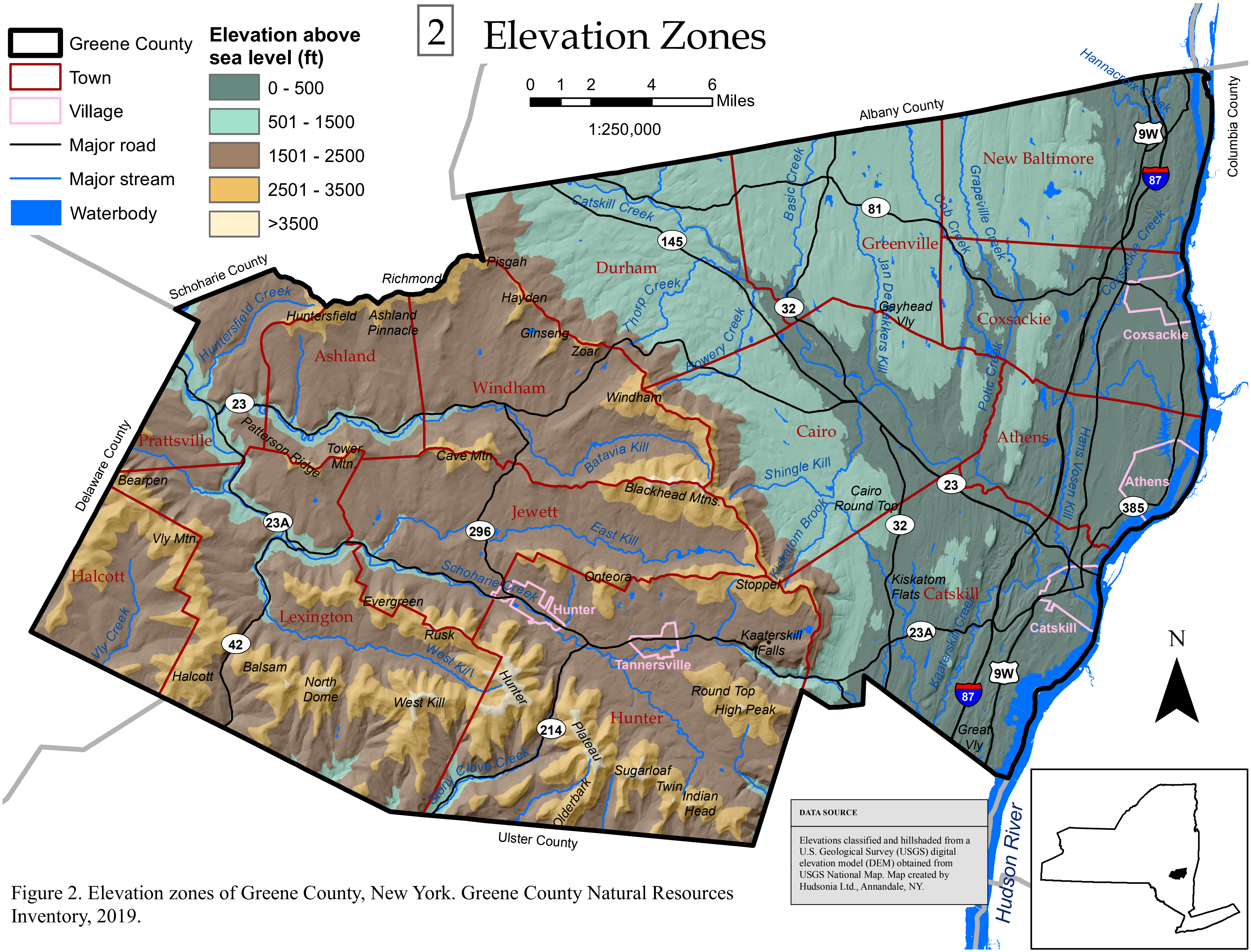


Figure 2. Elevation zones of Greene County, New York. Greene County Natural Resources Inventory, 2019.

3 Steep Slopes

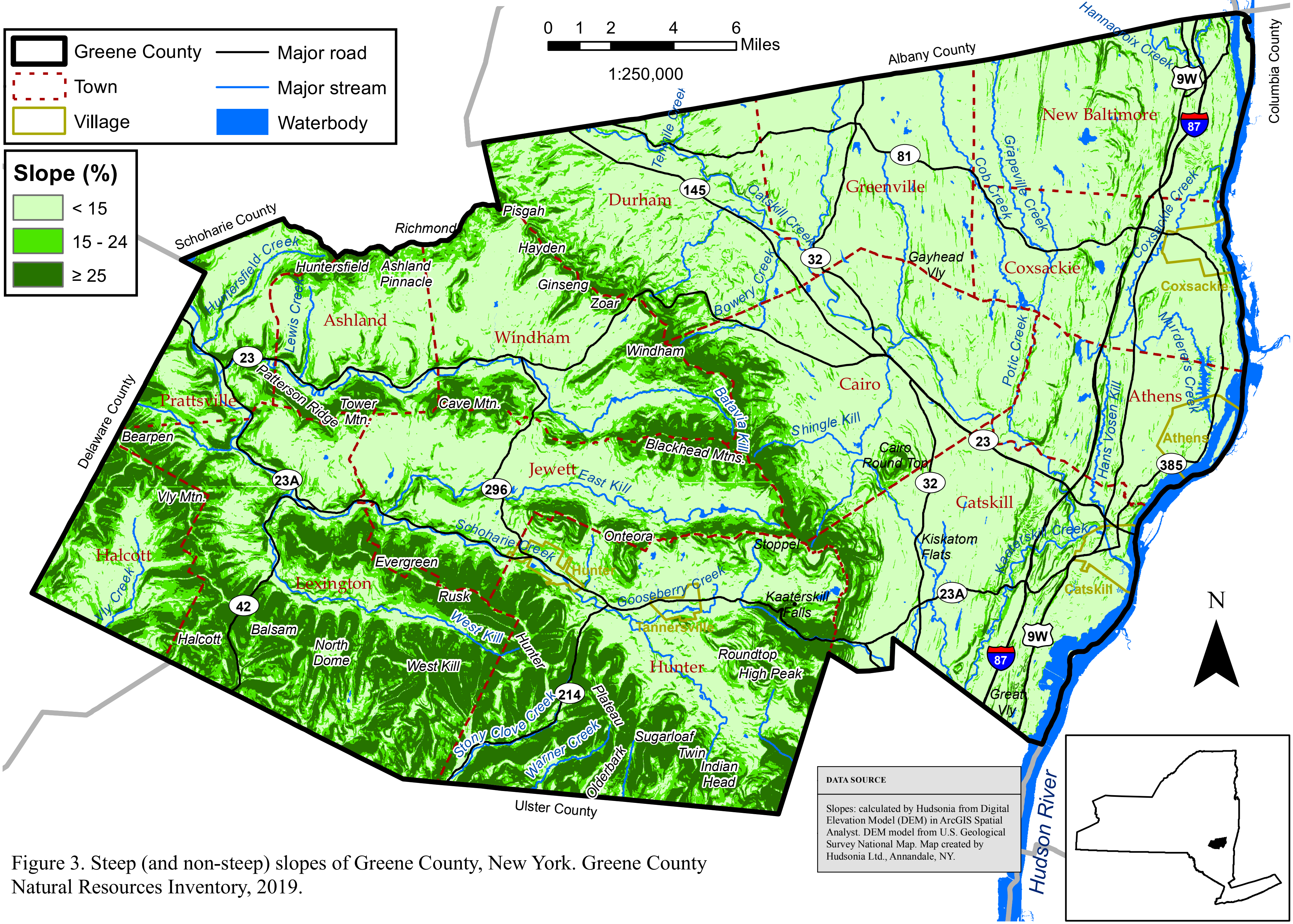


Figure 3. Steep (and non-steep) slopes of Greene County, New York. Greene County Natural Resources Inventory, 2019.

Bedrock Geology

During the period 419-365 million years ago, when the Catskills region was located south of the equator, the eastern edge of what is now North America collided with at least three continents, resulting in an uplift extending from eastern Greenland to Alabama in a mountain-building episode called the Acadian Orogeny. The ancient "Acadian Mountains" that resulted from that collision were immense here, rising to heights like those of the Himalayas or the Andes. Since those uplifting events, sediments from the weathering of rocks from those towering mountains created the ancient "Catskill Delta" from which the bedrock of the Catskills was formed (Titus 1998). Materials that washed in from terrestrial areas, and calcium carbonate from decay of marine organisms, settled to the ocean floor, creating layered deposits that ultimately became the sandstones, shales, limestones, and other sedimentary rocks of our region (Fisher 2006). The lowest strata of the Catskills rocks were deposited in marine environments ca. 419-388 million years ago. The upper strata were deposited in terrestrial environments ca. 388-375 million years ago, and supported some of the Earth's first forests (Stein et al. 2012).

Weathering of the ancient "Catskill Delta" has created a dissected plateau of horizontally layered rocks formed into the ridges, valleys, and peaks that we know as the Catskill Mountains.

Since then, weathering of the Catskill Delta has created a dissected plateau of horizontally layered rocks formed into the ridges, valleys, and peaks that we know as the Catskill Mountains. That weathering over tens- to hundreds-of-millions of years has been a more significant factor in creating the Catskills landscape than the repeated glaciations occurring just 2.6 million to 11,700 years ago (Ver Straeten 2013).

The rocks of the Catskills and the closest foothills are mainly of siliclastic sedimentary rocks (sandstones, mudrocks, conglomerates) with carbonate rocks here and there. Siliciclastic rocks are dominated by quartz, metamorphic and sedimentary rock fragments, and clay minerals (Ver Straeten 2013); carbonate rocks are primarily calcium carbonate or calcium magnesium carbonate.

The landforms and geology of Greene County form four distinct zones, each with its own variant of land use history. From east to west (low elevation to high; also oldest to youngest geologic layers), these are: greywacke and shale overlain by fairly flat lacustrine silt and clay deposits (the bed of glacial Lake Albany); a band of limestone (the "Kalkberg"); a broader area of rolling hills underlain by sandstone and shale (the "Hoogeberg"); and finally the shale, sandstone, and conglomerate of the Catskill peaks and valleys (figures 4 and 5).

Sandstones are siliciclastic sedimentary rocks composed of sediment grains 0.0025-0.08 inch (1/16 – 2 mm) in diameter that have been compacted and cemented together (Ver Straeten 2013). The name "bluestone" is applied to sandstone with relatively thin horizontal layering (ca. 1-8 inches [3-20 cm] thick) that splits easily into flagstones. Bluestone may be red, green, brown, gray, or blue.

Mudrocks are siliciclastic, fine-grained sedimentary rocks with grain diameters less than 0.0025 inch (1/16 mm). They include shale and mudstone, which are composed mainly of microscopic clay minerals. Mudstone is distinguished from shale by the absence of visible laminations.

"Bluestone" is an easily-split sandstone that may be red, green, brown, gray, or blue.

Conglomerates are gravel-rich sedimentary rocks with grains over 0.08 inch (2 mm) in diameter with relatively rounded, smooth grain margins; those with sharp margins are called "breccias."

Limestone and dolostone are the typical carbonate sedimentary rocks in the region, but carbonates also occur as cement in sandstones. Most limestones (calcium carbonate) are composed of calcareous shell material ground down to clay-size particles by physical and biological processes. Dolostone is a sedimentary rock composed primarily of dolomite (calcium magnesium carbonate). It is similar to limestone in many respects but somewhat harder and less soluble.

The remains of marine and terrestrial organisms buried in long-ago wetlands created the dark gray and black colors of the black shales and some of the other mudrocks of the Catskill region. The red of some of the sandstones, shales, and other sedimentary rocks of the Catskills indicates oxidation of the iron component. Soils formed from the weathering of these rocks are also red.

The Catskill landscape is much influenced by the varying "strength" of the different rock types. The sandstones and conglomerates on the steep slopes and cliffs have greater rock strength—i.e., are less susceptible to weathering. The lower-strength, more easily-weathered mudrocks and muddy sandstones, and rocks with weaker cementing materials are on the gentler slopes (Ver Straeten 2013). The differential weathering of the rock types accounts for the distinctive stair-step topography of the Catskills mountainsides.

Figure 4 shows the bedrock geology zones within the county—the conglomerates at the highest elevations and the sandstones, shales, and mudstones at the lower elevations of the Catskill Mountains; the black and gray shales, siltstones, sandstones, and minor carbonates in the narrow zone along the Catskill front; the shales and sandstones of the 500-1500 ft elevations in the central part of the county; the limestone band along the Kalkberg, and the graywacke at the lower elevations along the eastern edge of the county.

Surficial Geology

The term "surficial geology" refers to the loose ("unconsolidated") materials overlying the bedrock. Much of this material was transported and deposited by glaciers and some by post-glacial processes such as sediment deposition along floodplains. Organic sediments in wetlands developed in place from slowly decaying plants and animals.

Great ice sheets, advancing and retreating over many thousands of years in the northeastern US, transported and deposited large amounts of rock and other unconsolidated material. The most recent ice sheet—called the Wisconsin—receded approximately 16,500 years ago in the southern part of the county, and 14,000 years ago in the northern part (Fisher 2006), leaving behind much loose mineral material overlying the bedrock—the glacial till, glacial outwash, and glacial lacustrine deposits (see sidebar and Figure 5). These are the mineral and structural bases for most of our soils, which formed over the ensuing thousands of years as plants, animals, water, weather, and biological processes transformed a thin layer of material at the Earth's surface.

Unconsolidated sediments cover the bedrock over most of the county. Glacial till predominates, but glacial outwash and kame deposits occur in valley bottoms, and glaciolacustrine sand, silt, and clay occur in a broad zone along the Hudson River and in small areas along Schoharie Creek and Catskill Creek.

Glacial outwash—composed primarily of sand and gravel—is mostly along stream corridors and valley plains (Figure 5).

As the last ice sheet was melting, it left behind a deposit of ice and debris at Newburgh that acted as a dam to impound glacial meltwater and create an immense lake—Lake Albany—extending north to Glens Falls in Warren County. Over the next 5000 years (ca. 18,000 – 13,200 years ago), fine sediments—silts and clays—settled on the lake bottom. When the lake drained after the retreat of the glacier and the rebounding of the land when relieved of that great weight, extensive terraces of clay, silt, and sand on the former lake bottom were left behind (Brigham-Gette 1988, Dineen 1988). In Greene County, this glacial lacustrine terrace extends 1-5 miles west from the Hudson River to approximately the 150-ft elevation contour, depicted in Figure 5 as the lacustrine sand, silt, and clay

SURFICIAL DEPOSITS

(Loose material over bedrock.)

Glacial till Mixtures of unsorted mineral materials of various textures (fine to cobble-size), deposited by melting glacial ice.

Glacial outwash Coarse mineral materials (sands and gravels) deposited by glacial meltwater streams.

Glacial lacustrine deposits Fine silts, clays, and sands that settled in glacial lakes and ponds.

Alluvium Clay, silt, sand, or gravel, sorted by texture and weight, and deposited by running water in the glacial or post-glacial period to the present.

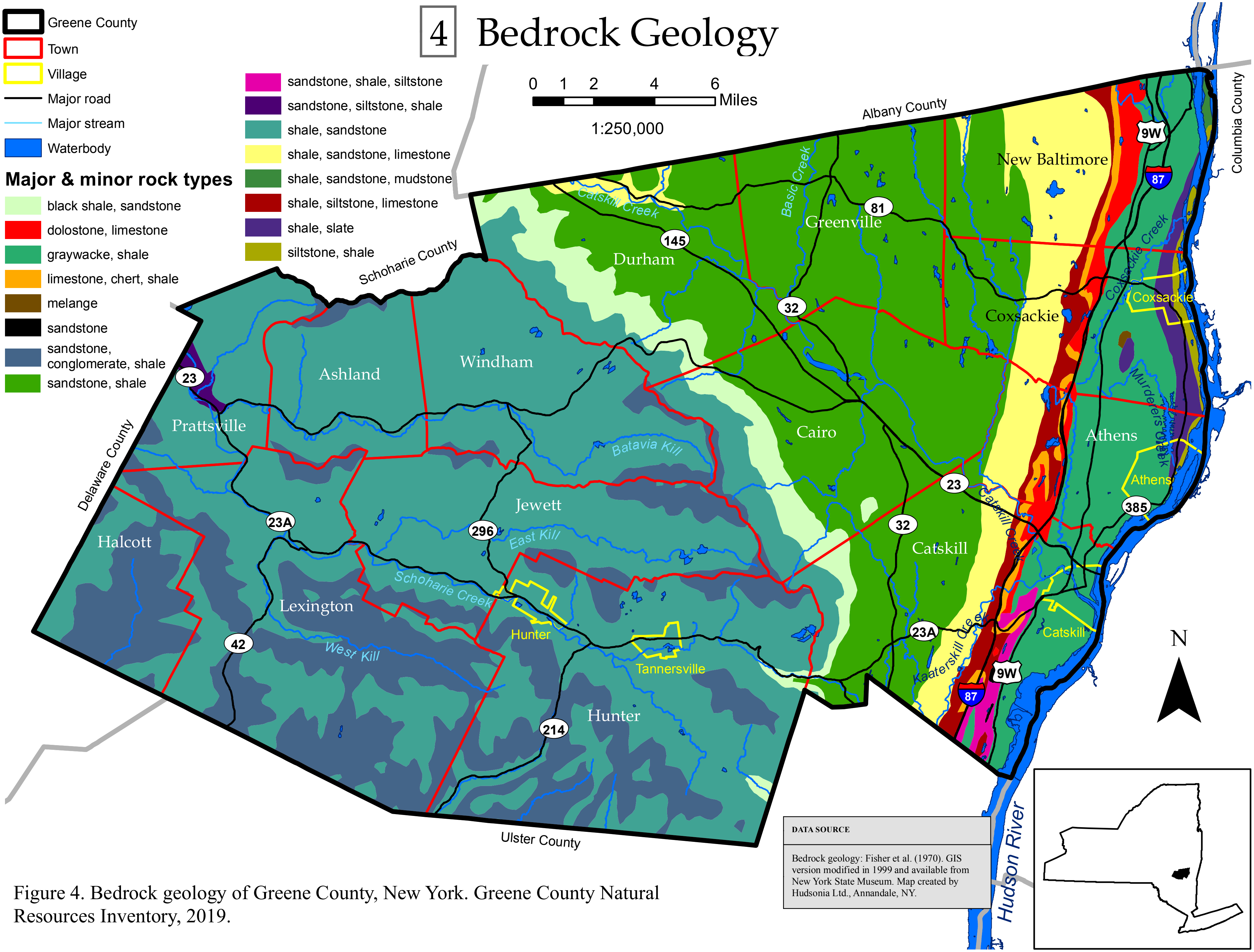


Figure 4. Bedrock geology of Greene County, New York. Greene County Natural Resources Inventory, 2019.

5 Surficial Geology

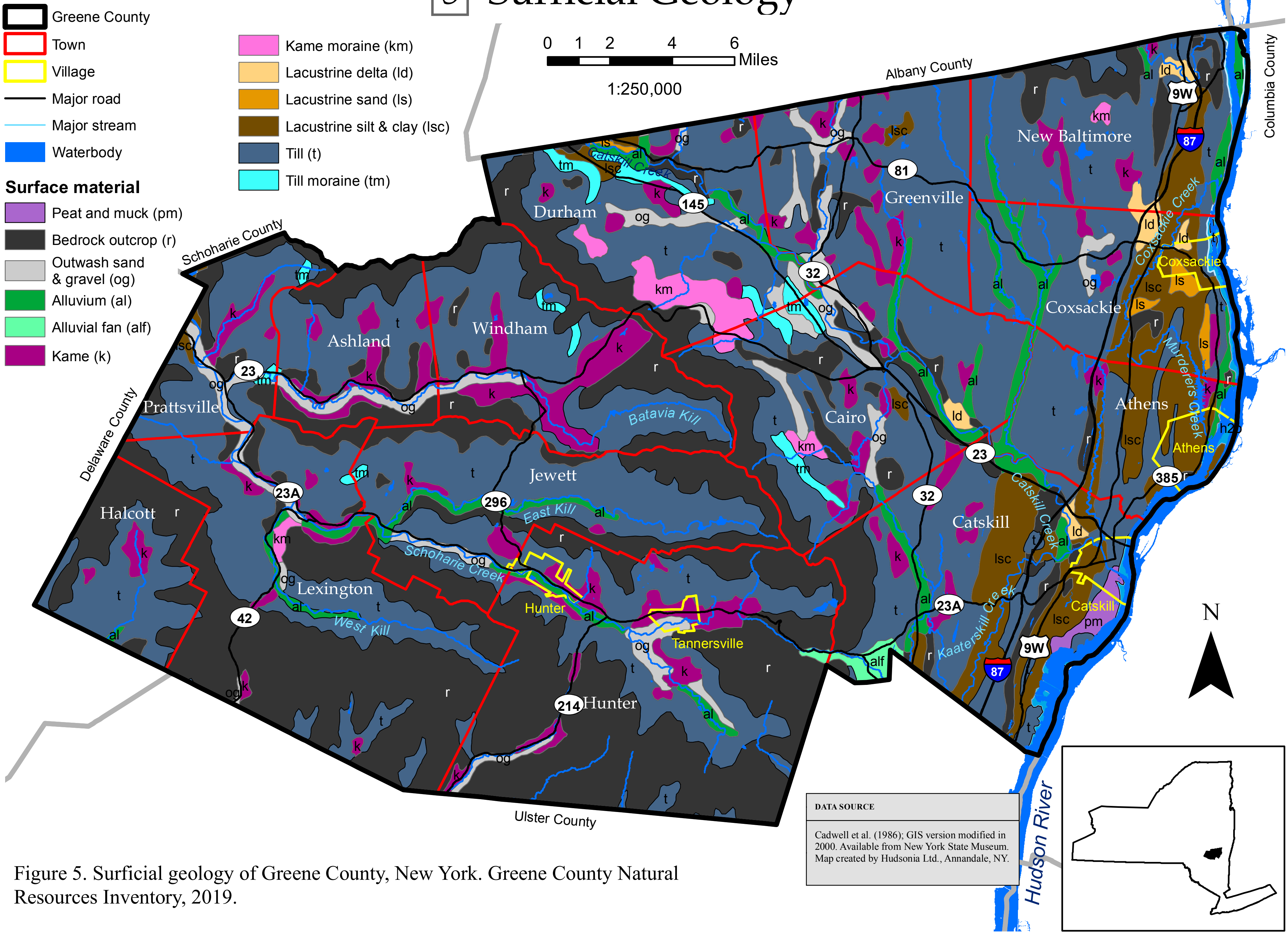


Figure 5. Surficial geology of Greene County, New York. Greene County Natural Resources Inventory, 2019.

units in the Hudson River corridor. Sediments from other glacial lakes occur in smaller areas at Kiskatom Flats, along Schoharie Creek, and along the upper reach of Catskill Creek in Greene County.

Glacial till—unsorted mineral material—is prominent throughout the county and is the parent material for most of our upland soils. Glacial outwash and the Lake Albany clays are much more limited in extent (Figure 5). Alluvium —sediments deposited by running water—is found in present-day and former floodplains along streams. Alluvium can be of any texture, fine clays to coarse gravel, but is typically sorted by particle size and weight. Some basins, depressions, and other areas where water has been held at the ground surface for long periods (hundreds or thousands of years) have developed a deep layer of organic sediments—plant and animal matter in various stages of decay; the material may be several meters deep in some of the oldest and wettest wetlands.

Water

A watershed is the entire land area that drains to a particular feature, such as a stream, pond, or wetland. Every part of the landscape is in the watershed of one or more waterbodies. Most of Greene County is within the larger Hudson River watershed—the eastern half and parts of the Catskills draining to the Hudson River estuary and much of the western half draining (via Schoharie Creek) to the Schoharie Reservoir (Figure 6), one of many reservoirs in the New York City drinking water system. The Schoharie Creek continues north from the reservoir to the Mohawk River—the largest tributary to the Hudson—but a significant portion of the water is also shunted south through the Shandaken tunnel to the Esopus Creek and thence to the Ashokan Reservoir, another of the NYC water sources. The Ashokan drains to the lower Esopus Creek, a significant tributary of the Hudson River. Most of the southern slopes of the Balsam-to-Sugarloaf range are in the Ashokan Reservoir watershed.

> In the Greene County reach, the Hudson River is entirely freshwater, and ranges from ca. 1500 ft wide at its narrowest at New Baltimore to ca 1.3 miles wide at its widest at Inbocht Bay in Catskill.

The only part of the county that is not in the Hudson River watershed is most of the Town of Halcott, which drains via Vly Creek and several other streams to the Upper East Branch of the Delaware River. The East Branch is itself impounded near Downsville (Delaware County) to create the Pepacton Reservoir, also in the New York City water system.

Thus, all of the land area in the Batavia Kill, Schoharie Creek, and East Branch watersheds (Figure 6) and most of the land in the Esopus Creek watershed feeds the NYC reservoirs. While most of the

6 Major Watersheds

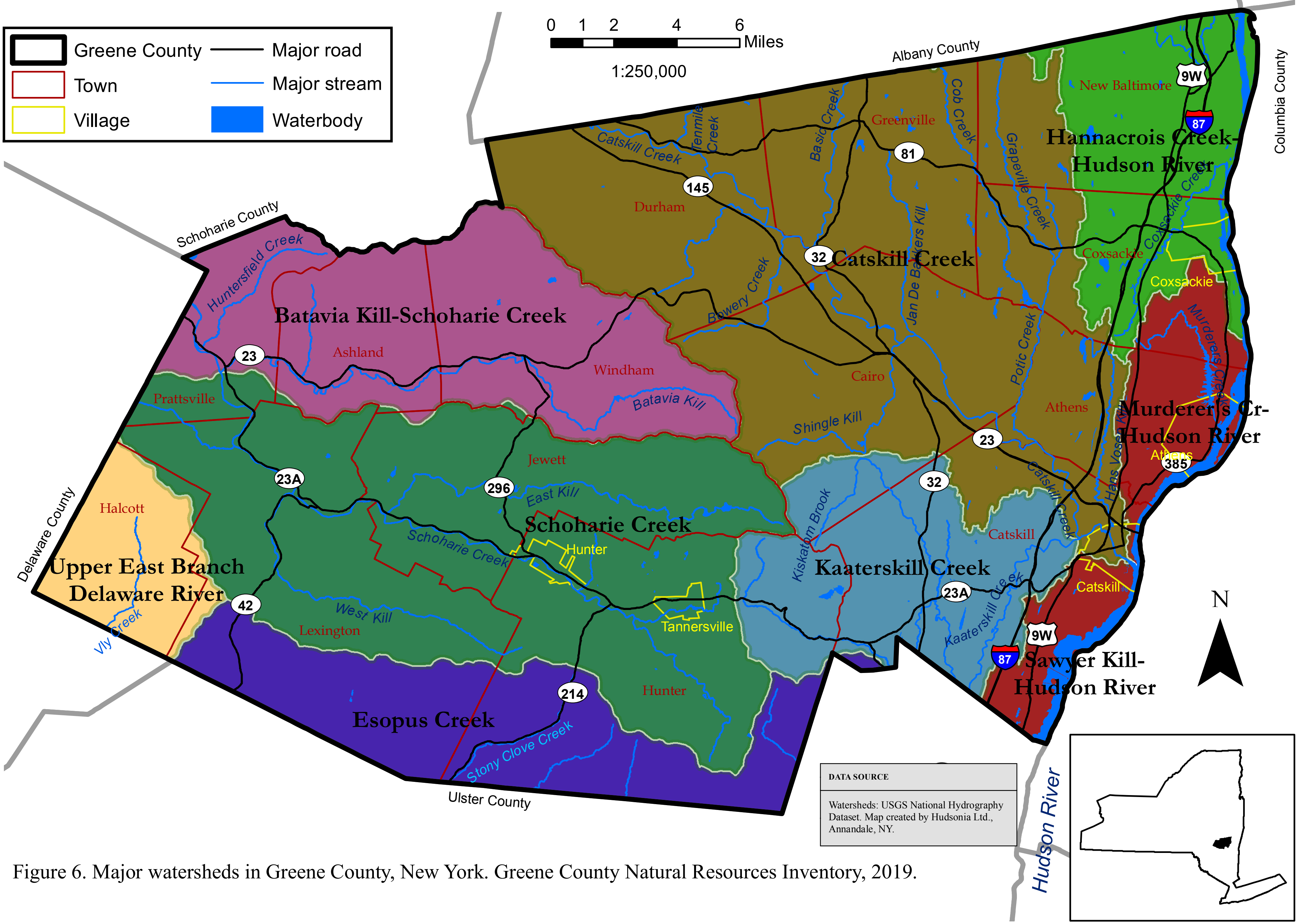


Figure 6. Major watersheds in Greene County, New York. Greene County Natural Resources Inventory, 2019.

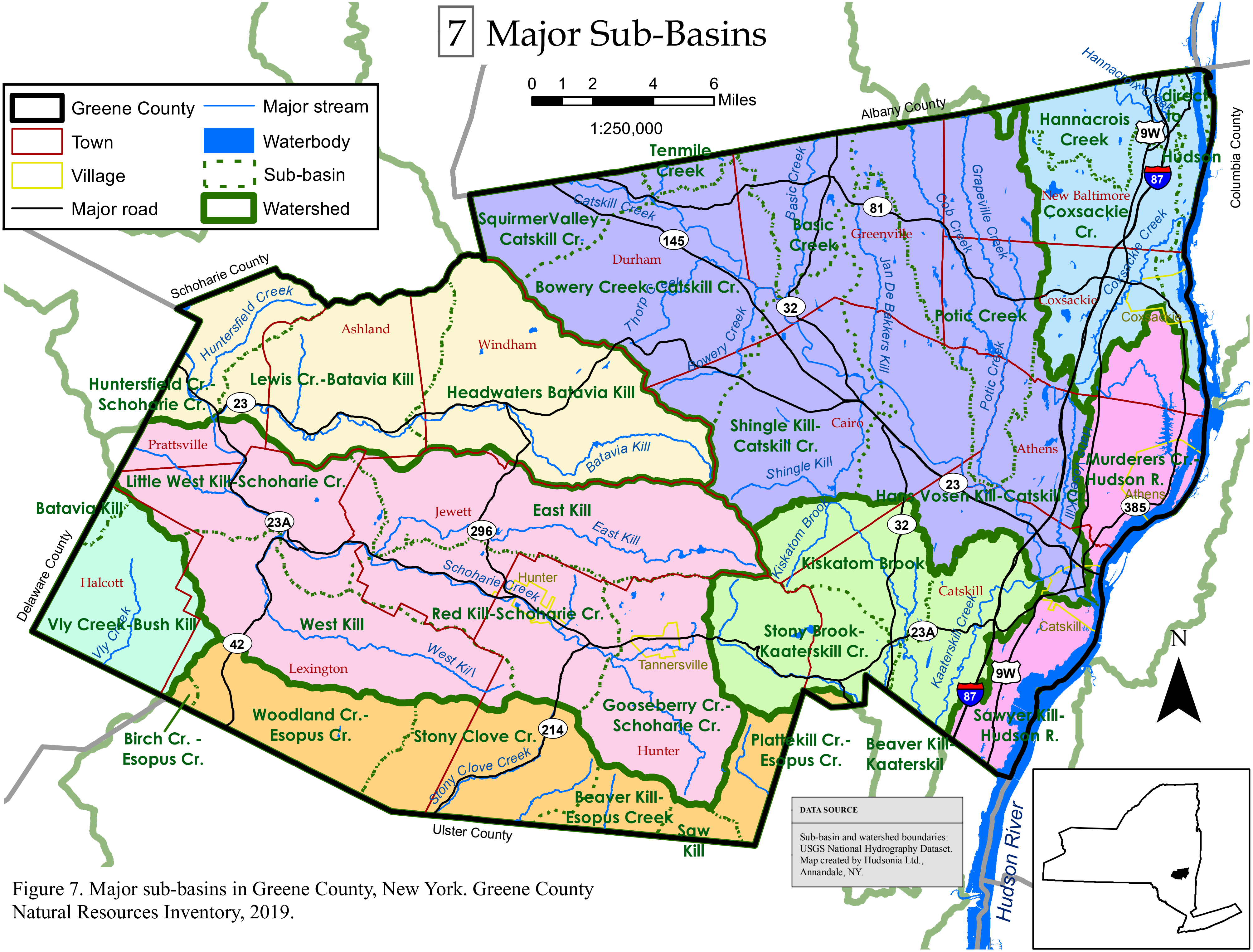


Figure 7. Major sub-basins in Greene County, New York. Greene County Natural Resources Inventory, 2019.

Esopus Creek watershed in Greene County drains to the Ashokan Reservoir, the areas in the Saw Kill and Plattekill Creek sub-basins drain to the Lower Esopus, downstream of the reservoir.

Within each major watershed are sub-basins—the watersheds of smaller streams—each containing networks of perennial and/or intermittent streams that drain the land and provide essential water sources for habitats, wildlife, and the human community (Figure 7).

The Hudson River—the largest surface water feature in Greene County—is tidal for the 153 miles from its mouth in New York Harbor to the Federal Lock and Dam in Troy. The tides rise and fall approximately twice per day, with a typical amplitude of ca. 4.5 feet (varying by location). In the Greene County reach, the river is entirely freshwater, and ranges from ca. 1500 ft wide at its narrowest at New Baltimore to ca. 1.3 miles wide at its widest at Inbocht Bay in Catskill.

Apart from the Hudson, the largest streams in Greene County are Catskill Creek, Kaaterskill Creek, and Coxsackie Creek—which all drain to the Hudson estuary—and the Batavia Kill, East Kill, West Kill, and Schoharie Creek, which all drain via Schoharie Creek to the Schoharie Reservoir and thence to the Mohawk River, or artificially to the Ashokan Reservoir via the Shandaken Tunnel. Figure 8 shows those large streams, most of the other perennial streams in Greene County, as well as some of the intermittent streams.

The size of a stream is determined by the extent and character of the land in its watershed. The size, gradient, hydroperiod, and water quality of any reach of a stream are all crucial factors influencing the kinds of fish and other aquatic organisms it will support.

A stream is inextricably tied to its floodplain—the area adjacent to the stream channel that floods frequently or infrequently. The floodplain provides habitat for plants and animals that require or benefit from proximity to the stream; provides organic material that is essential to the stream habitat structure and food web; and helps to regulate stream flows both during and outside of flood events.

To help with planning for land uses and infrastructure, the Federal Emergency Management Agency (FEMA) has identified and mapped the areas along larger streams that are expected to be inundated by floodwaters at predicted frequencies. These "flood zones" are described below in the **Natural Resources** section.

Ponds and small lakes, both natural and constructed, are common throughout the county. Most were constructed by excavation in upland or wetland areas or by damming small streams, and occur as backyard ponds (e.g., for recreation, fire control, or landscaping ornament) or farm ponds for watering livestock or irrigating crops.

Catskill Creek at the Mawignack Preserve. Photo: Bob Knighton © 2019

Larger lakes are also widely distributed. Most were created by excavation or dams, but a few developed naturally in glacial kettles or other depressions. Sleepy Hollow Lake, stretching ca. 2.5 miles north-to-south in Coxsackie and Athens, was created in 1972 by damming Murderer's Creek to create lakeside lots for a large residential development project. Its perimeter is intensively developed with roads and houses. The largest lakes in the county are Sleepy Hollow Lake, Coxsackie Reservoir, North/South Lake, Hollister Lake, and Potic Reservoir. The Schoharie Reservoir (1129 acres) lies mostly outside of Greene County, but 46 acres of it laps into Prattsville. The highest elevation lake (2251 ft asl) is Onteora Pond near Tannersville (Town of Hunter). The lakes of ten acres and larger are listed in Table 3.

The Batavia Kill and Schoharie Creek and their tributaries all feed the Schoharie Reservoir, one of nineteen reservoirs in the New York City drinking water system. The Schoharie Reservoir spans portions of the towns of Conesville and Gilboa in Schoharie County, Roxbury in Delaware County, and Prattsville in Greene County. The (western) Vly Creek drains to the Upper East Branch of the Delaware River which feeds the Pepacton Reservoir, also in the New York City water system. Stony Clove Creek and the other small streams draining the southern slopes of the southern Catskill peaks in the county all drain to the Esopus Creek, some feeding the Ashokan Reservoir (in the New York City system), and some the Lower Esopus below the reservoir. Four other Greene County waterbodies—Coxsackie, Medway, and Potic reservoirs and Sleepy Hollow Lake—are also used as public drinking water sources.

Groundwater is the water that resides beneath the soil surface in spaces between sediment particles and in rock fissures and seams. Groundwater supplies the drinking water for the rest of the county's residents and businesses. It also feeds our upland habitats, springs, ponds, and wetlands, and is the source of base flow for most of our perennial streams. Those surface water resources in turn support farms, fish, and wildlife, aquatic plants, and human recreation, and are important components of some of the county's scenic landscapes. The unconsolidated aquifers shown in Figure 8 are areas where groundwater may be especially accessible for our uses, but groundwater also occurs in other geologic settings throughout the county. Bedrock fractures hold the groundwater tapped by many of our domestic wells outside of the unconsolidated aquifer areas.

Table 3. Lakes of Greene County, New York. Included here are lakes of 10 acres and larger.

Name	Town	Size (acres)	Elevation (ft asl)
Beaver Dam Lake	Greenville	40	653
Broncks Lake	Coxsackie	61	302
Canoe Lake	Athens	12	217
Colgate Lake	Jewett	28	2051
Coxsackie Reservoir	Coxsackie	102	400
Green Lake	Athens	41	253
Hollister Lake	Athens	76	305
Lake Heloise	Windham	23	1962
Lake Rip Van Winkle	Hunter	21	1857
North/South Lake	Hunter	88	2129
Onteora Pond	Hunter	20	2251
Potic Reservoir	Coxsackie	75	430
Rockefeller Lake	Cairo	20	440
Schoharie Reservoir*	Prattsville*	46*	1129
Silver Lake	Windham	14	1844
Sleepy Hollow Lake	Coxsackie & Athens	309	59
Van Luven Lake	Catskill	11	220

* Most of the 1159-acre Schoharie Reservoir lies in Schoharie County, but 46 acres lap into Prattsville, Greene County.

8 Streams, Ponds, and Aquifers

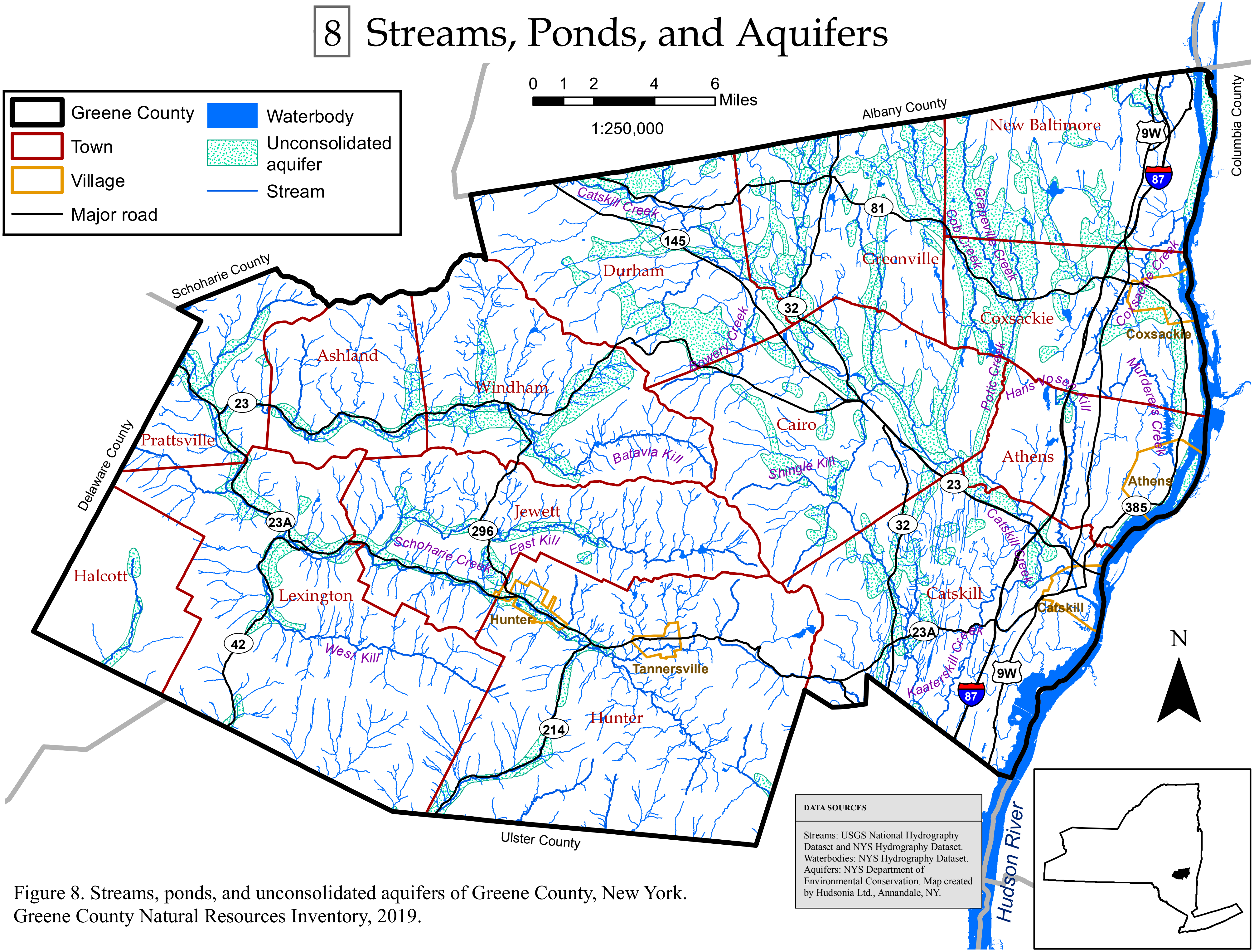


Figure 8. Streams, ponds, and unconsolidated aquifers of Greene County, New York. Greene County Natural Resources Inventory, 2019.

DATA SOURCES

Streams: USGS National Hydrography Dataset and NYS Hydrography Dataset. Waterbodies: NYS Hydrography Dataset. Aquifers: NYS Department of Environmental Conservation. Map created by Hudsonia Ltd., Annandale, NY.

NATURAL RESOURCES

The natural resources of Greene County that are the heart of this document are briefly described below. These include the rocks and soils, lakes, ponds, streams, wetlands, forests, meadows, and rocky crests that constitute the visual landscape and contribute to the ecosystems that provide us with clean air, abundant and clean water, food, and habitats for plants, wildlife, and human communities.

Mineral Resources

The mineral resources of Greene County are fundamental to the habitats, water quality, and agriculture of the county, and have been used directly for shelter, tools, and commerce since the earliest days of human settlement. This section describes some of the past, current, and potential uses of those resources since European arrival. The bedrock of Greene County and some of the mining history are described in the **Physical Setting** section (above) and **Land Uses** section (below).

Bedrock

Sandstones of the Catskills have long been used as "dimension stone" and aggregate. Dimension stone is rock material that is trimmed to particular sizes and shapes to make blocks or slabs for construction, such as for structural units for buildings and as thinner slabs for use as building trim, curbstones, or paving stones (Dineen 1976). Bluestone, a red, green, brown, or bluish-gray sandstone, has been quarried for trimwork on buildings. Kudish (2000) mapped 30 abandoned bluestone quarries in Greene County from his own and others' observations. Bluestone mining in the Catskills peaked in the late 1800s and as of 1903 Greene County had only two bluestone quarries (Dickinson 1903). By 1919 the most accessible sites throughout the Catskills were played out, and the architectural fashions were shifting from stone to reinforced concrete and steel (Dineen 1976).

Sandstone aggregate is used as a filler in concrete and asphalt. Small sandstone quarries still operate at several locations in the county. Today there are active sandstone quarries in Ashland, Catskill, Coxsackie, Lexington, Thompson, and elsewhere.

Shale has been quarried for aggregate, brickmaking, and cement manufacture. Kudish (2000) noted six abandoned shale pits in Greene County—four in the Huntersfield range, one at Onteora Park, and one on South Mountain. In 2019 there were six active licenses for commercial shale quarries, in

Athens, Coxsackie, Durham, and New Baltimore. Zinc and lead ores have been mined in other parts of the Catskills but not in Greene County.

Carbonate bedrock in Greene County occurs mainly in the Kalkberg. It has been mined for production of natural and Portland cement, dimension stone, aggregrate for concrete and road-building, railroad ballast, riprap, lime production, and agricultural limestone. "Natural cement" was produced in the 1800s and early 1900s from certain kinds of limestone by crushing, heating, and grinding it to use as mortar, but production in the Catskill region dropped off by the 1920s. "Portland cement" is produced by crushing limestone, mixing it with crushed shale or clay or silica, heating it, and then grinding finely and curing. As of 1973, three Greene County operations were still producing Portland cement from local raw material (Dineen 1976), but none are active today.

Mining of limestone for building stone was a major industry in the Catskills in the 1800s but was finished in the region by 1911. Limestone has also been mined for production of lime—a calcium oxide used in masonry, cement, paper manufacturing, and other chemical processes (Dineen 1976). Agricultural limestone is a very finely crushed stone used on cropfields and lawns to reduce acidity, stabilize soil characteristics, and provide calcium to plants. Two limestone mines are still active in Catskill.

Surficial Deposits and Soils

The surficial deposits—the glacial outwash, till, and lacustrine material left atop the bedrock by the receding glacier, and the alluvium deposited along streams—are the materials in which most of our soils have formed. Some have also been important extractable resources, especially the lacustrine clays and the outwash sands and gravels.

The deep clay deposits in the Lake Albany plain in the eastern part of Greene County were mined into the early 1900s for brickmaking at Coxsackie, Athens, and Catskill. The Hudson River region was then the largest brickmaking region in the world and was the dominant industry on the river (Hutton 2003), but most of the clay mines and brickworks were closed by the 1950s.

Soils

(*"Soils" are organic or unconsolidated mineral materials that have been acted on by weathering and biological processes.*)

Soil types are distinguished and classified according to depth, texture, color, chemistry, and wetness or dryness. Soil characteristics are much influenced by the "parent" materials of origin (e.g., the bedrock, surficial deposits, or organic material), and by topography, climate, hydrology, vegetation, and time.

Sandy and gravelly soils formed in glacial outwash occur along stream corridors and in kame deposits here and there. The largest contiguous areas of sandy and gravelly soils are along Basic

Creek, Catskill Creek, the Batavia Kill (and tributaries), and Schoharie Creek. Small gravel mines are here and there in glacial outwash and kame deposits in the county.

A glacial "kettle" is a depression created by a stranded block of ice left behind by the receding glacier. Kettle holes typically filled with water and, over time, decaying organic sediments developed into deep layers of peat. Kettles are uncommon wetland types in the Hudson Valley but are found here and there in glacial outwash areas. The deep peat in some of these wetlands has been mined in the past, and some kettles have a layer of marl beneath the accumulated peat. Marl is a calcium carbonate-rich mud or mudstone that can be used, like limestone, as a soil conditioner. It was apparently mined from a New Baltimore location (Luther 1906) and may also have been mined from kettles elsewhere in the county.

The Hudson River corridor was the largest brickmaking region in the world by the early 20th century, but most of the clay mines and brickworks were closed by the 1950s.

The clayey soils on the Lake Albany plain are predominantly silt loams and silty clay loams in the Hudson-Vergennes complex (Broad 1993). These soils are on fairly level terrain extending 1-5 miles from the Hudson River shore, but nearer the Hudson River have been deeply eroded by streams in dramatic dendritic (branching) patterns especially evident in New Baltimore, Coxsackie, and Athens.

Wetland soils ("hydric soils") include those classified as "very poorly drained" or "poorly drained" and some instances of those classified as "somewhat poorly drained." (These classifications are found in the county soil survey [Broad 1993] and on the Natural Resources Conservation Service [NRCS] website.) Wetland soils are those that remain saturated in their upper layers long enough during the growing season to develop anaerobic conditions and, hence, to support wetland-adapted ("hydrophytic") plants. Some wetland soils are saturated or inundated year-round, and some may be saturated for only a few days or weeks in the spring. Greene County wetland soils are variously developed in mineral or organic material. The oldest, wettest wetlands—such as the Great Vly at the southeastern edge of the county, or Emerald Bog at the Mountain Top Arboretum—have developed very deep layers of peat, but those that typically dry out for significant periods during the growing season may have little or no peat accumulation.

The oldest, wettest wetlands—such as the Great Vly at the southern edge of Catskill—have developed very deep layers of peat.

Soils are a critical resource for plants and for animals that rely on them directly or indirectly for food and shelter, and are essential for most agricultural crops. Soil types differ from each other depending on their parent material (the mineral or organic material that they formed in), depth above bedrock, texture, and chemistry, and their wetness or dryness. All of these characteristics help to determine the kinds of biological communities that become established. For example, the shallow, droughty mineral soils of rocky barrens support plants such as pitch pine, scrub oak, and blueberries; the wettish, somewhat calcareous mineral soils of a wet clay meadow support plants such as fox sedge, Bush's sedge, false beardtongue, and eastern red cedar; and the deep organic soils of an acidic bog support *Sphagnum* mosses, leatherleaf, sheep laurel, and pitcher plant.

Most of our soils have taken thousands of years to develop from the mineral material deposited by glaciers or by streams, or the accumulated organic material in certain wetlands, so they are irreplaceable in the human time scale. When soils are lost to erosion or polluted or damaged in other ways, they cannot be easily replaced.

> Soils are slow to develop and easily damaged, and are irreplaceable in the human time scale.

The county soil survey (Broad 1993) provides maps of Greene County soils and describes many of their characteristics and their suitability for human uses such as lawns, septic leachfields, structural support for roads or buildings, and agriculture. Soil maps and descriptions for any Greene County location can also be viewed online at the Web Soil Survey of the Natural Resources Conservation Service. The Web Soil Survey also has updated names for Greene County soil types (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx). See a discussion of the best farmland soils in the **Farmland Resources** section, below.

Near the Hudson River is a broad area of deep, fine-textured, well drained to somewhat poorly drained soils in the Kingsbury-Rhinebeck-Hudson association, developed in the lakebed of the past glacial Lake Albany. The general terrain is flat or gently sloped, except for the eroded steep-sided drainageways and ravines that have formed in the clayey deposits. The clayey soils are mildly acidic to mildly alkaline. On hills and ridges within and west of that zone are soils in the Nassau-Farmington association. These are shallow, well drained to excessively drained soils formed in glacial till, on gentle to very steep slopes; they occupy much of the limestone and shale ridges of the Kalkberg that run north-to-south through the eastern tier of towns.

Between the Kalkberg and the Catskills eastern escarpment are the Catskill foothills at elevations up to 1500 ft asl. These areas are mostly underlain by soils formed in glacial till, although alluvium occupies the floodplains along the major streams (Catskill Creek, Batavia Kill, Schoharie Creek, West Kill, East Kill and the Kiskatom Flats), and glacial outwash and kame deposits occupy parts of those valleys. The soils of the Catskill Mountains are predominantly formed in glacial till, and tend to be acidic and moderately to very deep on the lower slopes, and shallow at the higher elevations, where bedrock is typically either exposed or within about 28 inches of the soil surface.

Soils have immeasurable value to the human community. They are responsible for the presence of most of our vegetation, for most kinds of agriculture, for the purification of water, and for immense amounts of carbon storage. Soils are the foundations of our forests, meadows, and wetlands, as well as our farmland, lawns, gardens, and golf courses. The diversity of plants, animals, and ecological communities depends in large part on the structure, chemistry, and biology of the soils.

The soil types depicted in the county soil survey maps have been identified by soil scientists through remote sensing and field observations, and then mapped on the basis of the landscape setting and other factors. Although much field work was conducted for the survey, many of the mapped soil units have not been visited by a soil scientist. Furthermore, any map unit (polygon) for a particular soil type may contain up to two acres of other soil types. For these reasons the soil maps are not suitable for detailed site-specific land use planning, but they nonetheless provide a wealth of information on the general character of the soils at any site.

Soils are the largest reservoir of carbon in most ecosystems (Mitsch 2016). Carbon is stored both in the soil organic matter—composed of live and decomposing organisms—and in the soil mineral material. Where soils remain substantially undisturbed, the carbon can remain sequestered for thousands of years. But disturbance such as soil erosion, drying, removal of vegetation, plowing, or excavation can lead to rapid releases of carbon to the atmosphere, contributing to the greenhouse gases responsible for global warming. Conventional cultivation results in large (up to 50%) losses of soil carbon to the atmosphere (Johnson 1992). Carbon storage as well as soil fertility tends to be increased by use of perennial crops and tillage systems that rely on cover crops, nitrogen fixation, incorporating organic matter into the soils, and no-till or minimum tillage practices (Johnson 1992, Byrne et al. 2018).

Plowing and other kinds of soil disturbance can lead to rapid releases of carbon to the atmosphere, contributing to the greenhouse gases responsible for global warming.

The Natural Resources Conservation Service of the US Department of Agriculture has identified the soils best suited to agriculture, and classified them as Prime Farmland Soils and Farmland Soils of Statewide Importance. See the **Farmland Resources** section (below) for further discussion of these soils.

Uncompacted soils that are high in organic matter and have diverse and abundant microbiota are the most effective for water retention, carbon storage, and herbaceous crop production. Soils with other characteristics—shallow soils, low-fertility soils, wetland soils, or those with uncommon mineral or chemical composition—can have great value for native biological diversity. The habitat implications of some of these soil characteristics are discussed in the **Biological Resources** section.

Water Resources

The term "water resources" refers both to surface water— i.e., springs, streams, lakes, ponds, and wetlands—and to groundwater, the water that resides beneath the soil surface. The quantity and quality of surface and groundwater available to humans and natural habitats depend on the conditions in the land areas that drain to those resources.

Water is used in domestic households, agriculture, industry, recreation, and nearly all other human activities. Because clean and abundant water is critical both to ecosystems and to the Greene County human community, the protection and conservation of surface water and groundwater resources is of paramount importance to the municipalities of the county.

New York State Public Health Law requires that all drinking water supply systems with greater than 1000 service connections provide their customers with annual water quality reports. The purpose of the law is to ensure that customers are informed about the quality of their water supply as well as the responsibilities, activities, and infrastructure of their water supplier. The annual reports provide the results of tests for contaminants, and are available from the water district managers; most are available online. Most of the public water systems in the county are drawn from groundwater wells, but four are from surface water reservoirs—the Potic Reservoir (in Coxsackie) supplies the Village of Catskill; the Coxsackie Reservoir (Coxsackie) and Medway Reservoir (New Baltimore) serve the Village of Coxsackie. Sleepy Hollow Lake supplies drinking water to the private residential community along its shores and is also an emergency water supply for the Village of Athens. The Schoharie Reservoir feeds the New York City drinking water system.

Groundwater

Groundwater wells supply most of the water for residents, farms, businesses, and industry in the county. Groundwater also feeds our upland habitats, as well as springs, ponds, and wetlands, and is the source of base flow for our perennial streams. Those surface water features in turn support fish and wildlife as well as human recreation, and are important components of some of the county's scenic landscapes.

Drinking water wells throughout the county tap into groundwater from a variety of shallow and deep sources. Most of the shallow wells—tens of feet deep— are in the coarse glacial outwash deposits (sand and gravel), and the deep wells—tens to hundreds of feet deep—are in the finer and mixed glacial till material or in bedrock fractures, seams, and solution cavities.

Groundwater is fed and replenished by rainwater and snowmelt that seeps through soils and other surficial material and through rock pores and fissures. It can be depleted by overextraction or by inadequate recharge from the surface, and can be degraded by contaminated seepage. Our surface waters are fed in part by rain and snow, but most are also fed by groundwater.

An unconsolidated aquifer is a place where groundwater is stored in saturated sand and gravel deposits. Most such aquifers are in glacial outwash and kame deposits, and some are in lacustrine sands (Figure 5). The aquifers represent the largest and most accessible potential water sources for shallow wells. The aquifer areas are important for recharging groundwater through the coarse, permeable sand and gravel material, but that material is also an efficient conduit for contaminants introduced by above-ground human activities. For those reasons, protection of the aquifer areas from inappropriate uses is especially important. Figure 8 illustrates the general locations of unconsolidated aquifers identified by NYSDEC throughout the county. More detailed maps can be created for municipalities by hydrogeologists based on data from well-drillers' logs and other local geological information.

Most Greene County villages and hamlets that have public water systems rely on groundwater sources, but the villages of Catskill and Coxsackie obtain their water from surface water reservoirs.

Coarse, permeable sand and gravel is an efficient conduit for recharging aquifers, but also for contaminants introduced by above-ground human activities.

Springs are places where groundwater discharges to the ground surface under gravitational pressure. Springs occur in a variety of settings throughout the county, emerging unseen into wetlands, streams, and waterbodies, but also more visibly into upland habitats. Many of our streams, lakes, ponds, and wetlands are fed in part by springs. Springs that originate from deep underground emerge at a fairly constant temperature, usually in the range of 45-55°F year-round, so they help to maintain cool stream temperatures in summer—an important characteristics for many aquatic organisms—and a warmer environment in winter compared to the surrounding landscape. The habitat values of springs and seeps are discussed in the **Biological Resources** section below. In addition to their ecological importance, springs can be important drinking water sources for humans and livestock. Some have been modified with constructed or excavated basins and spring houses.

SURFACE WATER

Greene County has abundant streams, lakes, and ponds (Figure 8) that have influenced indigenous uses of the land, as well as the locations and character of European settlements, industry, and commerce since the 17th century. These water features are also integral to the natural habitats of the county, and the wildlife, plants, and communities that depend on their proximity to surface water.

Running water was the main power source for industry in the 17th through 19th centuries, powering saw mills, grist mills, textile mills, and manufacturing of all kinds. Dams and weirs—sometimes several in sequence along a single stream—disrupted the stream ecology, and the widespread land clearing for agriculture, charcoaling, and the tanning industry further depleted stream water quality and streamflows. The abandonment of water power and regional reforestation since the 1920s, and environmental protection laws since the 1960s, have all helped to restore some of the former water quality and aquatic habitats of the county's streams and lakes. Nevertheless, our surface waters are still subject to obstruction from dams and culverts, pollution from agricultural lands, roads, and residences in rural areas, and stormwater runoff from roads and urban areas.

Residential development around some of the lakes has contributed nutrient pollution to the lakes and has partially cut off the biological communities of lakes from the surrounding terrestrial habitats that were once integral to the lake ecologies.

Streams

Today our streams are used most for recreational fishing, occasional trapping, and swimming, and some are tapped for irrigating crops or watering livestock. The Windham Mountain ski area draws significant volumes of water from the Batavia Kill and from groundwater wells for snowmaking in the fall, winter, and spring, and the Hunter Mountain ski area draws from Schoharie Creek and from water storage reservoirs for that purpose. But overall, present-day uses of streams are minor compared to those of the 18th and 19th centuries (see the **Land Uses** section, below).

Figure 8 shows most of the perennial streams (i.e., those with year-round flow) in the county, and some of the smaller streams that run only intermittently throughout the year. Intermittent streams provide valuable instream habitat and are used by many kinds of terrestrial wildlife. They also supply essential water, organisms, and organic materials to larger streams, lakes, and ponds. The presence of these smaller streams can sometimes be predicted from contour lines on a topographic map, or identified on an aerial photograph, but often they are found only from on-the-ground observations. Users of this *NRI* should be alert to the presence of small streams that do not appear in the map figures in this document or in other publicly available maps.

The water quality, flow volumes, and flow patterns of a stream, as well as the types and quality of instream habitats, depend to a large extent on characteristics of the stream's watershed—the entire land area that drains to the stream. The depths and textures of the soils in the watershed, the depth and quality of organic duff at the soil surface, the kinds of vegetation, the extent of impervious surfaces (e.g., roads, parking lots, roofs), the management of stormwater, and the amount of ditching and other surface water channelization throughout the watershed all influence the volumes and patterns of surface runoff during precipitation and snowmelt events, the degree of water infiltration to the soils, and the amount and quality of water reaching streams, wetlands, ponds, and groundwater reserves throughout the year.

Ledges along Catskill Creek. Photo: Chris Graham © 2019

Floodplains

A "floodplain" is the area bordering a stream, lake, or pond that is subject to flooding. Some streamside areas flood annually or more frequently, and some flood only in the largest storms or snowmelt events. Floodplains at some locations are just a few feet wide and elsewhere are a half-mile wide or wider, depending on the local topography and the stream flow volumes.

The Federal Emergency Management Agency (FEMA) maps the areas expected to flood at statistical intervals based on historical flood records. The "100-year flood zone" is the area believed to have a 1% chance of flooding in any given year. For property owners this means, for example, that during the span of a 30-year mortgage, a house in the 100-year flood zone has a 26 percent chance of being flooded at least once in that mortgage period (Holmes and Dinicola 2010). The "500-year flood zone" is the area believed to have a 0.2% chance of flooding in any given year.

> A house in a 100-year flood zone has a 26 percent chance of being flooded at least once over a 30-year period.

FEMA delineates flood zones only on the larger streams, even though small streams can also have significant floodplains. Furthermore, the flood zones for most of the county are delineated from a 2007-2008 baseline, so do not reflect the flooding from the large storms of 2011 and 2012, or the future storms that may be even larger. The flood zones along approximately 10.7 miles of streams in the Town and Village of Hunter and the Village of Tannersville, however, were updated in 2011-2012.

Floodplains serve critical roles in stream ecology and flow dynamics. A well-vegetated floodplain stores water, absorbs excess runoff, and serves as a groundwater recharge area. It helps to stabilize the streambank, reduce stream channel erosion, moderate stream water temperatures, and trap and remove sediments and other pollutants from runoff and floodwaters. Characteristics of the topography, soils, and vegetation at any particular location govern the effectiveness of the streamside and floodplain habitats for providing these services. Well-vegetated floodplains also provide important habitat for terrestrial plants and animals, and contribute woody debris and other organic detritus to the habitat structure and food base for stream organisms (Wenger 1999). Many rare plants occur on streambanks and floodplains in the region, such as cattail sedge, Davis' sedge, and goldenseal.

Floodplain forest along Catskill Creek at the Mawignack Preserve. Photo: Jill Knapp © 2019

Forests along stream corridors provide important habitats and help to protect the stream.

The "riparian corridor" can be loosely defined as the zone along a stream that includes the stream channel, stream banks, floodplain, and adjacent areas, but it can be delineated differently according to local conservation concerns. Intact riparian areas tend to have high species diversity, and many species of animals depend on riparian areas in some way for their survival (Hubbard 1977, McCormick 1978). Floodplains and riparian corridors support many different kinds of habitats, including wetland and non-wetland forests, shrublands, meadows, and ledges. Forested stream corridors tend to be the most effective at providing the stream protection and habitat services mentioned above.

The New York Natural Heritage Program delineated "riparian buffer zones" which encompass the estimated 50-year flood zone based on US Geological Survey stream gage data and topography, and adjacent wetlands (Conley et al. 2018). (The 50-year flood zones were developed through modeling and have not been field-verified.) The mapped buffer zones overlap partially with the FEMA 100-yr and 500-yr flood zones, and extend beyond the FEMA zones at some locations. Also, the riparian buffer zones were delineated along many small streams that are not included in the FEMA flood zone mapping.

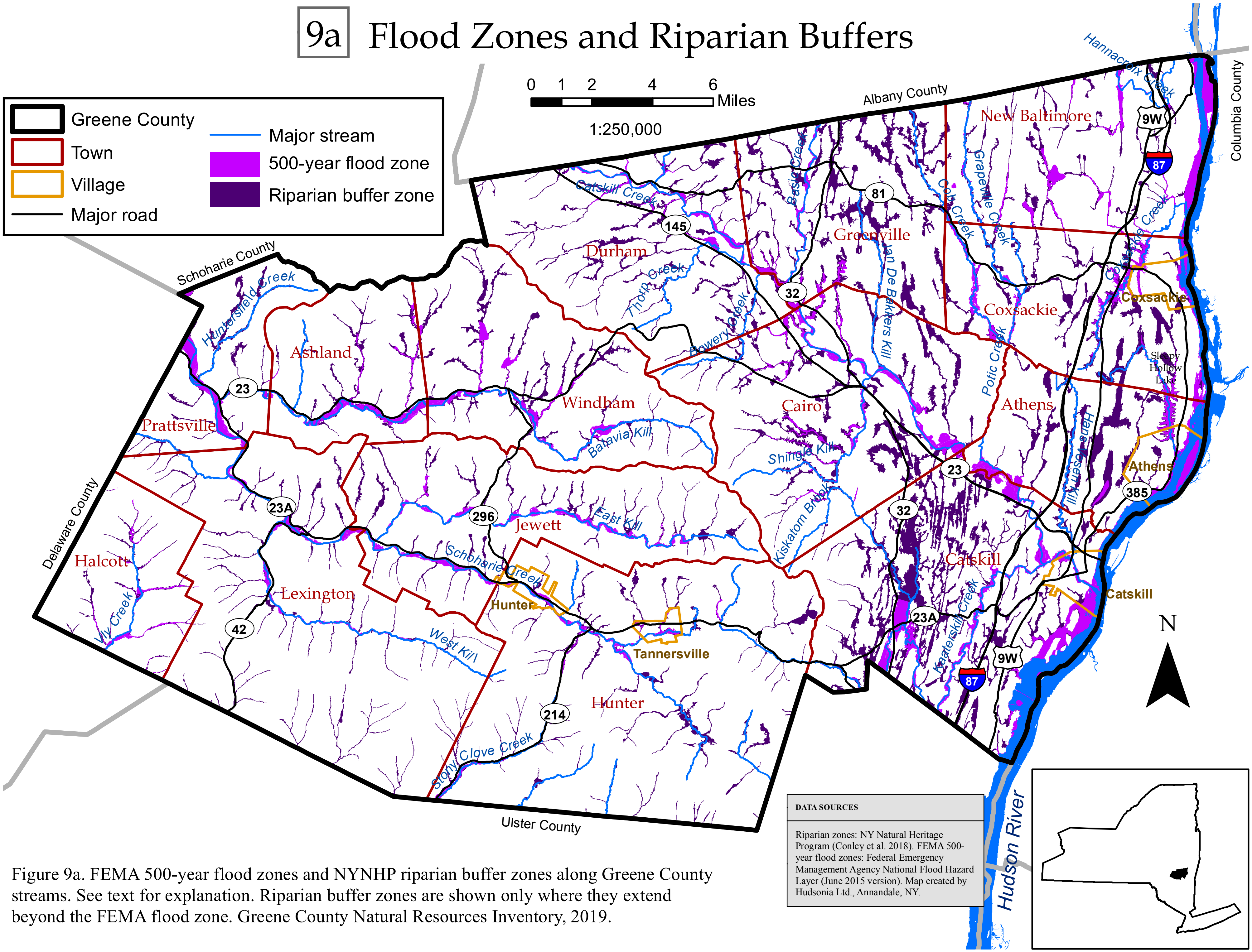
Figure 9a shows the FEMA 500-year flood zones and the NYNHP riparian buffer zones to provide a picture of the areas most likely to be affected in large flood events. The map can inform land use and stream protection efforts, but is <u>not</u> a substitute for the FEMA flood insurance rate maps (FIRMs).

<u>Active River Areas</u>

Streams are an unusually dynamic kind of ecological system, with water, substrates, and organic materials moving and changing continuously. The footprints of many streams narrow, widen, and shift on a seasonal or episodic basis in response to precipitation and snowmelt events or land uses in the stream's watershed. These changes and fluctuations account in part for the exceptional biological diversity of stream corridors (Smith et al. 2008).

The Nature Conservancy has developed the concept of the Active River Area (ARA) to describe some of the physical and ecological processes that drive and sustain a stream, and to provide a conceptual basis for restoring and conserving the landscapes most essential to the functions of stream ecosystems (Smith et al. 2008). The ARA concept recognizes that the ecological and biodiversity values of streams are closely tied to the dynamic interaction between water and land.

9a Flood Zones and Riparian Buffers



DATA SOURCES

Riparian zones: NY Natural Heritage Program (Conley et al. 2018). FEMA 500-year flood zones: Federal Emergency Management Agency National Flood Hazard Layer (June 2015 version). Map created by Hudsonia Ltd., Annandale, NY.

Figure 9a. FEMA 500-year flood zones and NYNHP riparian buffer zones along Greene County streams. See text for explanation. Riparian buffer zones are shown only where they extend beyond the FEMA flood zone. Greene County Natural Resources Inventory, 2019.

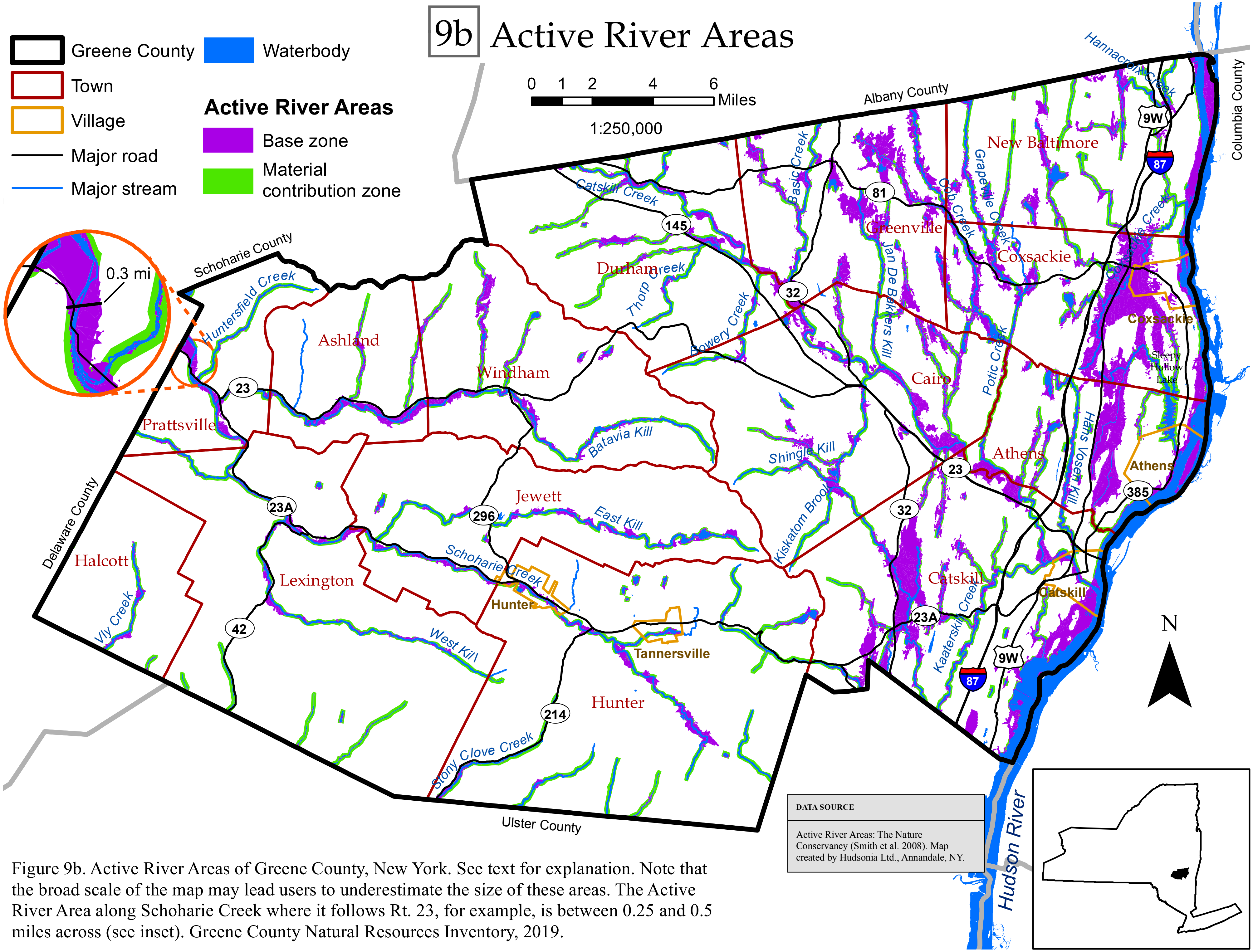


Figure 9b. Active River Areas of Greene County, New York. See text for explanation. Note that the broad scale of the map may lead users to underestimate the size of these areas. The Active River Area along Schoharie Creek where it follows Rt. 23, for example, is between 0.25 and 0.5 miles across (see inset). Greene County Natural Resources Inventory, 2019.

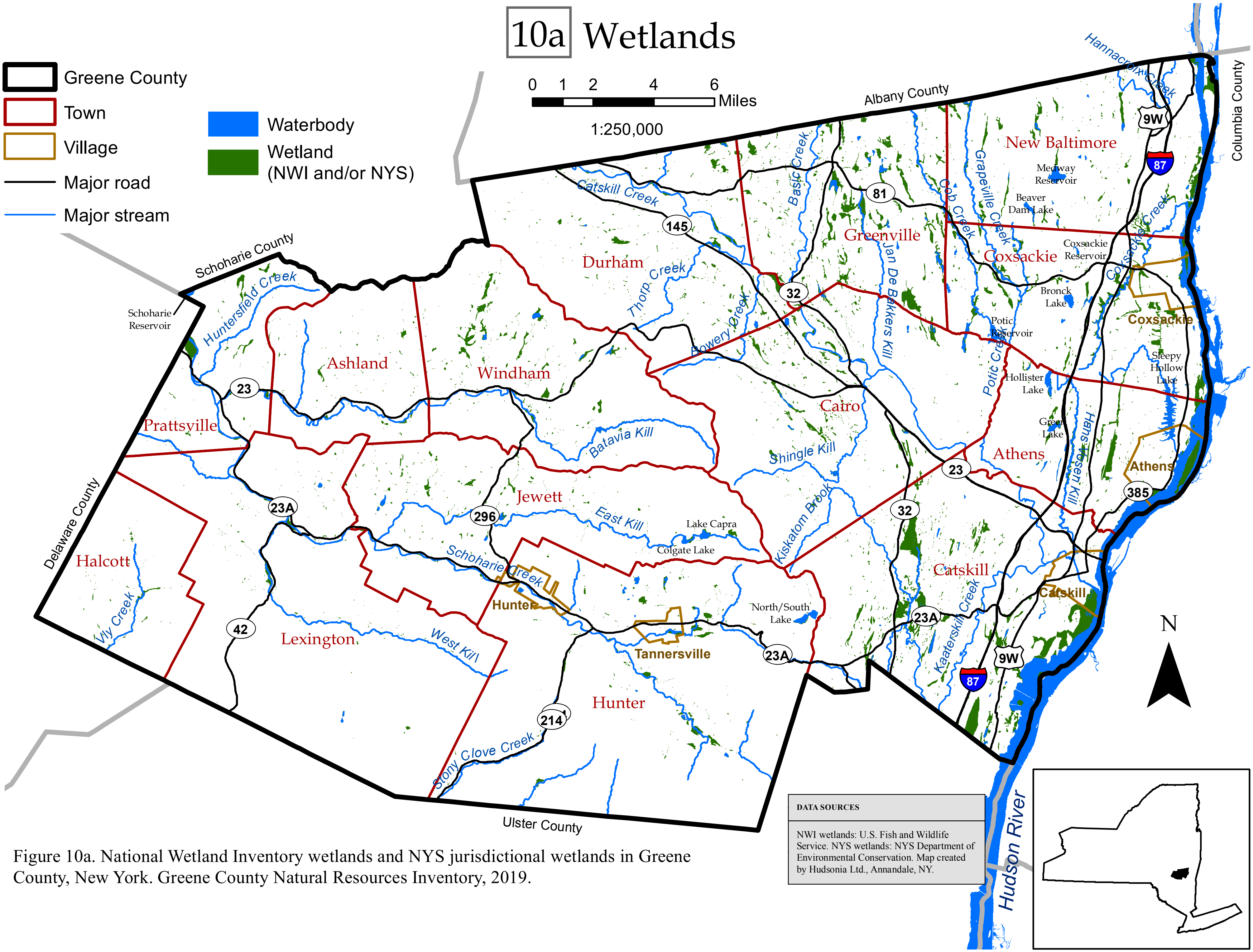


Figure 10a. National Wetland Inventory wetlands and NYS jurisdictional wetlands in Greene County, New York. Greene County Natural Resources Inventory, 2019.

10b Wetland Soils

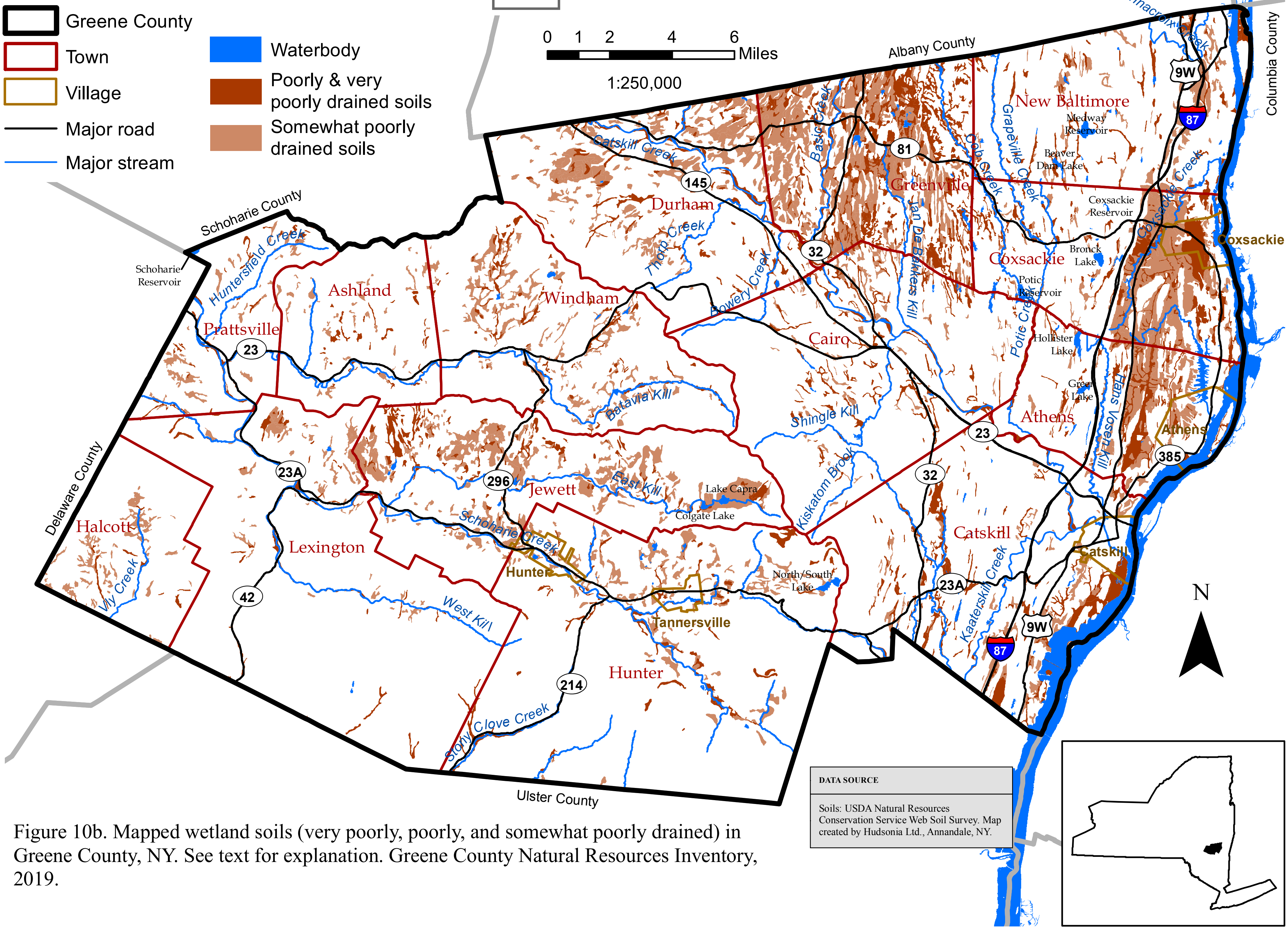


Figure 10b. Mapped wetland soils (very poorly, poorly, and somewhat poorly drained) in Greene County, NY. See text for explanation. Greene County Natural Resources Inventory, 2019.

Active River Areas include the stream itself and the present and past floodplains and adjacent areas that protect, nourish, and accommodate the stream during normal flow conditions as well as during droughts and floods.

The Active River Area includes five components:

- *material contribution zones*, which regularly contribute organic and inorganic (e.g., sediments, water) material to streams;
- *meander belts*, the lateral areas within which the channel migrates over time;
- *floodplains*, the streamside areas that flood regularly or episodically;
- *riparian wetlands*; and
- *terraces*, former floodplains that may still flood in the largest flood events.

The contributions of these components encompass the major processes influencing the stream—system hydrology, sediment transport, processing and transport of organic materials, and key biotic interactions (Smith et al. 2008)—all useful concepts when considering effective measures for stream conservation. Figure 9b shows the Active River Areas along the larger streams of Greene County. Similar concepts can be applied to smaller streams for local land use planning. (The ARA zones are based on coarse elevation data and have not been field-verified.) The **Conservation Principles and Measures** section below offers ideas for protecting the habitats of streams, floodplains, riparian corridors, and Active River Areas.

Wetlands

Wetlands are vegetated areas where the soils are saturated for prolonged periods during the growing season. Some have standing water most of the time; many have standing water that comes and goes during a year of normal precipitation; some have standing water only rarely, such as after a rainstorm or during a snowmelt event. Wetlands may be forested, shrub-dominated, or open, but all have plant species with special adaptations to the wet conditions. Some wetlands are associated with streams, lakes, or ponds, but many are hydrologically isolated from those waterbodies. Figure 10a shows the wetlands mapped by the US Fish and Wildlife Service National Wetland Inventory and by the NYS Department of Environmental Conservation. Figure 10b shows the wetland soils mapped by the Natural Resources Conservaiton Service, where other wetlands are likely to occur. Additional (unmapped) wetlands also occur outside the areas depicted in figures 10a and 10b.

Wetlands have been damaged and destroyed by human activities for centuries but are now widely recognized for their important ecological functions and essential services to the human community. Wetlands can store large volumes of water from rainstorms and snowmelt, and release it slowly to rivers, streams, and groundwater, thus slowing downstream and downgradient flood volumes. Wetlands are able to trap sediments and remove some pollutants from runoff before it enters a stream or lake. Wetlands help to stabilize the banks and shorelines of streams and lakes, and also provide essential habitat for plants and wildlife, including many species of conservation concern. The biological significance of wetlands is discussed in the **Habitats** section.

Ponds and Lakes

Small constructed ponds are numerous in the county. Some are farm ponds built for watering livestock, crop irrigation, or fire control. Many are backyard ponds built for fire control, recreation, or as aesthetic landscaping features. Some of the ponds and lakes are natural waterbodies, but many were created by excavation in upland areas or by damming streams; many of the latter were used as millponds and/or water sources for industrial processes. The creation of some others was incidental to mining of gravel or rock, and one was intentionally created as part of a residential and recreation development. A few of the large lakes are described below.

Colgate Lake is a dammed waterbody in the upper reach of the East Kill in the Town of Jewett. It is in the Colgate Lake Wild Forest, part of the Catskill Forest Preserve, and is bordered by the Windham Blackhead Range Wilderness Area to the north, east, and south. The dam at the outlet of the lake was originally built in 1887 and has been repaired and rebuilt throughout the years, most recently in 2007. NYSDEC stocks the lake annually with brown trout, and a car-top boat launch site is on Route 78. Near the lake are trails for hiking and designated primitive camping sites.
A trail takes you past the site of a former village and sawmill operated by Dutch settlers.

Lake Rip Van Winkle (also called Tannersville Lake) in the Village of Tannersville is a dammed segment of Gooseberry Creek, a tributary to Schoharie Creek. The lake is bordered by private residences and a public park that includes a playground, basketball court, a picnic area with pavilion, a small beach for swimming, and foot trails that are connected to the 2.7-mile multi-use Huckleberry Trail.

North/South Lake in the Town of Hunter is impounded on a small tributary to Spruce Creek, itself a tributary to Kaaterskill Creek. It is in the Windham-Blackhead Range Wilderness of the Catskill Forest Preserve. New York State purchased the land around North Lake and created the North Lake Campground in 1929 and eventually acquired additional land, including the land around South Lake. The lake is a popular destination for swimming, fishing, and non-motorized boating, and is surrounded by numerous hiking trails that offer scenic vistas. The site is a stop along the Hudson River School Art Trail and has the largest campground in the Catskill Forest Preserve. The lake is stocked annually by NYSDEC with tiger muskellunge.

The Schoharie Reservoir—part of the New York City drinking water system—was formed by the damming of Schoharie Creek. Most of the reservoir is in Delaware County but a small part is in the Town of Prattsville, Greene County. The Gilboa Dam at the northern reservoir outlet was completed in the 1920s, and named after the village that was flooded to create the reservoir. Non-motorized boating and fishing are allowed (with NYCDEP permit) on the reservoir NYSDEC stocks the reservoir annually with brown trout and walleye.

Sleepy Hollow Lake is a private recreational lake formed by damming Murderer's Creek and now surrounded by a 2,200 acre residential community. The lake and community cross into three municipalities: the Town of Athens, the Village of Athens, and the Town of Coxsackie. The lake is the drinking water source for the community, which operates its own water treatment plant, and is also an emergency water supply source for the Village of Athens.

Surface Water Use Classification

NYSDEC has classified many of the perennial streams and other waterbodies in the state according to the "existing or expected best usage of each water or waterway segment." The classes range from AA to D, and each may be modified to indicate suitability for supporting trout (T) or trout spawning (TS) (see sidebar). These classifications are based on limited information and do not necessarily reflect up-to-date or site-specific habitat conditions. NYSDEC has also established water quality standards for pollutants and other factors, such as dissolved oxygen and turbidity, to protect the uses associated with the waterbody classifications. Waterbodies that do not meet the standards for their "best uses" may be listed as "impaired" on the Priority Waterbody List (explained below).

NYSDEC Waterbody Classes

Class	Best Use
AA	drinking (with disinfection), bathing, fishing
A	drinking (with disinfection and treatment), bathing, fishing
B	bathing, fishing
C	fishing (reproduction and survival)
D	fishing (survival)
Modifiers	
T	sufficient dissolved oxygen to support trout
TS	suitable for trout spawning

Streams classified as AA, A, B, C(TS) or C(T) are "protected streams" subject to additional regulations to protect the associated uses. State permits are also required for disturbance of the bed or banks of those streams. Any perennial streams that have not been classified by NYSDEC share the classification of the larger stream that they flow into. Intermittent streams are considered to be Class D (Article 15 of the ECL, 6NYCRR Part 608).

Figure 11 shows streams and lakes coded by those water use classifications. Most stream segments in the county are classified as C. The only class A streams are Huntersfield Creek, a few miles of the Batavia Kill, the upper reach of Schoharie Creek, some of the small streams running down the south slopes of Sugarloaf, Twin, Indian Head, and Roundtop mountains, and small segments of a few other streams. The only class B streams are Vly Creek and tributaries (Halcott), Stony Clove Creek, Spruce Creek, Kaaterskill Creek, much of the Catskill Creek below Greenville, and small segments of a few other streams.

Stream size, gradient, substrate conditions, water temperature, water chemistry, and clarity all influence the occurrence and survival of fish species and aquatic communities. Obstructions in streams, such as dams or culverts, also strongly affect the aquatic communities above and below those features.

Greene County is extraordinarily endowed trout streams or trout spawning streams (Figure 11). Streams that support trout are a disappearing resource in other parts of the Hudson Valley due to water pollution, stream-bed siltation, removal of forest canopies in the stream corridors, altered stream flows, suspended culverts, and other consequences of human activities. The degradation of streams coincides with the decline of wild-reproducing populations of brook trout and other organisms of high-quality coldwater streams.

Greene County streams and the Hudson River itself are subject to impairment from sources such as runoff from construction sites, industrial sites, urban areas, and farmland; leachate from failing septic systems; discharges from sewage treatment plants; streambank erosion; atmospheric

Kaaterskill Falls. Photo: Larry Federman © 2019 deposition of pollutants; excessive water withdrawals; and contaminated sediments from past industrial activities. Commercial, industrial, and residential land development typically leads to more stormwater runoff carrying silt, nutrients, chlorides, and other contaminants into streams; stream flows that swiftly increase and decrease in response to runoff events; and unstable stream channels, bank erosion, and degraded habitat. Although the incremental harm from each new development site may seem minor, the cumulative effects of multiple such sites in a watershed can be significant (NYSDEC 2008b).

Priority Waterbodies List

An ongoing NYSDEC waterbody inventory program monitors water quality and trends throughout the state, and identifies the impaired streams, lakes, and ponds most in need of improvement (NYSDEC 2008b). Streams are assessed for invertebrates, water and sediment chemistry, and sediment toxicity, and are classified into six categories:

Impaired waterbodies: Well-documented water quality problems that result in precluded or impaired uses.

Waterbodies with minor impacts: Less severe water quality problems; uses are considered fully supported.

Threatened waterbodies: No apparent water quality problems or use restrictions, but may be threatened by land use or changes in the watershed.

Waterbodies with impacts needing verification: Believed to have water quality problems, but documentation is insufficient.

Waterbodies with no known impacts: No use restrictions, although minor impacts may be present.

Unassessed waterbodies: Insufficient water quality information.

The water quality data are evaluated to assess the ability of each waterbody to support specific water uses (e.g., drinking water supply, swimming, aquatic life, or secondary recreation). The program covers the entire state, but only a few stream segments and lakes have been sampled in Greene County—the mainstems and some tributaries of the Batavia Kill, Catskill Creek, East Kill, Hannacroix Creek, Kaaterskill Creek, and Schoharie Creek. Figure 12 shows the sampled and unsampled areas, and the impairment classifications that resulted, and Table 4 summarizes the data. (Greene County data are from sampling conducted 1999–2016, but most sampling was in the period 2002-2010.) Appendix B has the data sheets for those waterbodies that were deemed to have some level of "impacts" or impairment.

The main water quality problems in Greene County waterbodies were sedimentation from construction and streambank erosion, phosphorus and pathogens from agricultural operations, mercury from atmospheric deposition, septic leachate, sewage treatment discharges, and urban stormwater runoff.

11 Water Use Classification and Trout Streams

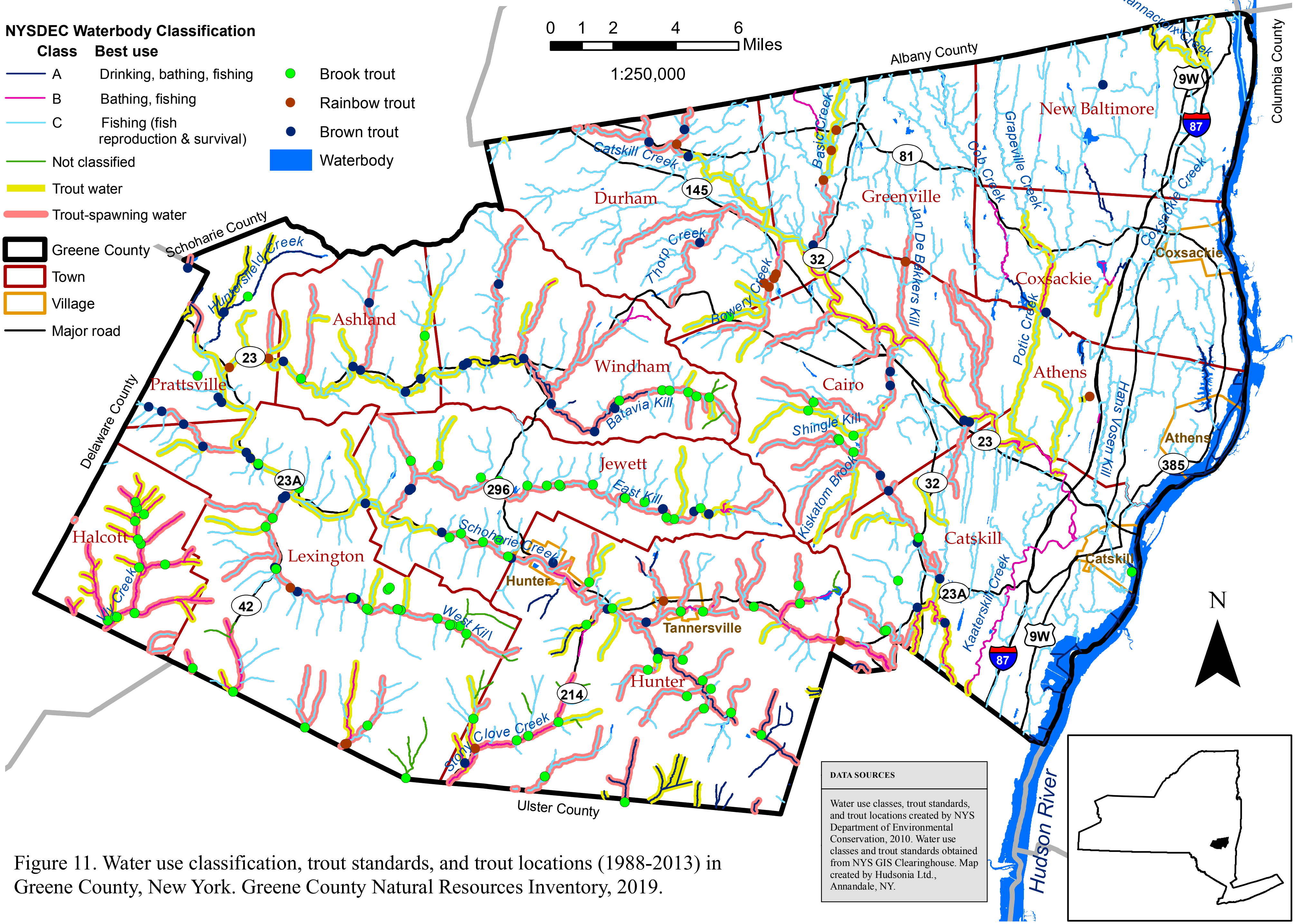


Figure 11. Water use classification, trout standards, and trout locations (1988-2013) in Greene County, New York. Greene County Natural Resources Inventory, 2019.

12 Priority (Impaired) Waterbodies

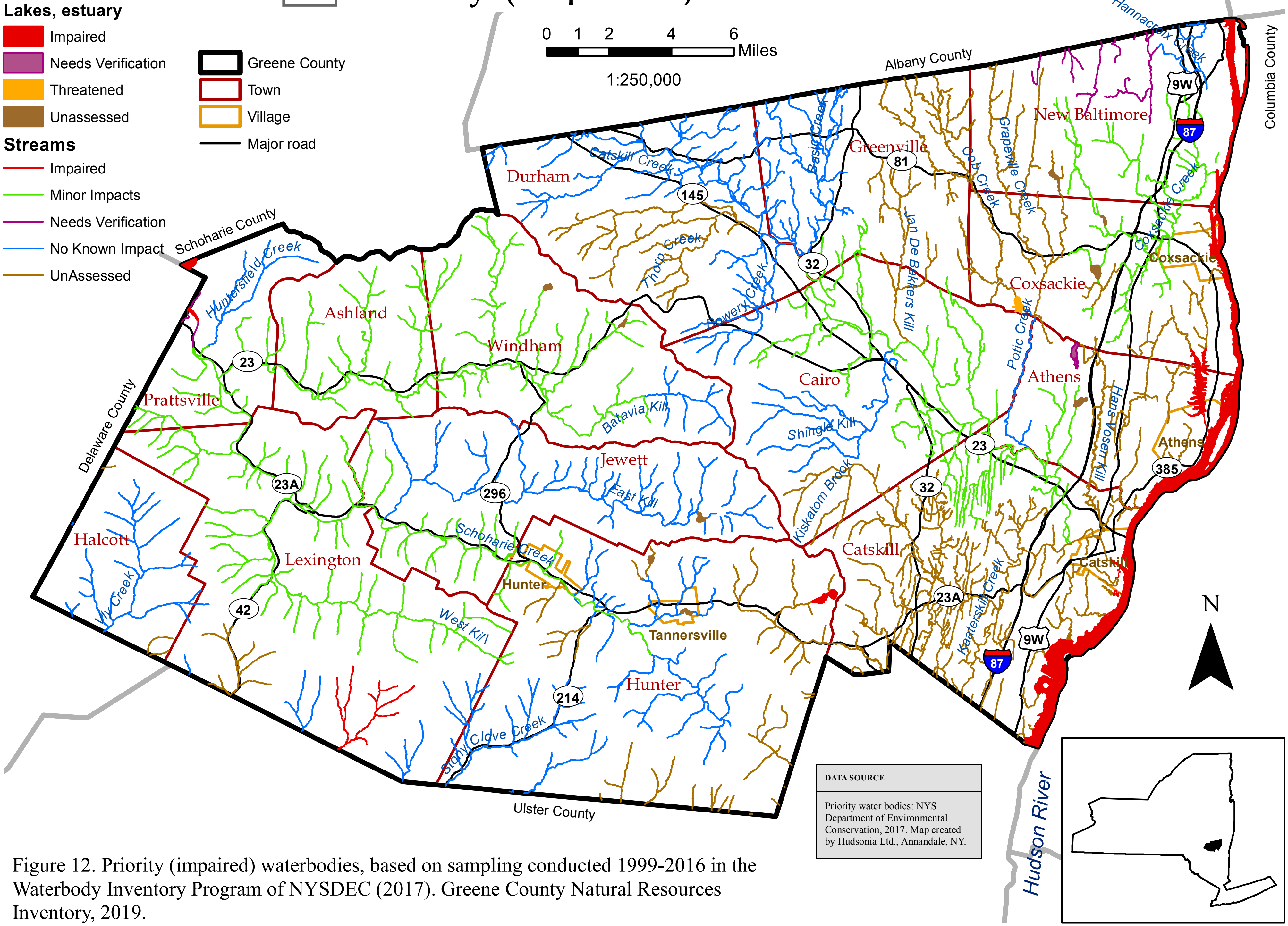


Figure 12. Priority (impaired) waterbodies, based on sampling conducted 1999-2016 in the Waterbody Inventory Program of NYSDEC (2017). Greene County Natural Resources Inventory, 2019.

Table 4. Summary of Greene County water quality sampling results in the NYSDEC Priority Waterbodies program, 2002-2012. Each stream segment (denoted in parentheses) is described in Appendix B.

Year	Waterbody (and segment)	Use Impairment	Type of Impairment	Sources of Impairment (known or suspected)
	Schoharie Creek drainage			
2002	Batavia Kill, lower, & tributaries (1202-0001)	habitat, hydrology	silt, sediment, Japanese knotweed	streambank erosion, habitat modification, construction, septic systems
2002	Batavia Kill, middle, & tributaries (1202-0058)	habitat, hydrology	silt, sediment, Japanese knotweed	streambank erosion, habitat modification, construction, septic systems, roadbank erosion
2010	Batavia Kill, upper, & tributaries (1202-0059)	(none)		
2010	East Kill & tributaries (1202-0063)	(none)		
2010	Huntersfield Creek, upper, & tributaries (1202-0056)	(none)		
2002	Manor Kill & tributaries (1202-0017)	(none)		
2002	Schoharie Creek, upper, main stem (1202-0021)	habitat, hydrology	silt, sediment, Japanese knotweed, thermal changes	streambank erosion, habitat modification, construction, roadbank erosion
2002	Schoharie Creek, upper, main stem (1202-0023)	habitat, hydrology	silt, sediment, Japanese knotweed	streambank erosion, habitat modification, roadbank erosion
2010	Schoharie Creek, upper, & tributaries (1202-0026)	(none)		
2002	Minor tributaries to Schoharie Creek (1202-0057)	habitat, hydrology	turbidity, silt, sediment	streambank erosion, habitat modification, hydrology modification
2002	Minor tributaries to Schoharie Creek (1202-0066)	(none)		
2002	Schoharie Reservoir (1202-0012)	water supply, fish consumption	mercury, silt, sediment	streambank erosion, atmospheric deposition, agriculture
2002	Minor tributaries to Schoharie Reservoir (1202-0054)	aquatic life, recreation	phosphorus, pathogens	agriculture
2002	West Kill & tributaries (1202-0062)	habitat, hydrology	turbidity, silt, sediment	streambank erosion, habitat modification, construction, hydrology modification
	Hudson River drainage			
2007	Basic Creek, lower, & tributaries (1309-0027)	(none)		
2012	Catskill Creek, middle, & minor tributaries (1309-0004)	public bathing, aquatic life, recreation, aesthetics	phosphorus, pathogens, odors, floating solids	municipal, other sanitary discharge, septic systems
2007	Catskill Creek, upper, & minor tributaries (1309-0011)	(none)		
2008	Coxsackie Creek & minor tributaries (1301-0092)	recreation	algal, weed growth, nutrients, pathogens	private, community, septic systems, urban, storm runoff
2008	Hollister Lake (1309-0007)	water supply	algal, weed growth, silt, sediment	habitat modification, hydrology modification
2007	Potic Creek, lower, & tributaries (1309-0019)	(none)		
2008	Potic Reservoir (1309-0024)	water supply	pathogens	agriculture, municipal
2008	Shingle Kill & tributaries (1309-0008)	(none)		
2008	South Lake, North Lake (1309-0017)	fish consumption	mercury	atmospheric deposition

Biological Resources

The term "biological resources" encompasses all the living organisms, biological communities, habitats, and ecosystems that constitute the living landscape. Biological resources are inseparable from physical features such as bedrock, soils, water, climate, and landscape setting.

Intact ecosystems make the Earth habitable by moderating the climate, cycling nutrients and other elements, purifying water and air, producing and decomposing organic matter, sequestering carbon, and providing many other essential and irreplaceable services. They also serve as the foundation of our natural resource-based economy.

> Much of the biological diversity of Greene County is yet unassessed and unknown.

The New York Natural Heritage Program has surveyed many sites in the county to confirm or discover rare species of plants and animals, and natural communities of especially high quality. But much of the biological diversity of the county is yet unassessed and unknown. For example, many groups of insects and other invertebrates are still unstudied, and knowledge of fungi, lichens, and mosses here is rudimentary, despite their fundamental importance to Greene County ecosystems.

Michael Kudish has studied the pre-history, history, vegetation, and ecology of the Catskills for decades, and has published numerous papers and articles on his research. Information from *The Catskill Forest: A History* (Kudish 2000) is included in some of the habitat descriptions below. Hudsonia Ltd. has surveyed plants, animals, and habitats at numerous Greene County sites over the last 38 years, and published the results in site-specific reports and papers. Hudsonia biologists created the *Biodiversity Assessment Manual for the Hudson River Estuary Corridor* (Kiviat and Stevens 2001) that describes many of the habitats of the region, some of the plants and animals of conservation concern that use those habitats, and principles and measures for effective conservation. The *Ecological Communities of New York State* (Edinger et al. 2014) describes natural

Slaty skimmer, a dragonfly of marshy ponds and muck-bottomed streams. Photo: Larry Federman © 2019 communities throughout the state, including those of Greene County. Below are listed these and other basic sources for information on biological resources of Greene County.

The Catskill Forest: A History (Kudish 2000)

Greene County Grassland Habitat Management Plan (Strong et al. 2014)

Biodiversity Assessment Manual for the Hudson River Estuary Corridor (Kiviat and Stevens 2001)

Schoharie Creek Watershed Conservation Assessment (Shirer et al. 2018)

Ecological Communities of New York State (Edinger et al. 2014)

The Second Atlas of Breeding Birds in New York State (McGowan and Corwin 2008)

New York Breeding Bird Atlas (https://www.dec.ny.gov/animals/51030.html)

The New York Dragonfly and Damselfly Survey 2005-2009 (White et al. 2010)

New York Herp Atlas (https://www.dec.ny.gov/animals/7140.html)

HABITATS

A "habitat" is the place where an organism or population lives or where a biological community occurs. A habitat is defined according to its biological and non-biological components—e.g., the vegetation, the climate or microclimate, the kind of rock, soil, or water substrate, and the hydrology. There exists no countywide map of habitats, but habitats have been identified and mapped in a few areas of special concern: the RamsHorn-Livingston Sanctuary, the grasslands along the Route 9W corridor, and an approximately 1000-ft-wide zone along 35 miles of the Catskill Creek (Figure 13).

Figure 14 is a coarse representation of land cover in Greene County identified by the US Geological Survey from interpretation of satellite imagery. The cover types were identified by remote sensing without field verification, and the data contain many errors and omissions but still provides a picture of the general distribution of land cover or habitats in the county.

The profiles of Greene County habitats below are compiled from several published sources and additional field observations of Hudsonia biologists in 2017-2018 in field work for this *NRI* project. Published sources include a report on biological surveys of state-owned lands along the Hudson River (Stevens 1999), *The Catskill Forest: A History* (Kudish 2000), a biodiversity assessment of the Town of Durham (Kiviat and Barbour 2001), a report on plant communities and Japanese knotweed along the Batavia Kill (Stevens and Folsom 2004), a draft management plan for the RamsHorn-Livingston Sanctuary (Barbour et al. 2004), a report on the habitats of the Catskill Creek corridor (Stevens et al. 2014), the *Greene County Grasslands Management Plan* (Strong et al. 2014), a natural resources inventory of the Mountain Top Arboretum (Stevens et al. 2018), and others.

Each profile describes the habitat, its distribution in the county, and some of the plants and animals that are characteristic of the habitat, as well as others that are of conservation concern. A dagger symbol (†) indicates a species with a statewide rarity rank. Appendix C lists more of the plants and animals of conservation concern that occur in these habitats in the county.

Upland Habitats

In this document, the term "upland" is equivalent to "non-wetland." Upland habitats may occur at any elevation, from near sea level on the Hudson River shore to the highest elevations in the Catskill Mountains.

Upland Hardwood Forest

Upland hardwood forests are extremely variable in species composition, sizes and ages of trees, vegetation structure, soil drainage and texture, and other habitat factors. Common trees of these forests in Greene County include maples (sugar, red), oaks (black, red, white, chestnut), hickories (shagbark, pignut), American beech, white ash, black birch, and black cherry. Individuals and small groves of eastern hemlock and eastern white pine are here and there within the hardwood forests. Sugar maple drops out where the soils of the foothills and mountains are shallow, but beech, cherry, red maple, and yellow birch persist into the higher elevations (Kudish 2000). Oaks and hickories are largely confined to the lower elevations and parts of the eastern escarpment affected by long-ago fires used by Native Americans and European settlers as a means of forest management (Kudish 2016). American basswood is common on the limy soils of the Kalkberg and the clayey soils of the Lake Albany plain. Some of the common forest shrubs of upland hardwood forests are witch-hazel, maple-leaf viburnum, serviceberries, and spicebush.

Forests on floodplains of streams include both wetland forests (swamps) and non-wetland forests, often closely intermingled. Typical floodplain forests include a mixture of upland and wetland plant species and floodplain specialists such as American sycamore, eastern cottonwood, American hackberry, and pin oak. Other common trees on floodplains include black locust, slippery elm, basswood, red maple, green ash, and American hornbeam.

Upland Conifer Forest

Eastern hemlock and eastern white pine are the dominant species in most of the conifer forests of the foothills and lowland areas, and forests of eastern red cedar occur on the Kalkberg Ridge and Lake Albany plain. Eastern hemlock forests are also common on north-facing slopes, ravines, and other cool areas of the Catskills, mostly below 3000 ft elevation (Kudish 2000). Individuals and forests of red spruce and balsam fir start occurring at elevations above 1500 ft and are common above 3000 ft. Red spruce-balsam fir is the major forest type at and near the summits of the Catskill

13 Areas with Previous Habitat Mapping

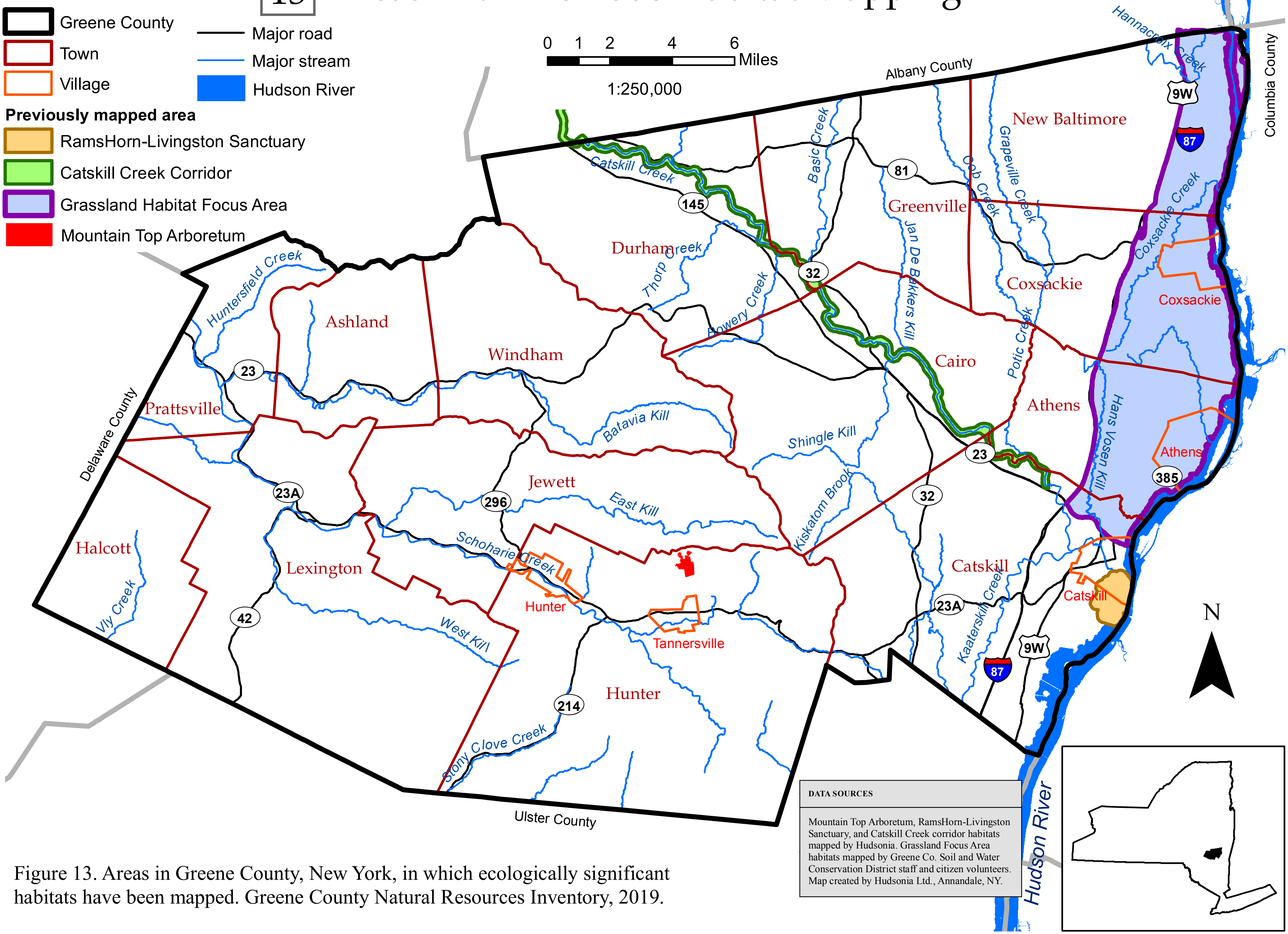


Figure 13. Areas in Greene County, New York, in which ecologically significant habitats have been mapped. Greene County Natural Resources Inventory, 2019.

14 Land Cover

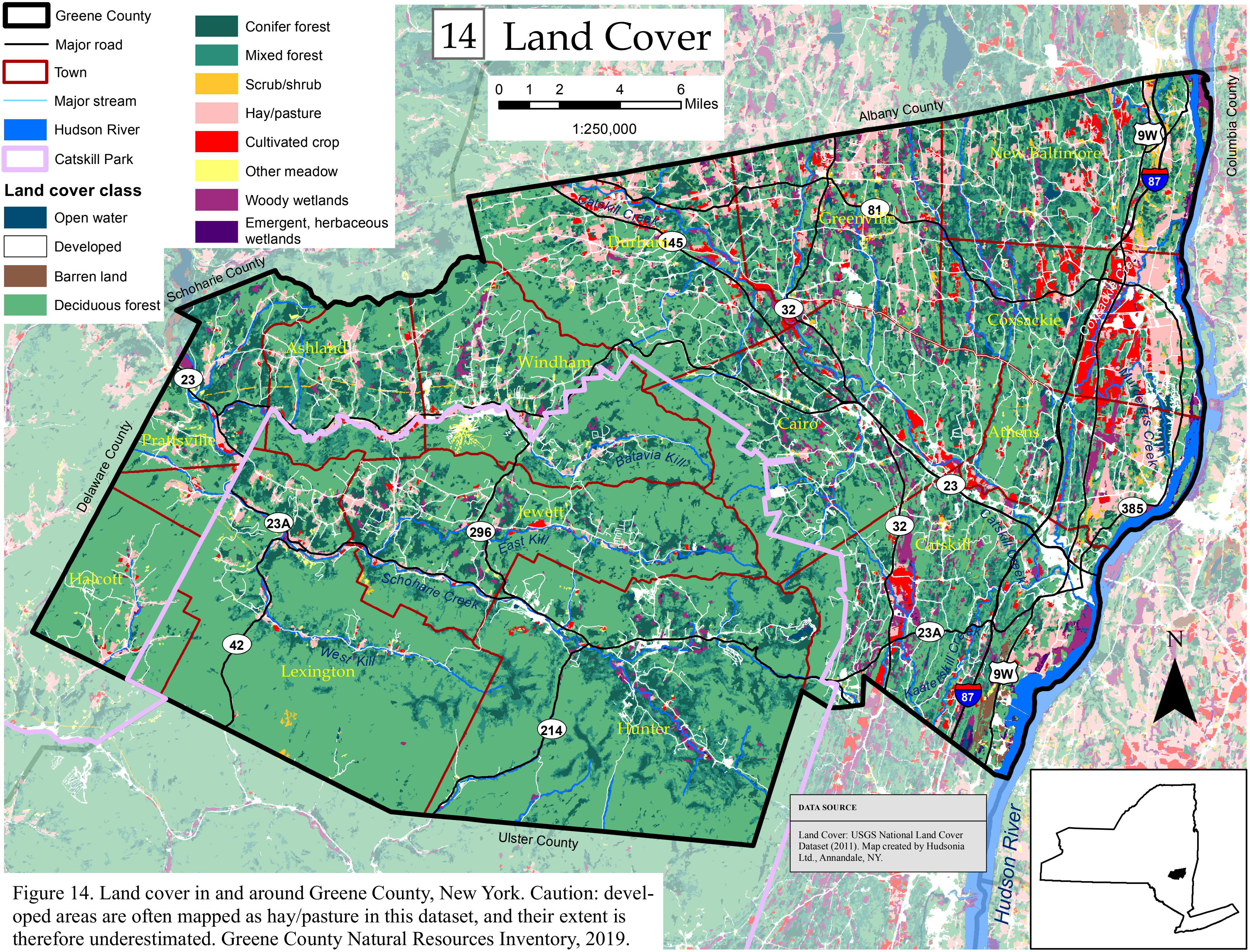


Figure 14. Land cover in and around Greene County, New York. Caution: developed areas are often mapped as hay/pasture in this dataset, and their extent is therefore underestimated. Greene County Natural Resources Inventory, 2019.

Mountain high peaks. Although eastern white pines occur as individuals and in groves in all kinds of settings, whole forests of white pine are typically on abandoned farmland and on coarse-textured soils formed in the lowland glacial outwash or kame deposits. Pitch pine is rare in Greene County, occurring mainly in the acidic rocky barrens of exposed shoulders and summits of the Catskills. Spontaneous stands of red pine are also rare, occurring mainly in places of repeated past forest fires (Kudish 2000). Plantations of white spruce, Norway spruce, red pine, European larch, and Scotch pine are here and there.

Hemlock forests typically have little vegetation in the shrub and herb layers due both to the deep shade of the hemlock canopy and to allelopathic effects, but openings in those forests have hardwood saplings and trees and diverse shrubs and herbs. Spruce and fir forests usually have a moss-covered forest floor.

The hemlock woolly adelgid, a non-native insect, has infested many hemlock forests in Greene County and other parts of the Hudson Valley, and is expected to cause widespread loss of these forests in the coming decades. The warming climate may hasten the spread of the insect into previously uninfested areas.

Upland Mixed Forest

The term "upland mixed forest" refers to non-wetland forested areas with both hardwood and conifer species in the overstory, where conifer cover is 25-75% of the canopy. Mixed forests are less densely shaded at ground level than conifer forests and tend to support a higher diversity and greater abundance of understory species than pure conifer stands.

* * * *

Forests of all sizes can provide valuable habitat and ecological services, but large forests are especially important for area-sensitive wildlife and provide movement corridors for many other kinds of wildlife. Standing live and dead trees are habitat for cavity-using amphibians, songbirds, and mammals, and downed wood provides food for invertebrates and fungi, and habitat for amphibians, reptiles, and mammals. Eastern box turtle† spends most of its time in upland forests and meadows, finding shelter under logs and organic litter, and spotted turtle† uses upland forests for summer dormancy and travel. Many snake species, such as timber rattlesnake,† northern copperhead,† eastern rat snake,† and red-bellied snake, forage widely in upland forests and other habitats.

Upland forests provide important nesting habitat for raptors, including red-shouldered hawk,† Cooper's hawk,† sharp-shinned hawk,† broad-winged hawk, and barred owl, and many species of songbirds, including warblers, vireos, thrushes, and flycatchers. American woodcock† forages and nests in young hardwood forests, shrublands, and swamps. Wood thrush,† cerulean warbler,† and scarlet tanager† are some of the birds that may require large forest-interior areas to nest successfully and maintain populations in the long term. High-elevation forests in the Catskills provide critical nesting habitat for Bicknell's thrush† and Swainson's thrush.

Large mammals such as black bear,† bobcat,† and fisher† require large expanses of forest, although they also hunt, forage, and roam through human-settled areas. Many small mammals are associated with upland hardwood forests, including eastern chipmunk, southern flying squirrel, and white-footed mouse. Hardwood trees larger than 5 inches diameter at breast height—especially those with loose, platy bark such as shagbark hickory, deeply furrowed bark such as black locust, or snags with cavities or peeling bark—can be used for summer roosting and nursery colonies by any of the nine species of bats that are known to or are likely to occur in the county.

> Forests are the most effective type of land cover for maintaining clean and abundant surface water and groundwater.

In addition to their tremendous value for wildlife, forests are the most effective type of land cover for maintaining clean and abundant surface water (in streams, lakes, ponds, and wetlands) and groundwater. Forests with intact canopy, understory, ground vegetation, and floors promote infiltration of rainwater and snowmelt to the organic duff and soils (Bormann et al. 1969, Likens et al. 1970, Bormann et al. 1974, Wilder and Kiviat 2008) and may be the best insurance for maintaining groundwater quality and quantity, for reducing rapid runoff and soil erosion, and for maintaining flow volumes, cool temperatures, water quality, bank stability, and habitat quality in streams. Forests and other intact habitats in floodplains and adjacent areas help to slow and disperse floodwaters.

Forests help to moderate local and regional air temperatures, and also provide long-term storage of large amounts of carbon in above-ground and below-ground biomass. Maintaining and restoring forests can help to offset some of the carbon emissions of human activities.

Forests covers ca. 67 percent of Greene County and upland hardwood forest is by far the most common habitat type in the county (Figure 14). Figure 15a shows the forest areas classified by size. Contiguous forests of 15,000+ acres occur in the Catskill Mountains, and other forests of 2000+ acres occur in the western part of the county. Forests of 200+ acres are common throughout the foothills and lowlands.

Figure 15b shows Greene County forests in a regional context and classified by The Nature Conservancy (TNC) and the New York Natural Heritage Program (NYNHP) as "matrix forests" and "linkage zones." Matrix forests are contiguous forest areas whose large size and intact condition allow them to support ecological processes and viable large-forest communities of plants and animals that cannot necessarily persist in smaller or poorer-quality forests. The matrix forests in

View from Hunter Mountain. Photo: Andy Reinmann © 2019

Greene County are the large contiguous forest areas in the Catskills, mostly in patches of 6000+ acres. The linkage zones are the next-largest adjoining and nearby patches (mostly of 2000+ acres) that may provide the best avenue of connectivity for the populations of plants and animals of the matrix forests; that is, the parts of the landscape that are most permeable for safe and efficient movement of migrating organisms between larger forest blocks. Some of these zones are "stepping stone" patches, or stream corridors, and others are broad areas of undeveloped land (NYNHP 2017). The main linkage zones in Greene County encompass the secondary hills of Windham and Ashland. The matrix forests and linkage zones may become even more important with the warming climate, as plants and wildlife are forced to shift their ranges northward or to higher elevations. Much of the matrix forests and linkage zones are on lands owned by NYSDEC or NYCDEP (Figure 37), but there are many gaps on privately-held land where conservation is not assured.

Crest, Ledge, and Talus

Crests, ledges, and talus are rocky habitats that often occur together where soils are very shallow and bedrock is partially exposed at the ground surface, either at the summit of a hill or knoll (crest) or elsewhere (ledge). Talus is the term for the fields of large rock fragments that often accumulate below steep ledges and cliffs. Some crest, ledge, and talus habitats support well-developed forests, while others have only sparse, patchy, and stunted vegetation. These rocky habitats often appear to be harsh and inhospitable, but they can support an extraordinary diversity of uncommon and rare

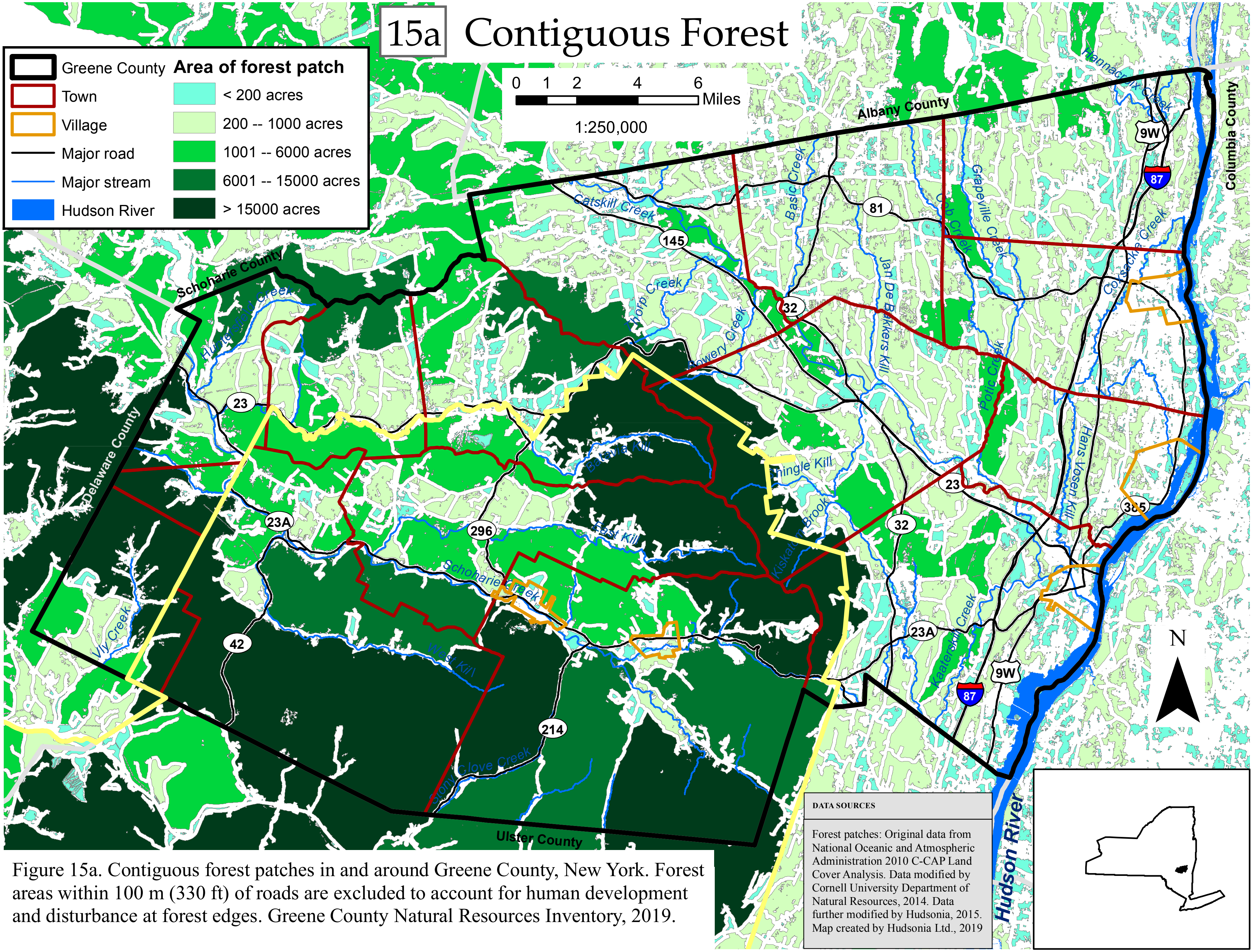


Figure 15a. Contiguous forest patches in and around Greene County, New York. Forest areas within 100 m (330 ft) of roads are excluded to account for human development and disturbance at forest edges. Greene County Natural Resources Inventory, 2019.

15b Forest Blocks and Linkage Zones

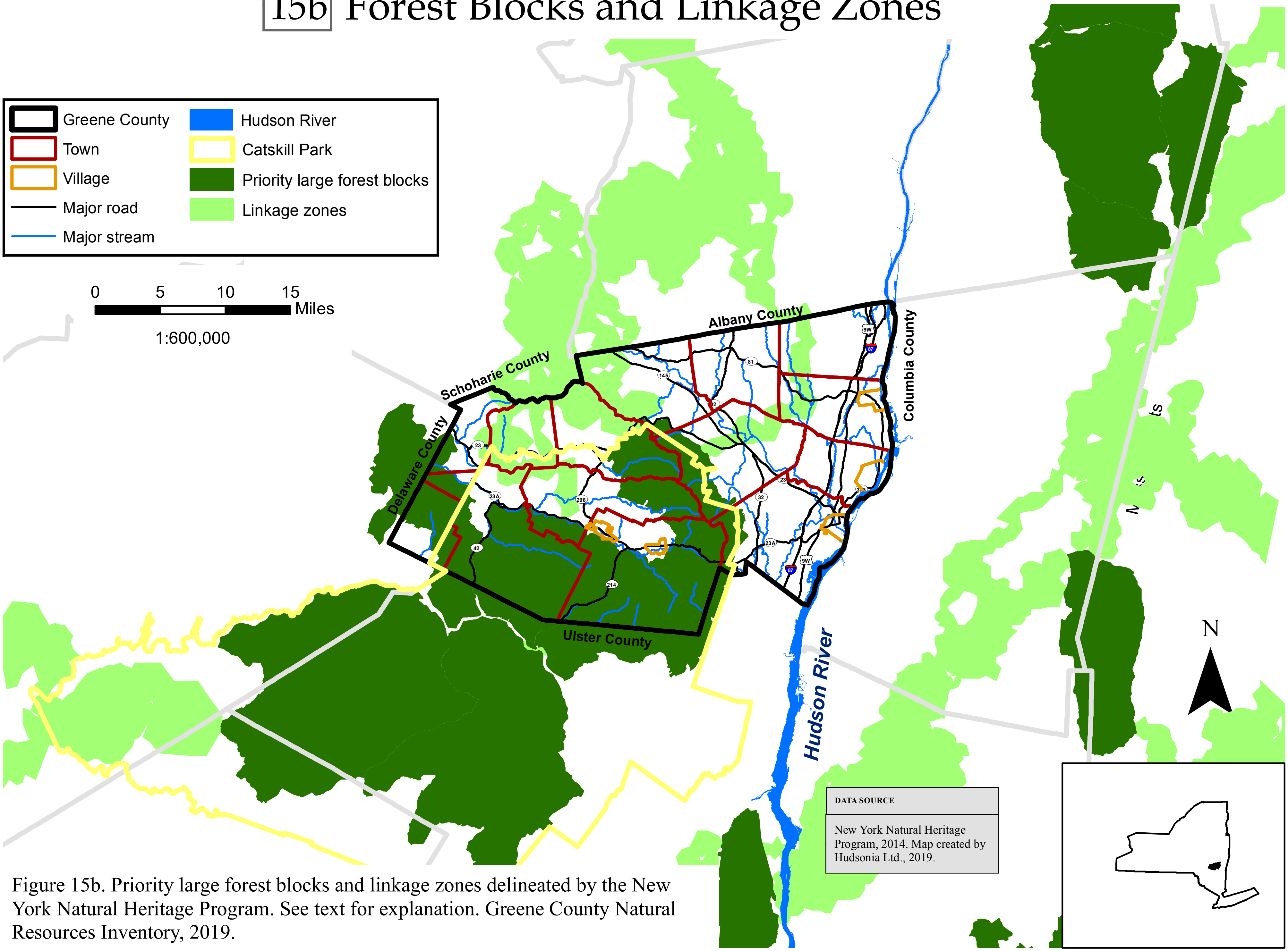


Figure 15b. Priority large forest blocks and linkage zones delineated by the New York Natural Heritage Program. See text for explanation. Greene County Natural Resources Inventory, 2019.

plants and animals. Some species, such as wall-rue,† purple cliffbrake,† and northern slimy salamander are found only in and near rocky places in the region. The communities and species that occur at any particular location are determined by many factors, including bedrock type, outcrop size, soils, aspect, exposure, slope, elevation, biotic influences, and kinds and intensity of human disturbance.

Calcareous ledges have plants such as maidenhair fern, maidenhair spleenwort, walking fern, wild ginger, hepatica, and wild columbine. Rocky habitats with larger fissures, cavities, and exposed (unforested) ledges may provide shelter, den, and basking habitat for black rat snake,† northern copperhead,† and other snakes of conservation concern. Northern slimy salamander† occurs in non-calcareous wooded ledge and talus areas. Breeding birds of crest habitats include blackburnian warbler,† worm-eating warbler,† and cerulean warbler.† Bobcat and fisher use crests and ledges for travel, hunting, and cover. Porcupine and bobcat use ledge and talus habitats for denning. Southern red-backed vole is found in some rocky areas. Eastern small-footed bat† roosts in talus habitat; it has not been documented in Greene County but could occur here, using caves for winter hibernacula and other parts of the landscape for summer roosting and foraging.

Crest, ledge, and talus habitats occur at all elevations in Greene County, from sea level up to the summits of the highest Catskill peaks. Figure 5 shows the areas where exposed bedrock is most prominent (coded as "bedrock outcrop [r]"). Ledges are exposed along significant lengths of the Batavia Kill and Catskill Creek, along Spruce Creek where it drops steeply down the eastern escarpment, and along other streams. Crest, ledge, and talus habitats are often embedded within other habitat types such as upland forests.

Rocky Barrens

A special subset of rocky crest habitats are the "rocky barrens" that occur on ridgetops and hillside shoulders with exposed bedrock, shallow soils, and vegetation dominated by some combination of pitch pine, eastern white pine, chestnut oak, scarlet oak, red oak, scrub oak, eastern red cedar, blueberries, black huckleberry, early azalea, deerberry, and sweetfern. Trees, if present, are often sparse and stunted. Common herbs include Pennsylvania sedge, poverty grass, common hairgrass, little bluestem, and bracken. Lichens and mosses are sometimes abundant. Due to the open canopy, exposed rock, and dry soils, rocky barrens tend to have a much warmer, drier microclimate in summer than the surrounding forested habitat and a colder microclimate in winter. These habitats are also exposed to extreme wind and ice conditions and, at least historically, wildfires. The harsh environment has a strong influence on the composition and structure of the plant community.

Rocky barrens can have significant habitat value for timber rattlesnake,† black rat snake,† black racer† (all very rare in Greene County), and other snakes. Deep rock fissures can provide crucial overwintering sites for these species, and the exposed ledges provide basking and breeding habitat in the spring and early summer. Birds of this habitat include common yellowthroat, Nashville warbler, prairie warbler,† field sparrow,† eastern towhee,† and whip-poor-will.† A number of rare butterflies that use scrub oak, little bluestem, lowbush blueberry, or pitch pine as their primary food plant tend to concentrate in rocky barrens, such as Leonard's skipper† and brown elfin. Rocky barrens can also serve as habitat for several rare oak-dependent moths. Rare plants of rocky barrens in the region include rusty woodsia,† clustered sedge,† dwarf shadbush,† bearberry,† and three-toothed cinquefoil.

Rocky barren. Photo: Chris Graham © 2019

Upland Shrubland

The term "upland shrubland" refers to shrub-dominated upland (i.e., non-wetland) habitats. In most cases these are lands in transition between meadow and young forest, but they also occur along utility corridors maintained by cutting or herbicides, in areas of recent forest clearing or blowdowns, and in ledgy areas with shallow soils. Soil characteristics and historical and recent land uses are important factors influencing the species composition of shrub communities. Shrublands may be dominated by non-native, invasive species such as Japanese barberry, Bell's honeysuckle, oriental bittersweet, and multiflora rose, or they may have diverse native grasses and forbs; native shrubs such as meadowsweet, gray dogwood, northern blackberry, and raspberries; and seedlings and saplings of eastern red cedar, hawthorns, eastern white pine, gray birch, red maple, quaking aspen, and oaks. Many non-native, invasive plants thrive in agricultural areas that were heavily grazed in the past or where agriculture was abandoned in the 1930s or 1940s, when many of our non-natives were starting to take hold in the region. Recently-logged areas tend to develop a shrub layer including abundant tree saplings and northern blackberry.

Rare butterflies such as Leonard's skipper,† may occur in shrublands where their larval host plants are present. Upland shrublands and other non-forested upland habitats may be used by turtles for nesting or aestivation (e.g., painted turtle, wood turtle,† spotted turtle,† and eastern box turtle†) or for foraging (eastern box turtle). Many bird species of conservation concern nest in upland shrublands and adjacent upland meadow habitats, including brown thrasher,† blue-winged warbler,† golden-winged warbler,† prairie warbler,† and eastern towhee.† Most of these birds avoid nesting near forest edges (Schlossberg and King 2008), so extensive shrublands (>12.5 ac) and those that form large complexes with meadow habitats may be particularly important for successful nesting (Shake et al.

2012). Several species of hawks and falcons use upland shrublands and adjacent meadows for hunting small mammals such as meadow vole, white-footed mouse, and eastern cottontail.

Shrublands are widely distributed in the county and are mostly small. Their greatest concentration is in abandoned agricultural fields of the Route 9W corridor.

Upland Meadow

Coxsackie hayfield, with Catskill Mountains in distance.
Photo: Jill Knapp © 2019

The term "upland meadow" can refer to upland non-forested, non-shrubby areas of all kinds, including cultivated fields, hayfields, pastures, oldfields, and rocky crests. Meadows can be variously dominated by any combination of grasses, sedges, and forbs. Non-native grasses of pastures, hayfields, and oldfields include species such as Kentucky bluegrass, orchard grass, smooth brome, bentgrasses, and timothy. Fallow fields and oldfields retain such grasses and also develop diverse forb communities with, for example, goldenrods, asters, ox-eye daisy, wild madder, knapweeds, and clovers. Meadows with shallow, nutrient-poor soils often support a higher abundance and diversity of native, warm-season grasses such as little bluestem, common hairgrass, and poverty grass, and other native plants.

The ecological values of these habitats can differ widely according to the types of vegetation present, disturbance histories (e.g., tilling, mowing, grazing, pesticide applications, trampling), and meadow size. Meadows of any size can be valuable habitats for small mammals, butterflies, moths, dragonflies, native bees, and many other invertebrates. Undisturbed meadows develop diverse plant communities and support an array of wildlife, including invertebrates, frogs, reptiles, mammals, and birds. Meadows on clayey soils, such as those in the Route 9W corridor, support an unusual array of statewide- and regionally-rare plants (Hudsonia, unpublished data). Extensive hayfields or pastures dominated by grasses may support grassland-breeding birds, depending on the meadow size and configuration, the mowing schedule, or the intensity of grazing.

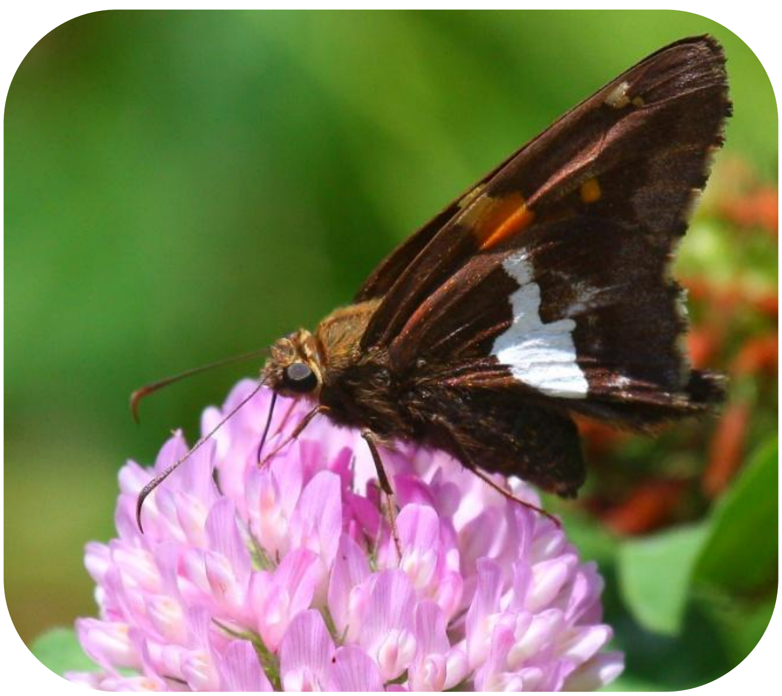
Intensively cultivated crop fields have comparatively little wildlife habitat value, although even they are used for foraging by white-tailed deer, raccoon, wild turkey, geese, songbirds, and other wildlife. Killdeer and turtles will nest in farm fields, but large percentages of nests fail due to predation and destruction by farm machinery.

Several species of rare butterflies, such as Aphrodite fritillary,† meadow fritillary,† dusted skipper,† Leonard's skipper,† swarthy skipper,† and striped hairstreak use upland meadows that support their particular host plants. Upland meadows are used for nesting by wood turtle,† spotted turtle,† eastern box turtle,† painted turtle, and snapping turtle. Wild turkey forages on invertebrates and seeds in upland and wet meadows. Upland meadows often have large populations of small mammals (e.g., meadow vole) and can be important hunting grounds for raptors, foxes, and eastern coyote.

Meadows of any size can be valuable habitats for small mammals, butterflies, moths, dragonflies, native bees, and many other animals.

Large meadows (10+ acres) have particular value for grassland breeding birds whose populations have experienced sharp declines in recent decades due primarily to loss of suitable habitats. Species such as grasshopper sparrow,† vesper sparrow,† savannah sparrow,† eastern meadowlark,† and bobolink† use large meadow habitats for nesting and foraging. Large meadows are also hunting sites for raptors in winter, including hawks, northern harrier, and short-eared owl. Different species require meadows of different sizes and conditions (vegetation heights, grasses vs. forbs vs. shrubs, depth of thatch). For example, based on data compiled by Morgan and Burger (2008) from multiple studies in the Northeast, grasshopper sparrow needs meadows of 50-100+ acres, vegetation of moderate height, and with little or no thatch and considerable bare soil, while sedge wren can nest successfully in meadows of 10-20 acres, with tall vegetation, a significant shrub component, moderate thatch, and wettish conditions.

Upland meadow habitats occur throughout the county (Figure 16), mostly in areas of active or abandoned agriculture, but also in utility corridors, abandoned cultural areas (such as former lawns or golf courses), and even high in the mountains where shallow soils and harsh conditions inhibit the establishment of shrubs and trees.



Male silver-spotted skippers perch on branches or tall forbs to monitor a small mating territory, which they vigorously defend against other males. Photo: Larry Federman © 2019

The meadows in the agricultural zone along the Route 9W corridor are of particular interest to conservationists because of their demonstrated importance for grassland breeding birds and for wintering raptors—especially northern harrier† and short-eared owl.† This area has been recognized as some of the best habitat in the Hudson Valley for grassland birds. It hosts seven of the eleven "high priority" species for conservation identified by the New York Grassland Bird Conservation Partnership (Morgan and Burger 2008). The *Grassland Habitat Management Plan* (Strong et al. 2014), developed through a partnership among the Greene County Soil and Water Conservation District, Greene County Industrial Development Agency, and a group of local citizens, planning boards, regional non-profit organizations, and state agencies, provides background information and guidelines for effective environmental planning to help municipalities, farmers, landowners and developers preserve the important habitat values of the corridor. To help evaluate the status of winter raptors and the success of conservation efforts, the *Plan* called for regular monthly surveys for winter raptors in December through March, to be carried out by NYSDEC and others. Through the efforts of volunteers and Soil and Water Conservation District staff, significant habitats in the Route 9W corridor have been mapped in some detail (Figures 17 and 18a-c).

> Large meadows (10+ acres) have particular value for grassland-breeding birds, whose populations have experienced sharp declines in recent decades..

Eastern meadowlark is one of the grassland bird species that requires large meadows to maintain local breeding populations.
Photo: Larry Federman © 2019

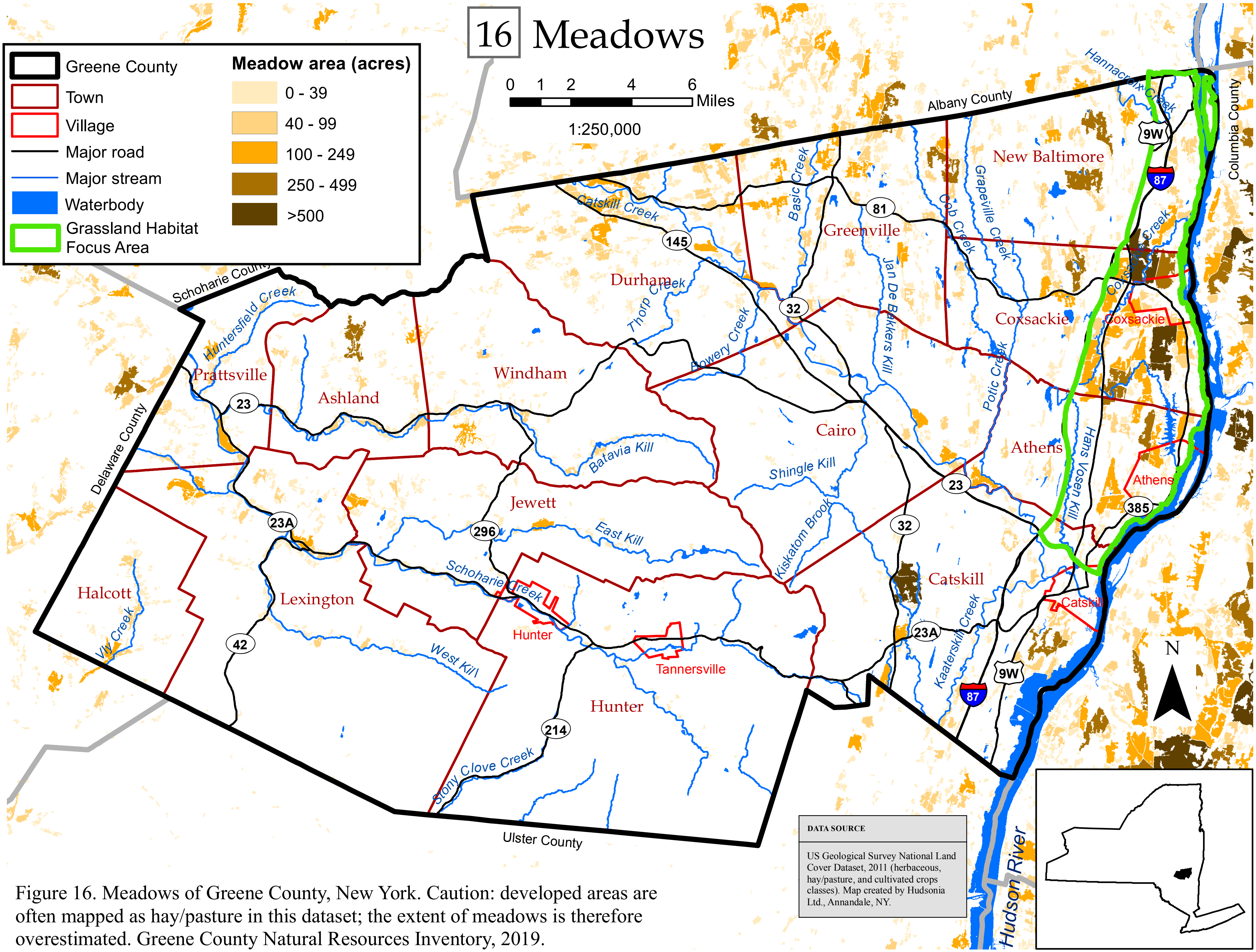


Figure 16. Meadows of Greene County, New York. Caution: developed areas are often mapped as hay/pasture in this dataset; the extent of meadows is therefore overestimated. Greene County Natural Resources Inventory, 2019.

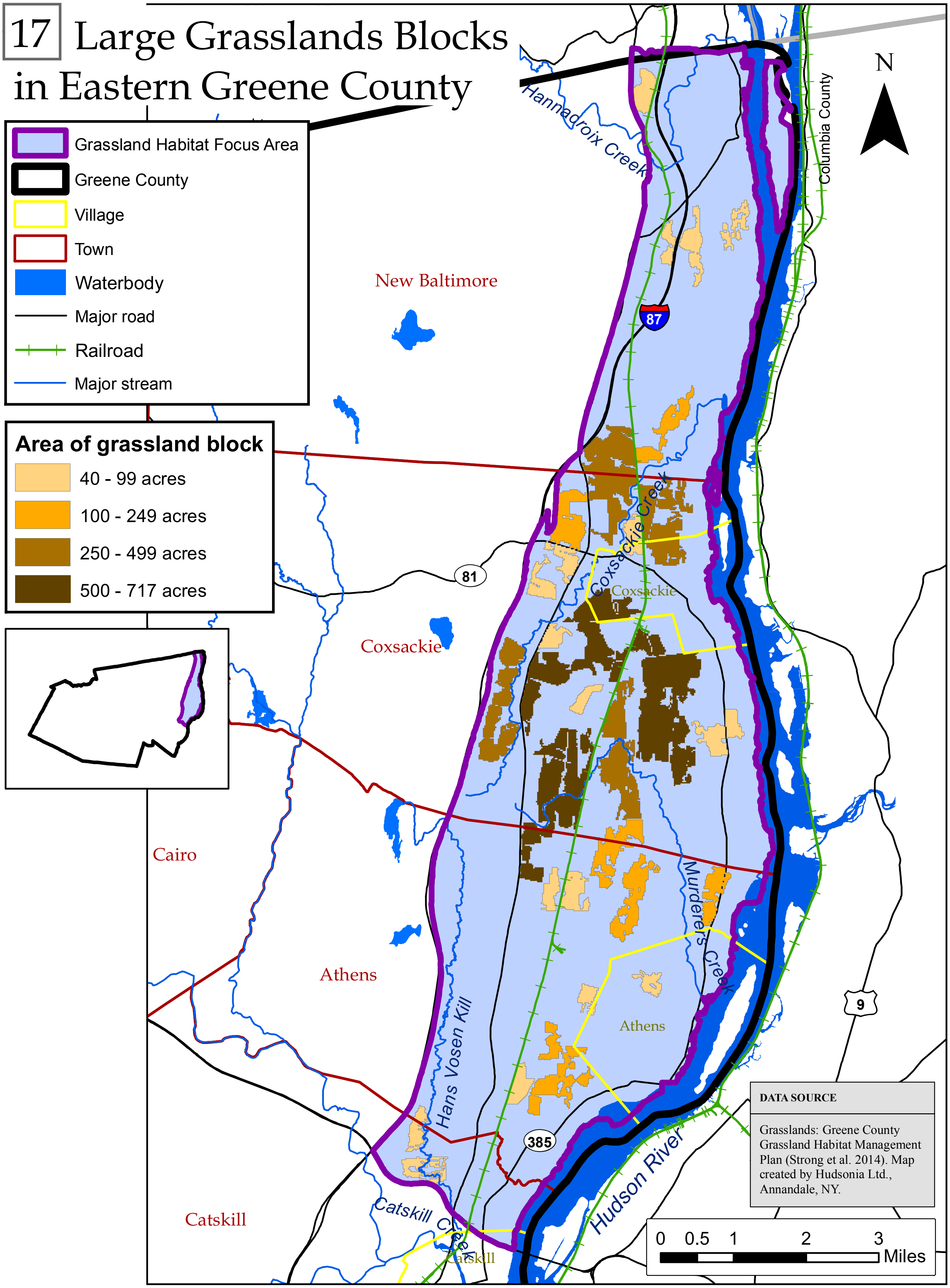


Figure 17. Large grassland blocks in the Grassland Habitat Focus Area of Greene County, New York. Greene County Natural Resources Inventory, 2019.

18a Habitats of Grasslands Focus Area: Athens & Catskill

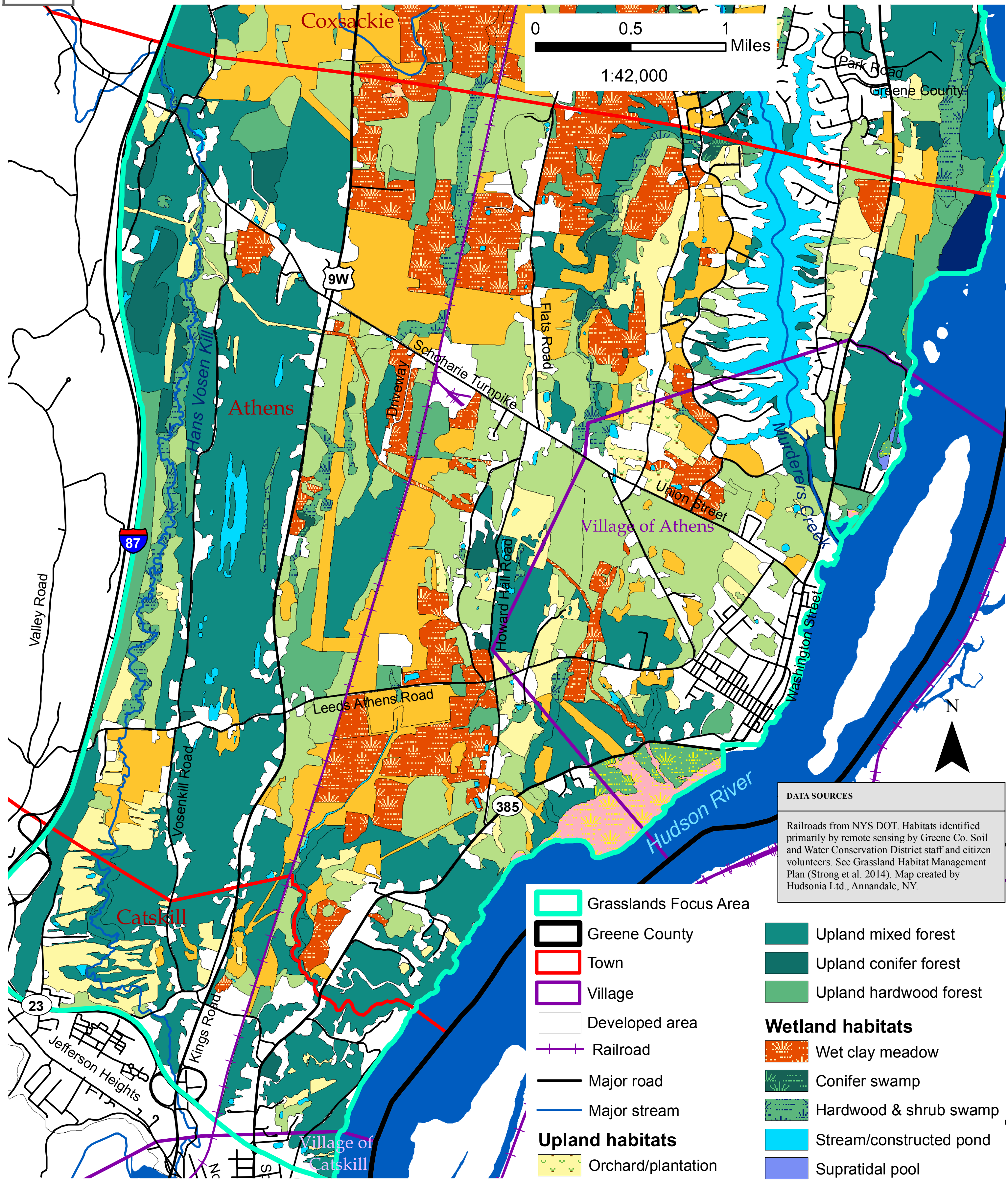


Figure 18a. Ecologically significant habitats of the Greene County Grasslands Focus Area: Towns of Athens and Catskill. Greene County Natural Resources Inventory, 2019.

18b Habitats of Grasslands Focus Area: Coxsackie

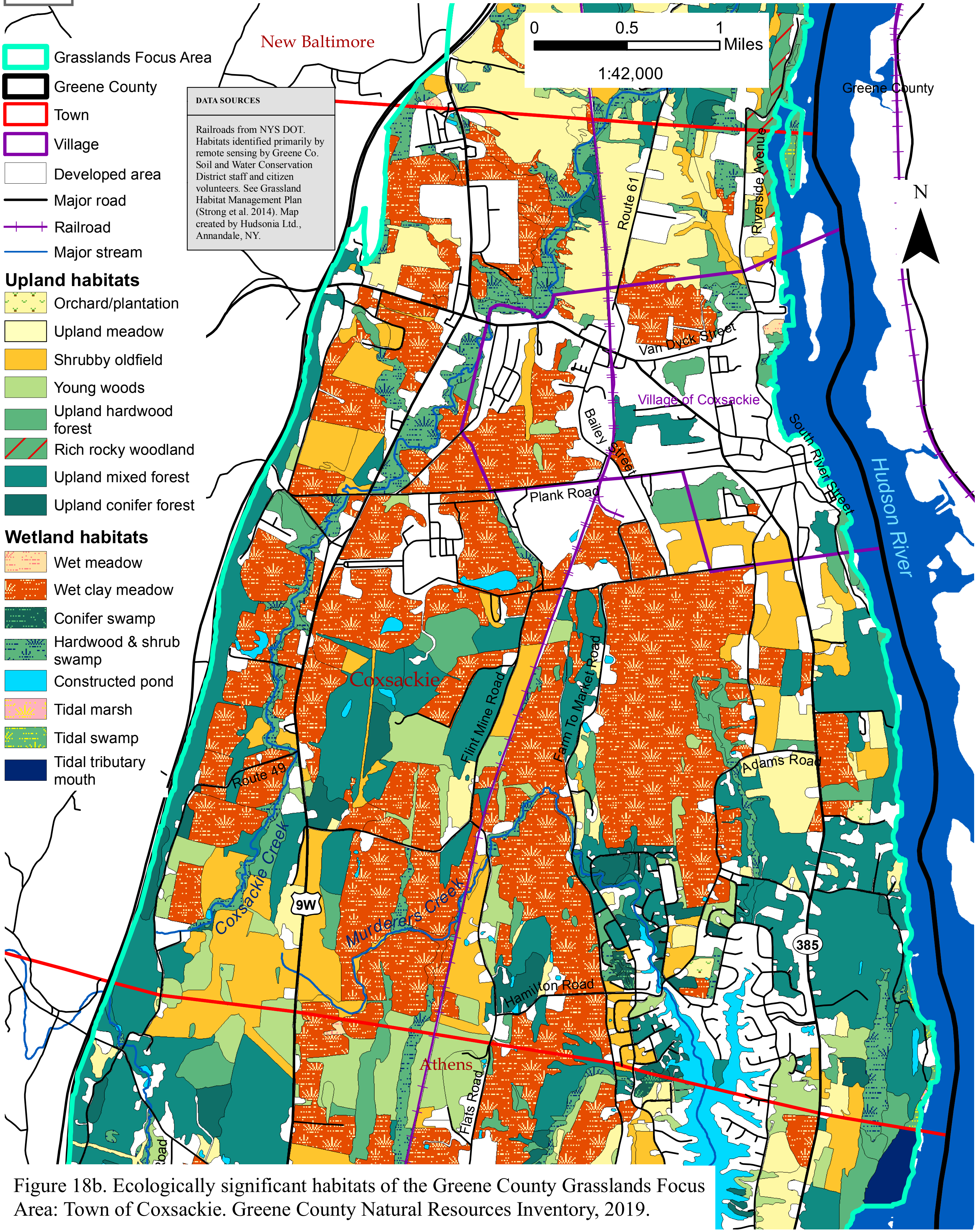


Figure 18b. Ecologically significant habitats of the Greene County Grasslands Focus Area: Town of Coxsackie. Greene County Natural Resources Inventory, 2019.

18c Habitats of Grasslands Focus Area: New Baltimore

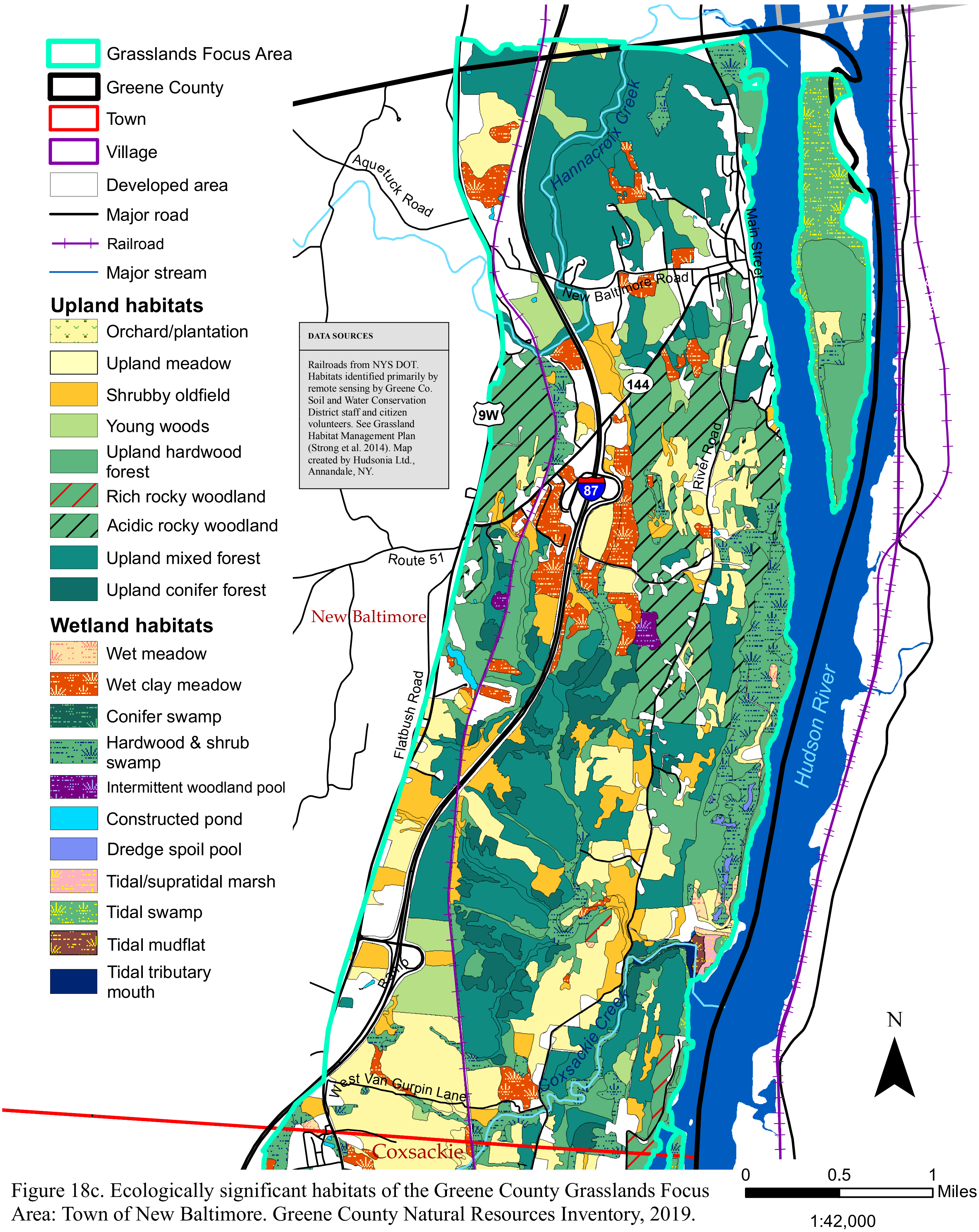


Figure 18c. Ecologically significant habitats of the Greene County Grasslands Focus Area: Town of New Baltimore. Greene County Natural Resources Inventory, 2019.

Wetlands, Ponds, and Streams

A wetland is a vegetated area where the surface soils are inundated or saturated for a prolonged period during the growing season. (By some definitions, unvegetated mudflats are also included as wetlands.) Wetlands come in many guises—marshes, swamps, wet meadows, fens, bogs—each of which is distinguished by the hydrology, the plant community, and in some cases the chemistry of the soil and water. Some wetlands have permanent standing water, and some have standing water for only brief periods after rain events, or none at all, and many have hydroperiods somewhere between those extremes.

Wetlands are one of the few kinds of land cover that receive any legal protection from the state or federal government, but many wetlands in Greene County are unprotected due to their small size or their isolation from other waterbodies. Wetlands appearing on the National Wetland Inventory maps and the New York State Freshwater Wetland Maps are shown in Figure 10a, and many other unmapped wetlands occur throughout the county.

Figure 10b shows the areas where the mapped soils are classified as "poorly drained" or "very poorly drained," or "somewhat poorly drained." Poorly and very poorly drained soils are the "hydric" soils that support wetlands; some areas of somewhat poorly drained soils also support wetlands. The soil maps are somewhat coarsely drawn, but nonetheless show the places within which additional wetlands not appearing on the NWI or New York State wetland maps are most likely to occur. Many small wetlands, however, such as intermittent woodland pools, wet meadows, or isolated swamps, are likely to occur outside the areas mapped as wetland soils, because they are below the size threshold for the soil units in the county soil survey. Users of these and other public maps should be aware that many wetlands do not appear on any wetland maps or soil maps and are only identified from onsite observations or from detailed site-specific remote sensing.

Described below are some of the general wetland types in Greene County. See a discussion of wetland regulations in the **Legislative Protections** section.

Non-Tidal Swamp

A swamp is a wetland dominated by woody vegetation (trees or shrubs). The most common woody species of hardwood swamps in Greene County are red maple, green ash, American elm, slippery elm, and swamp white oak (trees), and winterberry holly, highbush blueberry, silky dogwood, alders, and willows (shrubs). American sycamore, pin oak, and black gum may also be present. In swamps at higher elevations (2000+ ft), the elms, oaks, green ash, and sycamore drop out, and yellow birch, eastern hemlock, and red spruce are common. Typical herbs are skunk-cabbage, beggar-ticks, false-nettle, common jewelweed, Japanese knotweed, tussock sedge, and cinnamon, sensitive, royal, and marsh ferns. The trees of lowland conifer swamps are usually eastern hemlock with occasional white pine, but swamps of eastern red cedar occur on the calcareous soils of the Kalkberg and the Lake Albany plain.

Swamps are important to a wide variety of birds, mammals, amphibians, reptiles, and invertebrates, especially swamps that are contiguous with other wetland types or embedded within large areas of upland forest. Hardwood and shrub swamps along the floodplains of clear, low-gradient streams can be an important component of wood turtle† habitat. Other turtles such as spotted turtle† and eastern box turtle† frequently use swamps for summer foraging, drought refuge, overwintering, and travel corridors. Pools within swamps are used by several pool-breeding amphibian species. Jefferson/blue-spotted salamander† breeds in pools of forested or shrubby swamps, and four-toed salamander† inhabits swamps with rocks or abundant, moss-covered, downed wood or woody hummocks. Eastern ribbon snake† forages for frogs in swamps. Red-shouldered hawk,† barred owl,† great blue heron,† wood duck,† American black duck,† red-headed woodpecker,† and Canada warbler† nest in hardwood swamps.

Like other forested and shrubby habitats in the floodplains of streams, riparian swamps are especially valuable for stabilizing streambanks and floodplain soils, dampening flood flows, and keeping stream temperatures cool. Wetlands of all kinds are effective at removing excess nitrogen—by means of denitrification and plant uptake—from runoff before it enters a stream. Swamps are also effective at intercepting and settling out suspended sediments in surface runoff before it reaches a stream. Swamps both within and outside the floodplain are important for carbon sequestration, and climate moderation, and some swamps are sites of groundwater recharge.

Hardwood and shrub swamps are common and widespread in Greene County, occurring in a variety of settings—on seepy slopes, along streams, in depressions, and as part of large wetland complexes. Conifer swamps are common in the mountains and less so in the foothills and lowlands.

<u>Intermittent Woodland Pool</u>

An “intermittent woodland pool” is a small wetland partially or entirely surrounded by upland forest, typically with no surface water inlet or outlet (or an ephemeral one), and with standing water during fall, winter, and spring that dries up by mid- to late summer in most years. This habitat is a forested subset of the widely recognized “vernal pool” habitat that may occur in forested or open settings. Intermittent woodland pools may be devoid of vegetation or may have a few trees or patches of sedges, ferns, forbs or shrubs.

The seasonal drying and lack of stream connections ensure that these pools do not support fish, which are major predators on amphibian eggs and larvae. The fish-free environment makes this the critical breeding

> The fish-free environment of intermittent woodland pools makes this the critical breeding habitat for a special group of pool-breeding amphibians:

habitat for a special group of pool-breeding amphibians: Jefferson/blue-spotted salamander,† spotted salamander, and wood frog. (Another salamander of these pools—marbled salamander†—occurs in Ulster County and could move into Greene County with the warming climate.) These pools often support a rich invertebrate fauna, including some animals especially adapted to the seasonal drying, such as fairy shrimp, clam shrimp, and fingernail clam. They can also be important foraging, resting, and rehydrating habitats for terrestrial wildlife. The surrounding forest supplies organic detritus to the pools—the base of the pool's food web—and is the critical year-round habitat for adults of the pool-breeding amphibians. Several rare plants are known from Hudson Valley woodland pools, including swamp cottonwood,† false hop sedge,† cattail sedge,† and weak stellate sedge.

Radiocarbon-dating of peat samples show a forested bog at the Mountain Top Arboretum to be one of the two oldest known bogs in the Catskills, at 14,900 years.

Although intermittent pools in unforested settings have been little studied in the Hudson Valley, these are potential habitats for rare clam shrimps, and are used for breeding by American toad, and for foraging by shorebirds and other animals.

Intermittent woodland pools occur in forests in all parts of the county—in lowlands, high in the Catskill Mountains, and at all elevations in between. Many intermittent woodland pools do not appear on public wetland maps (such as the National Wetland Inventory maps or the NYS Freshwater Wetlands maps) because of their small size and their isolation from other wetlands, streams, or lakes, so they must be identified independently by remote sensing or field observations.

Bog

A"bog" is a particular kind of wetland that receives most of its water from precipitation instead of groundwater and has soils that are permanently saturated at or near the ground surface. As used in this *NRI*, the term encompasses the "dwarf shrub bog," and "perched bog" ecological communities described in the *Ecological Communities of New York State* (Edinger et al. 2014). The anaerobic environment created by the perennial saturation

Spruce bog. Photo: Andy Reinmann © 2019

slows biological decomposition and leads to accumulation, over time, of a deep layer of peat—partially decomposed organic matter. Bogs tend to have very acidic water and soils, and plant communities especially adapted to low-nutrient, acidic environments. *Sphagnum* mosses (peat mosses) are typically abundant, often forming large continuous mats. Some other plants typical of bogs in the region are black spruce, leatherleaf, sheep laurel, bog rosemary, small and large cranberries, pitcher-plant, and round-leaved sundew. A forested bog at the Mountain Top Arboretum has red spruce and eastern hemlock in the canopy, a variety of shrubs and herbs, and a continuous layer of *Sphagnum* and other mosses. Radiocarbon dating of peat samples extracted by Michael Kudish show this to be one of the two oldest known bogs in the Catskills, at 14,900 years (Stevens et al. 2019).

Radiocarbon-dating of peat samples show a forested bog at the Mountain Top Arboretum to be one of the two oldest known bogs in the Catskills, at 14,900 years.

A bog is a rare habitat in Greene County and in the Hudson Valley in general. The known bogs in Greene County are at high elevations (>2000 ft) in the Catskills, but there could be others yet undiscovered in the lowlands.

Marsh

A marsh is a wetland that has standing water for much or all of the growing season and is dominated by herbaceous (non-woody) vegetation. Marshes often occur at the fringes of deeper water bodies (e.g., lakes and ponds) or in close association with other wetland habitats such as wet meadows or swamps. The edges of marshes, where standing water is less permanent, often grade into wet meadows. Cattails, tussock sedge, lakeside sedge, woolgrass, reed canary-grass, common reed, bur-reeds, water-plantain, and purple loosestrife are some typical emergent marsh plants in Greene County. Some marshes are dominated by floating-leaved plants such as pond-lilies, water-shield, and duckweeds.

Several rare plant species are known from marshes in the region. The diverse plant communities of some marshes provide habitat for butterflies such as the Baltimore, monarch, and northern pearly eye. Marshes are also important habitats for reptiles and amphibians, including northern water snake, eastern painted turtle, snapping turtle, spotted turtle,[†] green frog, pickerel frog, and spring peeper. Numerous bird species, including marsh wren, common gallinule, American bittern,[†] least bittern,[†] great blue heron, Virginia rail, sora, American black duck,[†] and wood duck use marshes for nesting and nursery habitat. Pied-billed grebe[†] also uses this habitat where it occurs adjacent to open water areas. Many raptors, wading birds, and mammals use marshes for hunting or foraging.

Muskrat lodge in a Coxsackie marsh. Photo: Jill Knapp © 2019

Marshes are often closely associated with small and large streams, occurring both adjacent to the stream channel and elsewhere in the floodplain. They are thus intimately tied to the stream ecology, providing habitat for stream organisms and organic materials for the stream food web. As in other wetlands, the organic soil layer of marshes is especially effective at removing nitrogen from water via denitrification; plant uptake of nitrogen and phosphorus can also significantly reduce nutrient concentrations in water (Wenger 1999, Parkyn 2004). Marshes with dense vegetation can dampen flood flows and remove sediments from flood waters.

Wet Meadow

A "wet meadow" is a wetland that is dominated by herbaceous (non-woody) vegetation, and that retains little or no standing water during most of the growing season. The period of inundation or soil saturation is longer than that of an upland meadow but shorter than that of a marsh.

Some wet meadows have lots of purple loosestrife, common reed, reed canary-grass, or tussock sedge, while others have a diverse mixture of wetland grasses, sedges, rushes, forbs, and scattered shrubs. Mannagrasses, woolgrass, reed canary-grass, soft rush, spotted Joe-Pye-weed, common jewelweed, sensitive fern, and marsh fern are some typical native plants of wet meadows. *Carex* sedges are common to abundant in some wet meadows.

An uncommon subset of the wet meadow habitat is the "wet clay meadow," which occupies large areas in the Route 9W corridor of Greene County. Wet clay meadows develop on post-agricultural land on the clayey, somewhat poorly drained soils of the Lake Albany plain. Numerous species of rare plants and animals have been found in wet clay meadow habitats here and elsewhere in the Hudson Valley.

> Wet meadows are a large component of the Winter Raptor Concentration Area and other grasslands in the Route 9W corridor.

Wet meadows with diverse plant communities may have rich invertebrate faunas. Blue flag and certain sedges and grasses of wet meadows are larval food plants for regionally-rare butterflies. Wet meadows provide nesting and foraging habitat for songbirds such as red-winged blackbird and sedge wren,† wading birds such as American bittern,† and raptors such as northern harrier.† Upland meadows often have large populations of small mammals (e.g., meadow vole) and can be important hunting grounds for raptors, foxes, and eastern coyote. Wet meadows that are part of extensive meadow areas (both upland and wetland) are especially important to species of grassland-breeding birds and to foraging raptors. Wet meadows are a large component of the NYSDEC-designated Winter Raptor Concentration Area and the other grassland habitat areas in the Route 9W corridor that are the subject of state and local conservation efforts. Northern harrier,† hawks, and falcons hunt over those meadows in the warm months, and harrier† and short-eared owl† hunt there through the winter. Five species of state-listed rare plants have been found in the wet clay meadows of that corridor. The globally-rare Mattox's clam shrimp is known from wet clay meadow and clayey roadway puddles in Dutchess and Ulster counties.

Wet meadows in and near floodplains have particular value for treating polluted surface runoff before it enters the stream. Wet meadows and other wetlands are important sites for denitrification as well as plant uptake of nutrients, and densely-vegetated wet meadows are especially effective at capturing sediments. Floodplain wet meadows can help absorb and dampen floodwaters in mild to moderate flood events but are overwhelmed by severe flooding (Wenger 1999).

Springs and Seeps

> Springs and seeps help maintain the cool water temperatures of streams.

Springs and seeps are places where groundwater discharges under gravitational pressure to the ground surface, either at a single point (a spring) or diffusely (a seep). Springs often discharge unseen into ponds, streams, and wetlands but are more conspicuous where they discharge to upland locations. Springs and seeps originating from deep groundwater sources flow more or less continuously and emerge at a fairly constant temperature, creating an environment that is cooler in summer and warmer in winter than the surroundings. For this reason, seeps and springs sometimes support aquatic species that are ordinarily found at more northern or southern latitudes. The habitats created at springs and seeps are determined in part by the hydroperiod and by the chemistry of the soils and bedrock through which the groundwater flows before discharging. Springs and seeps are water sources for many streams, and they help maintain the cool water temperatures of streams—an important habitat characteristic for certain rare and declining fishes, amphibians, and other aquatic organisms. Springs and seeps with long hydroperiods also serve as water sources for animals during droughts and in winters when other water sources are frozen.

Golden saxifrage is a plant more-or-less restricted to springs and groundwater-fed wetlands and streams, and smaller forget-me-not seems especially tied to seeps and springs. A few rare invertebrates are restricted to springs in the region: the Piedmont groundwater amphipod could occur in the area (Smith 1988), and gray petaltail† and tiger spiketail† are two rare dragonflies of seeps. Northern dusky salamander,† mountain dusky salamander,† and spring salamander† use seeps, springs, and cool streams.

Springs and seeps occur at all elevations and landscape settings—forested and open lands, on level ground, at the foot of slopes, and on hillsides, shoulders, and ledges.

Ponds and Lakes

Described here are open water habitats that occur as naturally formed ponds and lakes, large pools lacking floating or emergent vegetation within marshes and swamps, and unvegetated constructed ponds.

Open water areas can be important habitat for many common species, including invertebrates, fishes, frogs, turtles, waterfowl, muskrat, beaver, and bats. Open water areas sometimes support submerged aquatic vegetation that can provide important habitat for aquatic invertebrates and fish. Spotted turtle† uses ponds and lakes during both drought and non-drought periods, and wood turtle† may overwinter and mate in open water areas. Wood duck,† American black duck, † pied-billed grebe,† osprey,† bald eagle,† American bittern,† and great blue heron† use open water areas as foraging habitat. Waterfowl use lakes and ponds as stopover sites during spring and fall migrations. Bats, mink, and river otter† also forage at open water habitats.

"Constructed ponds" are waterbodies that have been created by humans by excavation of damming, either in existing wetlands or stream beds or in upland terrain, for fishing, watering livestock, irrigation, swimming, boating, and aesthetics. Some are constructed near houses or other structures for ornamental or recreational purposes, or to serve as a source of water in the event of a fire. Some were created inadvertently where mining excavations intersected the water table. If constructed ponds are not intensively managed by humans, they can be important habitats for many of the common and rare species associated with naturally formed open water habitats (see below).

In general, the habitat value of a constructed pond is higher when the pond has an undeveloped, unmanaged shoreline, is relatively undisturbed by human activities, has more vascular plant vegetation, and is embedded within an area of intact habitat. Because many constructed ponds are not buffered by sufficient natural vegetation and undisturbed soils, they are vulnerable to the adverse impacts of agricultural runoff, septic leachate, and pesticide or fertilizer runoff from lawns and gardens. Many of the ponds maintained for ornamental purposes are treated with herbicides and perhaps other pesticides, or contain introduced fish such as grass carp and various game and forage fishes. Constructed ponds that are kept devoid of emergent or submerged vegetation have little habitat value but are sometimes used as drought refuges by turtles, amphibians, and other wildlife, and as stopover resting sites for migrating waterfowl. Those with significant vegetation may have nesting waterfowl and resident turtles, frogs, and salamanders. Since constructed ponds can serve as habitat for a variety of common and rare native species, applications of pesticides should be minimized whenever possible, and polluted runoff from roads, lawns, and farm fields should be directed elsewhere.

Although landowners often create ponds, in part, to "improve wildlife habitat," the habitat values of constructed ponds (and especially intensively managed ornamental ponds) do not ordinarily justify altering streams or destroying natural wetland or upland habitats to create them. In most cases, the loss of ecological functions of the pre-existing natural habitats far outweighs any habitat value gained in the artificially created environments.

The largest open water habitats in Greene County, apart from the Hudson River, are Sleepy Hollow Lake, the Coxsackie Reservoir, North-South Lake, Hollister Lake, and the Potic Reservoir. Small farm ponds and ornamental backyard ponds are common in the settled areas of the county.

Streams

Hollow Tree Brook in Diamond Notch Hollow.
Photo: Andy Reinmann © 2019

"Perennial streams" flow continuously throughout years with normal precipitation, although some may dry up during extreme droughts. They provide essential water for wildlife throughout the year, and are critical habitat for many plant, vertebrate, and invertebrate species.

"Intermittent streams" may flow for a few days or for many months during the year, but ordinarily dry up at some time during years of normal precipitation. They are the headwaters of most perennial streams and are significant water sources for lakes, ponds, and wetlands of all kinds. The condition of these streams therefore influences the water quantity and quality of those larger waterbodies and wetlands.

Streams serve many recreational, aesthetic, and water-supply functions for the human community; they are a critical component of the ecological landscape, providing essential habitats for wildlife, and supporting processes that maintain floodplains and associated ponds and wetlands. Our treatment of stream channels and banks, floodplains, and whole watersheds has a large influence on flood volumes and flood damage along streams.

The Appalachian tiger beetle is a NYS Species of Greatest Conservation Need known from only 10 streams in New York, one of which is in Greene County.

The aquatic communities of perennial streams can be diverse, especially in clean-water streams with unsilted bottoms. Brook trout† and slimy sculpin are two native fish species that require clear, cool streams for successful spawning. The Appalachian tiger beetle† inhabits sandy, gravelly, and cobble areas along forested stream edges; it is a NYS High Priority Species of Greatest Conservation Need known from only 10 streams in New York, one of which is in Greene County (NYNHP 2017). Wood turtle† uses perennial streams with deep pools and recumbent logs, and undercut banks or muskrat or beaver burrows. Perennial streams and their riparian zones, including sand and gravel bars, provide nesting or foraging habitat for many species of birds, such as spotted sandpiper, belted kingfisher, tree

Catskill Creek at the Mawignack Preserve. Photo: Jill Knapp © 2019 swallow, bank swallow, winter wren,† Louisiana waterthrush,† great blue heron, and green heron. Bats use perennial stream corridors for foraging, and muskrat, beaver, mink, and river otter† are some of the other mammals that regularly use stream corridors.

Intermittent streams provide microhabitats not present in perennial streams, supply aquatic organisms and organic drift to downstream reaches, and can be important local water sources for wildlife (Meyer et al. 2007). Their loss or degradation in a portion of the landscape can affect the presence and behavior of wildlife populations over a large area (Lowe and Likens 2005). Some intermittent streams support rich aquatic invertebrate communities, including regionally rare mollusks (Gremaud 1977) and dragonflies. Both perennial and intermittent streams provide breeding, larval, and adult habitat for northern dusky salamander, mountain dusky salamander,† spring salamander,† and northern two-lined salamander. The forests and, sometimes, meadows adjacent to streams provide foraging habitats for adults and juveniles of these species.

Habitats in a stream corridor perform a range of ecological functions that serve the stream and the surrounding landscape, and play a large role in local and downstream flood dynamics; for example:

-- stabilizing streambanks and reducing stream channel erosion
-- storing flood waters and reducing the velocity of floodflows
-- moderating stream water temperatures
-- trapping and removing sediment from runoff and floodwaters
-- trapping and removing nutrients, pesticides, and other contaminants from runoff and floodwaters
-- contributing woody debris and other organic detritus to the habitat structure and food base for stream organisms
-- providing habitat for terrestrial organisms (Wenger 1999)

Characteristics of the topography, soils, and vegetation at any particular location govern the effectiveness of the streamside and floodplain habitats for providing these services.

Poorly vegetated stream banks are vulnerable to erosion during high water events. Woody vegetation (trees and shrubs) on stream banks helps to reduce the velocity (and thus the erosive force) of flood waters, and the roots of woody vegetation help to hold erodible soils in place. The "roughness" created by the microtopography of the ground surface, the above-ground woody and herbaceous vegetation, woody debris, and rocks in the floodplain, as well as floodplain width, determine the degree to which the floodplain will reduce the velocity of floodflows. Areas densely-vegetated with a combination of woody and herbaceous plants are most effective at slowing floodwater and thus reducing downstream flood forces.

Well-vegetated riparian zones can reduce stream sedimentation by trapping sediments before they reach the stream; by reducing the velocity of sediment-bearing storm flows and thus allowing sediments to settle out; by stabilizing streambanks; and by contributing large woody debris to streams, which can temporarily capture large amounts of instream sediments.

> Densely-vegetated floodplains with a combination of woody and herbaceous plants are most effective at slowing floodwater and thus reducing the downstream flood forces.

Forests next to streams can have a large effect on reducing the temperature of stream water, both by directly shading the stream and by shading the floodplain and other areas through which the stream is fed by tributaries, overland flow, and shallow groundwater. High water temperatures reduce dissolved oxygen, a critical resource for stream organisms (Wenger 1999). Certain species of mollusks, amphibians, fish, and aquatic insect that do not tolerate high temperatures have declined or disappeared from many Hudson Valley streams where previously forested riparian zones have been cleared.

Catskill Creek, Batavia Kill, Schoharie Creek, West Kill, East Kill, Potic Creek, and Kaaterskill Creek are some of the county's perennial streams. All are fed by a multitude of smaller streams, both perennial and intermittent. The land cover and land uses in the stream corridors and the entire watersheds of these streams greatly influence the downstream response to large rainstorms and snowmelt events.

Tidal and Other Hudson River Habitats

The eastern boundary of Greene County extends generally to the middle of the Hudson River but also encompasses the major islands in this reach: Duck Island, Middle Ground Flats, Coxsackie Island, Rattlesnake Island, Houghtaling Island, and the western half of Seward Island (Figure 19).

Many of the Hudson River freshwater tidal communities are rare in the region and statewide (Penhollow et al. 2006). They include the deepwater areas of the river, as well as subtidal shallows, tidal mudflats, intertidal shores, tidal marshes and swamps, tidal creeks, and tidal tributary mouths. Greene County has several large freshwater tidal marshes and swamps, notably at the Village of Athens, West Flats, Vosburgh Swamp, Bronck Island, and RamsHorn-Livingston Sanctuary (Figure 19). There are stretches of natural shoreline of clayey soils or rocks (shingle or cobble), but significant lengths of shoreline are covered with sandy dredge spoil, and a few areas are hardened with concrete bulkheads, rock riprap, or other artificial revetments. Many of the dredge spoil areas have developed into upland meadow and forest habitats as well as tidal and non-tidal wetland habitats. Narrow mudflats extend along many of Greene County's tidal creeks into the interiors of tidal marshes and swamps.

NYSDEC has designated certain areas along the Hudson River as Significant Coastal Fish and Wildlife Habitats (SCFWH) that are deemed to be critical to the maintenance or re-establishment of species of fish and wildlife. The eighteen such areas in the Greene/Columbia County reach of the Hudson are shown in Figure 20; eleven of these are partially or entirely in Greene County. These SCFWH designations are in response to the Waterfront Revitalization and Coastal Resources Act of 1981 and Executive Law of New York, Article 42, Sections 910-920. A technical memorandum (Ozard 1984) sets forth the criteria for rating and designating these areas. Each designation is accompanied by a document describing the fish and wildlife resources that depend on the area, and providing other information to help evaluate impacts of proposed activities on the important habitat characteristics (https://www.dos.ny.gov/opd/programs/consistency/scfwhabitats.html).

Freshwater Tidal Creek

Tidal creeks are arms of the Hudson River that reach into tidal wetlands and other shoreline habitats. Some are fed entirely by the tidal wetlands and the Hudson River, and some are fed, in part, by nontidal streams draining adjacent upland areas. Some have permanent water that rises and falls with the tides, and some become merely moist mud-bottomed channels when the tide ebbs.

Tidal creeks may be tiny (less than 3 ft wide) to broad (50 ft wide). Substrates are typically silt, clay, or sandy dredge spoils, or sometimes rock rubble or gravel. Parts of tidal creeks often have submerged aquatic vegetation (SAV), tidal marsh, and mudflats.

> Tidal creeks often support rich invertebrate communities that are integral to the food webs of the Hudson River and tidal wetland habitats.

These habitats often have rich invertebrate communities that are integral to the food webs of the Hudson River and tidal wetland habitats. Fish-eating birds such as herons, belted kingfisher, osprey, and fish crow frequent tidal creeks. Ducks feed on plants and invertebrates in shallows and quieter waters of creeks, and some species may nest in habitats along creek margins. Juvenile Hudson River fishes use tidal creeks as refuge from predators. Map turtle[†] uses tidal creeks, and wood turtle[†] has been observed in the RamsHorn Creek (Kiviat and Barbour 1996) and probably uses others in Greene County.

Tidal creeks occur at many locations but some of the notable ones are at the RamsHorn-Livingston Sanctuary, the West Flats and Vosburgh Swamp, and the mouths of Catskill, Coxsackie, and Hannacroix creeks.

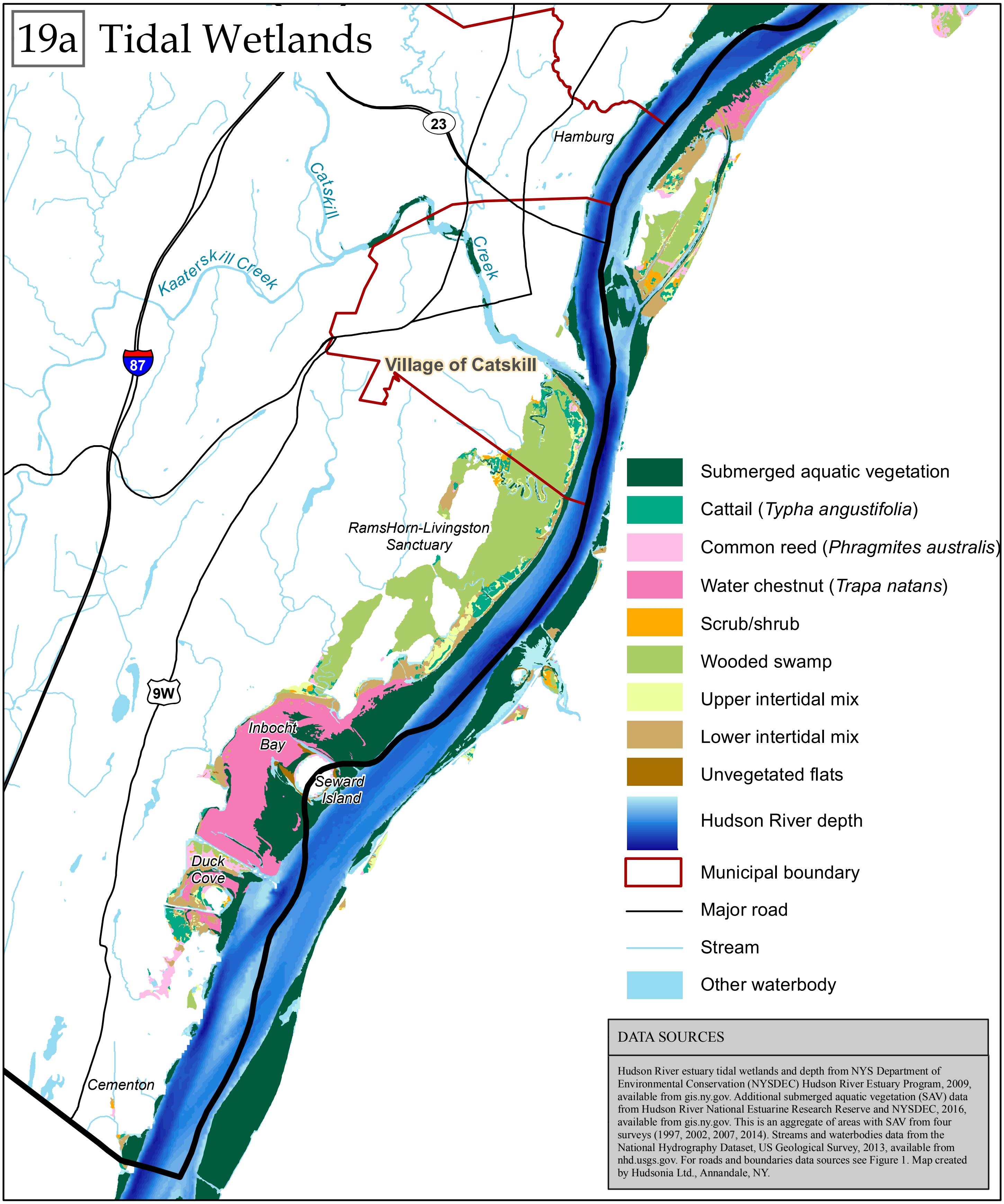
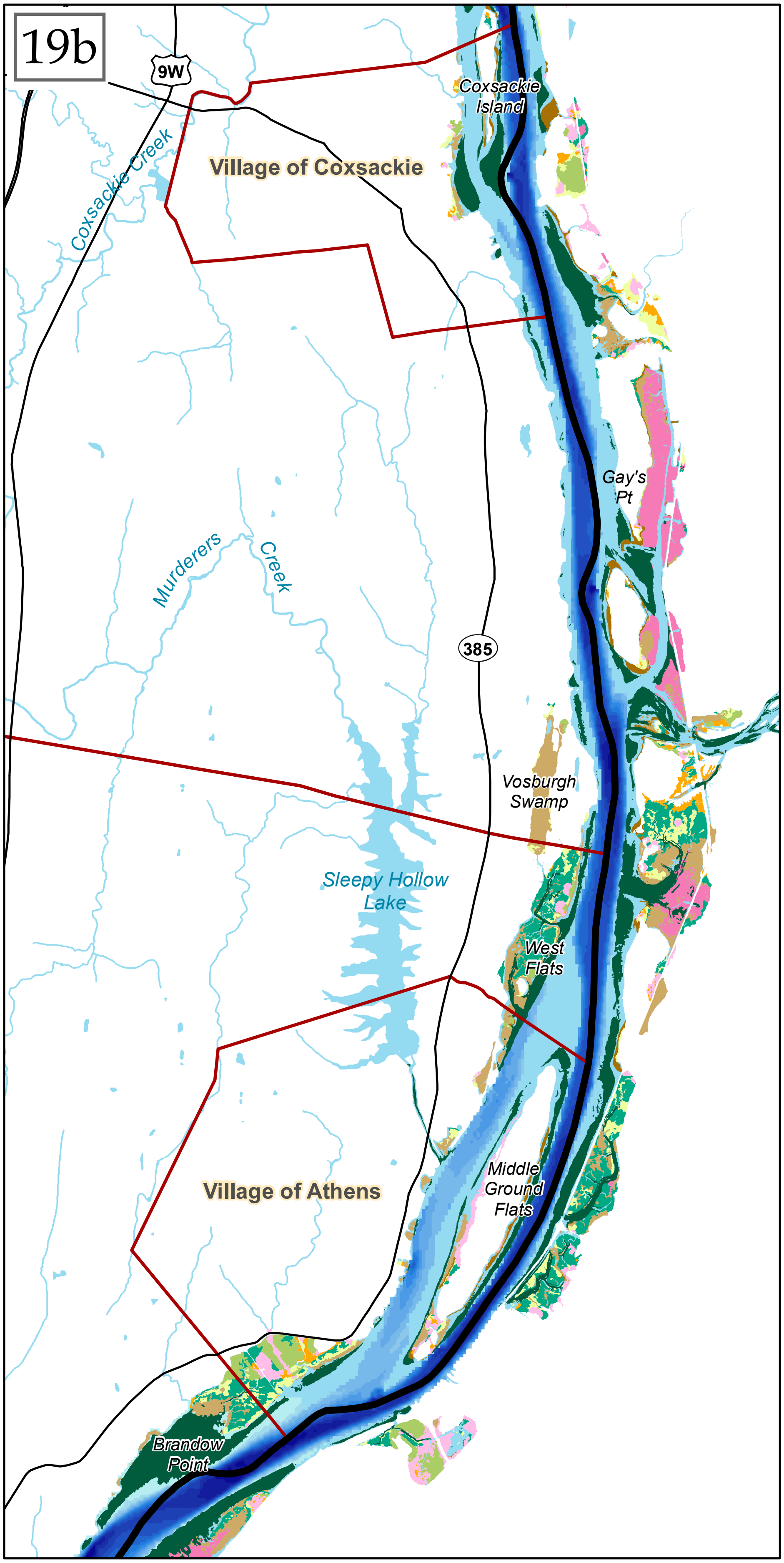
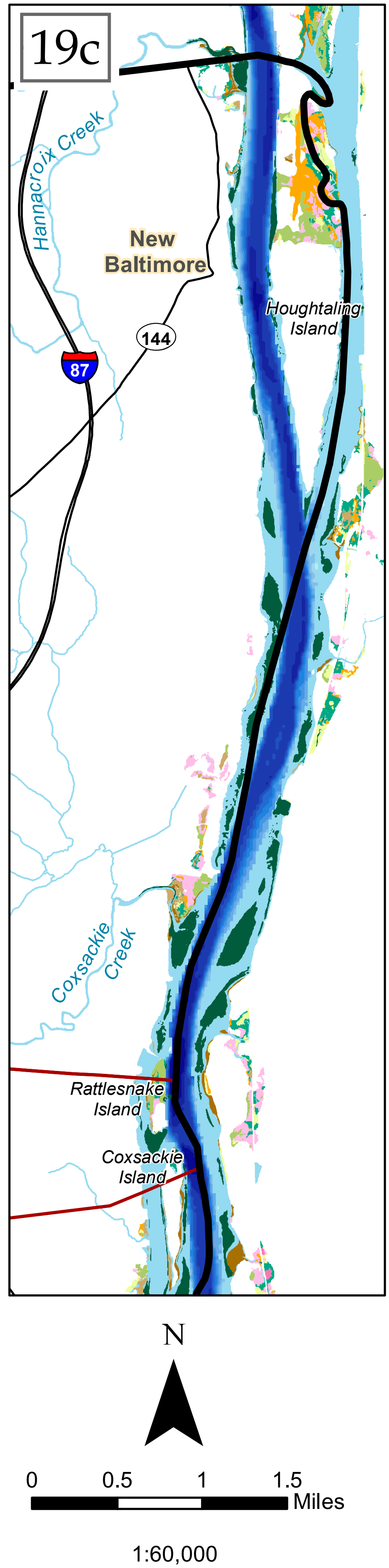


Figure 19. Hudson River tidal wetland habitats in Greene County, New York. Map sections shown from south (a) to north (c). Greene County Natural Resources Inventory, 2019.



19b
9W
Coxsackie Island
Village of Coxsackie
Coxsackie Creek
Gay's Pt
Murderers Creek
385
Vosburgh Swamp
Sleepy Hollow Lake
West Flats
Middle Ground Flats
Village of Athens
Brandow Point



19c
Hannacroix Creek
New Baltimore
Houghtaling Island
144
87
Coxsackie Creek
Rattlesnake Island
Coxsackie Island
N
0
0.5
1
1.5
Miles
1:60,000

Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) is the aquatic community of rooted underwater vegetation in areas that are continually flooded and usually less than 6 ft deep at low tide. The plants of Hudson River SAV in Greene County include American water-celery, curly pondweed, clasping pondweed, sago pondweed, horned pondweed, naiads, Eurasian watermilfoil, water-chestnut, and others.

SAV provides important habitat for macroinvertebrates and serves as nursery and refuge habitat for juvenile fish and as foraging sites for waterfowl that feed on both the invertebrates and the vegetation. The SAV also provides oxygen to the river water, an essential habitat component for Hudson River aquatic animals.

> Submerged aquatic vegetation serves as nursery and refuge habitat for juvenile fish and as foraging sites for waterfowl that feed on invertebrates and plants.

The locations of SAV in the Hudson River shift in response to herbivory and storms. NYSDEC has mapped the Hudson River SAV every few years since 1997, and Figure 19 shows all the Greene County areas where SAV has occurred recently or is likely to occur in the future.

Freshwater Intertidal Mudflat

The term "mudflat" refers to the near-level areas of the lower intertidal zone with low-stature, sparse vegetation that is usually submerged but is exposed briefly at low tide. The substrates of Greene County mudflats are mostly silt or fine sand. Mudflat vegetation grades into submerged vegetation at the lower end of the tidal range and into marsh vegetation at the upper end. Some typical plants are strapleaf arrowhead,† grass-leaved arrowhead, stiff arrowhead, spongy arrowhead,† and kidney-leaved mud-plantain.†

> Mudflats help to buffer tidal marshes and shores, dissipating wave energy and reducing erosion.

Plants of conservation concern of tidal mudflats in Greene County include ovate spikerush,† spongy arrowhead,† kidney-leaved mud-plantain,† and American waterwort.† Geese and wading birds feed on vegetation and invertebrates of these habitats, and bald eagle and osprey hunt over mudflats. The large bacteria communities of mudflats play important roles in the estuarine food web by breaking down organic matter (McLusky and Elliott 2006). Mudflats help to buffer tidal marshes and shores, dissipating wave energy and reducing erosion. Mudflats are extensive at Bronck Island, at West Flats, below the Village of Athens, at Brandow Point, and at the mouths of Catskill Creek and RamsHorn Creek.

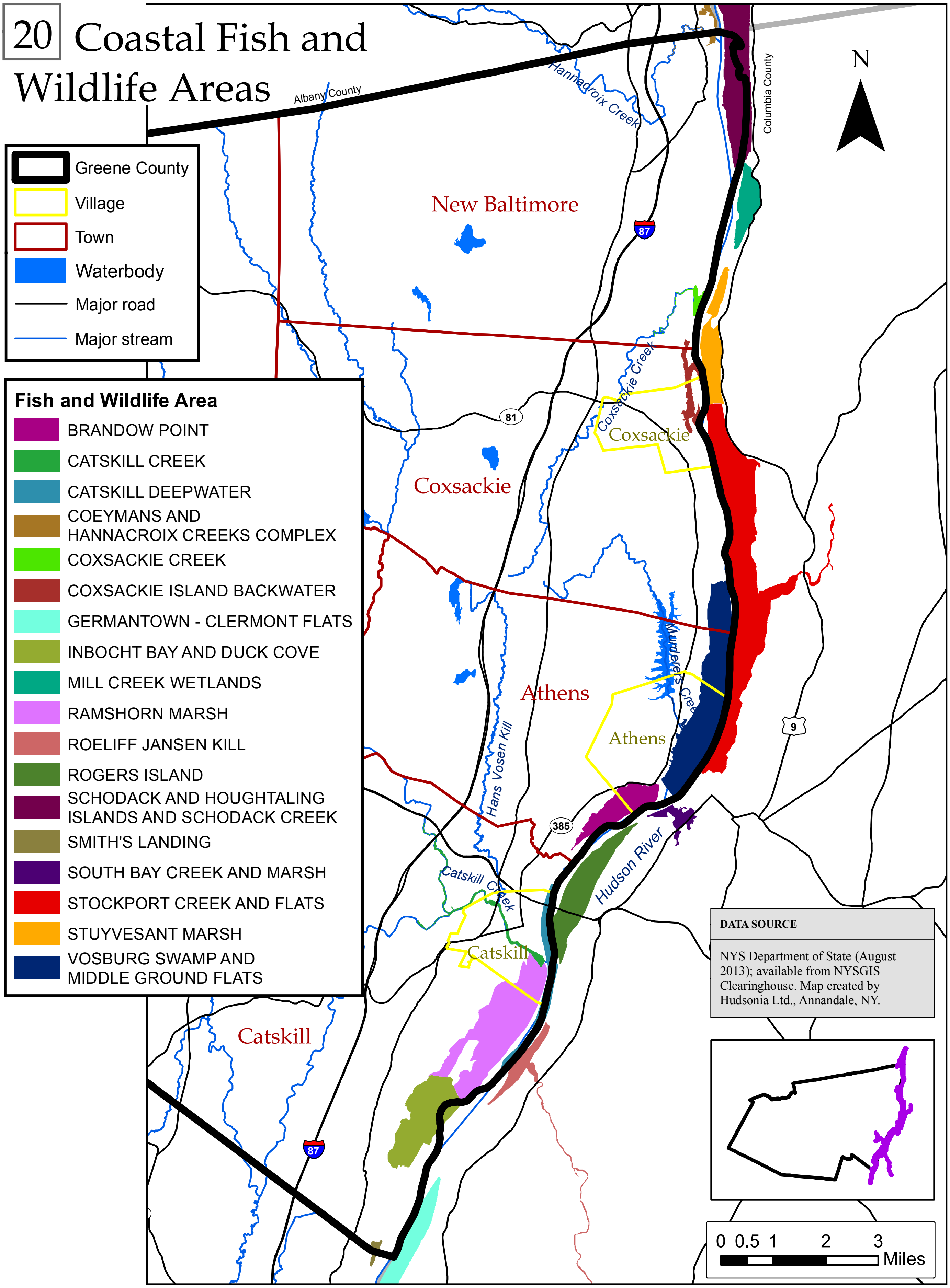


Figure 20. Significant Coastal Fish and Wildlife Habitats designated by NYSDEC in Greene and Columbia Counties, New York. Greene County Natural Resources Inventory, 2019.

Freshwater Tidal Swamp

A tidal swamp is a forested or shrubby wetland inundated regularly or intermittently by tides. Common trees in the Greene County freshwater tidal swamps are red maple, slippery elm, and green ash. Less common are black ash, American hornbeam, pin oak, American sycamore, American elm, eastern cottonwood, silver maple, boxelder, northern white cedar, and eastern white pine. The tidal swamp at the RamsHorn-Livingston Sanctuary has the unusual occurrence of swamp white oak, yellow birch, and black gum among the dominant trees (Barbour et al. 2004). Common shrubs are red-osier dogwood, silky dogwood, northern arrowwood, alders, swamp rose, and spicebush, and herbaceous species include skunk-cabbage, common jewelweed, marsh marigold, swamp buttercup, and sensitive fern (among many others). Rare plants include winged monkeyflower† and swamp lousewort.† Northern leopard frog uses tidal and supratidal pools within these swamps. Wood turtle† has been observed using a Greene County tidal swamp. Osprey† and bald eagle† use large trees at the edges of tidal swamps as hunting perches. Beaver, otter, and mink are regular inhabitants of these swamps, and bats may use the trees for summer roosts and the nearby tidal creeks and marshes for hunting.

The tidal swamp in the RamsHorn-Livingston Sanctuary is the largest in the Hudson River estuary, and is of unusually high quality.

Swamp lousewort is a NYS Threatened plant of freshwater tidal swamps, calcareous springs, calcareous wet meadows, and fens. Photo: Larry Federman © 2019

Tidal swamps in Greene County occur as part of wetland complexes with tidal marshes, creeks, mudflats, and shallows (Figure 19). The RamsHorn-Livingston Sanctuary (Figure 21) has the largest contiguous area of tidal swamp in the Hudson River estuary, and the swamp is of unusually high quality. The next largest tidal swamp in Greene County after RamsHorn is on Rattlesnake Island (New Baltimore).

21 Habitats at RamsHorn-Livingston Sanctuary

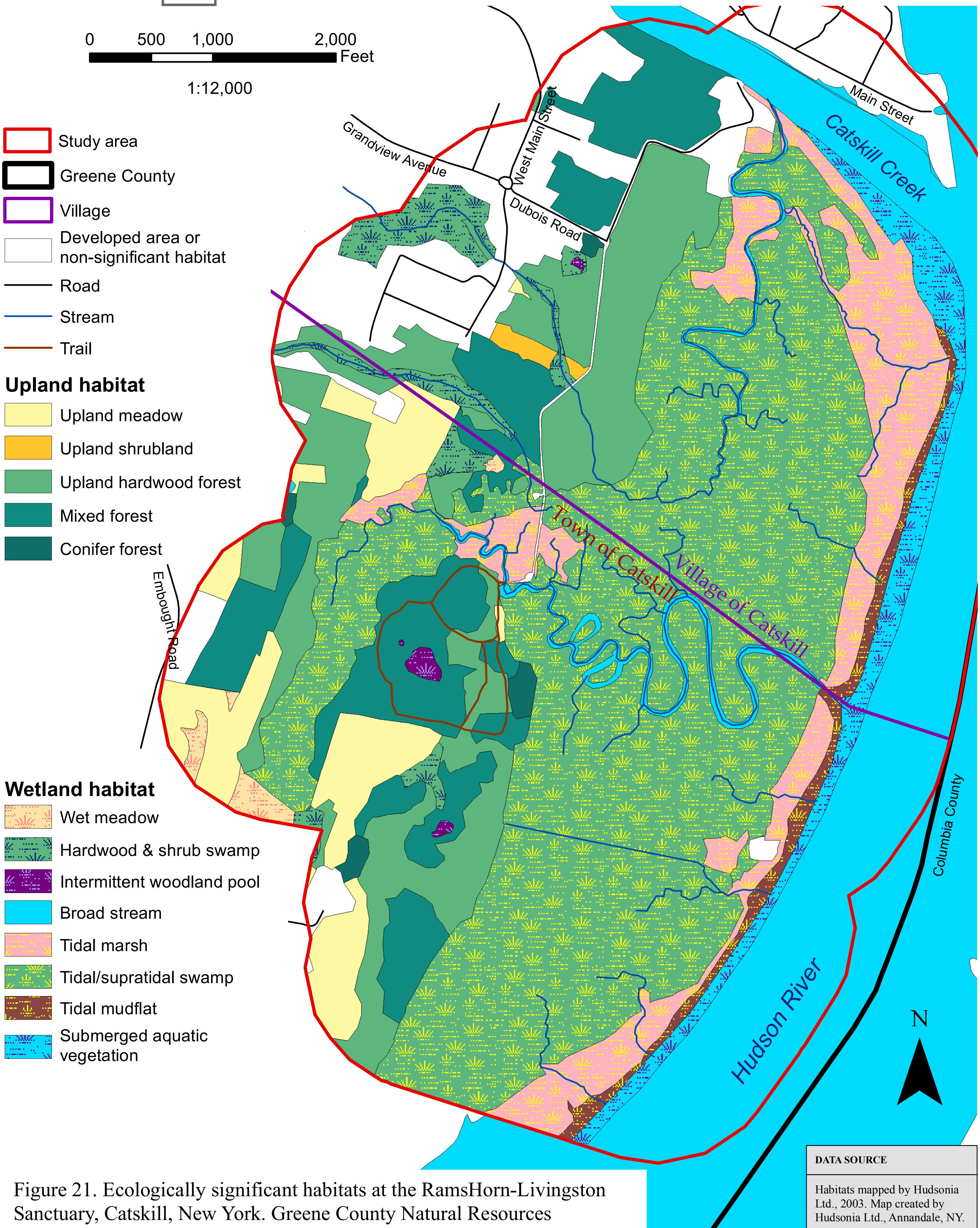


Figure 21. Ecologically significant habitats at the RamsHorn-Livingston Sanctuary, Catskill, New York. Greene County Natural Resources Inventory, 2019.

Freshwater Tidal Marsh

Freshwater tidal marshes are graminoid- and forb-dominated wetlands that are regularly flooded by tides. The herbaceous flora includes plants such as cattails, lakeside sedge, tussock sedge, woolgrass, threesquare, soft-stemmed bulrush, river bulrush, common reed, reed canary-grass, wild rice, sweetflag, large bur-reed, yellow iris, pickerelweed, arrow-arum, purple loosestrife, and spotted Joe-Pye-weed. Scattered shrubs may include alders, pussy willow, silky dogwood, winterberry holly, ninebark, and buttonbush. Goldenclub† occurs in Hudson River freshwater tidal marshes and is known from at least one Greene County location.

Freshwater tidal marsh is a rare habitat in the region and the state (Penhollow et al. 2006) that serves as critical nursery habitat for fish and shellfish and as nesting sites for songbirds, wading birds, and waterfowl, and is used by other kinds of wildlife—turtles, beaver, muskrat, river otter, white-tailed deer, and many others. Tidal marshes are also important resting and foraging habitat for migrating waterfowl. Animals of conservation concern in Greene County tidal marshes include American bittern† and least bittern,† which nest in this habitat, and bald eagle,† northern harrier,† and osprey, which hunt in large tidal marshes.

The Virginia rail's body is laterally compressed, making it easier to move through dense marsh vegetation. Photo: Larry Federman © 2019

Many of the tidal marshes in Greene County are part of larger tidal wetland complexes, such as those at RamsHorn, the Village of Athens, West Flats/Vosburgh Swamp, and the mouth of Coxsackie Creek. In Figure 19, areas of freshwater tidal marsh are shown as "lower intertidal mix" (including regularly flooded areas with floating-leaved, submergent, and emergent marsh plants such as spatterdock, three-square, sweetflag, and tearthumbs); slightly higher-elevation "cattail" and "upper intertidal mix" (dominated by a mix of plants including purple loosestrife, cattail, sweetflag, or three-square), and "common reed"-dominated marshes at the highest marsh elevations.

Dredge Spoil Habitats

Parts of the Hudson River shipping channel have been dredged since the late 1800s to keep the channel deep enough for large ocean-going vessels. The most intensive dredging took place between 1929 and 1943 (McVaugh 1947), but it still continues today. Dredge spoils—mostly sand and silt—from these operations have been placed in marshes, on islands, and along shorelines. Many of the areas of dredge spoil deposits have had 30-90+ years for vegetation to develop into well-established tidal mudflat, tidal marsh, meadow, bluff, and forest communities.

The largest dredge spoil areas in Greene County are at Seward Island, Middle Ground Flats, Coxsackie Island, Bronck Island, Houghtaling Island, and at the mouth of Hannacroix Creek. The most recent dredging operations have been depositing spoils at a federal site on Houghtaling Island.

Dredge spoil forest

Mature forests of eastern cottonwood, black locust, slippery elm, and black cherry now occupy many of the dredge spoil areas of Greene County. Other occasional trees include black oak, boxelder, and white ash. Non-native species such as Bell's honeysuckle, multiflora rose, oriental bittersweet, and garlic-mustard are abundant in places, but native shrubs, vines, and herbs such as gray dogwood, river grape, Virginia creeper, poison-ivy, enchanter's nightshade, and smooth goldenrod are also common. A few uncommon native plants—such as red baneberry, green dragon, one-flowered cancer-root, Schweinitz's flatsedge,† and Sprengel's sedge—have been found in dredge spoil forests of the Greene County-Columbia County reach (Barbour 1999b, Gretchen Stevens, pers. obs.). Garter snake is common in some dredge spoil forests, and there are old reports of box turtle† in this habitat, but reptiles and amphibians seem to be otherwise scarce (Nyman 1999). The sandy deposits with little topsoil and the scarcity of decaying downwood and other organic debris may limit the habitat value of these forests for reptiles and amphibians. Many common songbirds of deciduous forest habitats use the dredge spoil forests for nesting and foraging. Cerulean warbler† and bald eagle† nest in large trees of Hudson River dredge spoil forests, and bald eagle uses trees at the edges of marshes, mudflats, and shallows for hunting perches and roosts. White-tailed deer are abundant.

Many of the dredge spoil areas have had 30-90+ years for vegetation to develop into well-established tidal mudflat, tidal marsh, meadow, bluff, and forest communities.

Cerulean warbler and bald eagle nest in large trees of Hudson River dredge spoil forests.

Dredge spoil meadow

Upland meadow communities occur on dredge spoil along shorelines above the tidal zone, in forest openings, and on recent spoil deposits where woody vegetation has not yet become well-established. The herbaceous vegetation may be sparse or dense and often includes plants such as lovegrass, switchgrass, deer-tongue grass, Japanese stiltgrass, horseweed, black swallow-wort, and field horsetail. Schweinitz's flatsedge† has been found in one dredge spoil meadow in the region (Barbour 1999b), and painted turtle and snapping turtle nest in some of these meadows (Nyman 1999).

Dredge spoil wetlands
The irregular dredge spoil surface of berms and basins includes some areas that hold water for extended periods, creating small nontidal marshes, swamps, and vernal pools. Extensive tidal marshes and tidal swamps have also developed on dredge spoils. The plant communities of these wetlands are similar in many ways to those of swamps on native soils, although dredge spoil tidal swamps tend to have more eastern cottonwood, silver maple, and boxelder (Barbour 1999a). Rare and uncommon plants of dredge spoil wetlands in the region include lesser purple-fringed orchid, Fernald's sedge,† estuary beggarticks,† swamp lousewort,† and heartleaf plantain† (Barbour 1999b, Gretchen Stevens, pers. obs). Spotted salamander has been found to breed in apparently low numbers in vernal pools on dredge spoil, and blue-spotted salamander in a dredge spoil swamp, but the dredge spoil terrestrial habitats may be of low quality for salamanders in general (Nyman 1999).

PLANTS

Plants of Greene County, including trees, shrubs, forbs, graminoids, mosses, liverworts, lichens, and algae, are diverse and occupy all the varied habitats of the county from the Hudson River to the Catskill summits.

There is no comprehensive list of the plants of Greene County. *A Catskill Flora and Economic Botany,* Volumes I-VI (Brooks 1979) provides an overview of many of the plants in the Catskill Mountains, as well as keys, descriptions, and accounts of human uses. *The Catskill Forest: A History* (Kudish 2000) and other publications by Michael Kudish describe many of the past and present plant communities of the Catskills. Site-specific studies of places around the county by Hudsonia and others have added incrementally to the knowledge of Greene County flora. The website of the Catskill Mountain Club has photos of many native and non-native wildflowers of the Catskills (http://catskillmountainclub.org/events/common-wildflowers-of-the-catskills/).

All of our plant species are tied to particular kinds of environments. For that reason, you will find most grass species in meadows, marshes, and shrublands but not in deeply-shaded hemlock forests; you will find pond-lilies in marshes and ponds but not in wet meadows that lack standing water; and you will find chestnut oak in dry, rocky hillside forests but not in forested swamps. Conditions of moisture, temperature, light, and the chemistry and texture of soil or rock substrates are some of the obvious factors governing where a plant species might occur and persist. Among the less-obvious factors are relationships with other organisms; for example, beechdrops obtains its nutrients solely from the roots of beech trees, and pink lady's-slipper requires certain soil fungi for successful germination. Even the effects of long-ago land uses and catastrophic events (hurricanes, tornadoes, floods, wildfires) can be detected in plant communities of today. Also, the climate gradients in the county—south-to-north, west-to-east, low-to-high-elevation—have noticeable influence on the occurrence of certain plant species. While many of our plants are fairly common in suitable habitats, some are quite rare in the county, the region, or the state. Many of the rarities occur where either the general habitat or the microhabitat is unusual.

From a conservation standpoint, rare species of plants and animals are a particular concern because they are in the greatest danger of disappearing from our landscapes. Some are at or near the edge of their distribution range and are living close to the limits of their environmental tolerances. Some are surviving at locations disjunct from their main populations and may have limited resilience due to a small population size or a depleted gene pool. Some are in rare habitats, or in habitats that have been stressed by habitat fragmentation, pollution, overgrazing by deer, extreme weather events, or the many effects of the warming climate. Loss of rare species often indicates a degraded environment and can alert us to needs for protection and restoration before other species or communities are lost.

Rare species of plants and animals are a particular concern for conservation because they are in the greatest danger of disappearing from our landscapes.

Appendix Table C-1 gives the scientific names of all plants mentioned in the *NRI*, and Table C-2 lists the known Greene County plant species of conservation concern and the habitat(s) where each is likely to occur.

The New York Natural Heritage Program (NYNHP) has identified Areas of Known Importance around known occurrences of rare plant species in the county. These are areas deemed to be important for the continued persistence of those species, based on their life histories and habitats and the physical features of the landscape (figures 22a,,b). Areas of Known Importance are further described below.

<u>Non-native Plants</u>

The Greene County wild flora includes a mix of native species and non-natives that have been introduced in the last 350+ years, mostly from other parts of North America or from Eurasia. Many of the non-native grasses and forbs of pastures and hayfields were intentionally brought here to promote European-style agriculture. Many others were brought here as ornamental plants and have since spread into forests, shrublands, meadows, wetlands, and roadsides. Others were brought here unintentionally as hitchhikers on ships or other vehicles, with imported goods, or in travelers' luggage.

Some of these non-native plants are apparently harmless in their new environments, occurring as single individuals or in small stands that do not readily spread. Some are even beneficial, such as those that can quickly colonize and stabilize disturbed soil before native plants have time to establish. But some—the "non-native invasive species"—reproduce and spread rapidly, and threaten native plants and communities directly through competition, or indirectly by changing habitat characteristics by altering soil chemistry, soil microbiota, nutrient cycling, vegetation structure, or plant community composition (Travis and Kiviat 2016). In many cases where a non-native invasive species takes over a site, it is merely a symptom of a larger problem—such as damaged or contaminated soils, or excess nutrients from polluted runoff. Appendix Table C-3 lists many of the non-native invasive plants that occur in Greene County, their status, and their typical habitat(s). These plants are known to have invasive tendencies, but some are still offered for sale by nurseries and other gardening retailers. Removing them from landscaped areas will reduce their chances of spreading into nearby habitats and disrupting native biological communities.

In many cases a non-native invasive species infestation is merely a symptom of a larger problem—such as damaged or contaminated soils, or excess nutrients from polluted runoff.

Two organizations--the Catskills Regional Invasive Species Partnership (CRISP) and the Capital-Mohawk Partnership for Regional Invasive Species Management (Cap-Mo PRISM)—act as clearinghouses for information on non-native invasive species in the Greene County region and provide information and services for education, early detection, and control of non-native invasive plants and animals.

Animals

Greene County contributes significantly to the unusual biological richness of the Hudson Valley. The diverse biological communities of the county are a reflection of the complex bedrock geology and topography, glacial history, presence of the Hudson River estuary, and historic and present-day land uses that have created, altered, and maintained certain habitats that would otherwise be less common or extensive here.

Like most organisms, each animal species has a distinctive life history tied to a particular habitat or complex of habitats that fulfills its particular needs. A population will persist only if its habitats remain intact and its movement corridors safe. The wood turtle,† for example, needs low-gradient perennial streams and intact riparian corridors with a variety of forested and unforested, wetland and non-wetland habitats to meet its needs for foraging, nesting, resting, and overwintering. The cerulean warbler needs deciduous forests with mature trees for nesting and foraging here in its summer habitat, before migrating to the tropics for winter.

An important goal of the *State Wildlife Action Plan* is to engage private landowners in biodiversity conservation.

The *New York State Wildlife Action Plan* (NYSDEC 2015) identified conservation actions that would prevent more animal species from becoming critically imperiled. The *Plan* provides a list of NYS Species of Greatest Conservation Need (SGCN) that includes rare, declining, and at-risk species. The SGCN includes all New York State species on the federal or state lists of Threatened and Endangered species, as well as others identified by NYSDEC and the New York Natural Heritage Program (NYNHP) as species of regional conservation concern (NYSDEC 2015). The SGCN species are the focus of many ongoing and planned actions by New York State to identify, improve, restore, and protect important habitats. Included among these actions are education and technical assistance for local agencies and conservation organizations. Recognizing that land in private ownership supports much of New York's biological diversity, an important goal of the *State Wildlife Action Plan* is to engage the public in biodiversity conservation.

Starting with known locations of rare animal species, the NYNHP has identified parts of the landscape that encompass the habitat areas used by those species, and delineated them as Areas of Known Importance (figures 22a,b).

Profiled below are just a few of the animal groups that represent different kinds of life histories, habitats, and regions of the county. A dagger symbol (†) denotes animals that are listed as SGCN or as NYS Species of Special Concern. More complete lists of species of conservation concern and explanations of the rarity ranks are in Appendix C.

Periodical cicadas emerge every 17 years in New York, and complete their above-ground life-cycle (mating, egg-laying) in a few weeks. Photo: Kelly West © 2019

Invertebrates

The term "invertebrates" refers to all the animals that lack a spinal cord—an immense group that constitutes 97% of all animal species on Earth (May 1988). It includes insects, crustaceans, earthworms, millipedes, mollusks, and many other groups. The ecological importance of invertebrates cannot be overstated. They act as decomposers, soil builders, pollinators, distributors of seeds, grazers, predators, and prey.

We view some invertebrates such as butter-flies and dragonflies as colorful and charismatic; some such as bees or earthworms as useful; and others such as termites and mosquitoes as bothersome, but most invertebrates go about their lives unnoticed by us, despite their indispensable roles in our ecosystems. Indeed, some groups of organisms are so poorly known that many species here in the county and elsewhere have yet to be recognized and described by science. Mentioned below are descriptions of just a few of the invertebrate groups that are known to serve outsized functions in Greene County habitats.

Bees

Bees are the most important pollinators of wild and domestic plants, because they collect both nectar and pollen as food and have physical structures especially evolved for transporting pollen (Mader et al. 2011). In the process of visiting flowers to feed themselves and collecting pollen to feed their young, bees transport pollen between plants as they move from flower to flower on their collecting rounds. Many other insects, including butterflies, moths, beetles, wasps, and flies, visit flowers for the nectar and also carry pollen incidentally between flowers, but they are usually less efficient as pollinators because they lack the highly developed structures for transporting pollen in large amounts.

New York State has an estimated 416 species of wild bees.

New York State is home to an estimated 416 wild bee species. Of these, 21 species are introduced (including the honey bee) and 395 are considered native. Native bees are more effective pollinators of many plants, including domestic crops, than are honey bees, and many species of native bees are also able to forage earlier and later in the day, earlier and later in the season, and in wetter and colder conditions than honey bees (Mader et al. 2011).

Native bees feed on and collect nectar from a variety of plant species, but a few specialize on a particular species, genus, or family of plants for their pollen sources. For example, squash bees specialize on pollen from squashes, pumpkins, and cucumbers; a species of sweat bee specializes on primroses, and the pickerel bee specializes on pickerelweed. Some native bees are more efficient pollinators than honey bees for certain plants with tightly-held pollen, such as tomatoes, potatoes, and blueberries, because they are able to use a special "buzz-pollination" technique, vibrating their flight muscles at a certain frequency to release the pollen that is largely inaccessible to honey bees and other pollinating insects.

Populations of many native bee species in North American have been declining at local and regional scales due to causes such as habitat loss, pesticides, pollution, invasive species, pathogens, and climate change (IPBES 2016). Exposure to these multiple threats can make the bees more vulnerable to any particular threat, such as pesticides.

22a Areas of Known Importance

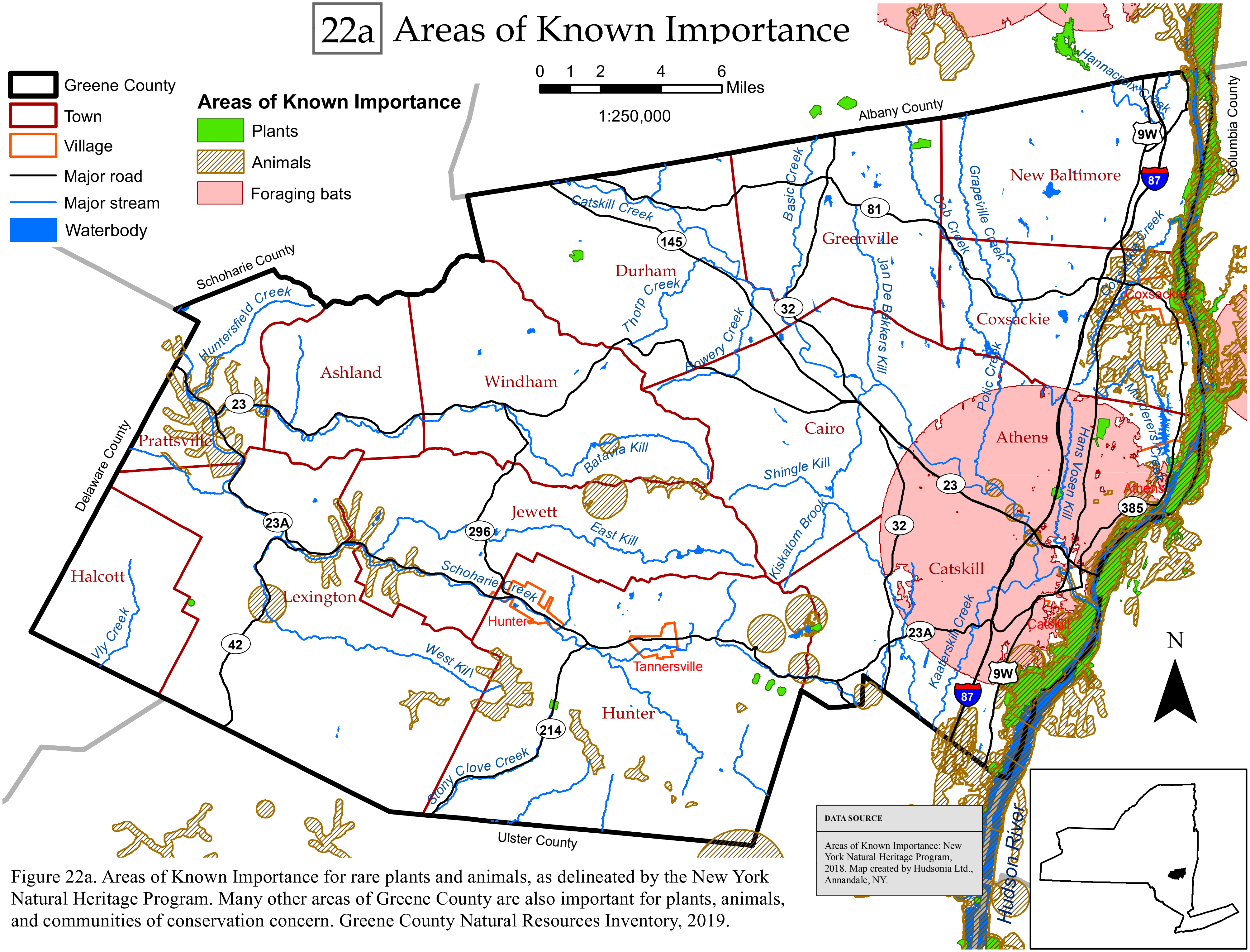


Figure 22a. Areas of Known Importance for rare plants and animals, as delineated by the New York Natural Heritage Program. Many other areas of Greene County are also important for plants, animals, and communities of conservation concern. Greene County Natural Resources Inventory, 2019.

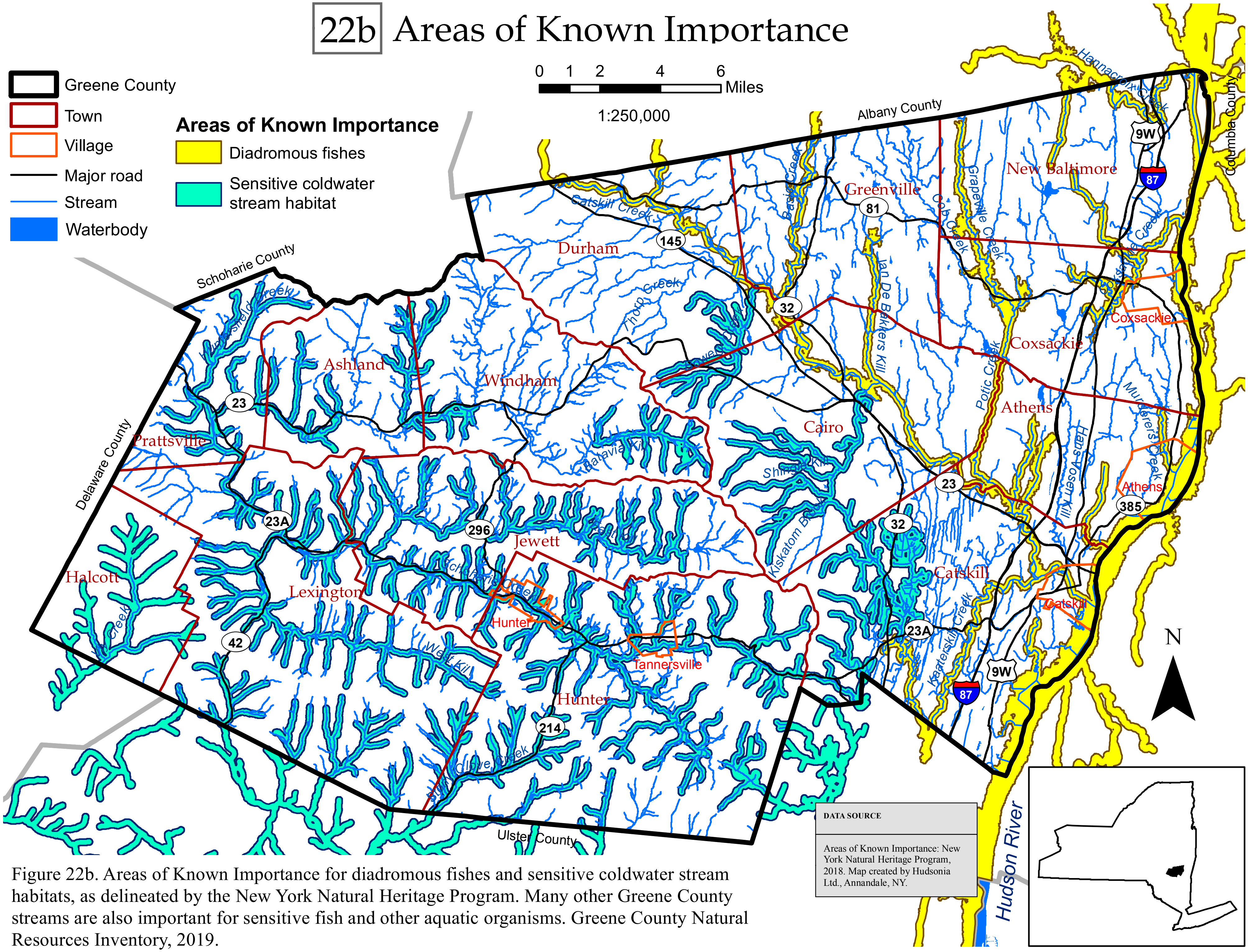


Figure 22b. Areas of Known Importance for diadromous fishes and sensitive coldwater stream habitats, as delineated by the New York Natural Heritage Program. Many other Greene County streams are also important for sensitive fish and other aquatic organisms. Greene County Natural Resources Inventory, 2019.

22c Significant Natural Communities--Western Greene County

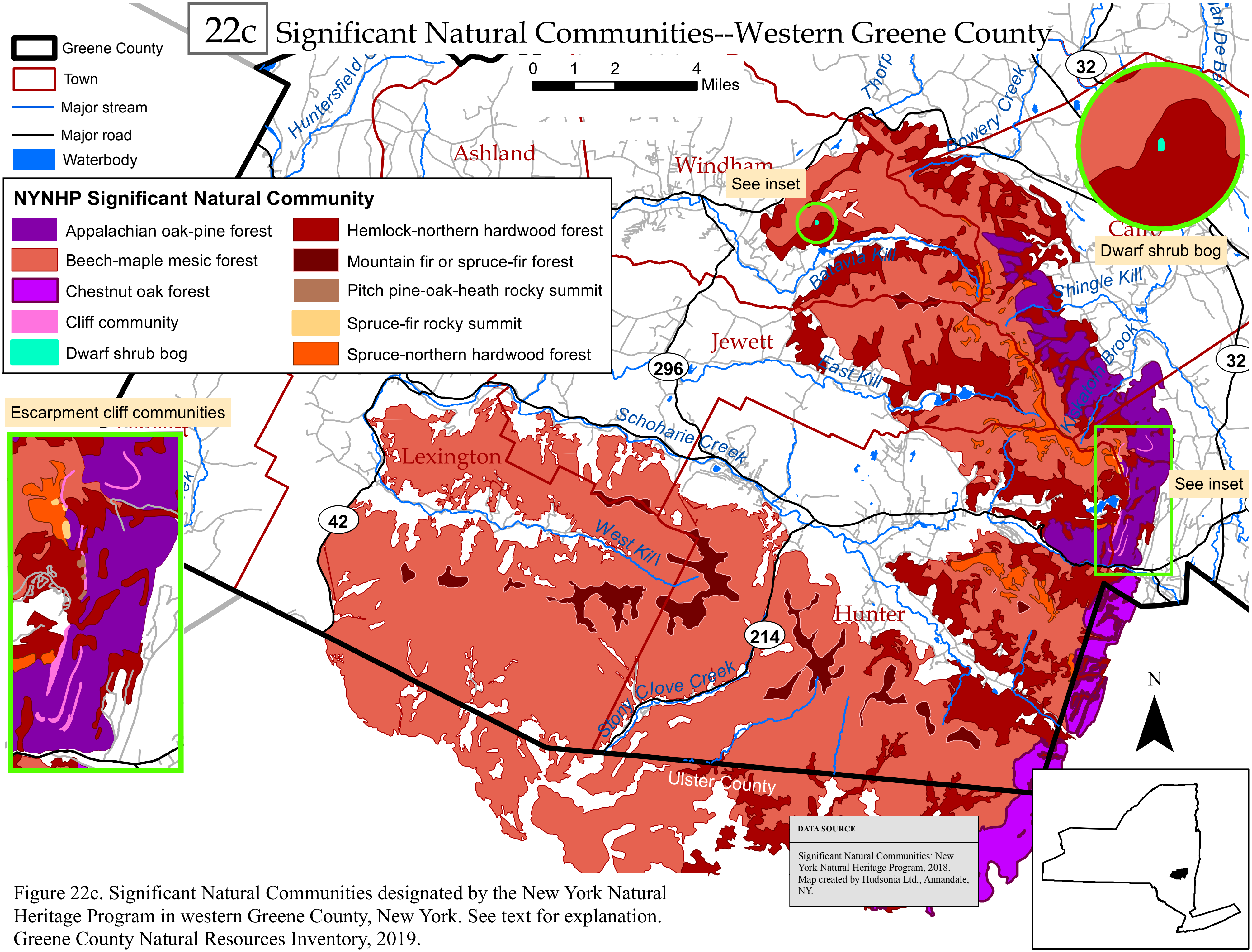


Figure 22c. Significant Natural Communities designated by the New York Natural Heritage Program in western Greene County, New York. See text for explanation. Greene County Natural Resources Inventory, 2019.

22d Significant Natural Communities--Eastern Greene County

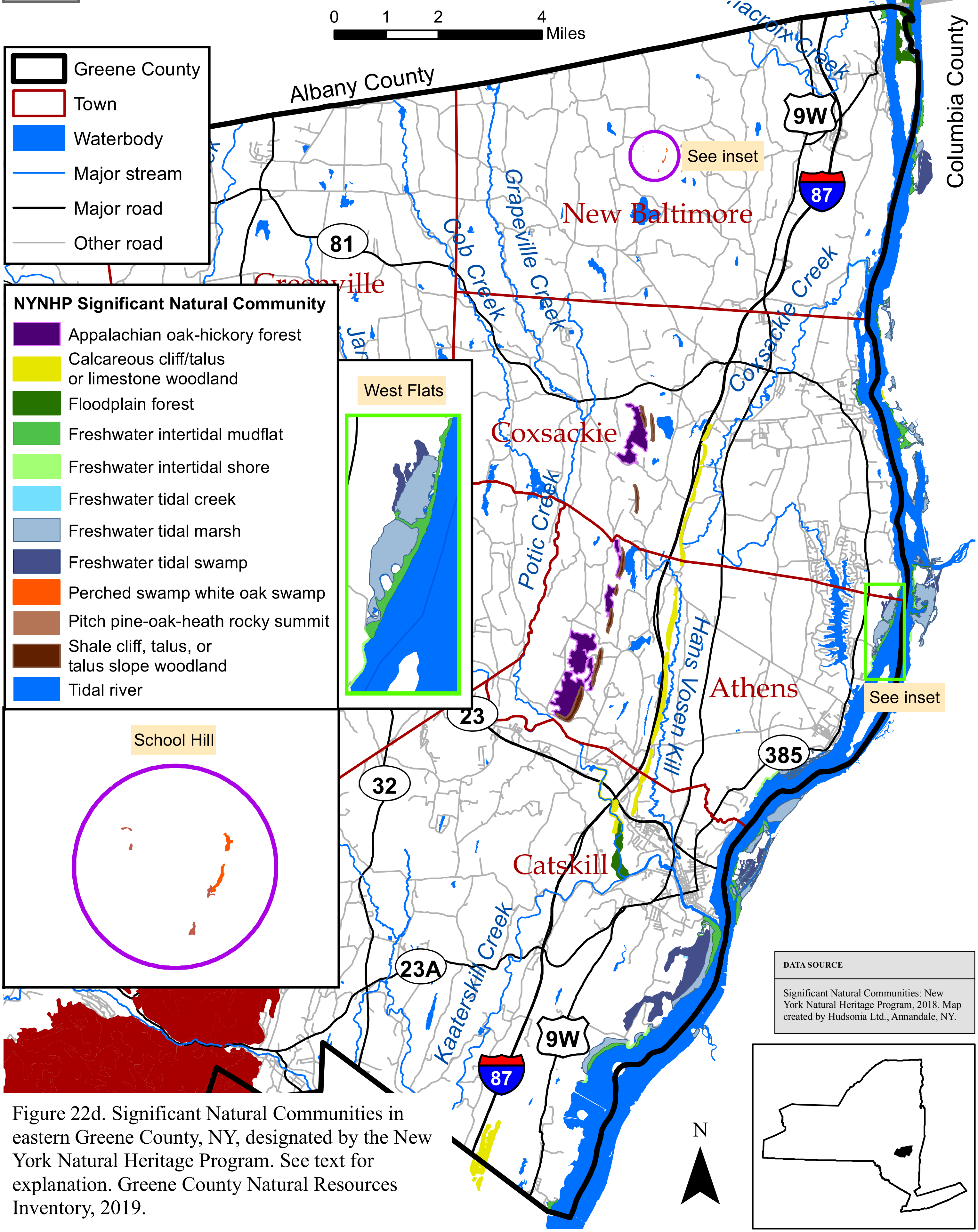


Figure 22d. Significant Natural Communities in eastern Greene County, NY, designated by the New York Natural Heritage Program. See text for explanation. Greene County Natural Resources Inventory, 2019.

Bees are especially sensitive to pesticides (fungicides, herbicides, insecticides) and other toxins, which they can absorb through their exoskeleton and also consume in contaminated nectar or pollen. The exposure is not only from above-ground applications to plants, but also from soil fumigants that can be harmful to ground-nesting bees and other beneficial soil biota (Mader et al. 2011). "Neonicotinoid" pesticides, now the most widely used class of pesticides worldwide, are absorbed by the treated plants and eventually stored in the plant tissue as well as the nectar and pollen, thus passing on the toxins to all organisms consuming those materials. Furthermore, only ca. 5% of the substance is absorbed by the target plants; the remainder disperses into the environment where it affects many other organisms (Wood and Goulson 2017).

Bees are especially sensitive to pesticides and other toxins which they can absorb through their exoskeleton and consume in contaminated nectar or pollen.

Bee visiting Rose of Sharon.
Photo: Kelsey West © 2019

Native bees and honey bees visit flowers in all habitats of the county, but the nesting habitats of individual species are more specialized. Most native bee species are ground nesters and need suitable soil conditions to support their tunnels and brood cells. Habitats with bare or sparsely vegetated, friable soil are important for nesting by many bees, wasps, and other insects. Other bees nest in hollow stems of woody plants or in channels created by beetles or other animals in standing trees or downwood (Mader et al. 2011). In general, maintaining diverse open and forested habitats that are free of toxic contaminants may be the best way to help sustain our populations of native bees, honey bees, and other insects that we rely on for pollination and a host of other services.

Dragonflies and Damselflies

Dragonflies and damselflies ("odonates") play key roles in ecosystems. They are predators in both their nymph and adult stages, and are themselves important prey of fish, amphibians, birds, bats, and other organisms. They are sensitive to the water chemistry, temperatures, and flows in their stream, pond, or wetland environments, as well as the kinds of vegetation and the kinds of aquatic predators present. For these reasons odonates are sometimes used as indicators of habitat quality and the health of aquatic ecosystems.

Dragonflies and damselflies are aquatic in the larval (nymph) stage, and each species has its own affinities for moving or still water; rocky, sandy, or silty substrates; sun or shade. Some are more sensitive than others to conditions of water temperature, water clarity, or dissolved oxygen levels. Some are disproportionately found along the Hudson River, and others are closely tied to special inland habitats such as acidic bogs, seeps, or rocky streams. As adults, many stay around wetlands, ponds, and streams, but some are more often seen hunting over upland meadows or along hedgerows or forest edges. As with most other animals, understanding their habitats can help you predict where certain odonate species are likely to occur.

Ebony jewelwing deposits its eggs on vegetation of temporarily flooded pools and swamps, and thus must begin early in spring to complete its life cycle before pools dry up. Photo: Larry Federman © 2019

In 2005-2009 the county was included in the New York Dragonfly and Damselfly Survey conducted throughout the state by NYSDEC and NYNHP, other professional biologists, and trained volunteers (White et al. 2010). Altogether, 51 odonate species were found in Greene County in those surveys, and perhaps another 17 species are expected to occur in the county (White et al. 2010).

Appendix Table C-4 lists the dragonflies and damselflies known to occur in Greene County along with the habitats where they are most likely to be found. Some are abundant or occasional, but many have been seen only rarely, and a few are acknowledged to be of statewide conservation concern.

> Loss and degradation of wetland and stream habitats seem to be responsible for the declines of many North American odonate species.

Loss and degradation of wetland habitats seem to be responsible for the declines of many North American odonate species. According to the Xerces Society (2014), at least 20% of all North American odonates are considered to be at risk of extinction. The larvae of most dragonfly and damselfly species are sensitive to changes in the hydroperiods of their stream and pond habitats, and to water pollution and siltation. The adults eat a great variety of insect prey but sometimes face limited food availability. They do best where diverse habitats—such as streams, marshes, wet meadows, upland meadows, shrublands, and forest—are in close proximity to each other, providing plentiful perching and basking sites and varied prey throughout the active season.

The best measures for supporting local odonate populations are maintaining water levels, seasonal hydroperiods, and good water quality in streams and ponds; avoiding the introduction of predatory fishes; and maintaining diverse, intact terrestrial habitats near streams and ponds.

Caterpillars of the spicebush swallowtail feed nocturnally, and shelter in folded-over leaves during the day. Photo: Larry Federman © 2019

Butterflies and Moths

Butterflies and moths are some of our most charismatic and conspicuous insects, and they play important but often hidden roles in ecosystems. They contribute to the pollination of certain plants, serve as prey to other organisms—including other insects, spiders, reptiles, amphibians, mammals, and birds—and, especially through their voracious caterpillars, consume and process large amounts of vegetation, making nutrients available to other parts of the food web. Some species of butterflies and moths are closely tied to particular habitats or plant species, and many are very sensitive to environmental contaminants, such as pesticides.

> Local butterfly populations will persist only if their host plant species are present.

Adults of butterflies and moths feed primarily on nectar and, although a few specialize on particular plant species, most are generalists, visiting whatever nectar-producing flowers are available during the adult flight periods. The larvae (caterpillars) of many species are much more specialized and require particular species or genera or families of plants. For example, the caterpillars of the monarch butterfly feed on milkweeds; those of the Baltimore checkerspot feed on white turtlehead; those of the tawny emperor feed on hackberry; and those of the deceptive snout moth feed on basswood. Some other host plants for butterfly larvae are nettles (for red admiral, eastern comma), cherries (tiger swallowtail), oaks (certain hairstreaks and duskywings), ashes (mourning cloak), and grasses (skippers). Clovers, asters, violets, and willows are also hosts for many other butterfly species of the county. Appendix Table C-5 lists the known host plants for Greene County butterflies. Good sources of larval food plants and nectar sources are key components of butterfly habitat, and local butterfly populations will persist only if their host plant species are present. Land management to encourage such species will help to ensure that butterfly food sources are not limiting.

Monarch larva on butterfly milkweed. Monarch adults migrate thousands of miles to wintering grounds in Mexico. The butterflies that return in spring are of the generation following those that left in fall. Photo: Kelsey West © 2019

Most butterfly species overwinter here as eggs, pupae, or adults (Cech and Tudor 2005) so, in addition to food sources during the active seasons, butterflies also need safe places for egg-deposition, pupation, and overwintering. Although not well understood, sites for basking and mating may also be important; for example, some butterflies are "hilltoppers" and congregate on open hill tops for mating. Pupation usually occurs in tall herbaceous vegetation, shrubs, trees, or woody debris, so leaving untidy patches of undisturbed soils and vegetation in fields or at field edges will help to maintain appropriate microhabitats. The few butterflies and moths that overwinter as adults find shelter in tree cavities, under loose bark, or under logs, rocks, or similar features.

Our eastern monarch butterfly migrates to upland forests of Mexico for the winter. The population is under stress from loss of forest habitat in their wintering grounds, mortality from exposure to cold and wet conditions during large storms in recent years, and loss of milkweed (the larval host plant) in their summer habitat due to intensification of agriculture. The monarch life history helps illustrate the complexity of ecological relationships that also affect many other butterfly and moth populations.

New York State has over 2500 species of butterflies and moths, occurring in all kinds of wetland and upland habitats. Appendix Table C-5 lists many of the butterflies of Greene County.

Mollusks

Mollusks are a diverse group of invertebrates that includes clams, mussels, snails, and slugs, among many others. They occur in upland, wetland, and aquatic habitats and play important roles in aquatic and terrestrial ecosystems. Freshwater snails, for example, are a food source for many other animals—e.g., crayfishes, fishes, amphibians, waterfowl, turtles, and mammals—and they consume algae and organic debris obtained from the surfaces of rocks, plants, and other substrates. Many species—those with gills—are sensitive to low levels of dissolved oxygen and even small amounts of petroleum hydrocarbons, certain metals, agricultural fertilizers and pesticides, and suspended sediments. They are thus considered to be good indicators of water quality. The snail species with lungs are more tolerant of pollution (Johnson 2009).

Most land snails (including shelled snails and slugs) live in the leaf litter of forests, organic debris (thatch) of oldfields, and in wetlands, but some also use gardens, agricultural fields, and lawns. They feed on live and dead herbaceous material, bark, rotting wood, fungi, and algae, and are eaten by a large array of invertebrate predators, along with salamanders, turtles, small mammals, and birds (Hotopp et al. 2018). Most of our land snails are native to the region, but a few non-natives have become pests to farmers and gardeners.

Hotopp et al. (2018) have documented the land snails of New York from existing literature, museum collections, and recent field studies. Appendix Table C-6 lists aquatic mollusks and land snails observed in Greene County, as well as those observed in nearby counties that are also likely to occur here.

Fishes

The fishes of tidal and nontidal waters of New York have been studied for centuries, and publications by Smith (1985) and Carlson et al. (2016) compile much of present-day knowledge of the presence and distribution of fish species throughout the state. The fishes of Greene County occupy our swift-running hillside streams and our sluggish and meandering lowland streams, as well as lakes, ponds, and the Hudson River. Which fish populations occur and persist in any stream depends on habitat characteristics such as water temperature, turbidity, dissolved oxygen levels, and substrate qualities.

Tributaries to the Hudson River provide important spawning habitat for certain migratory fishes. Anadromous fishes are those that come from the ocean to spawn; spend their early years in freshwater streams and rivers; and then migrate to the ocean where they grow to maturity. Some examples are striped bass, American shad, Atlantic sturgeon,[†] alewife, and blueback herring. Potamodromous fishes, such as white sucker and yellow perch, migrate from the freshwater reach of the Hudson into tributary streams to spawn. Catadromous fishes spawn in the ocean but migrate to freshwater habitats to mature. The Hudson has just one catadromous species—the American eel[†]—which arrives here from the Sargasso Sea in the tiny, translucent "glass eel" stage. The eel then spends many years in the Hudson River and tributaries, where it grows to adulthood before migrating back to its ocean spawning grounds. "Diadromous" is the umbrella term encompassing all of these life history migrations between fresh water and ocean environments. In addition to those large migrations between waterbodies, seasonal movements between different reaches of a single stream are also important for fishes and other aquatic animals as they search for suitable water depths, water temperatures, shelter, and feeding areas for different seasons, environmental conditions, and life stages.

The American eel arrives here from the Sargasso Sea in the tiny, translucent "glass eel" stage, and spends many years maturing in the Hudson River and tributaries before returning to its ocean spawning grounds.

The Hudson River tributaries, such as Catskill Creek, Coxsackie Creek, and Hannacroix Creek, are important to the lives and well-being of these fishes and to the ecology of the Hudson River. Dams on Hudson River tributaries, however, some of which have been in place for centuries, present insurmountable barriers to the upstream movement of most fish species and have disrupted the spawning migrations that occurred for thousands of years before European settlement. Culverts suspended above the stream bed pose similar barriers to fish migrations. Unlike other fishes, the American eel can move overland to circumvent or surmount some dams, waterfalls, and culverts, and does so in small numbers on some Hudson River tributaries.

Other fishes of Greene County do not depend on migrations to and from the Hudson River and the ocean but spend their entire lives in nontidal streams, lakes, and ponds. Some, such as bridle shiner and fathead minnow, inhabit slow-moving streams or ponds and are somewhat tolerant of polluted waters. Others such as brook trout[†] and slimy sculpin need faster-flowing, clean, cool, well-oxygenated streams.

Figure 23 illustrates the distribution of the larger Greene County streams classified according to size, gradient, and temperature—habitat characteristics that influence the entire aquatic communities of each stream segment. Stream size affects the kinds of invertebrates and fish and the trophic structure of the stream community. Stream gradient influences the shape of the stream bed, the flow velocity and the kinds of substrate materials. For example, high-gradient streams often have swift water, step pools, and boulder and cobble substrates, while low-gradient streams tend to have slow water with riffles and pools, and with alluvium, sand, gravel, and cobble substrates. Stream temperature affects levels of dissolved oxygen and determines which fish and invertebrate species can survive; triggers the onset of migration and developmental stages in stream organisms; influences the growth rates of eggs and juvenile fishes; and affects the body size and fecundity of fishes (Olivero and Anderson 2008). Knowing the size, gradient, and temperature of a stream can help you predict the kinds of fish and other aquatic animals that are likely to occur there.

To support recreational fishing, NYSDEC stocks trout annually in several Greene County streams and ponds. In 2018, for example, these streams and lakes were variously stocked with brown trout, 8-9 inches or 9-15 inches, in spring (April – June), and the same waterbodies were planned to be stocked in 2019:

Basic Creek	Colgate Lake	Kaaterskill Creek
Batavia Kill	East Kill	Schoharie Creek
Catskill Creek	Green Lake	West Kill

The non-native brown trout compete with the native brook trout for habitat and food resources, and may interfere with the growth of slimy sculpin, another native fish of coldwater streams (Zimmerman and Vondracek 2007).

23 Stream Habitats

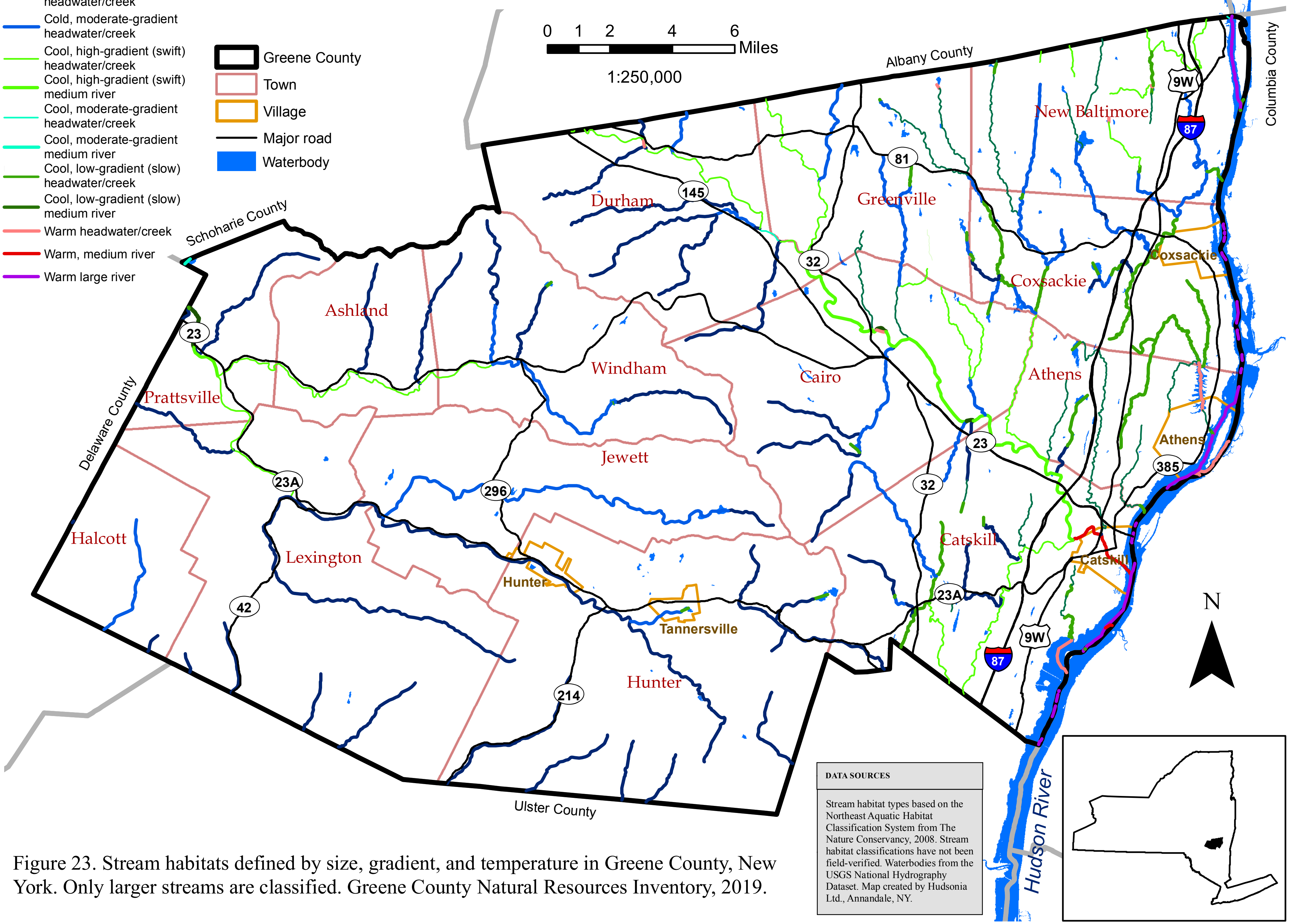


Figure 23. Stream habitats defined by size, gradient, and temperature in Greene County, New York. Only larger streams are classified. Greene County Natural Resources Inventory, 2019.

Table 5. Hudson River fish and crab consumption advisories from the NYS Department of Health, 2019 (https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/regional/catskill.htm).

Waterbody	**Fish species**	**Men over 15 & women over 50**	**Children under 15 & women under 50**	**Chemicals of concern**
Hudson River: Greene County, north of Rip Van Winkle Bridge	alewife, blueback herring, rock bass, yellow perch	up to 1 meal/month	do not eat	PCBs
	all other fish (including striped bass and walleye)	do not eat	do not eat	PCBs
Hudson River: Greene County, south of Rip Van Winkle Bridge	blue crab tomalley and cooking liquid	do not eat	do not eat	PCBs, dioxin, cadmium
	blue crab meat	up to 4 meals/month (six crabs per meal)	do not eat	PCBs, cadmium
	channel catfish, gizzard shad, walleye, white catfish	do not eat	do not eat	PCBs
	striped bass, brown bullhead, carp, largemouth bass, smallmouth bass, white perch, rainbow smelt, and goldfish	up to 1 meal/month	do not eat	PCBs
	all other fish	up to 4 meals/month	do not eat	PCBs
North-South Lake	largemouth bass	>15” up to 1 meal/month	do not eat	mercury
	all other fish	up to 4 meals/month	do not eat	mercury
Schoharie Reservoir	walleye	>18” do not eat	do not eat	mercury
	walleye	<18” up to 1 meal/month	do not eat	mercury
	smallmouth bass	>15” do not eat	do not eat	mercury
	smallmouth bass	<15” up to 4 meals/month	do not eat	mercury
	all other fish	up to 4 meals/month	do not eat	mercury
All other waters	yellow perch	up to 4 meals/month	>10” do not eat	mercury
	yellow perch	up to 4 meals/month	<10” up to 4 meals/month	mercury
	largemouth bass, smallmouth bass, walleye,	up to 4 meals/month	do not eat	mercury
	brook trout, brown trout, rainbow trout, rock bass, sunfish, bullhead, all other fish	up to 4 meals/month	up to 4 meals/month	mercury

Streams that support wild-reproducing brook trout are a declining resource in the Hudson Valley due to water pollution, stream-bed siltation, removal of forest canopies in the stream corridors, altered stream flows, and other consequences of human activities. The degradation of streams coincides with the decline of brook trout[†] and other organisms of high-quality coldwater streams. A large proportion of Greene County streams, however, are classified as "trout spawning streams" (Figure 11) because of their known or apparent capability for supporting wild-reproducing brook trout.

Figure 22b shows zones along selected streams and lakes that have been designated by the NYNHP as Areas of Known Importance for sensitive coldwater stream habitats. Those mapped areas include wild brook trout locations identified in NYSDEC fish surveys since 1980, as well as zones along associated stream and waterbody segments that are most likely to affect the stream habitat quality. The map does not account for stream habitat fragmentation that might be caused by dams and inadequate culverts preventing trout from occupying some of these areas. The identification and mapping of these coldwater stream habitat areas is intended to promote conservation and stewardship to maintain or restore high quality streams that may support wild native brook trout[†] and other sensitive stream organisms. The map does <u>not</u> indicate areas with public fishing rights, however, and many of these mapped areas are unsuitable for recreational trout fishing due to small fish populations and small fish size.

Despite dredging of PCB-contaminated sediments at Hudson Falls (Washington County) since 2011, PCB levels remain high in sediments and organisms throughout the entire downstream segment of the river. PCBs and some of the other Hudson River pollutants accumulate in the fat of animals and become concentrated at higher levels of the food chain. High levels of PCBs in fish, and of mercury, cadmium, and dioxin in blue crab, have led the NYS Department of Health to recommend that women under 50 and children under 15 years of age eat no fish or crabs at all from the Greene/Columbia County reach of the Hudson River, and that men over 15 and women over 50 eat no fish of certain species (channel catfish, gizzard shad, and walleye) and only 1-4 fish meals per month of others, depending on the species (Table 5) (NYS Department of Health 2019).

Appendix Table C-7 lists the fish species known to occur in tidal and nontidal habitats of Greene County.

<u>**Amphibians and Reptiles**</u>

Of the 69 species of amphibians and reptiles occurring in New York State (Gibbs et al. 2007), at least 39 species (57%) occur in Greene County. The county has thirteen species of salamanders, eight toads and frogs, six turtles, and eleven snakes. Although each species has its own habitat affinities, as a group these animals use all parts of the landscape, including the freshwater tidal river and tidal wetlands, intermittent and perennial streams, nontidal wetlands of all kinds, upland meadows, shrublands, forests, and exposed ledges and talus. Table 6 lists these species and their habitats, and below are brief descriptions of just a few that represent various parts of the Greene County landscape.

The mudpuppy† is a large, entirely aquatic salamander of rivers and lakes. It occurs here in the Greene County reach of the Hudson River but nowhere else in the county. The northern dusky salamander is closely tied to forested streams and seeps, where adults spend much of the daytime beneath rocks and woody debris and emerge at night to forage, rarely moving more than a few feet from the stream or seep. The spring salamander is an animal of well-shaded rocky streams, seeps, springs, and nearby forests. The two-lined salamander is another species of forested streams and seeps, but is sometimes found in unforested streams or even long distances from water (Gibbs et al. 2007). Jefferson salamander,† spotted salamander, and wood frog are in the special group of "vernal pool-breeding amphibians" in this region because of their need for intermittent woodland pools (vernal pools in forested settings) for breeding and nursery habitat. Although they use the pools for breeding and nursery habitat, the adults and metamorphosed juveniles spend most of the year in the surrounding upland forests, so the pool and forest are equally important to maintaining local populations of these amphibians.

Greene County is outside the normal range for the marbled salamander† (another pool-breeding amphibian) but it does occur in Ulster County and could appear in the future in Greene County with the warming climate.

The red eft, the juvenile and sub-adult stage of the eastern newt, is an animal of upland forests. The adult newt inhabits permanent ponds. Photo: Larry Federman © 2019

While some of our amphibians spend most of their time in and near water, the red-backed salamander and slimy salamander spend nearly all their time in upland (non-wetland) habitats. Many others, including the pool-breeding group (above), gray treefrog, and spring peeper, need wetlands and ponds for breeding but are otherwise terrestrial.

Common garter snake and DeKay's brown snake are probably the two most abundant snakes in the county, but garter snake is the one we see most often. Both species use all kinds of upland habitats, including yards and gardens. The smooth green snake† uses wet meadows more than other habitats. It is not uncommon in Greene County but is often unseen because it spends much time under rocks, logs, and other cover objects and, when not sheltering, its bright green color blends with the meadow vegetation. Black rat snake† uses all kinds of upland habitats during the warm months, and overwinters in deep rock crevices or rock talus or sometimes other sheltered areas including the basements of buildings (Gibbs et al. 2007).


Wood turtles spend much of the year in and near low-gradient, perennial streams. Photo: Larry Federman © 2019

Although many of our snakes are capable swimmers, the northern watersnake is the only aquatic snake in the county. It occupies a great variety of habitats with permanent water—lakes, ponds, streams, marshes, and other wetlands—and, although sometimes found on land, it rarely moves very far from wet areas.

The only venomous snakes in Greene County are timber rattlesnake† and copperhead.† Both occur only in very localized areas of the Catskills. The rattlesnake uses rocky areas for basking, breeding, and overwintering, and many other habitats for hunting throughout the warm months. The copperhead spends much of its time in forests near exposed ledges and talus. Southeastern New York is at the northern limit of its range (Gibbs et al. 2007).

The turtles most commonly seen by Greene County residents are the painted turtle and snapping turtle. These species use a wide range of tidal and nontidal wetland and pond habitats. Painted turtles are often seen basking on logs, rocks, or shorelines, and both species are often seen crossing roads during their nesting migrations in the spring or early summer. They nest in unshaded upland areas near their home wetlands, including roadsides, lawns, and meadows. Our other turtles are less conspicuous and more specialized in their habitat needs, and all but the painted turtle are listed as NYS Species of Greatest Conservation Need.

In this region the map turtle† is restricted to the Hudson River and tidal tributary mouths, where it can be seen basking on rocks, logs, and pilings; it nests onshore in unshaded sandy soils. The wood turtle† mainly uses lowland perennial streams. Although it spends much time in and near streams and overwinters in streambanks, during the warm months it also travels widely to other wetland and upland habitats for foraging and nesting. These travels expose the turtles to the many hazards posed by vehicles on roads, driveways, agricultural fields, and lawns. Wood turtle has also been found using a freshwater tidal swamp in Greene County. The spotted turtle† uses a variety of wetland and upland habitats. It overwinters in a wetland; nests in unshaded wetland or upland habitats in the spring; spends long periods in upland habitats in summer, and forages in a variety of wetland habitats. The box turtle†—uncommon in the county—is the most terrestrial of our Greene County turtles, spending most of its life in upland forests, shrubland, and meadows, but it uses wetlands or ponds at times in the summer, especially during heat waves or droughts.

Table 6. Amphibians and reptiles of Greene County, New York.

Occurrence data are from the New York State Reptile and Amphibian Atlas and the New York Natural Heritage Program.

Common Name	Scientific Name	Habitat	Statewide Status[1]
SALAMANDERS			
Allegheny mountain dusky salamander	*Desmognathus ochrophaeus*	cool stream, seep, upland forest	
blue-spotted salamander[2]	*Ambystoma laterale*	swamp, vernal pool, upland forest	SC, SGCN[HP]
eastern newt	*Notophthalmus viridescens*	perennial pond, other wetland, upland forest	
eastern red-backed salamander	*Plethodon cinereus*	upland forest	
four-toed salamander	*Hemidactylium scutatum*	swamp, upland forest	SGCN[HP]
Jefferson salamander[2]	*Ambystoma jeffersonianum*	vernal pool, upland forest	SC
long-tailed salamander	*Eurycea longicauda*	cool stream, seep, upland forest	S2S3, SC, SGCN[HP]
mudpuppy	*Necturus maculosus*	perennial stream	SC, SGCN
northern dusky salamander	*Desmognathus fuscus*	cool stream	
northern slimy salamander	*Plethodon glutinosus*	talus, upland forest	
northern two-lined salamander	*Eurycea bislineata*	small forested stream	
spotted salamander	*Ambystoma maculatum*	vernal pool, upland forest	
spring salamander	*Gyrinophilus porphyriticus*	rocky stream, forested seep	
TOADS & FROGS			
American toad	*Bufo americanus*	everywhere	
bullfrog	*Rana catesbeiana*	forest, meadow	
gray treefrog	*Hyla versicolor*	shallow pool, upland forest	
green frog	*Rana clamitans*	pond, marsh	
northern leopard frog	*Rana pipiens*	pond, marsh, meadow	
pickerel frog	*Rana palustris*	meadow, upland forest, wetland	
spring peeper	*Pseudacris crucifer*	upland forest, wetland	
wood frog	*Rana sylvatica*	vernal pool, upland forest	
TURTLES			
eastern box turtle	*Terrapene carolina*	upland forest, meadow	S3, SC, SGCN[HP]
northern map turtle	*Graptemys geographica*	Hudson River	S3, SGCN
painted turtle	*Chrysemys picta*	pond, marsh, stream	
snapping turtle	*Chelydra serpentina*	pond, lake, wetland, meadow	SGCN

(continued)

Table 6. (cont.)

Common Name	Scientific Name	Habitat	Statewide Status[1]
TURTLES (cont.)			
spotted turtle	*Clemmys guttata*	wetland, upland forest	S3, SC, SGCN
wood turtle	*Glyptemys insculpta*	perennial stream, upland forest, meadow	S3, SC, SGCN[HP]
SNAKES			
common garter snake	*Thamnophis sirtalis*	everywhere	
copperhead	*Agkistrodon contortrix*	upland forest, ledge, meadow	S3, SGCN
Dekay's brown snake	*Storeria dekayi*	upland forest, meadow, wetland, yard	
eastern rat snake	*Elaphe alleghaniensis*	upland forest, ledge, talus	SGCN
eastern ribbon snake	*Thamnophis sauritus*	open wetland	SGCN
milksnake	*Lampropeltis triangulum*	meadow, upland forest, barnyard	
northern water snake	*Nerodia sipedon*	pond, lake, wetland, stream	
red-bellied snake	*Storeria occipitomaculata*	upland forest, meadow, wetland, yard	
ring-necked snake	*Diadophis punctatus*	upland forest, forest opening	
smooth greensnake	*Liochlorophis vernalis*	wet meadow, other wetland, open forest	SGCN
timber rattlesnake	*Crotalus horridus*	upland forest, meadow, ledge, talus	S3, T, SGCN[HP]

[1] Statewide rarity ranks are explained in Appendix D.
New York Natural Heritage ranks: S1, S2, S3
New York State ranks:
E = Endangered; T = Threatened; SC = Special Concern (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html)
[2] Most of the representatives of Jefferson or blue-spotted salamanders in Greene County are Jefferson/blue-spotted hybrids.

Birds

Pine siskins spend most of their time foraging high in the canopies of dense forests. Photo: Larry Federman © 2019

The New York State Ornithological Association has records of 252 bird species breeding in New York State, and the *Breeding Bird Atlas* (BBA) (McGowan and Corwin 2008) shows that many were confirmed or probable breeders in Greene County in one or both of the 1980-85 and 2000-2005 BBA surveys. These include waterfowl, shorebirds, wading birds, raptors, songbirds, and others. Additional species overwinter here or travel through during migrations.

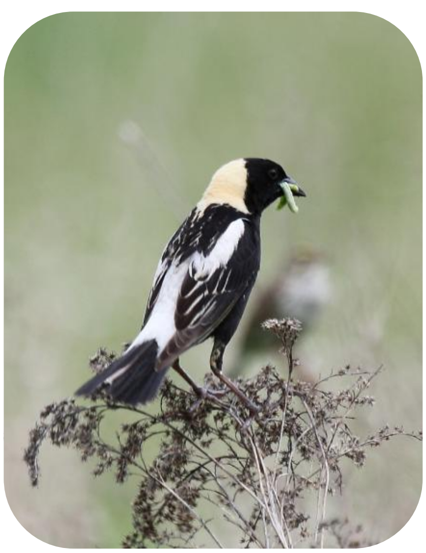
Like other animals, most bird species are associated with particular kinds of habitats that suit the species' life history. Some species are well-adapted to human-settled landscapes, where they take advantage of lawns, gardens, shade trees, hedgerows, pastures, cropfields, or even buildings and bridges. Others need permanent water (e.g., pied-billed grebe†) or the interior areas of large meadows (e.g., grasshopper sparrow†) or large forests (e.g., black-throated blue warbler†) to better defend their nests from predators that frequent the habitat edges. Some need forests with large trees (e.g., cerulean warbler†) and others do best in young forests or shrublands (e.g., American woodcock†). Some prefer forests with abundant shrubs in the understory, and some prefer open understories. Knowledge of habitat types and characteristics can help you predict the kinds of birds that are likely to nest, roost, or hunt at a given location.

Yellow warbler nests in shrubby habitat bordering wetlands, constructing a compact, cup-shaped nest out of dried grasses, weed fibers, and plant down. Photo: Larry Federman © 2019

The population status of Greene County bird species—that is, their presence and their abundance or rarity—depends on a great variety of factors, including some that are beyond our control. Stresses from loss or degradation of wintering habitats in the southern US or the tropics or stopover habitats on migration routes can weaken the birds or reduce the numbers that reach their Greene County breeding grounds and nest successfully. For some species this region is near the southern or northern limits of their breeding range and climate tolerances, so the birds may be especially vulnerable to weather extremes and other stresses. For many birds the habitat conditions here are a large factor in determining their population status, and our uses of the land may strongly influence the survival and persistence of local populations.

Factors affecting Greene County bird habitats include fragmentation (e.g., of large meadows or large forests), loss of suitable habitat due to succession (as of meadow to shrubland, shrubland to young forest, young forest to mature forest), human disturbances, pesticides, water pollution, and climate change, among others. In many cases, combinations of factors may be at play. For example, observations of eastern whip-poor-will† in the two Breeding Bird Atlas surveys declined by 57% throughout the state. Reasons for the declines are unknown, but some possible causes are forest maturastion, increases in industrial pollution and pesticide use, declines in saturniid moths (a major food source), loss of open-understory forest due to fire suppression, and loss of forests due to land development and agriculture (Medler 2008, Cink et al. 2017). Declines of ruffed grouse have been attributed to loss of young forest habitat.

The term “grassland breeding birds” refers to several ground-nesting bird species that require large meadow areas to reproduce successfully and maintain local populations in the long term. These include species such as northern harrier,† bobolink,† eastern meadowlark,† vesper sparrow,† savannah sparrow, grasshopper sparrow,† and upland sandpiper† that use meadows for nesting as well as feeding. The dramatic declines of grassland breeding birds in the Northeast since the 1960s have been attributed to loss of large meadows due to intensification of agriculture, abandonment of agriculture and subsequent transitions to shrubland and young forest, conversion to developed uses, and burgeoning populations of human-subsidized predators such as raccoon and striped skunk. Conservation of grassland birds is discussed in the **Conservation Principles and Measures** section, below.



Bobolink requires large fields, preferably without trees, to maintain viable populations. Photo: Larry Federman © 2019

Meadows are also essential foraging, hunting, or courtship habitat for several other birds. For example, American woodcock† uses meadows for springtime courtship displays, and meadow edges (along with shrublands and forests) for foraging throughout their active season. Meadows in near proximity to shrublands, young forests, and streams may be preferred. American kestrel† hunts in meadows and uses hedgerows, forest edges, and isolated large trees for hunting perches and nesting. Eastern bluebird nests in tree cavities or artificial nest boxes in or at the edges of large meadows. Eastern kingbird nests in trees or shrubs of meadows, shrublands, or orchards and hunts in open areas.

Among the birds that nest in shrublands are common species such as northern cardinal, common yellowthroat, song sparrow, and chestnut-sided warbler, and less common or rare species such as prairie warbler,† blue-winged warbler,† golden-winged warbler,† and brown thrasher.[†] The populations of many shrubland-nesting birds have declined in recent decades with the decline of shrubland. Fire suppression and declining agriculture over the last 60-80 years has reduced shrubland extent to an 80-year low in the Northeast (King no date, NRCS 2012). Most upland shrublands are temporary habitats that, without occasional natural (e.g., fire, tornado) or artificial (e.g., brush-hogging) disturbance, will transition to young forest over two to three decades.

Breeding and wintering birds of conservation concern in Greene County are listed in Appendix Table C-8.

Mammals

Wild mammals occur in all kinds of habitats in Greene County, including human-made structures. Many mammal species are well-adapted to human-settled landscapes, and some, such as white-tailed deer and raccoon, even thrive on the bounty of our cropfields and gardens. American beaver, muskrat, river otter, and mink are rarely far from streams, ponds, lakes, or marshes. Others, such as bobcat, black bear, eastern coyote, and foxes, range widely over the landscape for hunting and foraging, although they may retreat to a remote place for denning. Meadow vole populations can be immense in large meadows, where they are a favored prey of eastern coyote, foxes, and raptors. Snowshoe hare mostly stays at the higher elevations of the Catskills, while eastern cottontail occurs in non-forested areas throughout the lower elevations. Table 7 lists all the mammals known or likely to occur in Greene County.

Most of our mammals spend their entire lives here, but three bat species—eastern red,[†] silver-haired,[†] and tri-colored bats[†]—migrate to southern places for the winter. Bats are the mammals of greatest conservation concern in the county. Of the nine bat species known or likely to occur here, all but two are listed as NYS Species of Greatest Conservation Need (SGCN). Those that spend the winter in caves are subject to the white-nose syndrome (WNS), a fungal disease that has spread rapidly through eastern caves since 2006 and has devastated the populations of many bat species. The long-eared bat,[†] for example, has suffered 99% mortality from WNS in some hibernacula. New York State regulates land use near known bat-occupied caves and sets rules for cave visitation to protect bats (www.dec.ny.gov/animals/106090.html; www.acris.nynhp.org/ report.php?id=7407; www.dec.ny.gov/press/111753.html).

White-tailed deer occupy a unique place in the ecology and history of the region. They are an indigenous component of northeastern ecosystems, have long provided humans with food, clothing, shelter, and tools, and are still a significant resource for recreational hunting. But their populations have exploded in and near our settled landscapes in recent decades, creating nuisances for property owners and gardeners, economic losses for farmers, road hazards, and ecological problems in forests, while contributing to public health hazards due their role in the life cycle of the black-legged tick which transmits Lyme disease to humans and other mammals.

Table 7. Mammals of Greene County, New York.

Occurrence data are from Whitaker (in prep) and Hudsonia Ltd., and from Farmscape Ecology Program observations at the Mountain Top Arboretum (Stevens et al. 2018)

Common Name	Scientific Name	Statewide Status[1]
MARSUPIALS		
Virginia opossum	*Didelphis virginiana*	
INSECT-EATERS		
long-tailed shrew	*Sorex dispar*	
masked shrew	*Sorex cinereus*	
northern short-tailed shrew	*Blarina brevicauda*	
smoky shrew	*Sorex fumeus*	
water shrew	*Sorex palustris*	
eastern mole	*Scalopus aquaticus*	
hairy-tailed mole	*Parascalops breweri*	
star-nosed mole	*Condylura cristata*	
BATS		
big brown bat	*Eptesicus fuscus*	
eastern red bat	*Lasiurus borealis*	SGCN
eastern small-footed bat[2]	*Myotis leibii*	SC
hoary bat	*Lasiurus cinereus*	SGCN
Indiana bat[2]	*Myotis sodalis*	S1, E
little brown bat	*Myotis lucifugus*	SGCN[HP]
northern long-eared bat	*Myotis septentrionalis*	S1, T
red bat	*Lasiurus borealis*	SGCN
silver-haired bat	*Lasionycteris noctivagans*	S2S3B
tri-colored bat	*Perimyotis subflavus*	S1
CARNIVORES		
black bear	*Ursus americanus*	
raccoon	*Procyon lotor*	
ermine (short-tailed weasel)[3]	*Mustela erminea*	
fisher	*Martes pennanti*	
long-tailed weasel	*Mustela frenata*	
mink	*Mustela vison*	
river otter	*Lutra canadensis*	
striped skunk	*Mephitis mephitis*	
eastern coyote	*Canis latrans*	
gray fox	*Urocyon cinereoargenteus*	
red fox	*Vulpes vulpes*	
bobcat	*Lynx rufus*	

(continued)

Table 7. (cont.)

Common Name	Scientific Name	Statewide Status[1]
RODENTS		
woodchuck	*Marmota monax*	
northern flying squirrel	*Glaucomys sabrinus*	
southern flying squirrel	*Glaucomys volans*	
eastern gray squirrel	*Sciurus carolinensis*	
red squirrel	*Tamiasciurus hudsonicus*	
eastern chipmunk	*Tamias striatus*	
American beaver	*Castor canadensis*	
deer mouse	*Peromyscus maniculatus gracilis*	
white-footed mouse	*Peromyscus leucopus*	
southern bog lemming[3]	*Synaptomys cooperi*	
meadow vole	*Microtus pennsylvanicus*	
rock vole	*Microtus chrotorrhinus*	
southern red-backed vole	*Clethrionomys gapperi*	
woodland vole[3]	*Microtus pinetorum*	
muskrat	*Ondatra zibethicus*	
Norway rat[3]	*Rattus norvegicus*	
black rat[3]	*Rattus rattus*	
house mouse	*Mus musculus*	
meadow jumping mouse	*Zapus hudsonius*	
woodland jumping mouse	*Napaeozapus insignis*	
common porcupine	*Erethizon dorsatum*	
HARES & RABBITS		
snowshoe hare	*Lepus americanus*	
eastern cottontail	*Sylvilagus floridanus*	
New England cottontail[4]	*Sylvilagus transitionalis*	S1S2, SC
HOOFED MAMMALS		
white-tailed deer	*Odocoileus virginianus*	

[1] Statewide rarity ranks are explained in Appendix D:
E = endangered; T = threatened; SC = special concern (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html)
S1, S2, S3 = NYNHP ranks

[2] The New York State Museum has no vouchered specimens for small-footed bat or Indiana bat in Greene County, but they overwinter nearby and are likely to use Greene County habitats for summer foraging and roosting.

[3] The New York State Museum has no vouchered specimens for ermine, southern bog lemming, woodland vole, black rat, or Norway rat in Greene County, but they are known to occur in nearby counties and are likely to also occur in Greene County.

[4] There are historical records of New England cottontail in Greene County, but known populations today are only east of the Hudson River.

White-tailed deer grazing and browsing ("herbivory") profoundly affects forest structure and succession. When deer populations are high, selective browsing and seed predation prevent the regeneration of many of our forest tree, shrub, and wildflower species and encourage infestations of non-native plants. Those alterations to the plant community also affect bird nesting habitat, the invertebrate fauna, and the prevalence of tick-borne diseases (Waller and Alverson 1997). The ecological threats from the large deer population are discussed further in the **Threats to Resources of Concern** section.

SIGNIFICANT BIODIVERSITY AREAS

The NYSDEC has identified twenty-three "Significant Biodiversity Areas" (SBAs) throughout the ten counties of the Hudson River estuary corridor. Three of these occur partially in Greene County: the Catskill Mountains SBA, the Hudson Valley Limestone and Shale Ridges SBA, and the Upper Hudson River SBA (Figure 24). These are by no means the only significant areas for biodiversity in the county, but have been recognized for especially high concentrations of important, unusual, and vulnerable biological features.

> Three "Significant Biodiversity Areas" occur partially in Greene County: the Catskill Mountains SBA, the Hudson Valley Limestone and Shale Ridges SBA, and the Upper Hudson River SBA.

The Catskill Mountains SBA is recognized for large unfragmented forests, including some old growth forests, alpine communities, deep ravines, and rocky headwater streams. This area includes exemplary representatives of beech-maple mesic forest in the valleys and on the slopes, hemlock-northern hardwood forest in cool ravines and on steep slopes, spruce-fir communities at the highest elevations, and other special communities such as red maple-tamarack peat swamp, cliff communities, ice cave talus, spruce-fir rocky summit, pitch pine-oak-heath rocky summit, and sedge meadow. These habitats and communities support rare communities and significant populations of plants and animals of conservation concern, including forest interior nesting birds, nesting bald eagle, black bear, coldwater fish species, rare snakes, and rare plants. The Catskills are also part of the large landscape that feeds several drinking water reservoirs in the New York City water system. The Catskill Mountains SBA covers parts of the towns of Cairo, Catskill, Halcott, Hunter, Lexington, Jewett, and Windham in Greene County and extends to parts of Delaware, Sullivan, and Ulster counties.

The Hudson Valley Limestone and Shale Ridges SBA encompasses the limestone areas parallel to and mostly west of the Thruway. This is a regionally significant geologic feature with limestone bedrock that supports several rare mammal, amphibian, reptile, bird, and plant species. The northern section covers the Helder berg Escarpment in Albany County, and the southern section extends along the Potic Mountain ridge in Greene County. This SBA has unusual and high quality natural

24 Important Biodiversity Areas

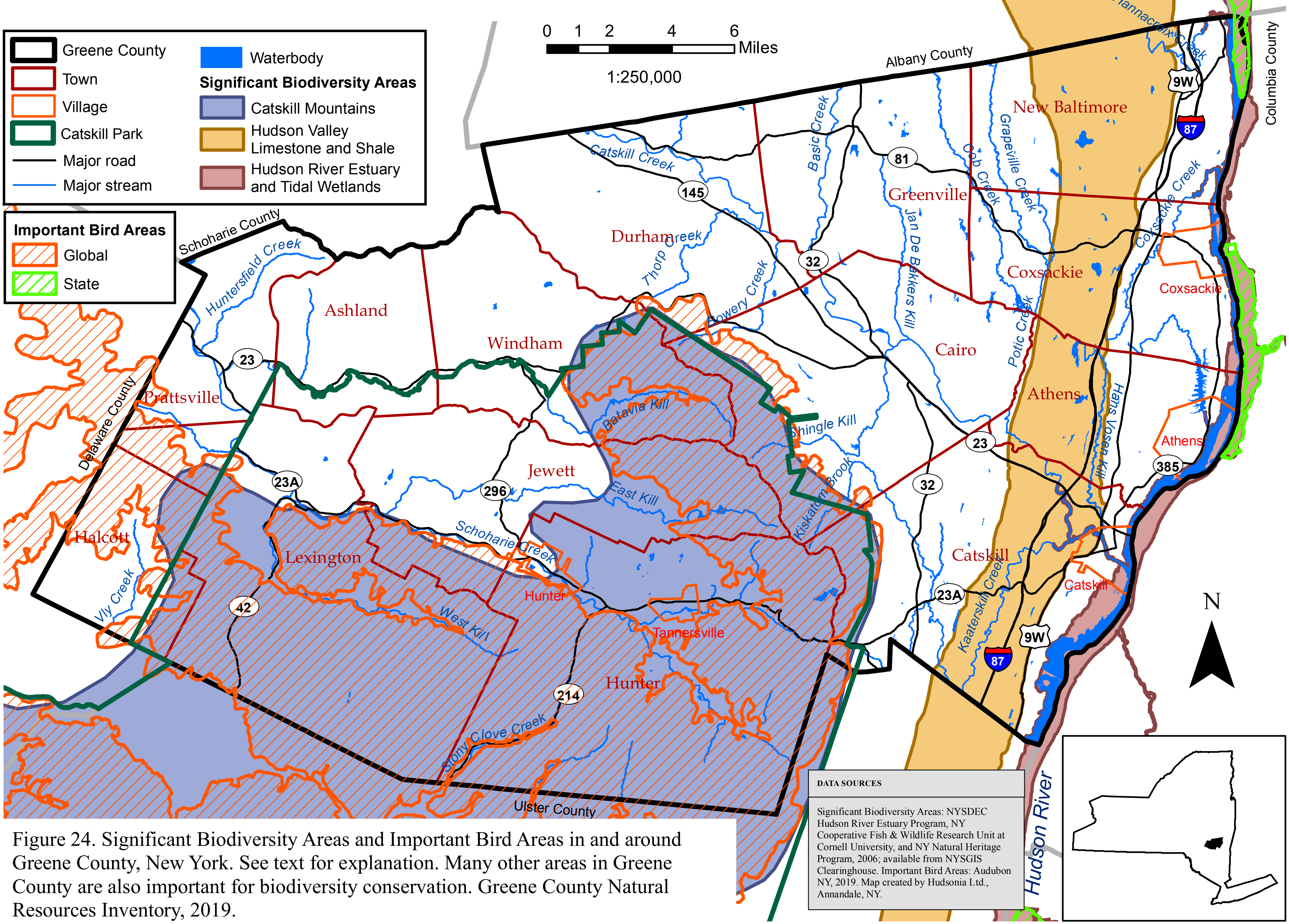
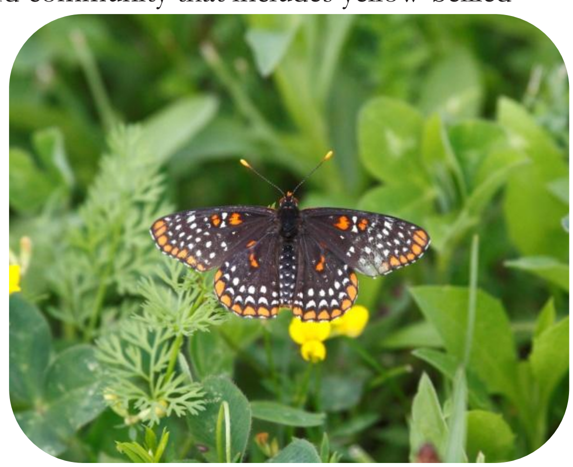


Figure 24. Significant Biodiversity Areas and Important Bird Areas in and around Greene County, New York. See text for explanation. Many other areas in Greene County are also important for biodiversity conservation. Greene County Natural Resources Inventory, 2019.

communities, including red maple-blackgum swamp, vernal pools, chestnut oak forest, Appalachian oak hickory forest, pitch pine-oak-heath-rocky summit, shale cliff and talus community, shale talus slope woodland, calcareous cliff community, calcareous talus slope woodland, red cedar rocky summit, and rocky summit grassland communities. 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 Hudson Valley Limestone and Shale Ridges SBA encompass parts of the towns of Athens, Catskill, Coxsackie, and New Baltimore and extends to Albany and Ulster counties.

The Hudson River Estuary and Tidal Wetlands SBA extends from the Battery at the southern tip of Manhattan to the federal dam in Troy. Many of the tidal communities of the Hudson River estuary—the river channel itself, the freshwater tidal wetlands, tidal creeks, and tidal tributary mouths—are considered regionally, statewide, or globally rare (Penhollow et al. 2006) and support numerous rare species of plants and animals. The wetlands serve as nursery habitat for Hudson River fish and shellfish, nesting and foraging sites and migration stops for birds, and important sources of nutrients for the Hudson River food web. They also filter, process, and break down pollutants, absorb floodwaters and storm surges, and protect and stabilize the shoreline.

In addition to the three SBAs of Greene County, Figure 24 also shows the Important Bird Areas (IBAs) delineated by Audubon New York. The IBAs are places that have been identified by Audubon and partner organizations and agencies as critical for bird breeding, migratory stop-over, feeding, and overwintering. The "Catskill Peaks" area is considered a bird area of global importance because it provides nesting habitat for the sub-alpine bird community that includes yellow-bellied flycatcher,† Swainson's thrush, Bicknell's thrush,† and blackpoll warbler, among others. The Schodack Island/Houghtaling Island IBA is considered to be of statewide importance because it provides nesting habitat for cerulean warbler† and great blue heron, and roosting and perching habitat for osprey and bald eagle.† The IBA designations are intended to draw attention to these areas for public education and for conservation planning and action.



Baltimore checkerspot† in the Coxsackie Creek Grassland Preserve. Photo: Larry Federman © 2019

Areas of Known Importance

While the SBAs cover broad areas with multiple features significant for biodiversity, the New York Natural Heritage Program (NYNHP) has identified more localized Areas of Known Importance for biodiversity throughout the state. These are areas deemed to be important for the continued persistence of rare plants, rare animals, and significant ecosystems identified through analysis of known occurrences of exemplary ecological communities or rare plants and animals, their life histories and habitats, and the physical and hydrological features of the landscape (Figure 22a-d).

The actual species of concern in each Area of Known Importance are not divulged here because of the sensitivity of the information. Rare species are vulnerable to illegal collecting, harassment, or removal, so the NYNHP and NYSDEC are careful to keep exact locations confidential unless there is an important reason to make them known to a landowner or the public. If there is a potential or imminent threat to an Area of Known Importance, further information can be obtained from the NYNHP.

Rare or exemplary natural communities in Greene County that have been recognized and mapped by the NYNHP include those listed below. Their locations are depicted in Figure 22c and 22d. Generic descriptions are in the *Ecological Communities of New York State* (Edinger et al. 2014), and online conservation guides for each are at http://www.guides.nynhp.org.

- Appalachian oak-hickory forest
- Appalachian oak-pine forest
- Beech-maple mesic forest
- Calcareous cliff community
- Calcareous shoreline outcrop
- Calcareous talus slope woodland
- Chestnut oak forest
- Cliff community
- Dwarf shrub bog
- Floodplain forest
- Freshwater intertidal mudflats
- Freshwater intertidal shore
- Freshwater tidal creek
- Freshwater tidal marsh
- Freshwater tidal swamp
- Hemlock-northern hardwood forest
- Limestone woodland
- Mountain fir forest
- Mountain spruce-fir forest
- Perched swamp white oak swamp
- Pitch pine-oak-heath rocky summit
- Shale cliff and talus community
- Shale talus slope woodland
- Spruce-fir rocky summit
- Spruce-northern hardwood forest
- Tidal river

Some of these are noted because they are rare in the region or the state, and some because they are particularly high-quality examples of common communities.

Among the Areas of Known Importance shown in Figure 22b are those identified for sensitive coldwater stream habitats. The mapped areas include locations with wild brook trout populations identified in NYSDEC fish surveys since 1980, and streamside areas most likely to affect the quality of the stream habitat. Most of the mapped areas have no public fishing rights, however, and many are unsuitable for recreational trout fishing due to small fish populations and small fish size.

The NYNHP Areas of Known Importance and NYSDEC Significant Biodiversity Areas carry no legal weight, but the designations are intended to guide planning, environmental reviews of land development projects, and other land use decision-making, and to promote conservation and stewardship of lands including and surrounding these areas. The maps can alert landowners, developers, municipal agencies, and other land use decision-makers to the potential for impacts to rare species and rare communities, so that the most sensitive areas can be protected.

When new land uses are contemplated within an SBA or an Area of Known Importance, people are encouraged to contact the NYNHP to learn more about the particular elements of concern in thevicinity. These areas are not to be interpreted, however, as the only areas of conservation concern, or the only areas where rare species may occur. Many parts of the landscape have never been surveyed for significant communities or rare species, so other occurrences are simply unknown. For these reasons, the maps of the SBAs and the Areas of Known Importance should never be used as a substitute for onsite habitat assessments or rare species surveys where such studies seem warranted.

Farmland Resources

Agriculture makes a very significant direct contribution to the Greene County economy (over $19 million in sales in 2017), and there are large areas of good farmland soils that are not in active agricultural use today. Figure 25 shows the extent of Prime Farmland Soils and Farmland Soils of Statewide Importance throughout the county, based on the soils map in the *Soil Survey of Greene County, New York* (Broad 1993).

Prime Farmland Soils

The technical criteria established by Congress to identify Prime Farmland Soils, include:

- adequate natural moisture content;
- specific soil temperature range;
- pH between 4.5 and 8.4 in the rooting zone;
- low susceptibility to flooding;
- low risk to wind and water erosion;
- minimum permeability rates; and low rock fragment content

Prime Farmland Soils are those that have the "best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and [are] also available for these uses." Typically they are deep soils on level or nearly-level land, and are well-drained, fertile, and stable. These soils have "the soil quality, growing season, and moisture supply needed to produce economically sustained high yields of crops when treated and managed according to acceptable farming methods, including water management" (Soil Survey Division Staff 1993). Farmland Soils of Statewide Importance are considered to be nearly as productive as Prime Farmland Soils and produce high yields of crops when properly managed (NRCS no date).

Table 8 lists the "prime" and "statewide important" farmland soils in Greene County. The soil types on any property can be viewed on an interactive map at the Web Soil Survey page of the Natural Resources Conservation Service. The map symbols in Table 8 correspond to those on the Web Soil Survey map and in the Soil Survey of Greene County (Broad 1993). Note that some soil types, such as Chenango gravelly loam, are listed as both "prime" and "statewide important" but the map symbol differs for each listing. The differences in those cases are the slopes on which the soils occur, indicated by the final upper case letter (A, B, C) in the map symbol. Prime Farmland Soils are on flat to gently-sloped terrain, up to 8% slopes (e.g., CnA, CnB) and some of the Farmland Soils of Statewide Importance are on moderate slopes, up to 15% (e.g., CnC).

Table 8. Prime Farmland Soils and Farmland Soils of Statewide Importance of Greene County. Map symbols are those on the county soil survey maps (Broad 1993) and on the Web Soil Survey of the NRCS.

Soil Name	Map Symbol	Soil Name	Map Symbol
Prime Farmland Soils		Farmland Soils of Statewide Importance (cont.)	
Barbour loam	Ba	Covington and Madalin soils	Co
Basher silt loam	Bs	Elka channery loam	ElC
Chautauqua loam	ChB	Hudson and Vergennes soils	HvC
Chenango gravelly loam	CnA, CnB	Kingsbury and Rhinebeck soils	KrA, KrB
Elka channery loam	ElB	Lackawanna channery loam	LaC
Elmridge very fine sandy loam	EnA, EnB	Lewbeach channery silt loam	LeC
Hudson and Vergennes soils	HvB	Lordstown channery silt loam	LoC
Lackawanna channery loam	LaB	Maplecrest gravelly silt loam	MaC
Lewbeach channery silt loam	LeB	Mardin gravelly silt loam	MdB, MdC
Lordstown channery silt loam	LoA, LoB	Morris channery silt loam	MoA, MoB, MoC
Maplecrest gravelly silt loam	MaB	Nunda silt loam	NuC
Middlebury silt loam	Mk	Onteora silt loam	OnB, OnC
Nunda silt loam	NuB	Oquaga very channery silt loam	OrB, OrC
Riverhead loam	RhA, RhB	Riverhead loam	RhC
Tioga loam	Ta	Tuller channery silt loam	Ts
Tunkhannock gravelly loam	TuA, TuB, TvB	Tunkhannock gravelly loam	TuC
Valois gravelly loam	VaB	Valois gravelly loam	VaC
Farmland Soils of Statewide Importance		Valois-Nassau complex	VdB
Arnot channery silt loam	ArA, ArB	Vly very channery silt loam	VeB, VeC
Burdett channery silt loam	BuC	Volusia channery loam	VoA, VoB, VoC
Canandaigua silt loam	Ca	Wellsboro channery loam	WeB, WeC
Chautauqua loam	ChC	Willowemoc channery silt loam	WmB, WmC
Chenango gravelly loam	CnC		

Prime farmland may be cultivated land, pasture, forest, or other land potentially available for growing crops, but does not include developed land or surface water areas. The maps, however, do not account for development that has occurred since the soils were mapped in the 1980s. The soils identified as "prime farmland if drained" are too wet unless artificially drained enough to meet the prime farmland criteria.

Protecting areas of the county with the best farmland soils will help to preserve the ability to efficiently produce high-quality local food. Active farmlands are an important part of the county's scenic landscapes that attract visitors and businesses and are highly valued by county residents. Many farms also attract visitors by having public events, pick-your-own operations, and on-farm stands. Farm produce sold at farm stands, farmers markets, and local stores and restaurants supports both farmers and local businesses.

Meadows in winter. Photo: Chris Graham © 2019

Agriculture creates open habitats—pastures, hayfields, row cropfields, fallow fields, and oldfields—that are used in various ways by native plants and animals. Meadows can provide important habitats for invertebrates, mammals, grassland birds, and other wildlife, as well as plants of conservation concern (see the **Habitats** section above). Farm practices that build living soils, conserve and protect water resources, and support local ecosystems can improve habitats for rare and vulnerable wildlife and native plants, while maintaining or improving farm productivity and efficiency. Some of these practices include mowing, tilling, and grazing schedules, patterns, and techniques that improve habitat for butterflies, bees, nesting birds, and nesting turtles. Other practices include land management for water and soil conservation; management of field borders to improve pollination, reduce pest problems, and support wildlife; and reduction in the use of broad-spectrum, persistent pesticides (herbicides, insecticides, algicides, fungicides, rodenticides).

Maintaining intact habitat areas and building living soils in cropland areas can reduce agricultural pests and foster populations of native insects that are beneficial to agricultural crops, including pollinators, pest predators, and parasitoids. Reducing tillage can improve soil health, reduce the need for artificial soil amendments, and reduce soil loss due to erosion. It also increases carbon storage and is thus a climate-friendly practice. (No-till techniques that rely on herbicides, however, may harm the soil life and other non-target organisms.) There is now considerable literature on agricultural practices that support local ecosystems and native biological diversity, and use ecological processes and interactions to boost farmland productivity (e.g., Shepherd et al. 2003, NRCS 2010, Mader et al. 2011, Hatfield et al. 2012, Travis 2013, 2014, Xerces Society 2014).

The Hawthorne Valley Farmscape Ecology Program in Columbia County is studying the interaction of local habitats with biodiversity and with the pests and beneficial organisms that influence farm production in the Hudson Valley. They issue occasional reports and blogs with updates on their findings (see www.hvfarmscape.org/agroecology).

25 Agricultural Soils

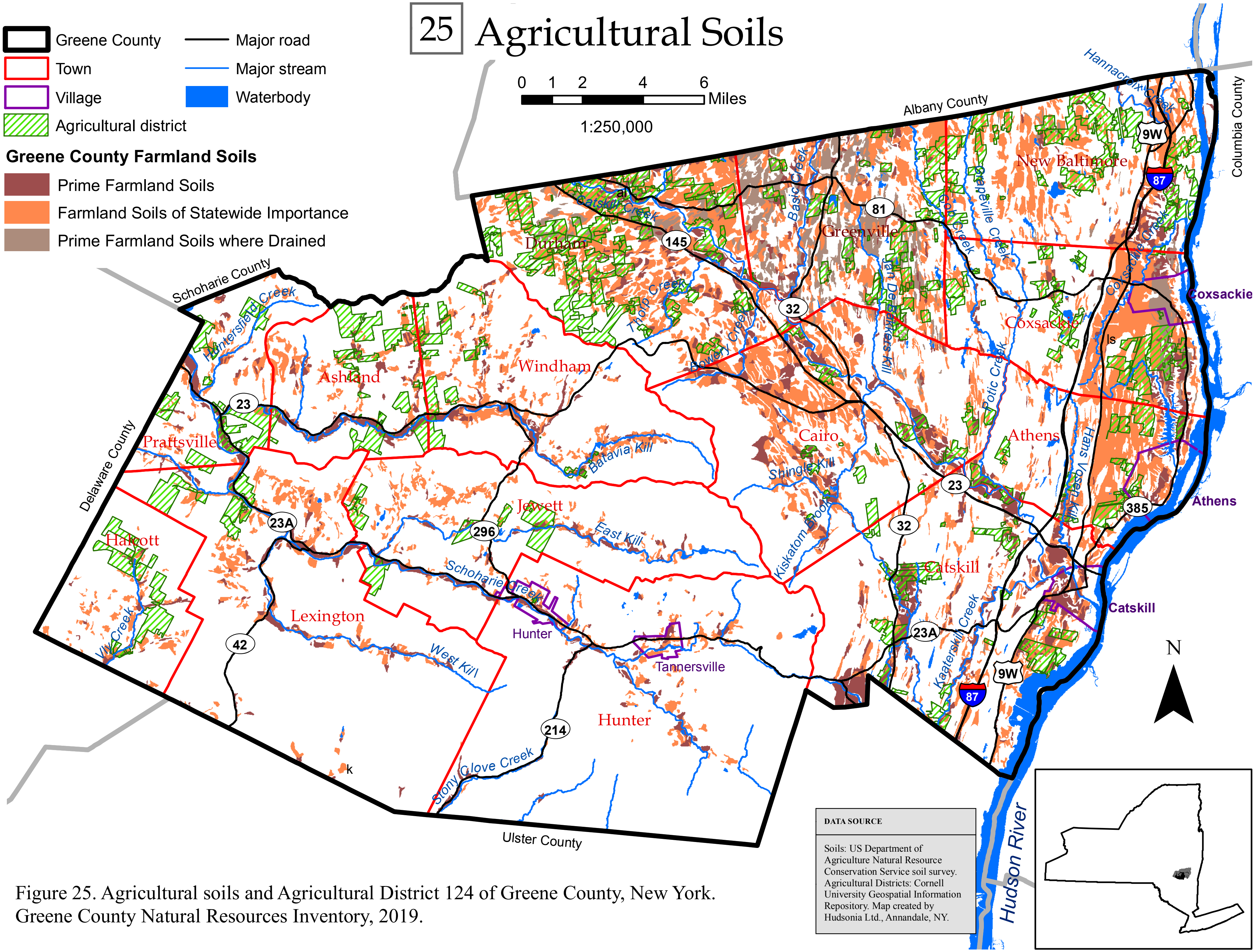


Figure 25. Agricultural soils and Agricultural District 124 of Greene County, New York. Greene County Natural Resources Inventory, 2019.

DATA SOURCE

Soils: US Department of Agriculture Natural Resource Conservation Service soil survey. Agricultural Districts: Cornell University Geospatial Information Repository. Map created by Hudsonia Ltd., Annandale, NY.

Renewable Energy Resources

Renewable sources for power generation are undergoing a renaissance in New York due to state and federal subsidies and incentives, falling costs for installation and operation, and widespread concern over carbon emissions and other environmental damage associated with mining, refining, transporting, storing, and burning fossil fuels.

Wind Energy

Wind is a renewable source of energy that can provide economical electric power in locations with the right conditions. In 2017 over 1,000 wind turbines were operating in New York, providing almost 3% of in-state electricity production (AWEA 2017).

Wind turbines come in all sizes, from small, residential models generating 1-2 kW, to medium-sized commercial models in the 100-kW range, to large, utility wind turbines with megawatt (MW) energy production. "Wind farms" are utility sites with multiple large turbines that connect to the grid via high-voltage transmission lines. "Distributed wind" refers to single turbines for residential, farm, school, or community use that offset some or all grid power usage near the point of end use (a so-called "behind the meter" connection). Small wind turbines typically have towers 60-100 ft tall, whereas utility-scale turbines have towers 260 ft or taller. Large wind farms are best suited to the windiest locations, such as in large parts of the western US, or offshore sites in the East. Although there may be adequate local sites for small wind farms in Greene County, distributed wind has potential in many more areas.

Wind power is proportional to the cube of wind speed, so a small increase in average annual wind speed translates into a large increase in power. Average wind speed also increases greatly with height above the ground. For a location to be feasible for commercial wind power production with today's technology, wind speeds must average at least 13.4-14.5 mph (6 to 6.5 m/second) (NYSERDA 2014, DWEA 2016) at 260 ft (80 m) above the ground (or the height of the turbine).

Figure 26 shows the areas of Greene County with the highest wind energy potential. Not surprisingly, most of the windiest sites are at the summits of the highest Catskill mountains. Most of these are within the Catskill Preserve (see the state-owned land in Figure 37), however, where utility development is prohibited. Just a few places outside the preserve are ranked "good" or better for commercial wind power, and nearly all of these are west of the escarpment.

With today's technology, distributed wind, which uses smaller turbines, is practical at an average wind speed of at least 10 mph (4.5 m/s), and may be a reasonable option in many other parts of the county. As with other kinds of alternative energy generation, wind power technology could change rapidly. If the efficiency of small turbines improves, areas with lower wind speeds could become more viable for power generation in the future.

Average wind speed and turbulence at any particular site is affected by topography, aspect, and trees and other obstacles, and is quite variable monthly and annually. Maps of modeled average annual wind speed only predict general areas with adequate wind speed. To accurately determine if a site has enough wind, data need to be collected onsite for at least several months to one year—ideally at the height and location of a potential turbine—and then extrapolated for the longer-term using nearby weather station or airport wind data.

> With today's technology, a backyard windmill is practical at an average wind speed of at least 10 mph.

Distributed and community wind projects, sited appropriately, are probably a low risk to wildlife, especially compared to the risks to birds, bats, and the rest of life on Earth posed by nonrenewable energy development. Bird collision deaths caused by turbines are currently estimated to be 100 to 10,000 times lower than those caused by other human-related sources, including feral and domestic cats, transmission lines, buildings and windows, and communication towers. As wind energy development continues, however, continued research on wildlife impacts and improvements in turbine design, siting, and operation will be important.

The *County Strategies for Successfully Managing and Promoting Wind Power*, prepared by the National Association of Counties and the Distributed Wind Energy Association (an industry organization) explains key differences in wind system technologies and best practices for distributed wind, such as rotor turbine height, lighting, and safety. It is a guide to developing wind energy projects designed as a tool for county officials and planners to learn about local wind ordinance development, explore key ordinance criteria, and consider best practices (http://www.naco.org/sites/default/files/documents/NACo%20County%20Strategies%20for%20Successfully%20Managing%20and%20Promoting%20Wind%20Power%20in%20America's%20Counties_0.pdf).

Solar Energy

Greene County receives an ample amount of solar radiation year-round to support photovoltaic (PV) solar electricity generation, and the relatively low manufacturing and maintenance costs and long life of solar PV panels make them a competitively-priced energy source.

For residents or businesses deciding whether to install a solar PV system, there are several key considerations. First is the number of hours of available sunlight due to exposure and topographic position. A potential PV site must have a south- or west-facing roof or ground location unshaded by trees or buildings. Areas located on north- or east-facing slopes may lack adequate sunlight. Valley locations may also be shaded by adjacent slopes. Air clarity is also important; areas that frequently experience visible haze, dust, or smoke will have reduced solar potential. The rules, requirements, and fees for connecting a small solar array to the grid are set by the electric utility company and should be well-known to local solar installers.

Costs for equipment and installation of PV systems are predicted to steadily decline in the coming decades, from approximately $3,900/kW in 2015 to $2,500/kW in 2030 for a residential system in upstate New York (NYSERDA 2014). Federal and state tax credits and state rebates result in steep reductions in costs for individual installations.

Figure 27 shows the mean daily solar irradiance in Greene County, calculated using the Area Solar Radiation tool in ArcMap 10 Spatial Analyst. This tool estimates the global (direct + diffuse, but not including reflected) radiation based on latitude and topography at a scale of 100 ft (30 m).

Rooftop and free-standing solar arrays for residences, institutions, and businesses are now common throughout Greene County and are anticipated to become more so in the future. Community solar and utility-scale solar projects are also expected to increase. Two immense solar farms with hundreds of acres of solar panels have been proposed on active and former farmland in the Route 9W corridor of Athens and Coxsackie, and are under review by state agencies.

Common criticisms of solar farm projects include loss of high quality farmland; loss of significant habitats; impacts on wildlife; impacts on scenic resources and rural character; and human safety. Siting solar arrays in road verges, brownfields, and other disturbed and unused spaces avoids or minimizes the loss of farmland and significant habitats.

Geothermal Energy

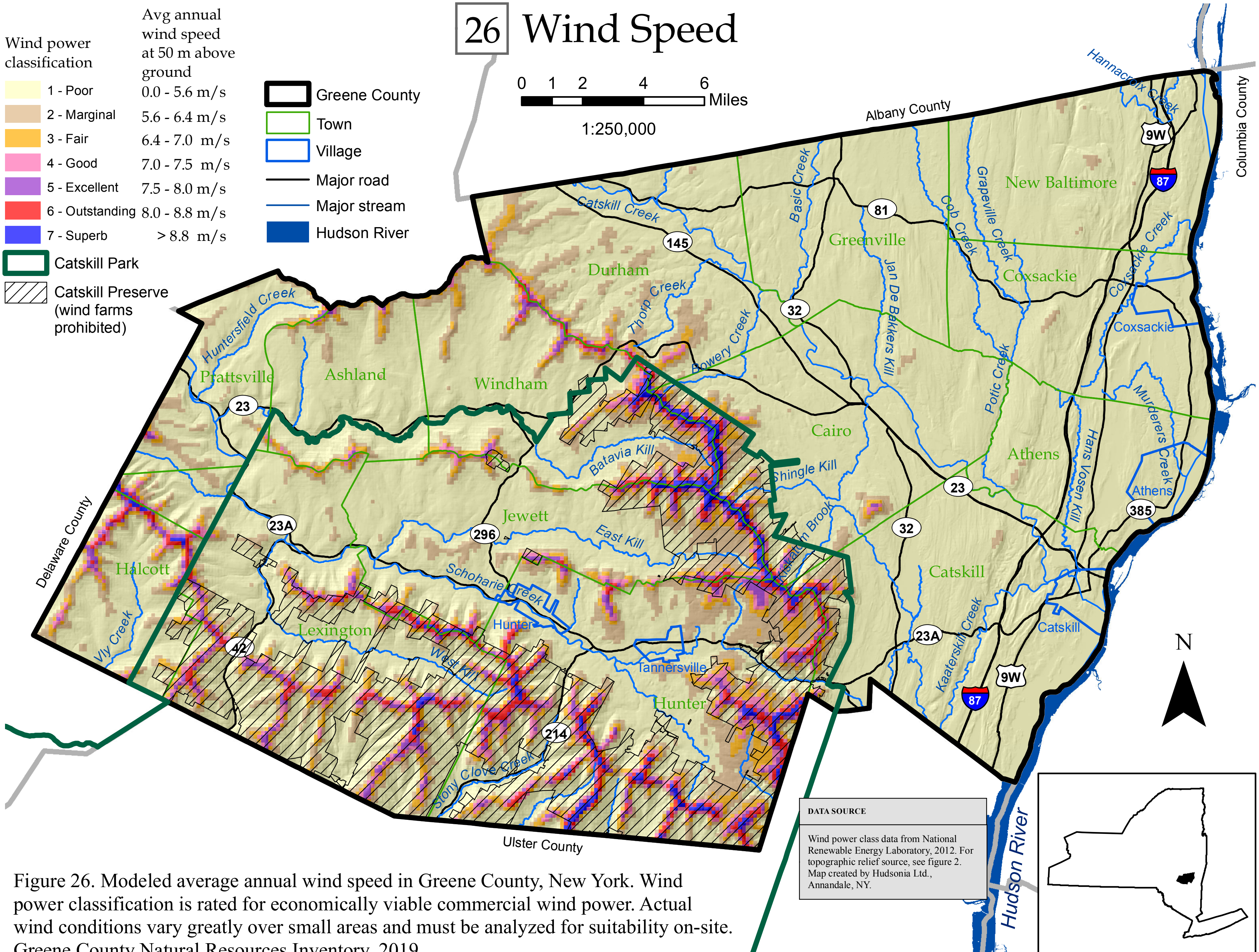
Geothermal energy refers to the Earth's internal heat. We currently use this energy in several ways, and it has much more potential for development of new technologies. The most common technology currently used for residential and commercial heating and cooling is the ground-source heat pump (GSHP). Electricity can also be produced from geothermal resources, including from a new method of deep drilling called enhanced geothermal systems (EGS). The potential for EGS or other geothermal electric production, however, is much greater in the western US than in the East.

Ground-source heat pumps use the constant temperature underground (55-60 degrees F) to pre-heat water for space-heating in winter and pre-cool water for air conditioning in summer. Electricity is used to pump water through the system and to heat or cool the water the additional amount needed. In regions with cold winters, such as New York, GSHPs are more energy efficient than air-source heat pumps and much more efficient than fuel oil, propane, or natural gas furnaces (Goetzler et al. 2009). In a 2017 analysis, residential GSHP systems performed similarly throughout New York State and resulted in heating cost savings of $680 (± $119) per year compared to fuel oil furnaces (NYSERDA 2017).

High first costs are the largest barrier to GSHP adoption (NYSERDA 2015). Costs of installing a GSHP system are highly variable, because they depend on soil and site characteristics, but they are universally more than a new furnace or air-source heat pump, in the range of $10,000 to over $40,000. There may be site limitations, complex site-specific design, and a limited number of drillers, any of which can make installation expensive. However, new technologies continue to bring costs down. For instance, a more efficient heat pump with less expensive installation is now available in parts of the Hudson Valley (NYSERDA 2015, Marley 2018). As of 2018, New York State offers rebates to approved designers and installers of these systems to help reduce costs for building owners, and there are federal tax credits for installing renewable energy-powered systems. The high costs associated with limited production of parts and limited numbers of trained installers will likely decrease. With today's technologies and the benefits of federal and state subsidies, a ground source heat pump may be financially practical for many new (owner built) residences, but only for some retrofit situations.

White trillium, Elka Park. Photo: Kelsey West © 2019

26 Wind Speed

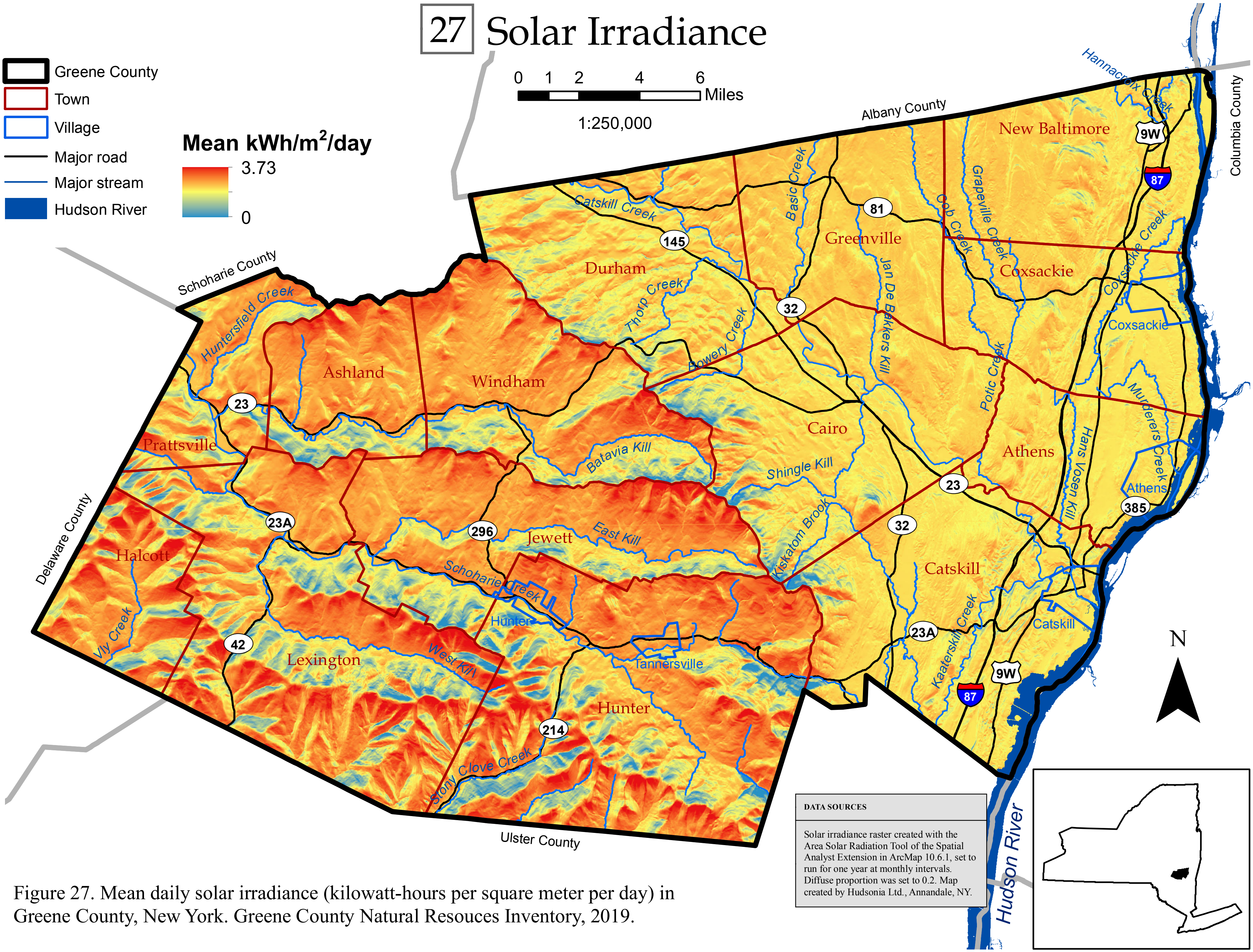


DATA SOURCE

Wind power class data from National Renewable Energy Laboratory, 2012. For topographic relief source, see figure 2. Map created by Hudsonia Ltd., Annandale, NY.

Figure 26. Modeled average annual wind speed in Greene County, New York. Wind power classification is rated for economically viable commercial wind power. Actual wind conditions vary greatly over small areas and must be analyzed for suitability on-site. Greene County Natural Resources Inventory, 2019.

27 Solar Irradiance



DATA SOURCES

Solar irradiance raster created with the Area Solar Radiation Tool of the Spatial Analyst Extension in ArcMap 10.6.1, set to run for one year at monthly intervals. Diffuse proportion was set to 0.2. Map created by Hudsonia Ltd., Annandale, NY.

Figure 27. Mean daily solar irradiance (kilowatt-hours per square meter per day) in Greene County, New York. Greene County Natural Resouces Inventory, 2019.

Scenic Resources

The scenic beauty of Greene County is the natural resource that is perhaps most appreciated in our daily lives—the Hudson River; the Catskill Mountains and the spectacular falls and rocky streams tumbling off the Catskills slopes; the lowland streams through ledgy, marshy, forested, or meadow landscapes; the open pastures, hayfields, and historic farmsteads; the brilliant colors of forested hills in the fall;, and the hushed beauty of forested and open landscapes in the winter.

Most Greene County municipalities have no formal guidelines or regulations for protecting scenic places from new land development.

Today, when the livelihoods of most residents of Greene County are no longer directly dependent on farming, hunting, fishing, mining, and other natural resource-based occupations, the scenic qualities of the area and its recreational opportunities provide the most immediate connections to the land. Public places with scenic views provide universal access to the beauty of the landscape. The county's scenery also attracts visitors. Tourism supports a significant part of the county's economy, bringing over $148 million in visitor expenditures, adding nearly $10 million in local taxes, and supporting over 3,100 jobs in 2013 (Tourism Economics 2014). Moreover, the visual benefits extend far beyond the county boundaries: the Catskills eastern escarpment is visible from a large viewshed that extends east into Rensselaer, Columbia, and Dutchess Counties, and even beyond into Vermont, New Hampshire, Massachusetts, and Connecticut.

The scenic qualities of the landscape are ranked very high among the concerns of Greene County residents, as documented in surveys conducted for municipal Comprehensive Plans. Several municipal comprehensive plans refer to protection of scenic resources in a general way as a goal or strategy but do not identify specific locations of concern. For example, the Town of Cairo Comprehensive Plan (2003) lists maintaining scenic views of the Catskill Mountains as a major goal (Goal 3) of the Plan, and suggests several nonregulatory means of achieving that goal:

- conducting an inventory to identify major viewsheds and landowners of the relevant parcels;
- working with landowners to maintain or enhance views of the mountains from roads;
- developing an interpretive or landscape tour of the town;
- developing roadside pull-offs with interpretive signage;
- producing a property owners' manual with information on how to manage properties in keeping with the character of the area and to protect views;
- developing management agreements with property owners to maintain views from the road and use of conservation easements (purchased by or donated to a local land trust) to protect scenic areas;
- using incentives such as tax abatements to encourage the protection of important viewsheds, or assistance grants to help property owners maintain views; and
- developing a scenic driving tour of the town.

In a public survey conducted during preparation of the Town of Halcott Comprehensive Plan (2003), 90% of respondents agreed that visual resources should be protected from inappropriate or poorly sited development. The Halcott subdivision regulations (2011) authorize the planning board to "establish the preservation of all natural features which add value to residential developments and to the community, such as large trees or groves, water courses and falls, historic spots, vistas and similar irreplaceable assets." Among the General Standards in the subdivision regulations is: "Protect where feasible…natural features which visually punctuate the landscape, such as hedgerows, tree copses, stone walls, and visually prominent places such as knolls and hilltops. Preferred locations for building are locations of lower topographic settings where development will be visually less obtrusive." In a survey conducted for the Town of Jewett Comprehensive Plan (2007), most respondents felt that all aspects of the environment explored in the survey were "very important," and at the top of the list were drinking water and surface water quality and scenic views.

Concerns about the visual quality of the landscape are mentioned in most or all of the Comprehensive Plans of Greene County municipalities, but local zoning ordinances or other local legislation give few firm directives to help landowners, developers, the planning board, town board, or other agencies protect scenic areas where new land development is proposed. Many ordinances do, however, provide some general guidance for locating or screening new structures to minimize their visual impact on the immediate viewshed.

Floodplain meadow at the Mawignack Preserve. Photo: Jill Knapp © 2019

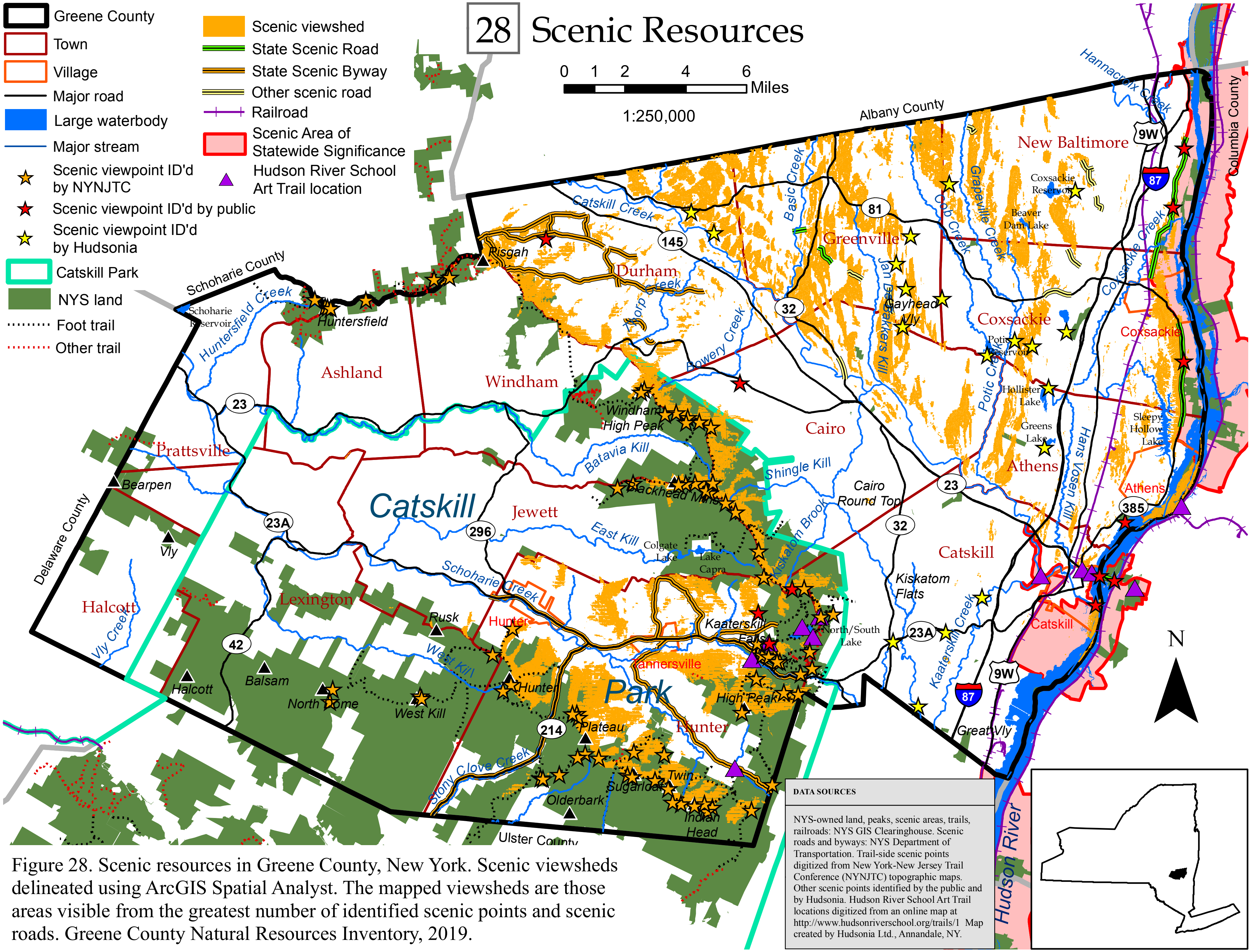


Figure 28. Scenic resources in Greene County, New York. Scenic viewsheds delineated using ArcGIS Spatial Analyst. The mapped viewsheds are those areas visible from the greatest number of identified scenic points and scenic roads. Greene County Natural Resources Inventory, 2019.

Figure 28 shows areas with formal designations for their scenic importance, as well as other especially scenic places around the county that are publicly-accessible. The map includes the Scenic Areas of Statewide Significance (SASS) identified by the NYS Department of State that are partially in Greene County: the Columbia-Greene North SASS and the Catskill-Olana SASS. Each encompasses "unique, highly scenic landscapes which are accessible to the public and recognized for their scenic quality."

Catskill-Olana SASS

The Catskill-Olana SASS in the Town and Village of Catskill is most notable for being the location that inspired and was home to two of the renowned artists of the Hudson River School of Painting, Thomas Cole and Frederic Church. Perched atop Church Hill in Columbia County, Church's home Olana is just visible from the Catskill shoreline. In Greene County this SASS follows sections of the Catskill and Kaaterskill Creek corridors that are predominately free of urban disturbance. A whitewater reach of the Catskill Creek flanked by dramatic ledges is especially scenic. The large wetland complex of the RamsHorn-Livingston Sanctuary has an exceptional example of a freshwater tidal swamp, marsh, mudflat, and creek. To the south and beyond the more developed areas, active farmland prevails, interspersed with hedgerows and forests.

Columbia-Greene North SASS

The Columbia-Greene North SASS is a narrow zone along the Hudson River shoreline stretching 15 miles north-to-south in the towns of New Baltimore, Coxsackie, and Athens and the Village of Coxsackie (as well as Columbia County locations). Islands are a common feature in this part of the river, breaking up an otherwise broad, open expanse of the Hudson. The Greene County shore zone has a wide range of land forms, including alluvial plains, wetlands, bluffs, and coves. While there is some land development along the shoreline, the topography and drainage in this area prevents most types of construction, leaving the natural areas relatively undisturbed. Beyond the shoreline and the hardwood forests atop the bluffs is a large expanse of pastures and other meadows, small creeks, and ravines. Distant views of the Taconic Hills to the east and the Catskill Mountains to the west form distinct backdrops to the region.

Greene County has numerous Scenic Roads and two NYS Scenic Byways (Figure 28). Scenic Roads are designated in Article 49 of the NYS Environmental Conservation Law. Scenic Byways are transportation corridors recognized by the NYS Department of Transportation for exceptional scenic, recreational, natural, or cultural features; they are managed to protect such characteristics and to encourage economic development through tourism and recreation. Under the Scenic Byways program, the Commissioner of Transportation is authorized to review projects occurring along the roadway; construct facilities for the use of pedestrians and bicyclists, rest areas, turnouts, highway shoulder improvements, passing lanes, overlooks, and interpretive facilities; make improvements that enhance access for purposes of recreation; and protect historical and cultural resources in adjacent areas.

Municipalities are encouraged to conduct local surveys to identify the scenic places valued by and accessible to the public.

The Durham Valley Scenic Byway, for example, includes a 21-mile network of roads in the Town of Durham. The byway corridor runs from the Catskill escarpment to the rolling hills of the Durham Valley, and has broad scenic views of the valley, and of historic houses, farms, stone bridges and walls, streams, and the Catskill Mountains. The byway includes a famed "Five State View" that extends over the Hudson River Valley to New Hampshire, Vermont, Massachusetts, and Connecticut and north to the Adirondacks. The Mountain Cloves Scenic Byway in the Town of Hunter includes 41 miles of roads that run through some of the most dramatic landscapes of the high peaks and cloves of the northern Catskills. There are plans to extend the Scenic Byway into the towns of Jewett and Lexington.

Many of the scenic viewpoints marked on the Scenic Resources map (Figure 28) were identified by the New York/New Jersey Trail Conference along foot trails in the high peaks. Additional scenic viewpoints were identified by the Greene County public at two public events in 2018 and by a Hudsonia field survey. Hudsonia used a viewshed tool of ArcGIS Spatial Analyst to delineate the areas of scenic vistas visible from those viewpoints. Still, the Scenic Resources map shows only a small sample of the scenic places in the county. Local surveys can be conducted by municipalities to identify all the other places valued by and accessible to the public, so that impacts to those places can be considered in town planning, policy-making, and land use decisions.

The Hudson River, looking south from Brandow Point. Photo: Jill Knapp © 2019

Recreation Resources

The Hudson River, the Catskill Forest Preserve, and other publicly- and privately-owned lands and waters provide a wide array of opportunities for public enjoyment of the outdoors (Figure 29). Some of these are described below. Not described here are the private recreation sites owned and managed by sporting clubs, marinas, and other organizations for use by members or paying guests.

Catskill Forest Preserve

The Catskill Forest Preserve encompasses 287,500 acres of state-owned land within the Catskill Park, a large part of which lies in Greene County. The Greene County portion of the preserve includes five of the six highest peaks in the Catskills and some of their most dramatic scenic landscapes. The preserve is mostly forested but also includes meadows, lakes, wetlands, streams, waterfalls, and open ledges and cliffs, and provides opportunities for hiking, camping, hunting, fishing, skiing, mountain biking, rock climbing, canoeing, and snowmobiling.

Rail Trails

Many of the railroads in southeastern New York that were abandoned in the 20th century are being converted to rail trails—paved and unpaved paths for walking, biking, skiing, and other non-motorized uses. The Kaaterskill Rail Trail, now just 1.5 miles long, is part of a larger project that hopes to connect the Village of Hunter with the North/South Lake Campground.

Hudson River School Art Trail

The Hudson River School Art Trail, now in development, is a historic theme trail system linking 20 Hudson Valley sites that inspired the work of 19th century artists such as Thomas Cole, Frederic Church, Asher B. Durand, Jasper Cropsey, and Sanford Gifford. Nine of the sites are in Greene County, and include landscapes that were the subjects or viewpoints of some of the most famous works of the Hudson River School artists. More information about the Art Trail is at http://www.hudsonriverschool.org/trails/1.

Hudson River Greenway Water Trail

The Hudson River Greenway Water Trail is a National Water Trail for recreational paddlers that extends in New York from northern Saratoga County in the Adirondack Park and northern Washington County at the head of Lake Champlain to Battery Park in Manhattan. Greene County has seven access sites along the Water Trail, and several more are eastward in Columbia County (Figure 29). Maps and other information for the Water Trail are at http://hudsonrivergreenwaywatertrail.org/index.php.

Plein air painting at the Octaparagon Preserve. Photo: Bob Knighton ©

Privately-Owned Preserves

Several conservation organizations and other private entities own and manage land that they make available for public use. For example, the Greene Land Trust owns and/or manages several properties for conservation and public enjoyment: the Coxsackie Creek Grasslands Preserve, the Coxsackie Wetland, the Mawignack Preserve, and The Willows at Brandow Point. Scenic Hudson owns several conservation sites in Greene County, including Long View Park and nearby land in New Baltimore, Four-Mile Point Preserve in Coxsackie, the Mawignack Preserve in Catskill, and the RamsHorn-Livingston Sanctuary; the last is jointly managed by Scenic Hudson and Audubon New York. The New Baltimore Conservancy manages several properties that are owned by other entities: the Hannacroix Creek Preserve (owned by the Open Space Institute), the Hudson River Interpretive Trail (owned by the Town of New Baltimore), and Long View Park and nearby land (owned by Scenic Hudson). The Catskill Center owns and manages the Platte Clove Preserve, which is open to the public for passive recreation. The Mountain Top Arboretum in the Town of Hunter is managed for conservation and for public enjoyment and education, and includes both an actively managed arboretum, and a large area of natural habitats.

New York State Forests

Greene County has six New York State Forests: South Mountain, Mount Pisgah, Ashland Pinnacle, Huntersfield, Bearpen Mountain, and Cairo Lockwood (Figure 29). These places provide a range of recreation opportunities for the public, including hiking, biking, cross-country skiing, snowshoeing, horseback riding, primitive camping, hunting, fishing, trapping, and snowmobiling. Some are managed by the state for timber, for game, or for biological diversity. Information about each state forest is available at https://www.dec.ny.gov/lands/34531.html, including the particular recreation opportunities at each site, along with maps, rules, and needs for permits.

Other NYS-Owned Lands
The Middle Ground Flats island between the Village of Athens and the City of Hudson is owned by New York State and managed by the NYS Office of Parks, Recreation, and Historic Preservation.

Public Boating Access
Public boat launch sites along the Hudson River are in the Village and Town of Athens, the Village of Catskill, and the Village of Coxsackie (Figure 29). Motorized craft are permitted on the Hudson, but some of the boat launches are accessible for trailered boats, and some just for cartop boats (e.g., canoes and kayaks). North-South Lake and Schoharie Creek have public boat launches for non-motorized craft.

Public Fishing Access
Throughout the state NYSDEC has purchased easements from willing landowners at specific locations along streams to allow public access for fishing. In most cases these are ca. 33-ft-wide strips along one or both banks of the stream. The land remains in private ownership, and public access to the strips is for fishing only, not for other uses. These Greene County locations are shown on Figure 29 along the Batavia Kill, Catskill Creek, East Kill, West Kill, and Schoharie Creek. Fishing is also permitted at public-access sites along the Hudson River and at State Forests, Wildlife Management Areas, and at some places in the Catskill Forest Preserve. Anglers also take advantage of roadside and bridge access to streams, as well as fishing on private lands with landowner permission.

Many Greene County streams have sites for public fishing access.
Photo: Michelle Yost © 2019

Other Public Parks
Some municipalities have small parks in or near villages, hamlets, and other population centers. Examples are a pocket park in Lexington, Rip Van Winkle Lake in Tannersville, the Ashland Town Park, Dolan's Lake in the Village of Hunter, Windham Path, Dutchman's Landing in the Village of Catskill, and the Riverfront Park in the Village of Athens. Walking trails, picnic areas, ballfields, swimming areas, public event spaces, and community gardens are some of the amenities provided by these parks. The Cohotate Preserve in the Town of Athens, owned and managed by the Greene County Soil and Water Conservation District, has trails and a picnic area for the public, and an Environmental Field Station used by the Columbia-Greene Community College.

29 Recreation Resources

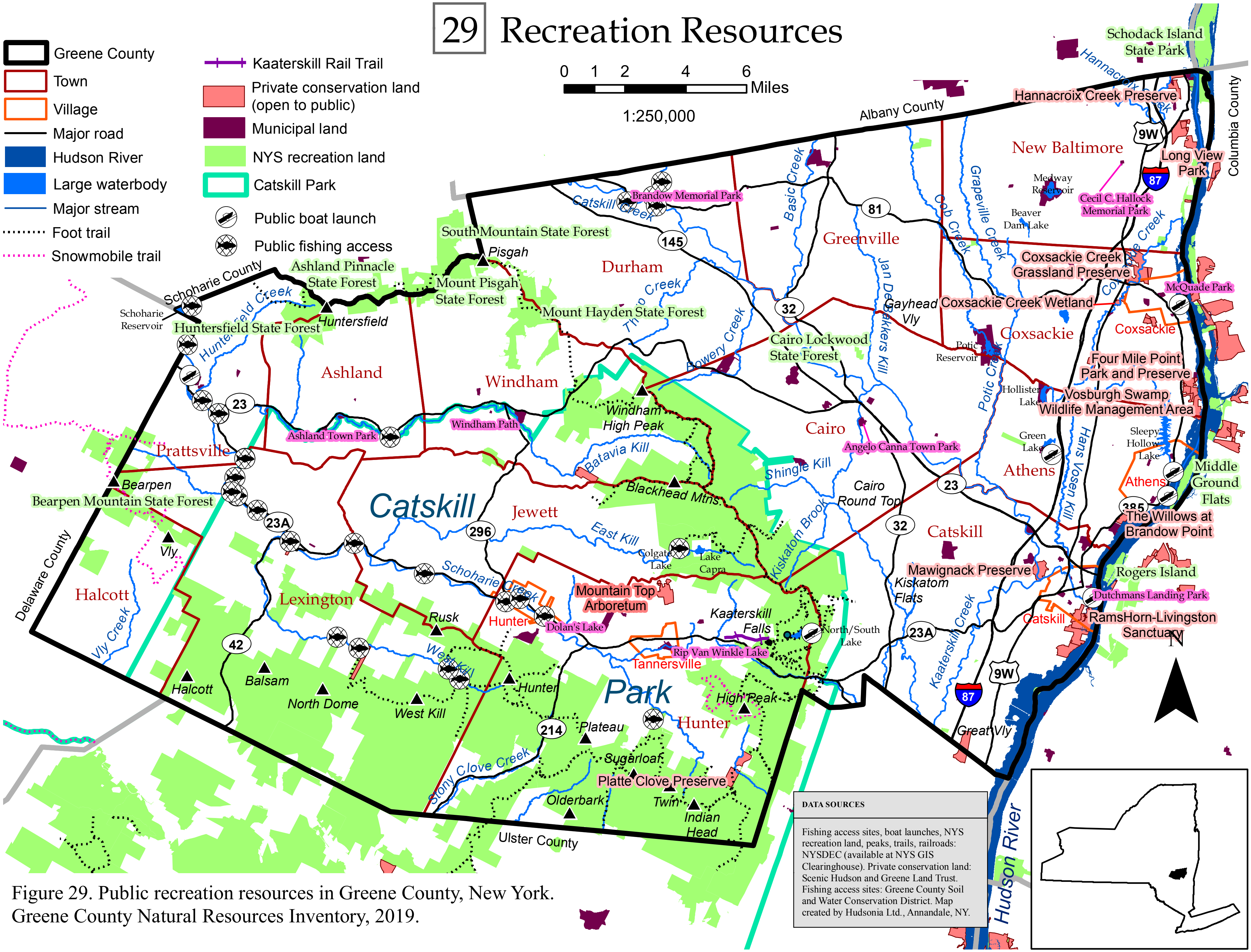


Figure 29. Public recreation resources in Greene County, New York. Greene County Natural Resources Inventory, 2019.

LAND USES, PAST and PRESENT

“View on the Catskill – Early Autumn” Thomas Cole 1837.

Natural resources have shaped the land use history of Greene County to a large extent, and the history of human uses has, in turn, wrought large changes in the land. An account of those uses helps us understand aspects of the present-day landscapes and natural resources. Dating from prehistoric times, the Hudson River has been an important travel and trade route and a source of abundant fish and other foods, so the densest populations of humans were and still are located near its banks. Flat lands and fertile soils near the river and in northern Greene County were important agricultural locations for European settlers, and abundant timber and water power fueled early industries.

Later, the river and railroads connected the county to major cities, stimulating industrial growth and agriculture. Clay deposits were mined for brick manufacture; these and the Hudson River industries of fishing, shipping, and ice harvesting were concentrated on and near the river. The limestone and, later, cement industries were centered on the narrow north-south belt of limestone (the Kalkberg), and bluestone for flagging was quarried in the sandstone hills.

The Catskill Mountains have their own land use and industrial history, including timber harvest, tanning, charcoal production, furniture-making, and many other forest product industries. The spectacular scenery of the Catskills has attracted artists, writers, and visitors for hundreds of years, and the biological richness and beauty of the mountains inspired the establishment of the Catskill Park and the Catskill Forest Preserve. In all these ways and more, natural resources have been central factors in the economic and cultural life of the county.

Early History

There is evidence of human occupation of the region since soon after the final retreat of the Wisconsin glacier ca. 14,000 years ago; in fact, one of New York State's oldest archaeological sites is located in the Town of Athens. The earliest human inhabitants were highly mobile as they foraged for mammals, fish, and plant foods. The first forests after the glacier retreated were coniferous, followed by northern hardwood-hemlock forests. A warming climate led to the expansion of grasslands and oaks, hickories, and other nut-bearing trees in the lowlands. People established seasonal settlements along large river valleys and maximized their harvest of wild foods with seasonal migrations (Lavin 2013). Around 2,000 years ago, the vicinities of Hudson River tidal marshes attracted more concentrated human settlement, and the river was part of a network of trade routes for shell beads (wampum) and stone tools.

> One of New York's oldest archaeological sites is located in the Town of Athens.

With the advent of agriculture, settlements in fertile valleys became larger and more permanent, although movements to seasonal camps for hunting, fishing, and gathering wild plant foods continued (Lavin 2013, Munoz et al. 2014). Maize was first cultivated in this region about 1,000 years ago, and the "three sisters" method of growing maize, beans, and squash together was used in the Hudson Valley from around the 1300s. Agricultural fields were cleared by girdling, cutting, and/or burning forest along fertile floodplains and terraces. Fields were cultivated and left fallow in rotation to preserve fertility, and then abandoned when fertility was exhausted (Thomas 1976). Fallow and abandoned fields were still used as food sources, as berries, grapes, and groundnuts, as well as game thrived in these early-successional habitats. In a forest zone surrounding the settlement's cleared fields, silvicultural practices included the use of fire to clear the understory for hunting, and management of forests to favor nut-bearing trees and other forest plants of value. The effects of Native American agriculture and silviculture are still evident in our present-day lowland forests. Native American use of the Catskill Mountains, however, appears to have been limited to seasonal hunting and travel (Kudish 2000).

> The "three sisters" method of growing maize, beans, and squash together was used in the Hudson Valley from around the 1300s.

Other openings in forests were created by natural disturbances but, despite both intentional and natural fires, blow-downs, and beaver meadows, most of the area that is now Greene County was still forested at the time that Europeans began settling the land in the 1600s.

When the first European colonies were established in the early 1600s, Algonquin-speaking peoples inhabited the Hudson Valley, with Mahicans generally to the north of Catskill Creek (and east of the Hudson) and Munsee groups to the south (Grumet 2009). The Catskill Mountains were Mohawk territory (the easternmost tribe of the Iroquois Confederacy), although they did not have settlements there. There was repeated conflict between the Mohawks and Mahicans during the period of European settlement (Beers 1884). Soon after European contact, many of the indigenous peoples throughout the Northeast died from disease epidemics such as small pox.

The remaining populations, however, had many decades of interactions with the European traders and settlers that included fur-trading and exchange of knowledge around medicine and agriculture (Vispo 2014). European land acquisition and farming practices, however, began to diminish subsistence resources and alter indigenous subsistence patterns, leading to conflict, impoverishment, and displacement of Native Americans, some of whom became laborers on European farms (Sellers 2016). Tribes sold off their land incrementally over the first century or so after European arrival, often in deals strongly favoring the buyers. By the 1750s, most Mahicans and Munsee had been evicted from the Hudson Valley, eventually ending up in Wisconsin, Canada, and Oklahoma and in small communities in Massachusetts and elsewhere in New York (Grumet 2009).

The first European settlers in Greene County were the Dutch, who established scattered farms along the Hudson River starting in the mid-1600s (Coxsackie was purchased in the 1660s and Catskill in the 1670s). Many of the first colonial farms were on the sites of abandoned Native American fields. English and Dutch settlement spread westward slowly in the century that followed. Permanent settlements were established at locations where transportation (by road or water) and water power were available—thus along the Hudson River shore at places where water depth allowed shipping access, and along tributaries such as Catskill Creek and Coxsackie Creek. Catskill soon became a trading center for fish, furs, and wheat. Many of the early roadways reaching inland from the Hudson River developed along Native American trails.

Many of the early roadways reaching inland from the Hudson River developed along Native American trails.

Greene County was formed from parts of Albany and Ulster counties in 1800, when it had a population of about 12,300 and a density of only 18 people/sq. mi. (compared to Columbia County with 54 people/sq. mi.). By 1850, population density had risen to 50/sq. mi., a number that was only surpassed in the late 20th century. Turnpikes—privately-constructed toll roads—were the first reliable transportation routes through the county. The Susquehannah Turnpike, completed in 1806, was one of the major routes for grains from the Ohio Valley to mills in Catskill in the years before the Erie Canal opened in 1825; the turnpike ran along today's Route 23 from Catskill into Cairo, and Route 146 from Cairo through Durham, and then westward into Schoharie County.

Mills were constructed along streams wherever a significant change in elevation could be exploited for water power. Sawmills were among the first buildings constructed. To promote land clearing, timber from undeveloped land was freely available according to Dutch and then English law (Sellers 2016). Logs were turned into construction materials for dwellings, farm structures, and ships. Many of the early hamlets in Greene County were established around mill sites. A historical marker in Catskill marks "the First Grist Mill in Greene County Built in 1675." Over the next two centuries great numbers of mills and industrial plants were established on streams throughout the county, producing lumber, flour, livestock feed, furniture, flagstone, tools, paper, and textiles for local use and for distant commercial markets, including New York City. Scarcely any stream with year-round flow was left unexploited for its water power, and 1867 maps of Greene County towns show several sawmills and gristmills in every town (Beers 1867). Other mills shown on the maps include those for wood, wood turning, paper, cider, wool, cotton, and sandstone. In 1788 an iron forge on the Shingle Kill in Purling used iron transported from mines in Ancram (Columbia County). Later, grain cradles, hand rakes, and buckets were manufactured at the forge site. Water power also supported factories for scythes, spinning wheels, distilleries, furniture, sleigh bells and other bells, and powder kegs (Vedder 1927). Most of the buildings and dams associated with the water-powered mills and factories are long gone, many of them washed away in flood events over the last 350 years.

> Scarcely any stream with year-round flow was left unexploited for water power in the 18th and 19th centuries.

Before extensive damming, many or most low-gradient streams in the eastern US had branching channels meandering through open, shrubby, or forested spring-fed wetlands that extended the width of the valley. After dam construction, millponds gradually filled with sediment (hastened by deforestation and agriculture in the watershed) and eventually supported meadows and forests; when dams were breached, the streams carved deeply into the deposited sediment, leading to single channels with high, eroding streambanks, inset floodplains, and dry upper terraces (at the previous millpond level). High sediment and nutrient loads in modern streams may be largely due to this history (Walter and Merritts 2008). In addition to destruction of these valley wetlands, dam construction interrupted fish migrations and altered the hydrology critical for other stream organisms.

Many settlements were established in the vicinities of tanneries in the early 1800s, where the bark of eastern hemlock was used to process animal hides. To feed the tanneries, large stands of hemlocks were cut and cleared, the bark stripped and hauled away, and the remaining wood left to rot in place. It is estimated that in its 20-year life, the Pratt tannery in Prattsville used approximately 100,000 cords of hemlock from an estimated 400,000 trees (Steuding 2008). Similar cutting for tanneries throughout the county led to loss of hemlock forests and most of the large old hemlocks at the time.

There were other significant environmental effects of early settlement land uses. Starting in the 17th century, wetlands were commonly ditched or drained to convert them to farmland (Sellers 2016). Rapid and extensive land-clearing often eroded soils. The widespread clearing, grazing, and cultivation led to establishment of certain prairie plant species and the proliferation of native and non-native weeds, crop diseases, and rats. Deforestation, free-ranging livestock, and hunting pressure led to the decline or disappearance of large animals including beaver, white-tailed deer, wild turkey, black bear, wolf, and mountain lion, although the Catskills provided a last refuge for many of these species. From 1800-1820, the county paid bounties on 96 wolves and 5 mountain lions (Beers 1884).

Industrial demands for charcoal and water power increased damming and deforestation through the first two centuries after European arrival. By the time of peak agriculture in Greene County, in the late 1800s, most land was cleared except for forests on steep slopes and at the highest elevations; pastures even extended up to approximately 3000 ft elevation on mountains (Kudish 2000). With the railroad in the late 1800s came increased industrial and residential development, and further changes in dominant agriculture.

Then, as agricultural and industrial production shifted away from the Northeast in the 20th century and populations shifted to urban areas, significant reforestation occurred throughout the county and continues today. In this recent period, however, ongoing residential development outside of villages and hamlets has fragmented forest and farmland; the global movement of people and materials has resulted in further establishment of non-native species; effects of white-tailed deer overpopulation have altered forest composition; and a warming climate makes even greater ecological change inevitable.

Hudson River Uses

Although Native Americans fished the Hudson River, its tributaries, and smaller streams in the watershed, they may have had little effect on overall fish populations or distribution because the human population was relatively small, villages were few and well-dispersed, and trade with other groups was modest. But commercial and non-commercial fishing were always part of the sustenance, local economies, and growth of the Hudson River shore towns established by Europeans, and early colonists quickly developed a fishing industry for export to Europe (Smith 1985, Stott 2007). Striped bass, American shad, and river herring (alewife and blueback) were some of the most important commercial fishes in the Hudson.

The river was used for travel and trade by Native Americans, and these uses were also paramount for European colonists. Shipping by water was (and remains, in some cases) the most economical means to transport goods. Raw materials and grain could be shipped from the Hudson Valley, New England, and western New York down the Hudson to New York City and overseas, with finished goods making the return trip. In 1825, the Erie Canal opened economical shipping routes to large parts of the Midwest.

Services to support fishing and shipping enterprises—foundries, machine shops, repair shops, net factories, and ship-building shops—were established at the major ports along the Hudson through the 1800s. Catskill Landing was a major port in the early 1800s, when there were 12 wharves, 12 warehouses, 200 buildings, 31 mercantile stores, and several shipyards for building brigs, sloops, and schooners. At that time, over $300,000 of produce was exported from Catskill to New York City annually (Vedder 1927). Exports included wheat, beaver pelts, fish, and walnuts (1000 bushels annually), among many other items.

Ice was harvested from ponds, lakes, and the Hudson River for local refrigeration from the earliest years of European settlement, but large-scale, commercial Hudson River ice harvests began in the 1880s to serve the New York City market. About one million tons of ice were stored annually for shipping to the city during the warmer months. There were more than forty ice houses along the river in Greene County in 1884, making them a dominant feature of the Hudson shoreline during this period (Beers 1884). Ice houses were immense (up to 400 ft long and four stories high) and were insulated and painted white to minimize melting; many were loaded via steam-powered conveyor belts (Harris and Pickman 2000). Most were along the Hudson's banks and on islands in Coxsackie, Athens, and Catskill (including along the banks of Catskill Creek), with a few in New Baltimore. The ice industry thrived until the 1920s, when centralized electrical power brought artificial refrigeration to New York City and to homes and businesses throughout the Hudson Valley (Harris and Pickman 2000). Concerns about Hudson River water quality around that time may also have dampened the ice market. There are no remaining ice houses in Greene County, but remnants of ice house foundations can be seen at Long View Park (New Baltimore), the Cohotate Preserve (Athens), and on Rattlesnake Island.

> In 1884 there were more than 40 ice houses along the Hudson River in Greene County.

The US Army Corps of Engineers began dredging a shipping channel through this reach of the Hudson in the late 1800s, and dredging intensified in the 1900s. The dredged channel is maintained to a minimum depth of 32 feet between New York Harbor and Albany (hudsonriverpilots.com). The sandy dredged material—"spoil"—has been deposited in wetlands and shallows, in bays, on islands, and along the Hudson River shoreline at locations convenient to the dredging operations, without regard for natural resources in the dumping areas. Beginning in the 1970, stricter policies have confined dredge spoil deposits to restricted areas such as the middle of Seward Island in Inbocht Bay and the southern part of Houghtaling Island. The oldest dredge spoil areas are now covered with mature forest; the youngest are open sandy flats and berms. The habitats that have developed on dredge spoil are described above in the **Biological Resources** section.

Overuse and abuse of the river over the last three centuries has taken a severe toll on Hudson River fish populations. Construction of the Troy dam in 1826 prevented runs of shad, striped bass, river herring, and other fish to the northern reaches of the Hudson, and construction of multiple other dams and culverts on Greene County tributaries disrupted spawning runs of fish and other movements of aquatic organisms in these streams. Overfishing in the Hudson, pollution, and artificial stream barriers have severely depleted fish populations and caused other harms to the ecology of the river and its tributaries.

Overuse and abuse of the Hudson over the last three centuries has taken a severe toll on fish populations.

By 1900, fish populations were so depleted by overfishing (aided by pollution) that in 1907 the New York State Fish and Game Commission established a hatchery in Livingston (Columbia County) to rear fingerlings of shad, herring, brook trout, and smallmouth bass to be released to some of the tributaries (Stott 2007). Severe pollution continued until the 1970s, when tighter regulations on industrial and sewage discharges started to bring marked improvement to the water quality of the river and its tributaries.

Still, some long-lasting industrial pollutants remain in river sediments and continue to harm the river ecology, aquatic animals, and humans. The 200 miles of the Hudson between Hudson Falls (Washington County) and the Battery in New York City was declared a Superfund site in 1984 by the US Environmental Protection Agency (USEPA) due to high levels of polychlorinated biphenols (PCBs) in the water and sediments. PCBs are harmful to humans and to many other organisms—invertebrates, reptiles, amphibians, birds, and mammals (Vos 1972, Crews et al. 1995, Adams et al. 2016). New York State has closed recreational and commercial fishing in the Hudson for many species, and has placed consumption restrictions on other species (USDOI et al. 2001).

Despite the dredging of PCB-contaminated sediments in Hudson Falls since 2011, PCB levels remain high in sediments and organisms throughout the entire downstream segment.

Today, the Hudson's dredged channel allows large ocean-going vessels to reach Albany, and from there cargo can move through the canal system, by rail, and by road to other parts of the state, to New England, and to Canada. Approximately 17.5 million tons of cargo were shipped up and down the Hudson in 2014. Petroleum products—crude petroleum, gasoline, and fuel oil—made up approximately 66 percent of the tonnage. Other cargo included gypsum, cement, grains, road salt, sand, gravel, iron ore, scrap metal, food products, sewage sludge, and many other raw materials and products (Coyne 2016).

Athens has asphalt-receiving facilities, accessible by barge (hudsonriverpilots.com). Athens, Coxsackie, and New Baltimore have small-craft docking facilities. Catskill, Athens, and Coxsackie have public hard-surface-ramp boat launches. Parks and preserves occupy some of the other waterfront and former docking sites along the Greene County shoreline, including Cornell Park in New Baltimore, Dutchman's Landing Park in Catskill, RamsHorn-Livingston Sanctuary in Catskill, Athens Riverfront Park, and Coxsackie Waterfront Park.

Passenger travel on the Hudson River is largely on recreational excursion boats. The river is much used for other recreation—boating, fishing, swimming, birdwatching, photography—and is a celebrated part of the Greene County scenic landscape.

Agriculture

Although colonial agriculture was much more intensive than the indigenous farming that went before, colonists did practice the traditions of "husbandry" that had evolved to sustain fertility and resources on small farms in Europe. Their methods relied on an integrated system of crops, livestock, pasture, woods, and water. For example, hay grown in naturally fertilized floodplains and marshes was harvested to feed livestock through winter, and then their manure was carefully applied to fertilize cropland. Woodlands were managed to provide a steady supply of wood for building, fuel, and a variety of essential products, while also providing forage for livestock (Donahue 2004). Fields were often left fallow every second or third year (Smith 1877).

Farms from colonial times through the mid-19th century were small, diversified family businesses, largely self-sufficient but also dependent on market income. Early settlers grew maize, wheat, flax, oats, barley, apples, and garden vegetables; and raised cattle, horses, sheep, pigs, poultry, and honey bees (Smith 1877, Thomas 1976). As examples of the integrated local economy, sheep were kept, and their wool was washed, carded, spun, woven, and fulled into cloth on the farm (later there were mills for carding and fulling), and then sewn into clothing at home or by a tailor. When a cow was butchered, the farmer brought the hide to be made into leather by the local tanner, and then into shoes by the local shoemaker. Native American trails through the Catskills became major trading routes, so that a large proportion of products from western New York came through Greene County to the Hudson River. The Village of Catskill had grain markets and flour mills of statewide importance (Sullivan 1927). The opening of the Erie Canal in 1825 connecting Albany and Buffalo, however, greatly reduced the cost of transporting goods between eastern and western New York, and so reduced commercial traffic through the Catskills.

Producing woolen cloth was briefly profitable (1809-1815), and in this period mills for carding, spinning, knitting, weaving, and fulling proliferated. Then in 1824, tariffs on imported wool and wool cloth raised the price of domestic wool and led to an explosion of sheep farming in much of the Northeast. The market revolution's shift from manure-based, mixed husbandry to intensive production of animal-based products (wool, milk, beef) resulted in increased productivity but also accelerated environmental degradation. The need for increased pasturage and hay for raising sheep and cattle led to accelerated deforestation. The county's maximum deforestation was sometime in the late 1800s. The price of wool dropped rapidly after 1850, leading to a regional decline in sheep farming, although in Greene County wool production continued to increase between 1855 and 1880 (Beers 1884). By the 1920s, farmland was being abandoned, a trend that continued through the 20th century (Beers 1884, Kudish 2000). In 1880, there were 240,700 acres of "improved farmland" in the county, but by 2019 farmed land totaled only about 35,750 acres.

The railroad came relatively late to Greene County. The line connecting Albany and New York City along the east bank of the Hudson, completed in 1851, was accessible by ferry from Catskill and Athens. A line along the west bank of the Hudson, connecting New Jersey and New York City to the Mohawk River lines west to Buffalo, opened in 1883. As transportation improved, farms began to shift from diversified, self-sustaining homesteads to more commodity-led production. According to census data from 1855, 1875, and 1880, farms were still quite diversified during this period: principle crops were hay, apples, oats, corn, potatoes, buckwheat, rye, wheat, barley, tobacco, cider, grapes, maple sugar, and hops. Animals and animal products included livestock, poultry, wool, butter, pork, honey, eggs, and cheese. Over 1.7 million pounds of butter, made at home, were sold in 1880 (Beers 1884); by 1917 there were ten creameries in the county. By the 1920s, hay, dairy, apples and other fruit, and vegetables were the principle crops (Sullivan 1927).

In 1880 there were 240,700 acres of "improved farmland" in the county, compared to ca. 35,750 acres of farmed land in 2019.

Technological and transportation advances in the 1940s dramatically influenced the sizes of dairy farms. Rural electrification in the 1940s brought artificial refrigeration and the spread of electric and mechanical milking technology. Milking machines enabled individual farms to manage much larger herds. The introduction of refrigerated tank trucks for hauling milk to dairy processing plants relieved the farmers of the need to haul their milk to milk stations daily, but required that each farm install a refrigerated bulk tank. The financial cost of these transitions drove many small farms out of business, so that after World War II, the trend has been toward fewer but larger dairy farms in the region (Stott 2007).

Table 9 gives summary farm statistics for Greene County from the 2017 Agricultural Census of the US Department of Agriculture. In 2017 Greene County had approximately 35,000 acres of "agricultural" parcels (including forests and other unfarmed land). The highest value of sales were from livestock (including poultry) and their products, vegetables, hay, and nursery/greenhouse crops. Greene County ranked the eighth highest of all counties in the state in sales of poultry and eggs. Although the county lost 67 farms and 8007 acres of farmland, and agricultural sales dropped by $2.6 million between 2012 and 2017 (Agricultural Census 2017), farming and associated businesses are still a significant part of the county's economy, and farmers are among the most important stewards of land and resources. As of January 2019 there were 286 farms and 38,333 acres in the Greene County agricultural district (District 124), of which 35,745 total acres were farmed and 12,556 were in crops (https://www.agriculture.ny.gov/ap/agservices/agdistricts.html).

Old farm equipment in the Route 9W grasslands corridor.
Photo: Bob Knighton © 2019

Table 9. Greene County farm statistics from the 2017 Census of Agriculture (USDA 2019).

A. Products and market values

Market value of agricultural products sold	**$ amount (in $1000s)[1]**	**State rank[1]**
Total value of agricultural products sold	19,761	47 (of 61 counties)
Value of crops including nursery and greenhouse	9,222	47 (of 61 counties)
Value of livestock, poultry, and their products	10,539	45 (of 58 counties)
Value of sales by commodity group		
Vegetables, melons, potatoes, and sweet potatoes	4,575	21 (of 60 counties)
Other crops and hay	1,281	49 (of 55 counties)
Nursery, greenhouse, floriculture, and sod	2,384	27 (of 60 counties)
Milk (from cows)	689	50 (of 51 counties)
Grains, oilseeds, dry beans, and dry peas	464	49 (of 55 counties)
Fruits, trees nuts, and berries	390	40 (of 60 counties)
Cut Christmas trees and short-rotation woody crops	128	26 (of 53 counties)
Sheep, goats, wool, mohair, and milk	77	50 (of 54 counties)
Horses, ponies, mules, burros, and donkeys	63	53 (of 55 counties)
Other animals and animal products	51	41 (of 58 counties)
Hogs and pigs	43	41 (of 55 counties)
Aquaculture	2	28 (of 34 counties)
Cattle and calves	U	U
Poultry and eggs	U	8 (of 57 counties)
Top crop items (by area)	**Acres[1]**	
Forage (hay/haylage)	8,529	
Vegetables harvested, all	1,143	
Corn for silage or greenchop	897	
Corn for grain	189	
Sweet corn	U	
Top livestock inventory items	**Number**	
Cattle and calves	2,632	
Goats	354	
Horses and ponies	215	
Broilers and other meat-type chickens	206	
Hogs and pigs	184	
Sheep and lambs	130	
Turkeys	83	
Layers (egg-producing chickens) and pullets	U	

[1] U = undisclosed amount
- = negligible amount

Table 9. (cont.)

B. Total value of sales and farm income.

Value of sales	Number of farms
<$1,000	40
$1,000 - $4,999	36
$5,000 - $9,999	27
$10,000 - $49,999	74
$50,000 - $99,999	14
$100,000 - $249,999	9
$250,000 - $499,999	1
≥$500,000	5
	Dollars
Total farm production expenses	18,490,000
Average per farm	89,758
Net cash farm income of operation	2,031,000
Average per farm	9,859

C. Principal producer characteristics.

Principal producer by primary occupation	**Number**
Farming	136
Other	114
Principal producer by sex	
Male	149
Female	101
Average age of principal producer (years)	61.3
Total producers by race[1]	
White	320
Asian	3
Black or African American	0
Native Hawaiian or other Pacific Islander	0
Native American	0
More than one race	0
Total producers of Spanish, Hispanic, or Latino origin[2]	7

[1] Data were collected for a maximum of four operators per farm.

Mining Industries

In central and northern Greene County, large areas of shale and sandstone bedrock includes much "bluestone," a fine grained, compact sandstone (Smock 1888). "Hudson River flagstone" or "North River flagstone" is a type of bluestone once quarried in Greene County and most commonly used for sidewalk flagging in New York City and other cities and towns. Most quarries were smaller than an acre (Kudish 2000), and worked by hand by just a few men. Between 1888 and 1912 there were records of sandstone quarries at Acra, Catskill, Kiskatom, Cairo, Coxsackie, Haines Falls, Hunter, Jewett, Leeds, Lexington, New Baltimore, Palenville, High Falls, Platte Cove, Prattsville, Tannersville, and Windham (Luedke et al. 1959). Quarries at the easily accessible sites were mostly exhausted by 1919 (Newland and Hartnagel 1928, Dineen 1976).

A band of Middle and Lower Devonian limestone, including Onondaga and Helderberg Group limestones, runs from just west of Albany south and then southeast to Port Jervis (Fisher et al. 1970). In Greene County, this band is parallel to and approximately 0.5-4 miles west of the Hudson River, running through the hamlets of Climax, Limestreet, Leeds, and Cementon. Limestone was quarried at places all along this belt for building, iron smelting, sculpture, monuments, and lime production. Lime, produced by heating limestone in a kiln, was first used for agriculture, plaster, and whitewash, and later for the production of Portland cement. Lime kilns appear on 1867 maps in the towns of New Baltimore, Coxsackie, Athens, and Catskill. The three Greene County cement plants, located along the Hudson near Cementon, opened in 1899, 1901, and 1916. In 1948, Portland cement was the most valuable mineral product of the state (Hartnagel and Broughton 1951).

In 1948, Portland cement was the most valuable mineral product of the state.

Although cement is still widely-used in the production of concrete, most cement plants along the Hudson River have closed. The last one in Greene County—the Holcim plant in Cementon—closed in 2012. Active and abandoned quarries cover a large area (approximately 0.5 by 4 miles) of the adjacent limestone ridge.

Sand and gravel deposits are widespread in the county but limited in extent, occurring mainly in the glacial outwash plains along stream corridors, in kame deposits, and in lacustrine sand deposits in the area of the former glacial Lake Albany (Figure 5). Since the earliest days of European settlement these materials have been (and continue to be) mined by farmers and other landowners for onsite uses; commercial mines are fewer but widely distributed around the county. In addition to general-purpose building sand, deposits of molding sand (very fine-textured, with a smooth, velvety feel) used in the casting of metals are also found near the Hudson River in Greene County. In the 1920s,

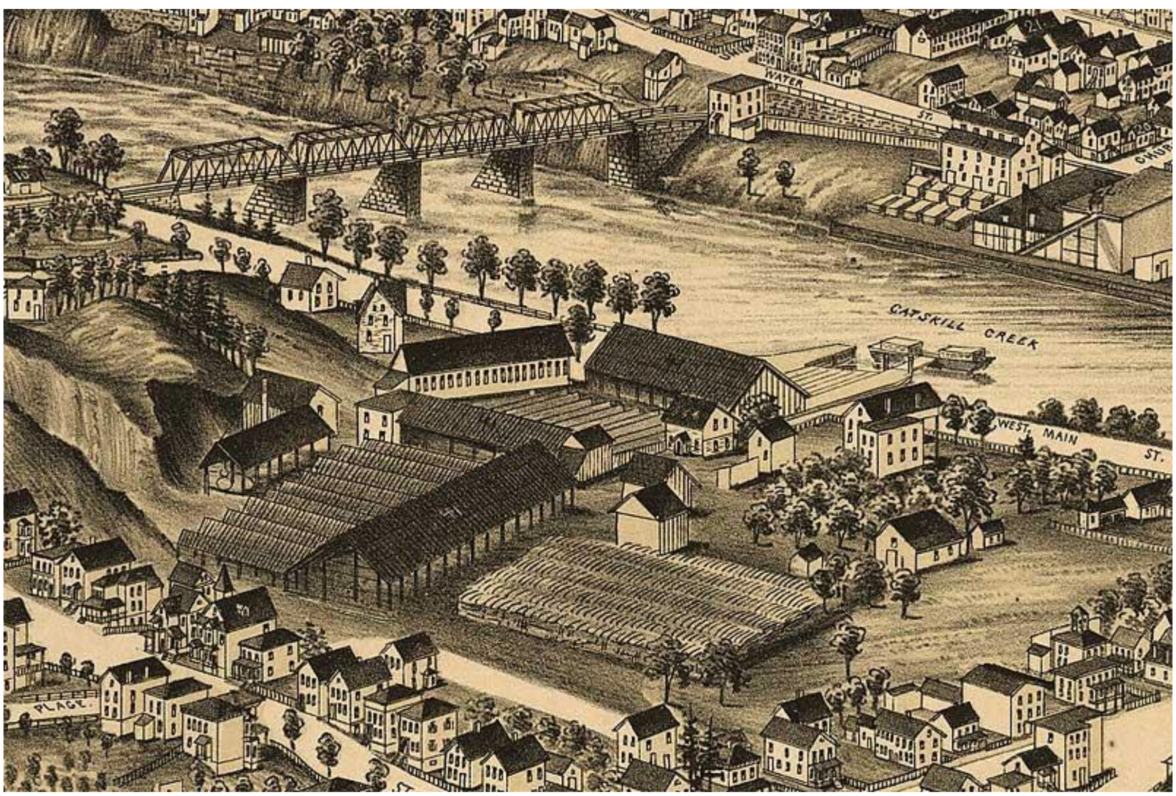
"Cementon." Austin Merrill Mecklem, 1935.

Sunrise glow on the Lehigh cement plant, 2008, looking west across the Hudson River from Germantown. Kristen Travis © 2019

Coxsackie was an important center of production; molding sands were shipped from the Hudson Valley across the country. Generally, molding sand was found in shallow deposits just under the soil, and soil was replaced after sand removal (Nevin 1925). An 1867 map shows several peat beds, which were likely mined for fuel, fertilizer, or a stock feed supplement.

The deep clay deposits in the eastern part of the county—the area of former glacial Lake Albany—were mined for brickmaking since the early days of European settlement, but large brickmaking operations were not underway until the late 1800s and early 1900s. In the late 1800s there were many brickyards in Catskill, Athens, and Coxsackie, mainly in the villages where there were docks for shipping. In 1910, Greene County had four brick factories, with an annual output of over 12 million bricks (Newland 1911). The industry thrived for awhile but declined in the 1920s and 1930s when concrete became the material of choice for structures in New York City.

In 1910, Greene County had four brick factories, with an annual output of over 12 million bricks.



Catskill brickyard. L.R. Burleigh, Troy, NY, 1889. Geography and Map Division, Library of Congress.

Forest Industries and Catskill Mountain Uses

Before European settlement, forests on the lower Catskills were approximately 50% beech, 20% hemlock, and 13% sugar maple. Those in the Hudson Valley proper, influenced by a warmer climate and Native American silvicultural practices, were dominated by oaks (McIntosh 1972).

The Catskills' large, old stands of hemlock fueled the county's first large industry. Tanning—the process by which animal skins are transformed into pliable and durable leather—used tannins in the bark of eastern hemlock and oak species. The Greene County tanning industry began in 1812 and peaked in the 1820s and 1830s (Sullivan 1927). Hides were imported from as far away as South America. Thriving hamlets sprang up around the tanneries, but by the 1850s, most hemlocks were gone and the tanneries deserted (Beers 1884). The de-barked trees fueled a derivative industry, shingle-making.

The sawmill industry was the largest forest products industry, producing lumber for buildings, ship timbers, and railroad ties, and wood for furniture and many other uses. After initial land-clearing for farms and tanning, selective logging for larger trees occurred over wider areas of the Catskills. White pine, red spruce, sugar maple, and other hardwoods were the preferred species. Resprouting hardwoods in cut-over areas were used for cooperage (barrel) and furniture factories. Other wood products included pulp and paper, excelsior (packing material), flooring, and veneer (Beers 1867, McIntosh 1972).

Charcoal was a primary industrial fuel in the 1800s. Charcoal was made by slowly heating logs in an outdoor earthen kiln—a pile of logs covered with soil and green vegetation. A smoldering fire would vaporize the moisture in the logs and leave only charcoal, which burns longer and hotter than firewood. Large areas of forests around the charcoal pits (kilns) were cut for charcoal production. Manufacture of potash from wood (used in industrial processes) may also have contributed to extensive forest clearing.

Catskill Park and Catskill Preserve

The **Catskill Preserve** comprises the 294,200-acre area in the Catskill Mountain region owned by the State of New York for purposes of conservation.

The **Catskill Park**, delineated by the so-called "blue line," is the 705,500-acre area where future acquisition of Catskill Preserve lands is to be concentrated. The Catskill Park includes most of the Catskill Preserve and additional areas of privately-held land.

The ecological consequences of forest loss were far-reaching, affecting soils, habitats, wildlife, streams, and the Hudson River, and they are still felt today. At the maximum extent of deforestation in New York State, the state established wilderness areas in the Catskills and Adirondacks to be protected from logging and other impacts. The Catskill State Forest Preserve began with about 33,900 acres in 1885 (Van Valkenbergh 2008) and includes nearly 300,000 acres today, with 79,200 acres in Greene County (NYSDEC 2008a). The state made fire control and prevention a priority, and fire towers were built on many peaks.

Several state reforestation areas were established in the county starting in 1929 to replant large areas with conifers for soil restoration and timber production. These are today's state forests—Bearpen, Huntersfield, Ashland Pinnacle, Mount Pisgah, and Cairo Lockwood—which are now managed for recreation, wildlife habitat, and ecosystem services, as well as timber. Forestry and timber production are also common on private lands.

The Catskill Mountains were famous early on as a destination for summer visitors, as well as artists and writers seeking solitude and natural beauty. Thomas Cole first painted the Catskills in the 1820s, bringing their beauty to a wider audience and sparking the beginning of the Hudson River School movement in American art. The Catskill Mountain House, built in 1824 and accessible by a day-long stagecoach trip from Catskill, was the first large mountain resort. In 1881, there were nine other hotels in the mountains (over 100 guests each, at Kaaterskill Falls, Hunter, Lexington, Palenville, and Tannersville), large hotels in the Village of Catskill, and a nearly-completed 1,000-guest resort, Hotel Kaaterskill. "And surrounding all these larger hotels are pleasant village homes, farm-houses, and lesser hotels, where the Summer visitor is welcome" (New York Times 1881).

By the 1950s, the Catskills had transitioned to a vacation destination for the middle class, and the large resorts were replaced by motels and "bungalow colonies." Tourism declined in the 1970s but has since been increasing. Visitors stay at inns and campgrounds, rent or buy weekend and summer homes, visit golf courses and ski slopes, and boat, hike, observe nature, fish, and hunt in extensive publicly accessible parks and preserves.

A View of the Two Lakes and Mountain House, Catskill Mountains, Morning (Thomas Cole, 1844)

THREATS TO RESOURCES OF CONCERN

Streams, ponds, wetlands, upland habitats, wildlife, and farmland are subject to numerous direct and indirect threats from human activities that include the obvious, such as filling a wetland or emitting atmospheric pollutants from industrial smokestacks, or the less obvious such as leachate from failing septic systems entering a lake. They include threats that may go unnoticed for years until the effects become apparent, such as depletion of groundwater supplies due to incremental additions of impervious surfaces, or loss of bird populations due to forest fragmentation, human-subsidized predators, or use of pesticides. Climate change poses over-arching and wide-ranging threats to water supplies, agriculture, wildlife, and human health. Some of the threats from climate change and other sources are described below. Ways to reduce these stresses or improve ecosystem resiliency are described in the **Conservation Principles and Measures** section.

Climate Change

Large rainstorms and snowstorms, ice storms, heat waves, and droughts have long been characteristic of Greene County and the Northeast in general, but overall climate patterns remained fairly consistent since European settlement until the latter part of the 20th century (Union of Concerned Scientists 2006). The climate is now changing rapidly, and some aspects are changing more rapidly in the Northeast than in the rest of the US or the world (Horton et al. 2011).

Here in Greene County, there has been great year-to-year variability in the length of the frost-free season, the depth and duration of the snowpack, and the frequency and duration of heat waves, for example, but the effects of global warming are likely to be felt more acutely in the coming years—larger and more frequent floods, higher temperatures, more severe droughts, more frequent and extensive wildfires and severe rainstorms, as well as some less dramatic symptoms such as increases in invasive pests, pathogens affecting humans, livestock, and wildlife, and depletion of native biological diversity (Rosenzweig et al. 2011).

Climate change is driven by emissions of greenhouse gases (GHGs) to the atmosphere—especially carbon dioxide, methane, and nitrous oxide—that trap heat near the Earth's surface. The increased emissions are largely due to human activities, such as production, transport, and burning of fossil fuels for electrical power; heating, and powering motor vehicles; and the accumulated effects of many other activities, such as deforestation, emissions from agriculture, and burning of wood and other organic materials. If worldwide GHG emissions are lowered in the coming years, then the

If carbon emissions continue to grow at the current rate, severe climate changes are likely to increase dramatically over the coming decades.

changes we experience will still be significant but reduced. But if emissions continue to grow at the current rate, these changes are likely to increase dramatically over the coming decades.

Recognizing the threats of climate change to infrastructure, farms, ecological communities, drinking water supplies, recreational opportunities, public health, municipal economies, and livelihoods of residents, the towns of Cairo, Hunter, and Jewett and the Village of Catskill have signed the Climate Smart Communities Pledge, which asserts a commitment to taking multiple actions to combat climate change and promote community resilience to climate change effects.

Much of the climate data in the discussion below is from the publication *Responding to Climate Change in New York State* (Rosenzweig et al. 2011, updated in 2014)—called the ClimAID report, published by the NYS Energy Research and Development Agency (NYSERDA). The ClimAID projections for air temperature, precipitation, heat waves, sea-level rise, and flooding for the state through 2100 were developed with regional data in a global model used for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. Greene County is in ClimAID Region 2 that encompasses seven counties west of the Hudson River in southeastern New York.

Some additional information applicable to the Northeast in general is from the Fourth National Climate Assessment (NCA4), published in November 2018—a product of the US Global Change Research Program. The message in Chapter 18 (Dupigny-Giroux et al. 2018) of the NCA4, which applies to the northeastern US, is similar to that of the New York ClimAID report, except that the changes are happening more rapidly than predicted a few years ago.

The Changing Local Climate

Annual average temperatures in New York have increased 2°F since 1970 and average winter temperatures have increased 5°F.

<u>Rising Air Temperatures</u>

Global air temperatures have been increasing for decades and temperature rise in the northeastern US has been much more rapid than national or global averages. In New York, annual average temperatures have risen 2°F since 1970, and average winter temperatures have increased 5°F. Higher temperatures are creating new problems for human health, agriculture, energy demand, and recreation, as well as for plants, animals, and habitats of natural areas. The average annual temperature in Greene County is projected to increase approximately 3-5°F by mid-century and upwards of 9°F by the 2080s (Table 10).

Table 10. Air temperature projections for ClimAID Region 2 (includes Greene County), from the 2014 ClimAID report.

	Actual 1971-2000	Projected 2020s	Projected 2050s	Projected 2080s	Projected 2100
Annual average air temperature	48 °F	52.2 – 53.1 °F	54.2 – 56.1 °F	55.4 – 59.6 °F	56.2 – 61.2 °F
Increase in annual average	-	2.2 – 3.1 °F	4.2 – 6.1 °F	5.4 – 9.6 °F	6.2 – 11.2 °F

Summer heat waves are expected to be more frequent, more intense, and lengthier. Even at the lowest projected rate of carbon emissions, Greene County summers by 2100 could be similar to those of North Carolina today (Union of Concerned Scientists 2006).

Rising Sea Level

Hudson River shoreline communities could experience a sea level rise of 5.9 ft by the end of this century if the rapid melting of the Greenland ice sheet continues at the recent pace.

Rising global air temperatures have led to an increased rate of sea level rise due to thermal expansion from warmer water temperatures, the melting of polar ice caps and other land-based ice, and other factors. Since 1900, sea level in the lower Hudson River and New York Harbor has risen 13 inches, and projections for additional sea level rise in the Hudson River are in the range of 1-9 inches by the 2020s and 5-27 inches by the 2050s (Table 11). The actual timing and magnitude of sea level rise will depend on the level of global greenhouse gas emissions and a variety of other known and unknown factors, but Hudson River shoreline communities in Greene County could experience an increase of as much as 71 inches (5.9 ft) by the end of the 21st century if the rapid melting of the Greenland ice sheet continues at the recent pace (6 NYCRR Part 490.4).

Table 11. Sea-level rise projections for the mid-Hudson region (6 NYCRR Part 490).

Time Interval	Low Projection	Low-Medium Projection	Medium Projection	High-Medium Projection	High Projection
2020s	1 in	3 in	5 in	7 in	9 in
2050s	5 in	9 in	14 in	19 in	27 in
2080s	10 in	14 in	25 in	36 in	54 in
2100	11 in	18 in	32 in	46 in	71 in

Some of the existing tidal wetlands along the Greene County shoreline will be drowned by sea level rise, some will remain but their character will change, and some new wetlands will develop landward of present-day tidal habitats. Sea level rise together with increased storm surges are likely to destroy some of the natural wetland and upland habitats that have served as storm barriers to landward property, infrastructure, and buildings.

Figure 30 shows predicted migration of Greene County tidal wetlands by 2100; Figure 31 shows a predicted sequence of changes to tidal wetland habitats at RamsHorn and Middle Ground Flats, just as examples. These predictions are from analysis conducted by Scenic Hudson (Tabak et al. 2016) using ClimAID data. Figure 30 shows that some parts of the villages of Catskill, Athens, and Coxsackie that now have pavement and structures may be inundated by 2100. Figure 32 shows the predicted extents of the 5-year flood zone under several different sea level rise scenarios along the Greene County shoreline, and the predicted extents of the 100-year and 500-year flood zones should sea level rise by 72 inches by the end of this century. This may be the most accurate prediction given the current rate of ice melt in the Arctic regions.

Figure 33 illustrates which of the Hudson River tidal wetlands are predicted to remain as wetlands—the "resilient" wetlands—(although their character may change), which ones may be lost (inundated), and where new wetlands might be created with the rising sea level by 2100. It also shows where new tidal wetlands may encroach on developed parts of the Hudson River shoreline (Tabak et al. 2016). For more discussion of tidal wetland migration, change, and resilience predictions and an interactive map, see "Protecting the Pathways" at www.scenichudson.org/climatechange.

The amount of rain falling in heavy storm events increased 74% between 1958 and 2011.

Changing precipitation patterns

In the northeastern US, precipitation has increased only slightly in recent decades but has become much more variable and more extreme. The amount of rain falling in heavy storm events increased 74% from 1958 to 2011. Precipitation patterns are difficult to predict, and the climate models are being continually refined on the basis of up-to-date regional data, but current models predict that total annual precipitation could increase as much as 11% by 2050 and 18% by 2100 (Table 12). The models also project more droughts, heavier rains in the intervening periods, and reduced snow cover in winter (Horton et al. 2011).

Table 12. Precipitation projections for the ClimAID Region 2 (includes Greene County), from the 2014 ClimAID report.

	Actual 1971-2000	Projected 2020s	Projected 2050s	Projected 2080s	Projected 2100*
Total annual precipitation (inches)	48	48.5 – 52	49.5 – 53.5	51.0 – 54.5	56.1 – 61.4
Increase in annual precipitation	-	1 - 8%	3 - 11%	6 - 14%	1 – 18%
No. of days each year with precipitation >1 inch	12	12 - 13	13-14	13-16	-
No. of days each year with precipitation > 2 inches	2	2	2-3	2-3	-

*- = Projection not available

Drought

In the higher-emissions scenario, long-term droughts that now occur every 20-30 years could occur every 6-10 years.

Periods of drought are predicted to become more frequent and more severe in New York. Droughts can threaten local drinking water supplies, crop production, and livestock, and can severely stress aquatic communities of streams and ponds, as well as plants and wildlife in upland and wetland habitats. Droughts can extend the low-flow period of streams and further stress the fish and other organisms that may already be suffering from pollution, warmer stream temperatures, and artificial stream barriers. Drought may become a long-term concern for agriculture and could threaten drinking water supplies throughout the county, including both surface water reservoirs and groundwater wells. In a higher-emissions scenario, long-term droughts (longer than three months) that now occur every 20-30 years could occur every 6-10 years (Union of Concerned Scientists 2006).

Wetlands that have perennially saturated soils develop deep layers of peat (decaying organic matter) that continue to accumulate over hundreds and thousands of years if the wetland hydrology and vegetation remain intact. Due to this capability for peat accumulation, wetlands have the greatest capacity of any ecosystem for long-term carbon storage, and are believed to hold 20-30% or more of the total stored organic carbon in the Earth's soils (Mitsch 2016). But the drying of wetlands due to a warmer climate and longer and more frequent droughts could result in large releases of carbon to the atmosphere, further exacerbating the conditions for global warming. Although both intact and disturbed wetlands can also be large sources of methane emissions to the atmosphere (methane is the third most important greenhouse gas) those emissions are far outweighed by the carbon storage services of an intact wetland (Mitsch 2016).

More frequent and intense heat waves pose threats to human health, agriculture, wildlife, and native plants, and are likely to alter many aspects of the natural landscape. Warmer, shorter winters are predicted to increase the occurrence of rainfall while the ground is frozen, which has numerous implications: hastening snowmelt, reducing groundwater recharge, heightening the likelihood of flooding, and increasing the frequency and consequences of drought. Warmer winters with less snow will alter the habitat suitability for native plants and animals. The frequency of extreme precipitation will continue to increase and may dramatically affect the quality and quantity of water supplies as well as the plants and animals of upland, wetland, and aquatic habitats. Alterations to air temperatures, snow cover, and freeze/thaw patterns are likely to disrupt the seasonal synchrony between pollinators and plants and between predators and prey. Warming temperatures are likely to significantly affect the composition and distribution of habitats and wildlife and force many species to migrate to cooler parts of the local landscape, to more northern latitudes, or to higher elevations as former habitats become unsuitable.

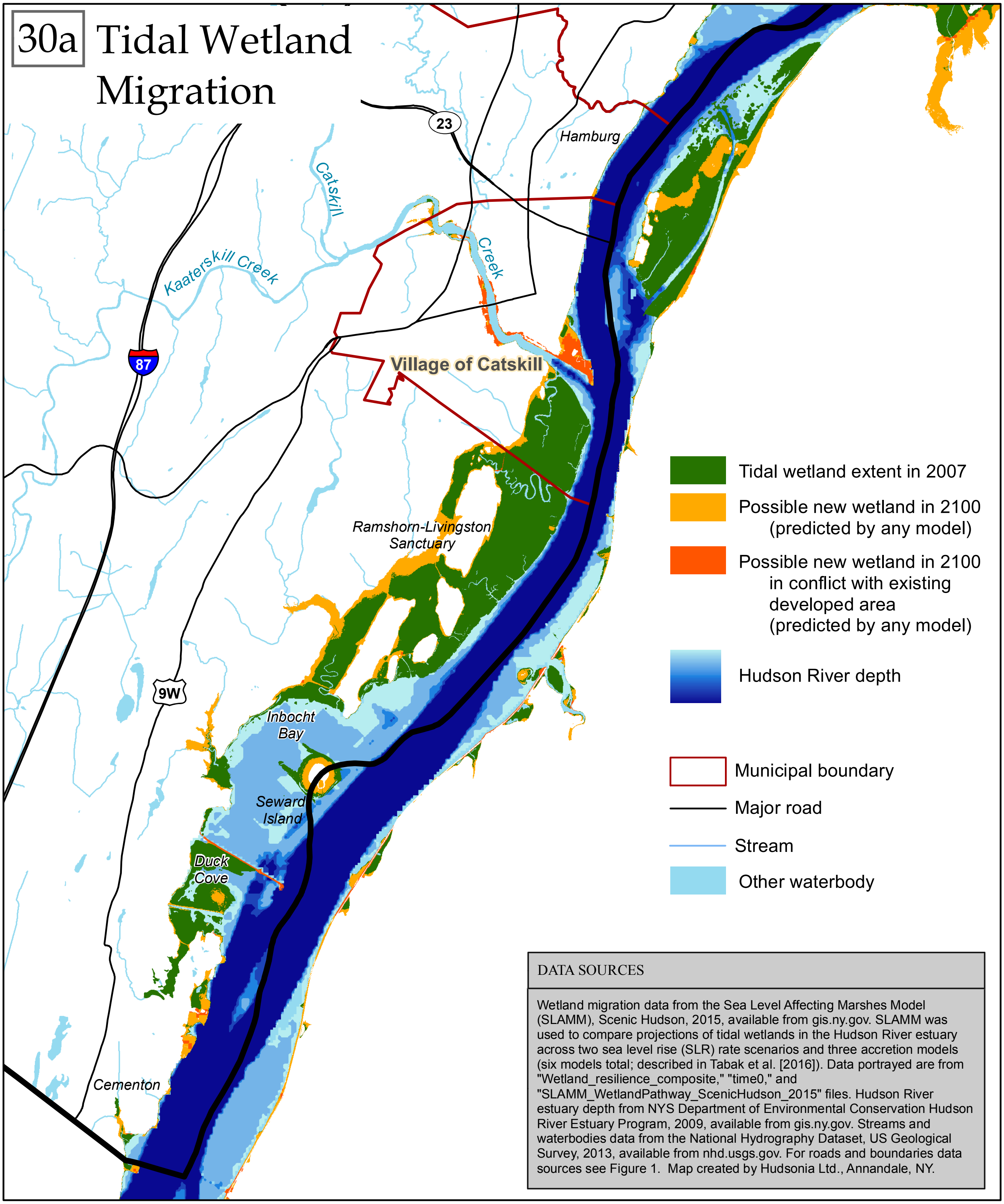
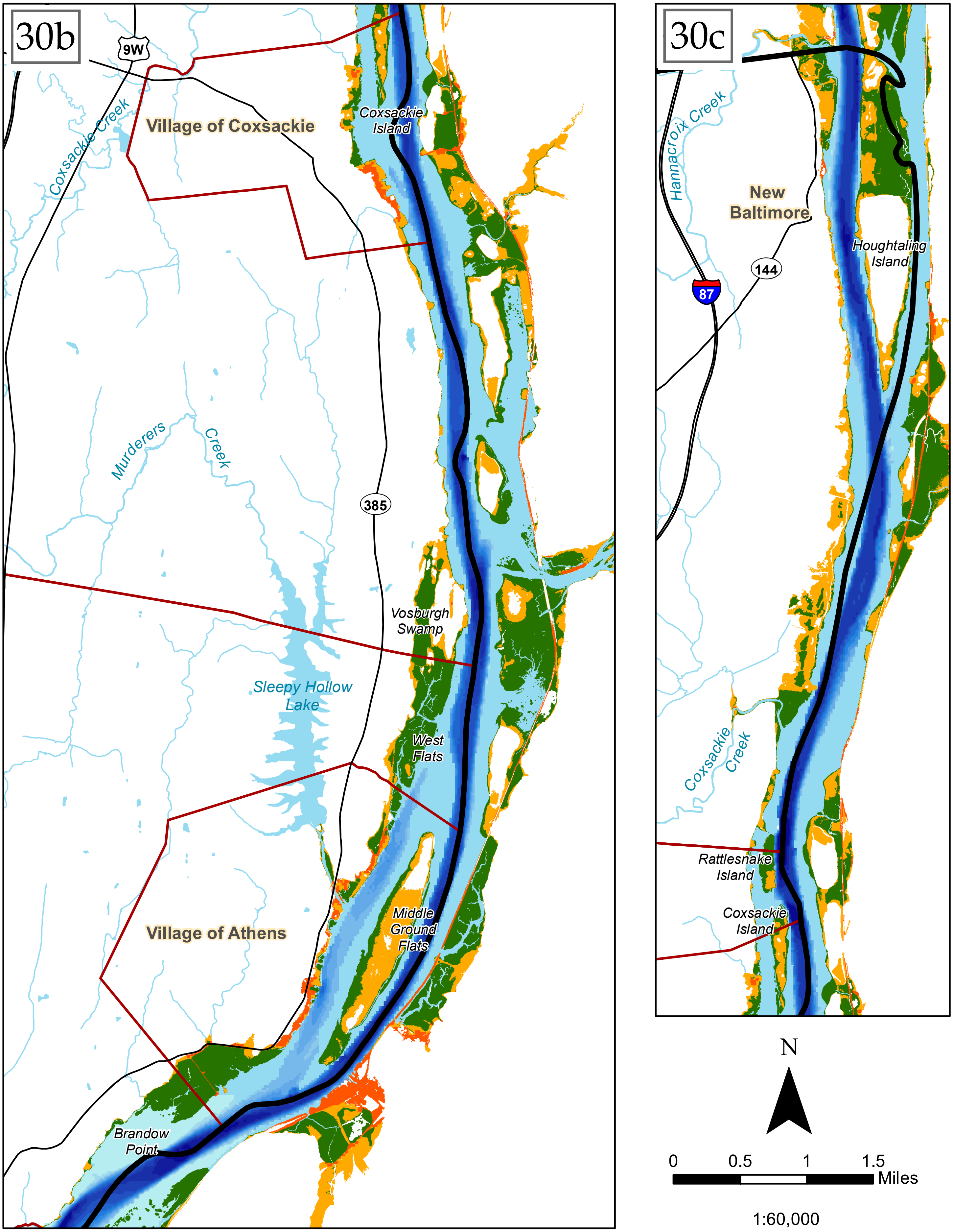
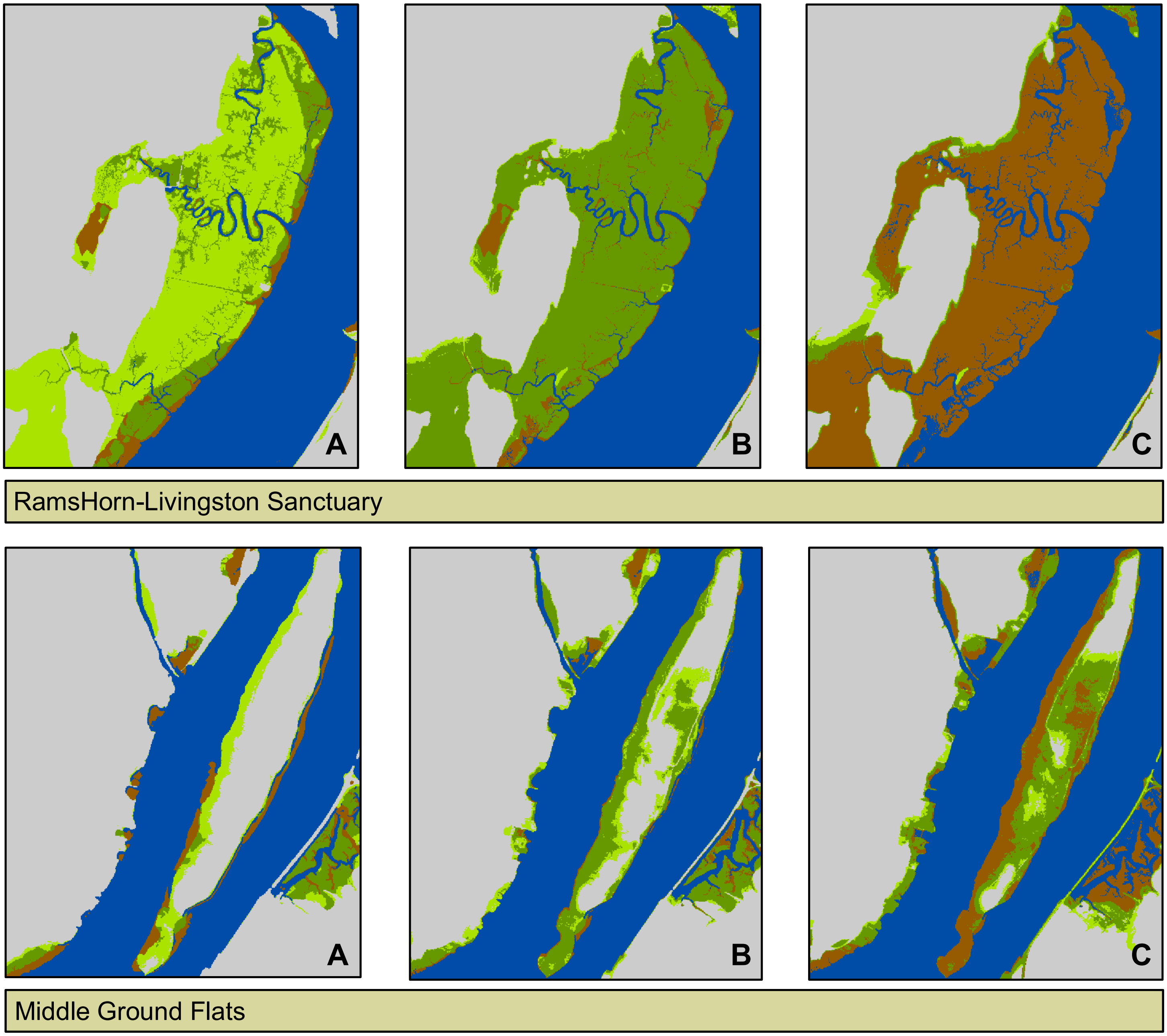
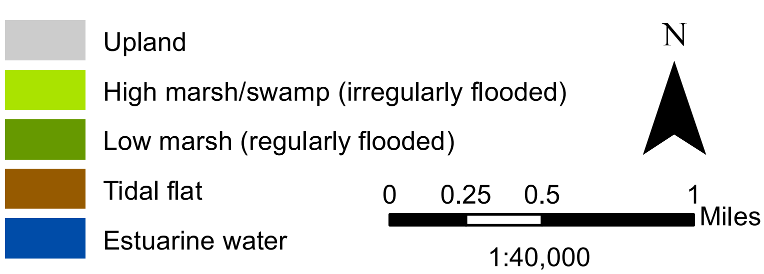


Figure 30. Predicted pathway of tidal wetland migration along the Hudson River in Greene County, New York, by 2100. Map sections shown from south (A) to north (C). Greene County Natural Resources Inventory, 2019.


30b
9W
Village of Coxsackie
Coxsackie Creek
Coxsackie Island
Murderers Creek
385
Vosburgh Swamp
Sleepy Hollow Lake
West Flats
Village of Athens
Middle Ground Flats
Brandow Point
30c
Hannacroix Creek
New Baltimore
Houghtaling Island
144
87
Coxsackie Creek
Rattlesnake Island
Coxsackie Island
N
0 0.5 1 1.5 Miles
1:60,000

31 Tidal Wetland Change (Examples)





DATA SOURCES

Tidal wetland change data from the Sea Level Affecting Marshes Model (SLAMM), Scenic Hudson, 2015, available from gis.ny.gov. SLAMM was used to compare projections of tidal wetlands in the Hudson River estuary across two sea level rise (SLR) rate scenarios and three accretion models (six models total; described in Tabak et al. [2016]). Data portrayed are from "time0," "medSLRlowACC_2100," and "highSLRmedACC2100" files. Map created by Hudsonia Ltd., Annandale, NY.

Figure 31. Examples of predicted tidal wetland change along the Hudson River under different sea level rise scenarios by 2100, Greene County, New York. A is "time zero" (2007); B is 2100 under a medium sea level rise-low accretion scenario; C is 2100 under a high sea level rise-medium accretion scenario. Greene County Natural Resources Inventory, 2019.

Some of the expected effects of climate change on human health, water resources, ecosystems, agriculture, and human health are outlined below.

Climate Change and Human Health

Climate-related health risks stem from heat events, extreme storms, disruptions of water supply and water quality, degraded air quality, changes in timing and intensity of pollen and mold seasons, and increased prevalence of infectious disease vectors and organisms. Expected health effects include increases in heat-related illness and death, respiratory disorders from exposure to increased air-borne allergens and air pollution, physical injuries from large flood events, and a range of infectious diseases. The actual extent of these health effects is difficult to predict, as are the magnitudes of the various changing climate factors. People with pre-existing disease or otherwise compromised health may be among the most vulnerable to the impacts of climate change. Those with diseases such as asthma, cardiovascular diseases, or infectious diseases may be especially sensitive (Kinney et al. 2011).

Heat

Heat-related health effects may disproportionately affect the elderly, the poor, the sick, those with limited mobility and social contact, and those lacking access to public facilities and public transportation or otherwise lacking air conditioning. The combined effects of extreme temperature and air pollution are likely to increase the incidence of illness and death during heat waves (Cheng et al. 2008). Cardiovascular disease—already the single greatest killer of New York State residents (Kinney et al. 2011)—can reduce a person's ability to regulate temperature in response to heat stress, so the predicted increases in summer temperatures and heat waves may pose particular risks to those with compromised cardiovascular systems.

> The combined effects of extreme temperature and air pollution are likely to increase the incidence of illness and death during heat waves.

Air pollution

Rising temperatures and increasing frequency of stagnant air events are likely to produce more days with high ozone levels—a risk factor for respiratory irritation and damage. The risks are greater for people who work or exercise outdoors, for children, and for those with respiratory disease (Kinney et al. 2011). Breathing ozone can cause lung inflammation and decrease lung function, and has been found to increase asthma episodes and cause respiratory failure leading to death.

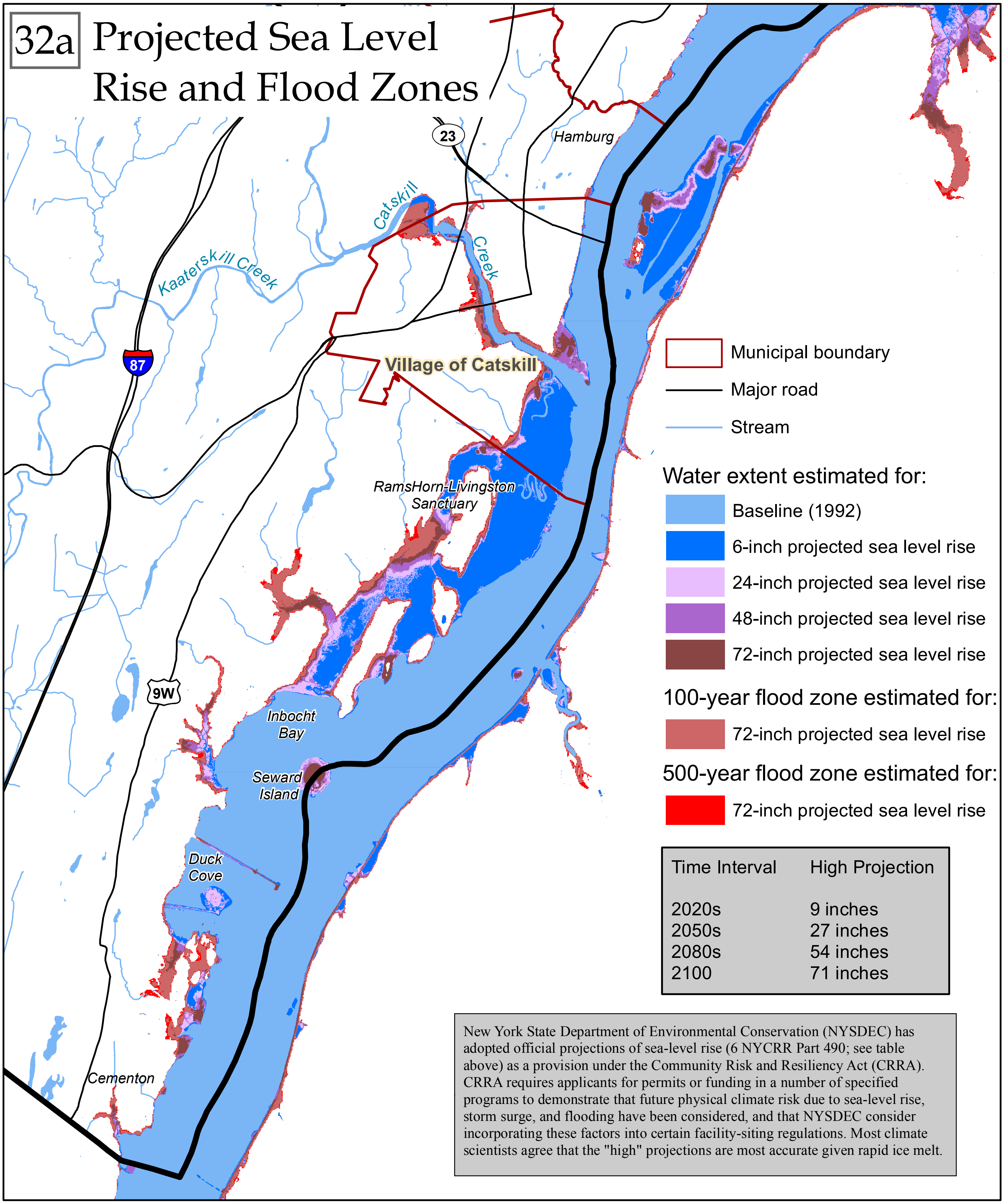
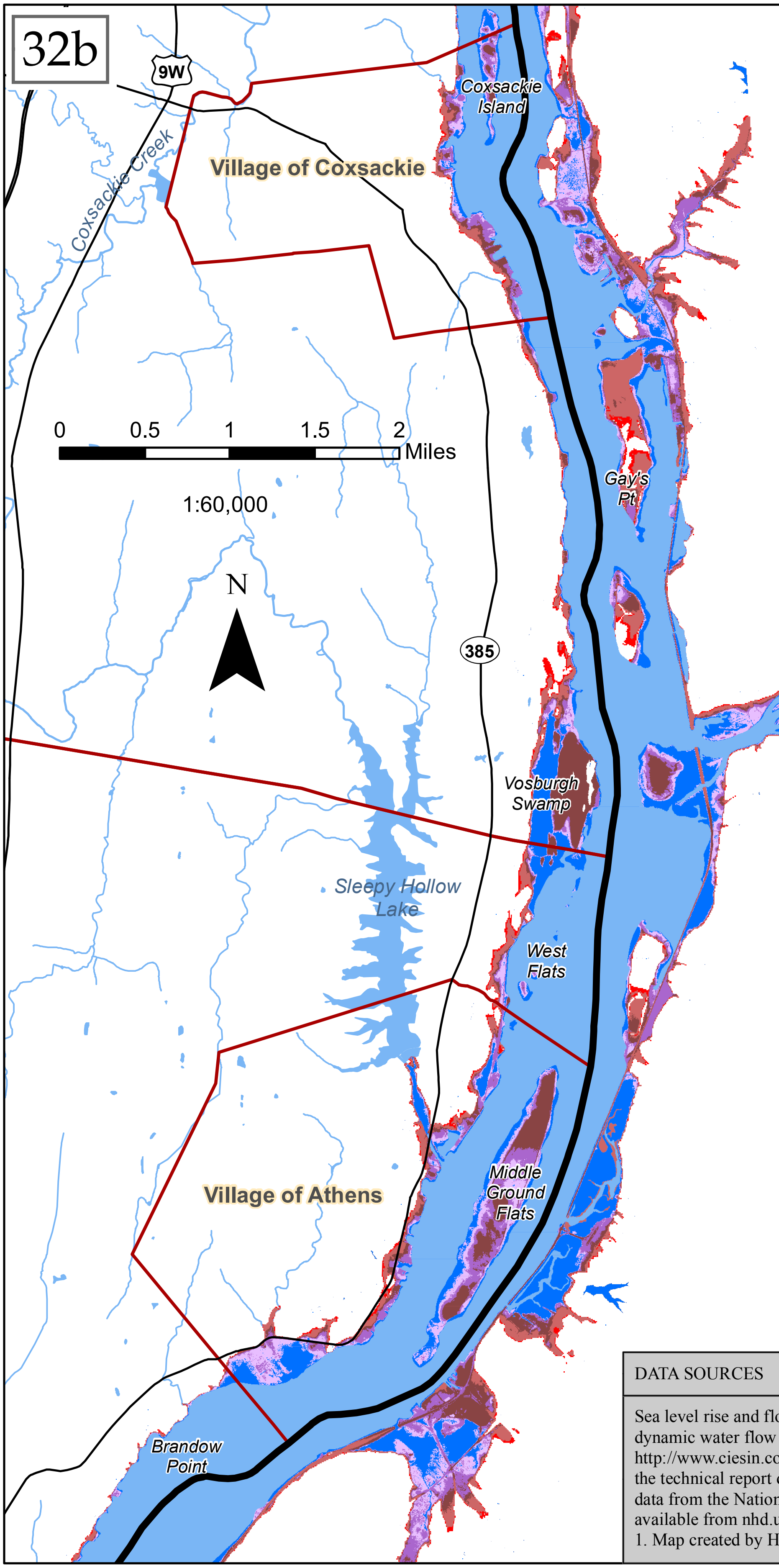
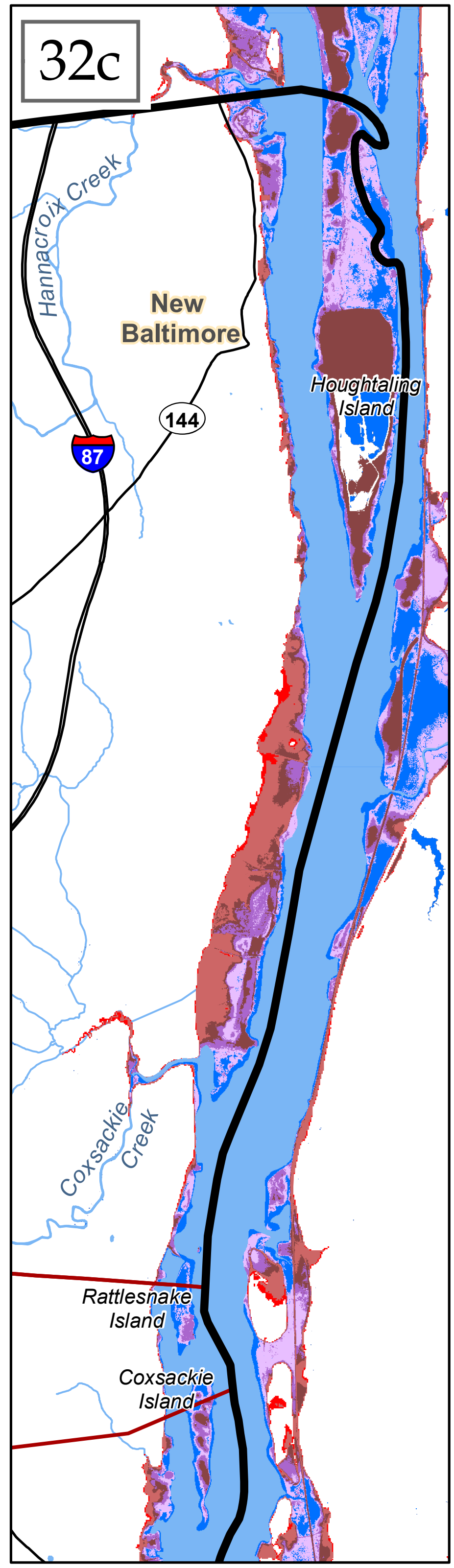


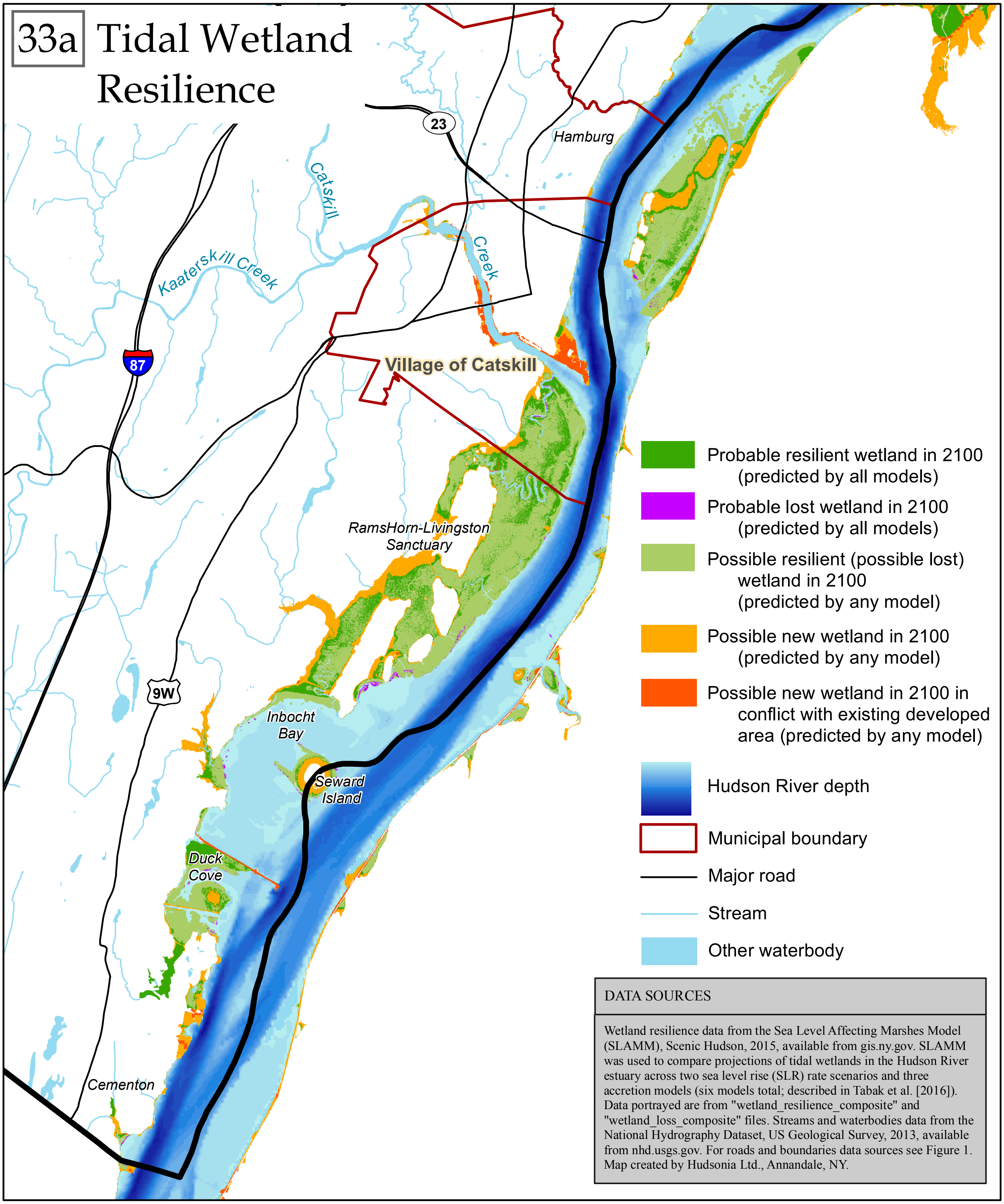
Figure 32. Sea level rise projections and estimated flood zones along the Hudson River in Greene County, New York. Map sections shown from south (a) to north (c). Greene County Natural Resources Inventory, 2019.





DATA SOURCES

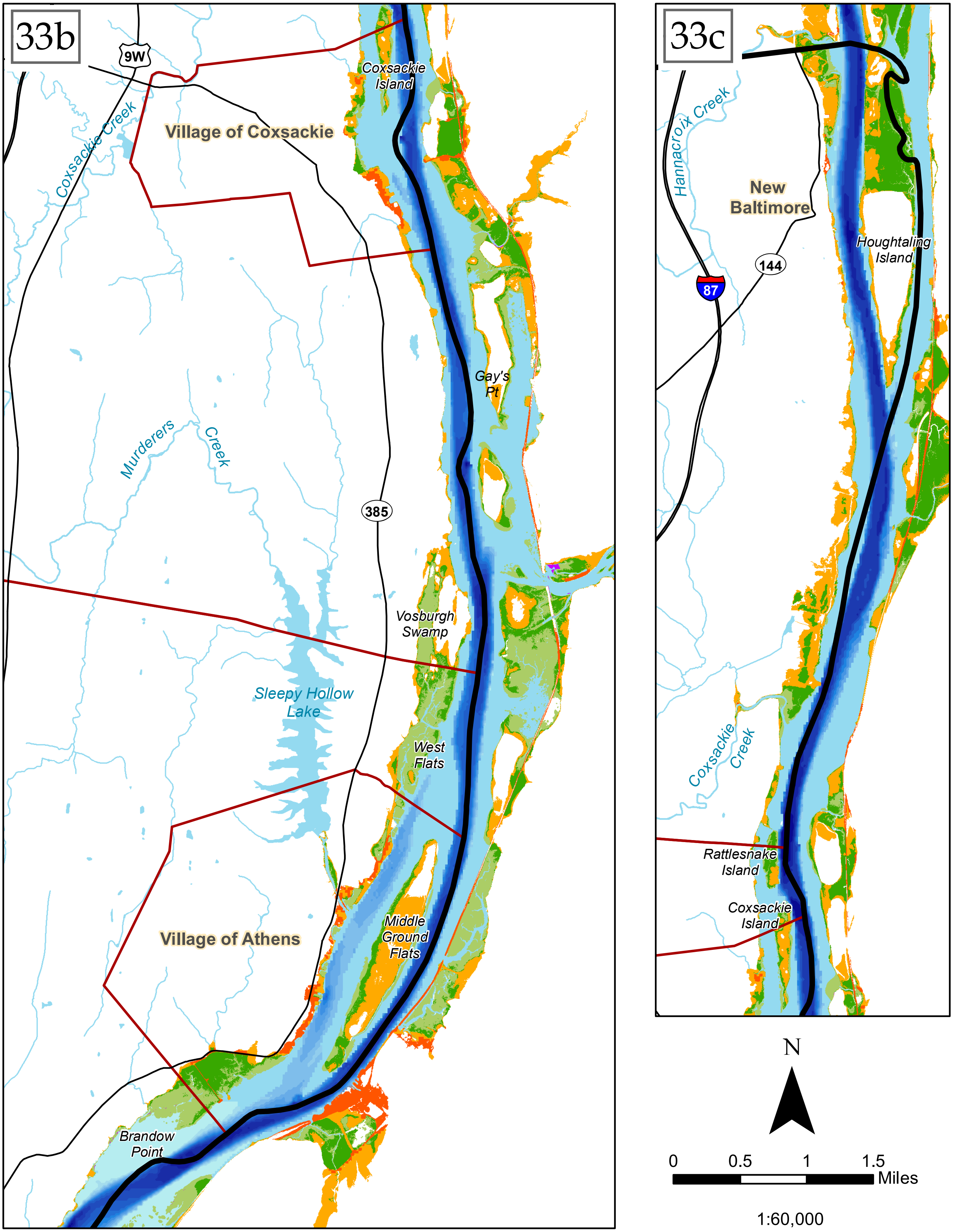
Sea level rise and flood zone data from Orton et al. (2015), derived from dynamic water flow modeling. Data and interactive mapper available at http://www.ciesin.columbia.edu/hudson-river-flood-map/ along with a link to the technical report describing modeling methods. Streams and waterbodies data from the National Hydrography Dataset, US Geological Survey, 2013, available from nhd.usgs.gov. For roads and boundaries data sources see Figure 1. Map created by Hudsonia Ltd., Annandale, NY.



DATA SOURCES

Wetland resilience data from the Sea Level Affecting Marshes Model (SLAMM), Scenic Hudson, 2015, available from gis.ny.gov. SLAMM was used to compare projections of tidal wetlands in the Hudson River estuary across two sea level rise (SLR) rate scenarios and three accretion models (six models total; described in Tabak et al. [2016]). Data portrayed are from "wetland_resilience_composite" and "wetland_loss_composite" files. Streams and waterbodies data from the National Hydrography Dataset, US Geological Survey, 2013, available from nhd.usgs.gov. For roads and boundaries data sources see Figure 1. Map created by Hudsonia Ltd., Annandale, NY.

Figure 33. Hudson River estuary tidal wetland resilience and loss predicted in Greene County, New York, by 2100. Resilient wetlands are those predicted to persist in some form until 2100. Map sections shown from south (a) to north (c). Greene County Natural Resources Inventory, 2019.



33b
9W
Coxsackie Island
Village of Coxsackie
Coxsackie Creek
Gay's Pt
Murderers Creek
385
Vosburgh Swamp
Sleepy Hollow Lake
West Flats
Middle Ground Flats
Village of Athens
Brandow Point
33c
Hannacroix Creek
New Baltimore
Houghtaling Island
144
87
Coxsackie Creek
Rattlesnake Island
Coxsackie Island
N
0
0.5
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Miles
1:60,000

Airborne particulate matter originates from a variety of sources, but some of the most important sources are combustion of fuels by motor vehicles, furnaces, and power plants; wildfires; and windblown dust. Particulates have been associated with premature deaths related to heart and lung diseases and increased hospital visits for respiratory problems. The risk of wildfires increases with higher temperatures, decreased soil moisture, and extended periods of drought. Wildfires produce fine airborne particulates that can be carried long distances from the fire where they originate.

Changing patterns and timing of temperature and precipitation can alter the timing and intensity of allergy triggers such as pollens and molds. Warming temperatures and higher carbon dioxide (CO_2) levels may create extended pollen seasons and spur greater pollen production and allergen potency in plants (Ziska et al. 2003). Warm temperatures and rising air moisture, especially after extreme storms, may also spur the growth of indoor and outdoor molds.

Pathogens

A warming climate and accompanying large rainstorms are likely to increase mosquito and tick populations along with the risk of diseases carried by some of those organisms. Many pathogens—such as those for Lyme disease, erlichiosis, West Nile virus, and malaria—have expanded their geographic range in recent decades in part due to warming winter temperatures (Quarles 2017). Other infectious pathogens may also be climate-sensitive, including those spread by contaminated food and water (Kinney et al. 2011).

A warming climate and accompanying large rainstorms are likely to increase mosquito and tick populations along with the risk of diseases carried by some of those organisms.

Droughts may provide new breeding sites for mosquito larvae by reducing ponded areas to isolated puddles lacking the aquatic predators that would otherwise keep mosquito populations in check. Warmer temperatures will spur mosquito reproduction and the growth of mosquito-borne pathogens (Quarles 2017). Even a small increase in average temperatures can boost rates of population growth and average population densities of mosquitoes (Kinney et al. 2011). In addition, the biting rates of mosquitoes and the replication rates of the parasites and pathogens they transmit has been found to increase with rising temperatures (Harvell et al. 2002). These conditions may help to explain instances of malaria and expansion of the West Nile virus in New York. West Nile is carried by certain species of *Culex* mosquitoes and spread by birds and humans. Droughts act to bring birds and mosquitoes together at reduced water sources, and also to reduce populations of dragonflies and other predators of mosquitoes (Epstein 2000, 2001). These phenomena together may hasten the spread of the virus. Warmer temperatures may also make this region hospitable to the *Aedes* mosquitoes that spread the Zika virus.

Ticks do not survive prolonged periods of very cold temperatures. Warming winter temperatures are a significant factor in the northward spread of Lyme disease (Leighton et al. 2012) and the increased numbers of Lyme-infected ticks in the Northeast (Levi et al. 2015). Climate models predict that their populations will continue to expand northward into areas now considered to be too cold to support them (Brownstein et al. 2005, Ogden et al. 2005). The flourishing populations of wood ticks and Lyme-infected black-legged ticks in Greene County have been aided by the warmer winter temperatures.

Perhaps an even greater threat than increased populations of pest organisms is the likelihood of greater use of pesticides, which can have wide-ranging detrimental effects on non-target species, including humans.

A greater threat than increased pest populations may be from increased use of pesticides, which can cause wide-ranging harm to non-target species, including humans.

Threats to Water Resources

Human activities on the land have been changing the character, habitat quality, and water quality of streams, lakes, ponds, and wetlands for centuries by obstructing stream flows, altering patterns and volumes of surface water runoff, increasing soil erosion and siltation of streams, altering surface water temperatures, reducing groundwater infiltration, and contaminating surface water and groundwater. These threats continue today, and climate change is exacerbating the stresses and adding new ones.

Groundwater

Groundwater can be depleted by reducing recharge from the ground surface (e.g., by expansion of impervious surfaces such as pavement and roofs) and by excessive groundwater withdrawals (e.g., for industrial processes or commercial products or from crowded wells in residential areas). The last could become a more common problem in the more densely-settled areas of the county with the increasing frequency and severity of droughts predicted by climate scientists.

Groundwater is vulnerable to point source and non-point source pollution such as applications of fertilizers and pesticides to farm fields and lawns, nitrates and bacteria from septic systems, deicing salts from roads and driveways, and volatile polluting substances, such as organic compounds from leaks and improper disposal of petroleum and other fluids. Groundwater is especially vulnerable to pollution in areas of coarse-textured soils (sand, gravel) or carbonate bedrock (limestone, dolostone) (Winkley 2009).

The most significant potential sources of groundwater contamination in rural parts of Greene County may be from agricultural or golf course applications of fertilizers and pesticides, leaking fuel storage tanks, and storage and applications of road salt. Other possible sources are from wastewater discharges (e.g., from crowded, failing, or institutional septic systems) and from active or inactive landfills or hazardous waste disposal sites (Heisig 1998). Unfortunately, a small volume of a harmful substance can contaminate a large volume of groundwater and, once contaminated, groundwater can be very difficult and costly to clean up (Winkley 2009). Most Greene County residents and businesses obtain their drinking water from groundwater wells, so the quality and quantity of groundwater should be of great conservation concern to residents, businesses, and town agencies.

A small volume of a harmful sub-stance can contaminate a large volume of groundwater and, once contaminated, ground-water can be very difficult and costly to clean up.

Surface Water

Adding impervious surfaces (roads, driveways, parking lots, and roofs) usually increases runoff and reduces groundwater infiltration, leading to erosion of stream banks and siltation of stream bottoms, degrading stream habitat quality and water quality, and reducing the base flows of streams. Runoff from impervious surfaces can also raise the water temperature of streams, leading to reduced levels of dissolved oxygen and degraded habitat for sensitive stream organisms.

Clearing vegetation and disturbing soils on steep slopes or in areas of shallow soils (e.g., during construction of roads, driveways, or houses) often increase the surface runoff of precipitation and snowmelt, erosion of soils, and destabilization and siltation of nearby streams. The consequences are reduced groundwater recharge, loss of soils, and degradation of stream habitats for fish and other stream organisms. Stormwater management measures employed at development sites are often inadequate to restore and maintain the patterns, volumes, and quality of surface runoff and groundwater recharge that occurred prior to development.

Roadside ditches often carry contaminants such as motor oil, heavy metals, road salt and other de-icing chemicals, sand, and silt into nearby streams and wetlands. Applications of fertilizers and pesticides to agricultural fields, golf courses, lawns, and gardens can degrade the water quality of groundwater and streams and alter the biological communities of streams, wetlands, and ponds. Leachate from failing septic systems often introduces elevated levels of nutrients, especially phosphorus and nitrogen compounds, into streams, lakes, and ponds, leading to a cascade of effects on water chemistry, biota, and whole aquatic ecosystems. Cunningham et al. (2009) found that the amount of nutrients and sediments entering a stream is affected by the amount of development within 300 ft of the stream. Streams, lakes, and ponds are also subject to atmospheric deposition of substances such as sulfur dioxide, mercury, and nitrogen from fossil-fuel-burning power plants in the Midwest, as well as nitrogen compounds from distant agriculture (Driscoll et al. 2001).

Removal of shade-providing vegetation along a stream or pond shore for landscaping or other purposes can lead to elevated water temperatures and severely impact the aquatic invertebrate, amphibian, and fish communities that depend on cool environments. Clearing of vegetation and conversion of riparian areas to developed uses can also reduce the important exchange of nutrients and organic materials between the stream and the floodplain, diminish the capacity for flood attenuation, and increase downstream flooding.

> Forests are very effective at promoting the infiltration of rainwater and snowmelt to the soils

Forested land is very effective at facilitating the infiltration of rainwater and snowmelt to the soils, thus making it available for uptake by vegetation, for recharging the groundwater, and for slowly feeding streams, lakes, and ponds. Clearing of forests can greatly reduce infiltration to the soils and greatly increase the rapid runoff of surface water. This leads to "flashy" streams that run at high volumes during runoff events and then dry up at other times because groundwater is unavailable to feed the base flow.

Climate Change and Water

A warming climate is expected to affect both the quantity and quality of Greene County's groundwater and surface water resources, as well as the habitat quality of streams and ponds. Both total annual rainfall and rainstorm intensity are predicted to increase in New York in the coming years, with multiple consequences to the land, water resources, and agriculture.

Flooding hazards may increase due to the increasing intensity of large rainstorms. The areas within the 100-year and 500-year flood zones illustrated in figures 9a and 32 will be particularly at risk, but additional areas may also be affected. The magnitude of flooding at any location will depend on the timing and intensity of large storms and the condition of the land—the ability to absorb large water volumes at the time of the storm—as well as the structures or other obstacles in the flood zone that may act to divert, concentrate, and accelerate flood flows.

The "100-year flood zone" shown on maps created by the Federal Emergency Management Agency (FEMA) is the area that, based on historical flood data, has a 1% chance of flooding in any given year. The "500-year flood zone" is the area believed to have a 0.2% chance of flooding in any given year. The FEMA flood zone maps (Figure 9a) for most of the county are from a 2007-2008 baseline and do not take into account more recent large storms, such as Irene, Lee, and Sandy in 2011-2012.

The flood maps for several stream segments in the Town of Hunter, however, reflect revisions based on 2011-12 flood data.

Large floods can damage roads, bridges, and other infrastructure, destroy agricultural crops, wash away farmland soil, carry pollutants and large volumes of sediments into streams, and damage or destroy buildings and other structures in the flood zone. Much of the water volume from large rainfall or snowmelt events will run off quickly into streams and be unavailable for recharging groundwater.

More extended and more frequent droughts are also predicted (Shaw et al. 2011) and are likely to affect public water supplies, private drinking water wells, and farm ponds for watering livestock, as well as streams, other natural habitats, and native plants and animals.

More extreme floods and droughts, as well as increases in water temperatures, are likely to adversely impact populations of trout and other sensitive stream organisms that rely on cool, clear streams and unsilted stream substrates. (See the **Threats to Biological Resources** section below.)

Threats to Biological Resources

Due to the great interdependence of aquatic and upland habitats, many of the threats to water resources outlined above also threaten the plants and animals of upland forests, meadows, shrublands, and other habitats. Additional threats include habitat loss and degradation of habitats, over-harvesting, non-native pests, and diseases, and the numerous effects of global warming.

Habitat Loss

> Intact ecological communities enable ecosystems to withstand stresses and adapt to changing environmental conditions.

Loss of habitat occurs when new roads or residential, commercial, or industrial development eliminates former meadow or forest habitat, for example, or when unprotected wetlands are drained, filled, or converted to ornamental ponds. Local, state, and federal laws provide limited protection to certain wetlands and streams and the habitats of listed rare animal species, but most upland (i.e., non-wetland) habitats and many small wetlands lack any legal protection and are especially susceptible to loss. The local or regional disappearance of a habitat can lead to the local or regional extirpation of species that depend on that habitat.

The full consequences of the extinction of particular species or habitats are unknown, but each organism plays a particular role in maintaining its biological community, and the maintenance of each community at the regional scale enables ecosystems to withstand stresses and adapt to changing environmental conditions.

Less obvious but more insidious than direct loss of habitat is the problem of habitat degradation, which can occur by many mechanisms and have consequences that are often invisible in the near term. A ubiquitous form of degradation is habitat fragmentation.

Habitat Degradation

Habitats that are not lost to other uses can nonetheless be severely degraded by chemical or thermal pollution, sedimentation, and other direct and indirect disturbances such as trampling, cutting, nighttime lights, noise, invasive species, and fragmentation. These can severely alter the biological communities, ecological functions, and ecosystem services of the habitat and can lead to local disappearance of sensitive species of plants and animals.

Habitat Fragmentation

Habitat fragmentation occurs when an intact habitat area is split by a road, driveway, utility corridor, or other feature, dividing it into smaller segments. The subdivision of a large meadow or a large forest into building lots, for example, acts to divide it into smaller habitat blocks that may be unsuitable for the "area-sensitive wildlife" species that require large habitat areas and are sensitive to human contact or disturbances. Fragmentation of forests into smaller blocks increases the area of forest "edge" habitat where there are higher light and noise levels and drier conditions, and where invasion by non-native plant species and by predators such as raccoons and domestic cats is more likely. Fragmentation makes the formerly deep interior forest areas newly accessible to songbird nest predators and brood parasites (such as the brown-headed cowbird) whose activities are ordinarily confined to open areas and forest edges. Roads and other developed areas dividing forests can also act as significant barriers and hazards to wildlife movement, and many animals avoid breeding near human activities.

The "edge effects" of human disturbance (from roads, residential areas, and other development) can reach well over 300 feet into forest patches (Wilcove et al. 1986). A road or driveway through a large meadow can similarly reduce the habitat values of the meadow for grassland breeding birds, making the formerly deep interior meadow areas newly accessible to nest predators and other disturbance.

The "edge effects" of human disturbance (from roads, residential areas, and other development) can reach well over 300 feet into forest patches.

Many species of wildlife require more than one habitat to fulfill their life history needs, and some species are far ranging, with territories or movement areas spanning hundreds or thousands of acres. The fragmentation of habitats inhibits the ability of wildlife to move across the landscape. For some wildlife, the fragmenting features can disrupt their travelways and render critical parts of their habitats inaccessible or expose them to mortality from vehicles, predation, or dessication.

Another kind of habitat fragmentation occurs along streams where dams, culverts, or bridges interrupt the continuity of stream habitats. From headwaters to mouth, a stream is a continuous ecosystem dependent on free movement of nutrients, organic detritus, sediments, and animals. Many of our fishes need different parts of a stream for feeding, spawning, nursery areas, drought refuge, shelter from predators, and overwintering. Access to cool pools in summer, deep pools in winter, suitable substrates for spawning, and shallow nursery areas inaccessible to predators. Invertebrate drift from upstream reaches can also be essential to maintaining fish populations. Similarly, invertebrates, amphibians, reptiles, and other animals also need to move freely to take advantage of various stream habitats and materials in different life history stages, seasons, and stream conditions.

Dams are an obvious impediment to these movements, but bridges and culverts, if improperly sized, designed, and installed, can also act as partial or total barriers, severely altering stream flows and disrupting the stream ecology. Culverts that are suspended above the stream bottom prevent the movement of organisms and materials. Undersized bridges or culverts disrupt natural flow patterns, causing upstream impoundment and increasing downstream velocities, often leading to streambed scouring and bank erosion, as well as damage to bridges, roads, and other infrastructure. These are widespread causes of degraded stream habitats that have led to the loss of whole populations of fish unable to navigate those barriers or tolerate the habitat alterations.

To accommodate floodflows and the movement of stream organisms, a culvert should be large enough so that stream flows are unimpeded, even during flood events, and the lower invert should be buried in the stream bottom so that water depth and substrate are similar within and outside the culvert. Additional information on sizing, design, and installation of culverts and bridges can be obtained at http://www.dec.ny.gov/permits/49066.html.

> Maintaining broad connections between habitat areas can ensure that the habitat and migration requirements of many native plant and animal species are conserved across the landscape.

Over the last several years the Hudson River Estuary Program and the Cornell Cooperative Extension have been conducting surveys to identify culverts that are too small to carry expected floodflows or are suspended above the streambed. All streams have not yet been surveyed, but the project is continuing. The survey results are provided to local, county, and state agencies to help them prioritize culverts for replacement so that risk to infrastructure is reduced and stream continuity is restored. Figure 34 shows the locations of barriers identified so far on Greene County streams.

34 Aquatic Barriers

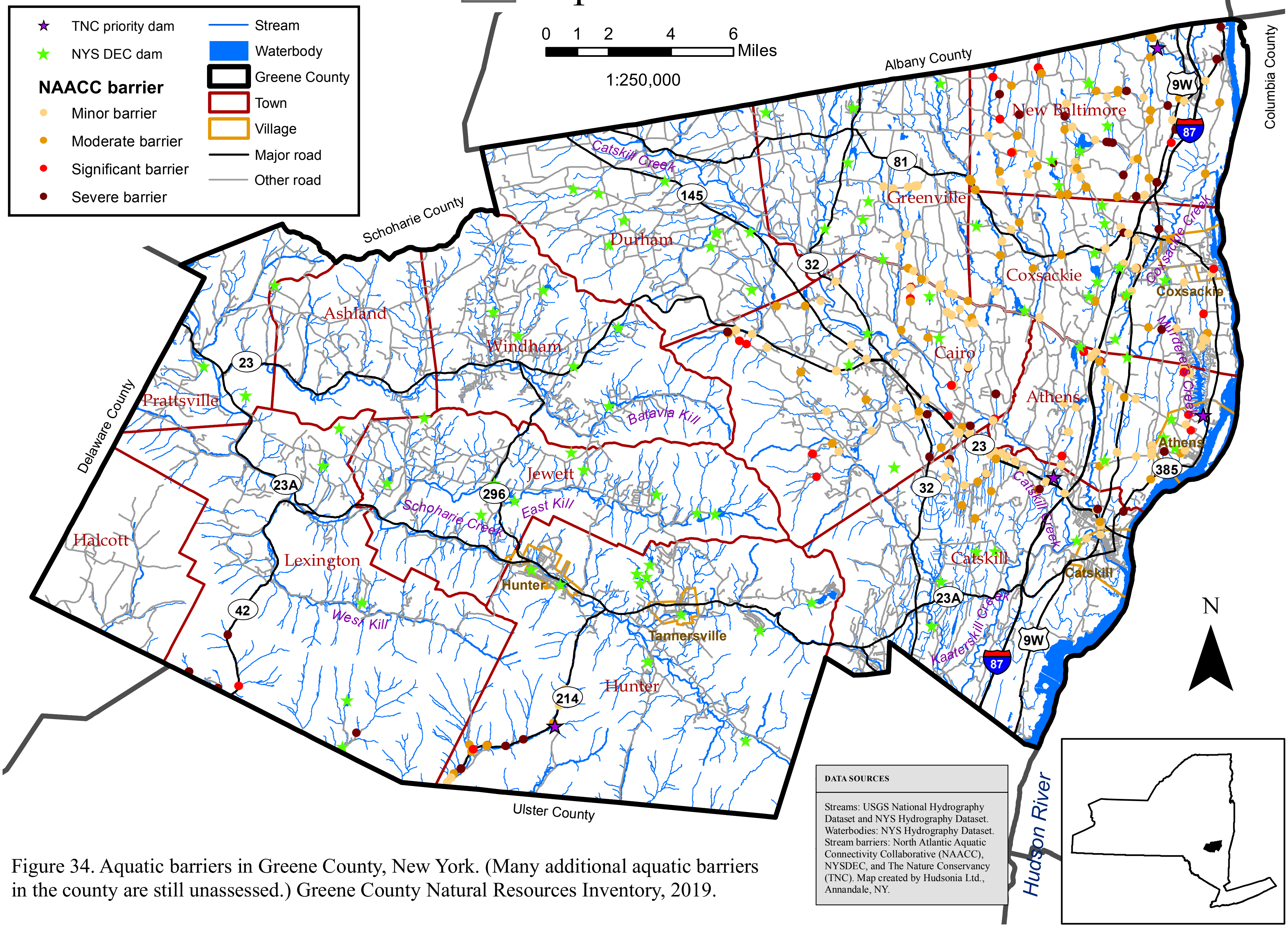

Figure 34. Aquatic barriers in Greene County, New York. (Many additional aquatic barriers in the county are still unassessed.) Greene County Natural Resources Inventory, 2019.

Maintaining habitat connectivity is critical for maintaining genetic exchange among distant populations and facilitating the migration of species under deteriorating environmental conditions or climate change. Species that are able to cross human-created barriers (such as roads) face greater mortality risk from vehicles and predators. Populations of species that are unable to cross barriers such as roads, walls, dams, or culverts, and thus are restricted to fragmented habitat patches, may become genetically isolated and face local extinction. Maintaining broad connections between habitat areas can ensure that the habitat, migration, and behavior requirements of many native plant and animal species are conserved across the landscape.

These days, a primary cause of ongoing habitat fragmentation in the region is rural sprawl—low-density development that occurs outside of population centers such as hamlets or villages. The county has few recent instances of large residential subdivisions where a property is broken up into 20 or more house lots. Instead, the main pattern of new development is subdivisions of 2-4 residential lots in a rural setting. The fragmentation of habitats is most severe when each lot is designed with the house located at the end of a long driveway. Utility corridors, roads, and even walking trails can have a similar fragmenting effect when located in an otherwise intact habitat area. Affluence, contemporary tastes, and today's engineering capabilities have led to more houses being built in places that were previously inaccessible or deemed unsuitable—such as hilltops, steep areas, and areas with shallow soils, where environmental damage is often greater.

Other Threats to Habitats

Forest habitats can be degraded in many ways besides fragmentation. Clearing the forest understory to create an appealing, park-like landscape destroys habitat for birds such as wood thrush,[†] which nests in dense understory vegetation, and hermit thrush, black-and-white warbler[†] and ovenbird,[†] which nest on the forest floor. Removal of native shrubs can also be an invitation to non-native invasive shrubs and forbs. Removal of mature and especially large trees eliminates habitat for lichens, fungi, and bryophytes, as well as the many kinds of animals that use cavities and that forage in and around large and decaying trees. Soil compaction and removal of dead and downed wood and debris eliminates habitat for mosses, lichens, fungi, birds, amphibians, reptiles, small mammals, and insects. Logging can damage the forest understory and cause soil erosion, compaction, and rutting, and sedimentation of streams. The soil disturbance, opened canopy, and introduced propagules carried by skidders and other equipment often leads to establishment of non-native invasive plants in previously uninfested areas. Human habitation in fire-prone forests leads to the suppression of naturally occurring wildfires, which can be important for some forest species and the forest ecosystem as a whole. Threats from recreational uses of forests are described in the **Recreation Impacts** section.

Crest, ledge, and talus habitats (including rocky barrens) often occur in locations that are valued by humans for recreational uses, scenic vistas, communication towers, and nowadays even for house sites. Construction of trails, roads, and houses destroys crest, ledge, and talus habitats directly, and causes fragmentation of these habitats and the forested areas of which they are often a part. Rare plants of crests are vulnerable to trampling and collecting; rare snakes are susceptible to road mortality, intentional killing, and collecting; and rare breeding birds of crests are easily disturbed by human activities nearby. The shallow soils of these habitats are extremely fragile and susceptible to erosion from construction and logging activities and from foot and ATV traffic. The specialized biological communities of rocky barrens are maintained by occasional wildfires, but such fires are suppressed where they occur near houses, barns, and other vulnerable structures. The scarcity of fires enables other, less-specialized forest species to colonize these areas and leads to the loss of the unusual plants and animals especially adapted to the rare barrens habitats.

Mowing of large upland meadows during the bird nesting season can cause extensive mortality of eggs, nestlings, and fledglings of ground-nesting grassland birds. Another threat to upland meadow habitats is the soil compaction and erosion caused by use of ATVs, farm equipment, and other vehicles, which can harm the soil structure and reduce the habitat value for invertebrates, small mammals, nesting birds, and nesting turtles.

Mowing of large upland meadows during the bird nesting season can cause extensive mortality of eggs, nestlings, and fledglings of ground-nesting grassland birds.

Pollution of air, water, and soils can come from a variety of sources, including agriculture, lawns, industry, roads, and vehicles. Cement kiln dust (CKD), for example, has the potential to leach arsenic, dioxins, and other contaminants into surface and groundwater. A 46-acre CKD landfill in Cementon is being remediated; a final cover was installed in 2016 to reduce high-pH impacts to the Hudson River (www.agruamerica.com).

Invasive Species, Insect Pests, and Diseases

Disturbances to soils from forest clearing, mining, and the construction of new houses and roadways, as well as domestic plantings in yards and gardens, often result in the spread of non-native invasive plant species. Establishment of many of these plants is favored by soil disturbance and unshaded conditions, and seeds and vegetative propagules of invasives are often transported by vehicles and earth-moving machinery from one site to another. Non-native species such as common reed, reed canary-grass, Japanese stiltgrass, Japanese knotweed, purple loosestrife, multiflora rose, Bell's honeysuckle, Japanese barberry, and tree-of-heaven are now widespread in Greene County but are most concentrated in areas in and near human land development and disturbance. Land development has the potential to promote the spread of these species into many high quality habitats and reduce the overall value of those habitats to native biodiversity.

Releasing leaf-eating beetles to control purple loosestrife (non-native) at the Coxsackie Creek Grassland Preserve. Photo: Bob Knighton © 2019

Non-native invasive species often lack significant consumers or diseases in their new environments and can outcompete native species for limited resources or space, resulting in the decline of native biological diversity. For example, the rusty crayfish (*Orconectes rusticus*)—native to the central and midwestern US—is large and aggressive, allowing it to escape predation and displace native crayfish. It has been found to reduce the populations of other important aquatic invertebrates, compete for food with native fish, and feed on fish eggs, especially trout (Conard et al. 2017). It may have arrived in our streams in fishermen's bait buckets, which can also carry other non-native animals, pathogens, and parasites.

The changing climate conditions may allow some insect pests and insect disease vectors to complete more generations per season and allow greater winter survival (Rodenhouse et al. 2009). Pathogens that are encouraged by less-severe winters will take advantage of the weakened condition of trees and other plants stressed by rising temperatures and droughts. Forest pests such as the hemlock woolly adelgid and the emerald ash borer are likely to transform our forest communities with wide-ranging ecosystem consequences. Invasive plants such as mile-a-minute-weed are expected to thrive under elevated atmospheric levels of carbon dioxide (Wolfe et al. 2011). Although the longer growing seasons may increase overall forest productivity (Kareiva and Ruckelshaus 2013), increases in pests and pathogens may cancel out the potential benefits to the timber industry.

The hemlock woolly adelgid (HWA) is a non-native aphid-like insect that has infested many eastern hemlock stands from Georgia to New England and has caused widespread loss of hemlock in the Hudson Valley. The adelgid typically kills a tree within 4-15 years and may cause the near extirpation of hemlock forests in the region (Orwig et al. 2002). The emerald ash borer (EAB) has recently arrived in the county and may kill most or all of the three native ash species of the region—white ash, green ash, and black ash. The pear thrip, an insect native to Europe, attacks domestic (pear, apple, plum, cherry) and native (serviceberry, black cherry) fruit trees and also native forest trees such as sugar maple, red maple, and American beech. A large outbreak can defoliate thousands of acres of forest and can be triggered by the warm, dry springs associated with global warming (Natural Resources Canada 2015). The warming climate might create more favorable conditions for these and other non-native forest pests.

Only four species of earthworms are known to be native to the Northeast (McCay et al. 2017); most of the worms we see in our lawns, gardens, meadows, and forests were imported, intentionally and not, from other places, starting with European settlers who brought plants (with soils) from home. European earthworms may also have been present in soils used as ship ballast. Introductions of worms continues through the present with the importation of horticultural plants from around the world and from other parts of North America, the transport and sale of worms for vermiculture and fishing bait, and probably in vehicle treads and by other inadvertent means.

While non-native earthworms have been highly valued by farmers and gardeners because of their ability to aerate soils and speed up nutrient cycling, those same actions can damage the soils, soil life, and plant communities of forests. The biota of our forest soils have adapted to slow decomposition of organic matter and slow processing of nutrients, which allows the accumulation of a deep layer of organic duff—leaves, twigs, and other organic debris in various stages of decay—on the soil surface. The duff is an important habitat component for vertebrates, invertebrates, fungi, and microbes of the forest floor, and helps to prevent soil erosion, maintain soil moisture, and provide nutrients for woody and herbaceous plants, invertebrates, and fungi. When earthworms are introduced to forest soils, they rapidly consume the organic duff, leaving bare soil that is no longer suitable for many native wildflowers, tree seedlings, ferns, fungi, ground-nesting or foraging birds, and amphibians (Bohlen et al. 2004). A Michigan study found that earthworm infestations were associated with crown die-back of sugar maples, perhaps because the loss of organic duff exposed these shallow-rooted trees to dessication (Bal et al. 2017). A recent arrival in New York, the snake worm (*Amynthas agrestis*), is especially large and voracious, and its parthenogenic reproduction allows a single adult to initiate a large local population. An infestation can remove the forest duff, alter the soil structure and chemistry, and create a forest floor habitat inviting to non-native plants such as garlic-mustard and Japanese stiltgrass (Raver 2007).

Human~Subsidized Wildlife

Human-caused changes to the landscape alter habitats and animal communities, favoring those species most adapted to open landscapes, small habitat patches, and human presence. For example, Canada goose, white-tailed deer, raccoon, and gray squirrel thrive in agricultural and residential areas and, when overabundant, cause cascades of ecological changes.

Human uses directly and unintentionally offer "resource subsidies" by providing food (such as household garbage, food or agricultural waste, stored feed, livestock, and pets) and winter shelter or den sites (such as attics, barns, sheds, and other structures), as well as intentionally by feeding birds and other wild animals. Native mammals that benefit from these subsidies include white-footed mouse, squirrels, and mesopredators including raccoon, Virginia opossum, striped skunk, and eastern coyote. Populations of these mammals are often large, and can have negative effects on populations of other wildlife and on humans.

Canada goose, white-tailed deer, and raccoon thrive in agricultural and residential areas and, when overabundant, cause cascades of ecological changes.

Eastern coyote successfully and rapidly colonized eastern North America starting in the early 1900s, due to the expansion of its preferred habitat (a mosaic of open, shrubby, and forested land), the extirpation of its main competitor, the eastern wolf, a growing population of white-tailed deer, and human-provided resource subsidies. Coyotes may cause declines in bobcat and red fox populations, and they sometimes prey on livestock. But they are also valuable as the only non-human predator that regularly preys on deer, and they help control deer populations where winter weather is severe (Ray 2000).

Raccoon populations have expanded rapidly in the Northeast since the 1930s, and often achieve the highest densities in urban and suburban areas, but they also thrive in rural residential and agricultural settings. They cause considerable agricultural damage, are a commonly reported nuisance in residential areas, spread disease, and depredate waterfowl, songbirds, other birds, and turtles. Striped skunk and Virginia opossum are also numerous in rural and urban areas, although less so than raccoons, and all three species use similar food resources and den sites. These mesopredators are vectors for numerous viruses (including rabies and canine distemper) and parasites, which affect other wildlife, pets, and humans. They also have large ecological influences on populations of their various prey species and of other carnivores (Ray 2000).

Many of the wildlife species that have become abundant in our residential and agricultural landscapes are "generalist scavengers" that also prey on songbirds. Some of these nest predators are American crow, blue jay, common grackle, raccoon, eastern gray squirrel, red squirrel, and Virginia opossum—as well as hawks and owls. In rural landscapes, songbird nest failure has been shown to increase with the abundance of potential nest predators (Rodewald et al. 2011).

The brown-headed cowbird is a native blackbird that originally occurred only in the open grasslands of the central and western US and Canada but moved east as the forested land was cleared by European settlers; it now inhabits most of North America. The brown-headed cowbird makes no nest of its own, but lays its eggs in the nests of other species. The eggs are early to hatch and the nestlings quick to develop, outcompeting the young of the host species for food. The cowbird benefits from forest fragmentation and has been implicated in the decline of many songbird species in the Northeast.

Feeding birds has been shown to increase local population sizes in some of the songbirds that consume birdseed, although the effect may be due to immigration, leaving the overall population unchanged. Provisioning may either increase or reduce the breeding success of these birds, depending on the species and situation. Feeding birds can increase nest predation on songbirds by increasing populations of the nest predators mentioned above.

Feeding large animals such as deer and bear leads to more frequent aggressive encounters and the need to remove problem individuals (Cox & Gaston 2018). Domesticated cats and dogs, whether feral or pets with access to the outdoors, pose serious threats to wildlife. Cats kill up to 4 billion birds and 22 billion mammals annually in the US. Free-ranging dogs kill fewer individuals but often chase or injure other animals. The presence of cats or dogs can cause wild species to shift their ranges, exhibit physiological or behavioral changes, or have reduced reproductive success. Rabies, canine distemper, and other viruses and parasites are regularly transmitted from pets to wildlife via contact or feces (Twardek et al. 2017).

The white-tailed deer is native to this region and has been a part of our forest ecosystems since long before European arrival on this continent. The present-day over-population of deer, however, has severely affected our forest communities. The reasons for the large population are many: for example, extirpation of major predators—eastern wolf and eastern cougar; abundant food sources in our cropfields, roadsides, lawns, and gardens; decline of recreational and subsistence deer hunting; and expansion of human-settled areas where deer are partially shielded from hunters and predators.

Selective browsing by deer prevents the regeneration of many of our forest tree, shrub, and wildflower species, and encourages infestations of non-native plants.

Selective browsing by deer prevents the regeneration of many of our forest tree, shrub, and wildflower species, and encourages infestations of non-native plants (Rawinski 2008). Deer herbivory on native understory herbs and shrubs (and perhaps non-browsing effects from deer, such as litter disturbance, soil compaction, and changes in soil chemistry) also promotes the invasion and spread of some non-native plants such as garlic-mustard and Japanese barberry, although palatable non-natives such as multiflora rose and Eurasian honeysuckles may be kept in check by deer in some situations (Eschtruth and Battles 2009 (Blossey and Gorchov 2017).

> The permanent loss of the wolf and cougar has profoundly affected the ecology of northeastern landscapes, affecting deer populations, forest regeneration, spread of tick-borne diseases, and invasive forest plant infestations.

Excessive deer herbivory also affects breeding bird communities, invertebrates that depend on understory plants, squirrel populations (which in turn affect bird nesting success), and tick abundance and the prevalence of tick-borne diseases (Waller and Alverson 1997). For example, where deer are more abundant, songbirds that use understory foliage (such as white-eyed vireo, hooded warbler, and prairie warbler) are less abundant (Jirinec et al. 2017). Deer also cause agricultural losses ($59 million in New York in 2002), collisions with vehicles (over 70,000 in New York in 2011), and damage to home gardens and landscaping (NYSDEC 2011).

Today the population of white-tailed deer is at a pestilential level in Greene County and much of southeastern New York, but reducing the population to a reasonable level has been an intractable problem. Should successful control measures eventually be discovered, a prudent goal would be to foster and maintain a modest, self-sustaining deer population that matches the carrying capacity of the land.

Unsustainable Harvest

The region has a long history of overfishing, overhunting, and over-gathering, which, at times, has imperiled or extinguished regional populations of certain species and has dramatically altered the ecology of the region.

Hudson Valley beaver were trapped to extinction by the mid-1700s to supply the fur trade with Europe, even before the widespread settlement of European colonists. The eastern wolf and eastern cougar were hunted to extinction throughout the Northeast by the 1890s. Wild turkey was also eliminated by over-hunting throughout the state in that period, and white-tailed deer was extinguished or nearly so in the Hudson Valley and nearby areas. The deer population has since recovered. Some of the wild turkeys from Pennsylvania that later repopulated areas of western New York were captured and transplanted in the 1950s-60s by NYSDEC to restore populations throughout the state. The wild turkey population in Greene County is now large and apparently thriving. Beaver have since returned and the regional population may be secure for the time being, although their ecological roles are somewhat curtailed due to widespread human interventions to limit flooding from beaver dams. The permanent loss of the wolf and cougar—top predators here for thousands of years—has had devastating effects on the ecology of northeastern landscapes, affecting, for example, deer populations, forest regeneration, spread of tick-borne diseases, and invasive forest plant infestations.

By 1900 overfishing had so severely depleted the Hudson River fishery that the NYS fish and game agency established a fish hatchery to artificially replenish or introduce certain species in the Hudson River and tributaries (Stott 2007). Fish stocking in Greene County streams continues today to support the recreational fishery. Overfishing, probably aided by water pollution and zebra mussel infestation, caused such severe depletion of American shad in the Hudson River and tributaries that NYSDEC closed the fishery in 2010, and it remains closed today.

Over-collection of certain wildflowers led to statewide restrictions on collecting "Exploitably Vulnerable" plants without landowner permission. Overharvesting of ramps (wild leek) and American ginseng continues to deplete local populations, however, and overharvesting of edible mushrooms and fiddleheads may have similar local effects.

Collecting of rare species of plants and animals has long been of concern to NYSDEC and the New York Natural Heritage Program. It is illegal to collect or harm state-listed Endangered or Threatened plants without the landowner's permission and to collect or harm state-listed Endangered or Threatened animals, but a black market for some rare species, especially rare reptiles, amphibians, and orchids, continues to thrive.

Climate Change and Ecosystems

Global warming is predicted to affect Greene County ecosystems in numerous ways, but the timing and magnitude of effects will depend in part on the worldwide levels of greenhouse gas emissions to the atmosphere. Mentioned below are just a few of the expected changes, many of which are already occurring in the region.

Warmer summer and winter temperatures, longer growing seasons, and elevated levels of atmospheric carbon dioxide will favor certain plants and disfavor others, and are thus likely to alter the composition of plant communities. Many of our native plants and animals have adapted over thousands of years to the seasonal temperature ranges of the Northeast and are ill-equipped to adapt quickly to the present-day pace of warming—several orders of magnitude faster than the temperature changes experienced during the most recent ice age (Wolfe et al. 2011). The widespread fragmentation of today's landscape by roads and land development poses additional obstacles to adaptation and migration in response to climate change.

While floods and droughts are normal and expected events in this region, extreme floods and droughts can add to the multiple stresses on ecosystems from human activities. Warming in the region is predicted to significantly affect the composition and distribution of habitats and wildlife, and will force many species to migrate to cooler microclimates, higher elevations, or higher latitudes as former habitats become unsuitable. Cold-adapted species such as sugar maple, brook trout, spring salamander, and fisher are especially at risk. Together with non-climate stressors such as habitat fragmentation, water pollution, invasive species, and overharvesting, climate change will have synergistic effects that magnify the stresses and hazards to wildlife (Hannah et al. 2005).

Already, many plant species now bloom 4-8 days earlier on average than in the early 1970s (Union of Concerned Scientists 2006) and 2-3 weeks earlier than they did a century ago (Ellwood et al. 2013)—an effect that may have far-reaching ecological consequences. For example, insect pollinators whose activity periods are closely tied to the historical flowering periods of their food plants may find that their pollen and nectar foods are unavailable at critical times in the pollinators' life cycles. This would add to the existing stresses from more frequent and more severe weather events and could severely harm regional populations of these insects.

Heat stress effects on native plants and animals may eliminate some of the cold-adapted species and communities from our landscapes. Warmer, shorter winters and prolonged winter thaws may make some perennial plants more vulnerable to mid-winter freeze damage by disrupting their accustomed dormancy period, and may subject the early leaves and flower buds to frost damage (Wolfe et al. 2011). Reduced snow cover will harm small mammals and other animals that depend on snow for insulation and protection from predators, but it may favor their predators, such as foxes and eastern coyote, and may also favor white-tailed deer—already over-abundant—whose intense grazing pressure has been transforming our forests for several decades.

Surface water temperatures will rise along with air temperatures. Higher water temperatures reduce the concentrations of dissolved oxygen—a key habitat component for fish and other aquatic organisms—in streams, lakes, and ponds. The life cycles of many stream invertebrates are closely tied to water temperatures and the seasonal patterns of water temperature fluctuations. Alterations to water temperatures will have large effects on the fish, salamanders, turtles, and other biota of streams and ponds—organisms that are already stressed by water pollution, siltation, and competition from non-native fish.

In general, most at risk will be the plants, animals, and communities with more specialized habitat or food requirements or specialized interactions with other species (e.g., butterflies and their host plants) that are likely to be disrupted by climate change, those with poor dispersal ability (i.e., with limited ability to move from a degraded habitat to a more suitable one), and those with already-low population levels, including endangered, threatened, and special concern species. Plants and animals likely to benefit from climate change are those that are habitat- and food-generalists, such as white-tailed deer, warmwater fishes (e.g., bass, pickerel, sunfish, white perch), adaptable songbirds (e.g., northern cardinal, American robin, house sparrow, and European starling), and non-native invasive plant species (Wolfe et al. 2011).

For the Greene County reach of the Hudson River, climate models predict a sea level rise of at least 11 inches by the end of this century, and as much as 70 inches or more under a high greenhouse gas emissions scenario. This will affect tidal wetlands and non-tidal shoreline habitats, as well as the built environment along the Hudson River shoreline. Some of the existing tidal wetlands will be drowned, while some will become different kinds of wetlands—i.e., a tidal marsh may become a mudflat or shallows, and a tidal swamp may become a marsh or mudflat. Where the shoreline topography allows, certain non-tidal areas along the shore may become tidal wetlands (figures 30-33). The timing of these changes is uncertain, as is the ability of tidal wetland plants and animals to adapt to these changing conditions.

American Lake Scene. Thomas Cole (ca. 1844)

Threats to Agriculture, Farms, and Farmland

Farmland is sometimes abandoned by farmers and non-farming landowners for a variety of reasons and then, if left undeveloped and unmanaged, it usually reverts to oldfield, shrubland, and eventually forest. All of those stages offer valuable habitat for native plants and animals, and the land can be returned to agricultural uses at any time, although reclearing a shrubland or forest is labor-intensive. Farmland is lost permanently, however, if the soils are excavated or contaminated, or if the land is developed with structures, pavement, roads, and driveways.

Soils can be easily damaged by poor farming practices, compaction, toxic contamination, and other disturbances and can be easily lost to erosion where unvegetated cropfields are exposed to large rainstorms or snowmelt events, or to the forces of floodwaters. Protecting areas with good farmland soils is a fundamental requirement for maintaining the potential for viable local agriculture and its large benefits for the county's economy, local and regional food security, the scenic character of the landscape, and the culture of the county's human community.

Agricultural land is often lost to developed uses both because of the financial needs of retiring farmers and because the open farmland is easy to convert to non-agricultural uses. Table 13 shows the changes in Greene County farm status in the period 2007 - 2017.

Table 13. Status of Greene County farms as of the 2017 USDA Farm Census. Acreage includes land both owned and used (rented or leased) by each farm operation.

	2007	2017	% change
Number of farms	286	206	-28
Land in farms	44,328 ac	34,979 ac	-21
Average size of farm	155 ac	170 ac	+8
Market value of products sold	$16,373,000	$19,761,000	+21
Average market value of products per farm	$57,249	$95,927	+67

The growth in demand for high quality local and organic food in the Hudson Valley and the greater New York metropolitan region during the last two decades comes at a time when escalating property values have made maintaining large farm properties unaffordable to many multi-generational farming families.

Partly due to the high costs of real estate in the county, some land that is farmed today is leased by farmers from non-farmer landowners. The short-term economic benefits of leased land arrangements are limited by farmers' needs for permanence, housing, and equity. A lease arrangement allows farmers to avoid some of the costs of land ownership but usually does not permit them to develop equity in the land, and leaves them vulnerable to the whims of the landowner. New farmers likewise face a critical shortage of accessible and affordable farmland.

Subdivision of large farmland parcels into smaller lots poses another threat to the viability of land for farming. While some types of farming, such as flower- or herb- growing, are practical on smaller parcels, many types of farm operations are inefficient and impractical on small parcels, so subdivision of the property can mean the end of farming on those parcels.

Even where conservation organizations have succeeded in acquiring conservation easements or development rights on important farmland parcels, keeping farms in active agriculture can be a major challenge. Farmland protection must go beyond open space protection to address access and affordability of farmland, and maintaining opportunities for farming on protected agricultural lands.

Climate Change and Agriculture

Climate change is likely to affect agriculture in a variety of ways—some even beneficial; for example, warmer summers, warmer winters, longer growing seasons, and higher atmospheric carbon dioxide (CO2) levels will favor some crops. But the mechanisms will be complex, with differential effects on crop growth, weeds, invertebrates, and pathogens. For example, higher CO_2 levels may benefit aggressive weeds even more than the crops and may increase their resistance to herbicides (Ziska and Runion 2006). Warmer temperatures will be harmful to many existing crops and livestock—especially dairy cows—adapted to cool climates, and will require adjustments to longstanding farm practices. For dairy cows heat stress can lead to lower milk production, reduced calving, and increased risk for health disorders. Heat stress similarly affects the well-being and productivity of other livestock, including beef cattle, pigs, and chickens (Klinedinst et al. 1993).

> Rising winter temperatures are allowing the northward expansion of agricultural pests that reduce crop production.

Increased frequency of summer droughts will stress many crops, and more frequent large rainstorms and flood events will lead to direct losses of crops, soils, and nutrients, as well as costly delays in field access for farm equipment due to wet soils. Some insect pests, pathogens, and weeds will be favored by less severe winters. Rising winter temperatures are already allowing the northward expansion of agricultural pests that reduce crop production. Disruption of heat/thaw patterns may be especially harmful to woody plants (e.g., fruit trees) and perennial herbs (Wolfe et al. 2011). Warming temperatures may have the effect of uncoupling the activity periods of insect pollinators from the flowering periods of both crop plants and native plants that rely on those pollinators.

Perennial fruit crops are affected by the climate year-round, and the stresses experienced in one growing season may affect growth and productivity for two or more years afterward. While apple trees may benefit from longer growing seasons and increased atmospheric carbon dioxide, warm winters may reduce fruit production the following summer, especially for the cold-adapted varieties, and summer heat stress and drought may harm the fruit quality. Greater variation in springtime temperatures can be especially harmful to fruit crops; when warm springs are punctuated by hard frosts, fruit damage becomes more likely. Transitioning to warm-climate fruit varieties is an appropriate response, but will nonetheless be costly to farmers. These kinds of effects will put additional financial strain on farm operations whose profitability is already marginal.

Disruption of the late winter/early spring freeze-thaw cycles will reduce the quality and quantity of maple syrup production. Indeed, sugar maples may be entirely displaced from the region by 2100, with suitable cool, moist habitat remaining only on the highest peaks in the Adirondacks (Wolfe et al. 2011).

Recreation Impacts

Outdoor recreation increases our understanding and appreciation of the natural world; improves our physical and mental health; promotes family and social bonding; increases our productivity; and contributes to the local economy. Outdoor recreation is of great value to the residents, visitors, and businesses of Greene County, and expanding opportunities for public recreation is a goal probably shared by many communities in the county, especially those outside of the Catskill Park. Nevertheless, the use of natural areas for recreation inevitably comes with environmental costs. These can be anticipated by land managers and mitigated by appropriate planning, design, and management techniques.

> Walking trails located near the forest edge instead of in the interior would cause less disturbance to sensitive forest-interior wildlife species.

Trails for biking, ATVs, snowmobiling, and even walking can be disruptive to habitats and wildlife. Noise and pollution from motorized vehicles can disturb wildlife and harm forest habitats. Trampling and vehicle use cause damage to vegetation, reduced organic duff, and compaction and other changes to soils. These in turn can change plant communities along trails and other trampled areas, promote the introduction and spread of non-native plants, and alter patterns of surface runoff in ways that increase erosion and stream sedimentation. Trails provide an avenue into forests for non-native invasive plants. Trails that create an open canopy over the trail can invite nest predators and brood parasites into the forest interior. Even quiet, non-consumptive recreation such as hiking or birdwatching during the breeding and nesting season can disrupt the courtship behavior of adult birds and lead to abandonment of eggs or nestlings (e.g., for grassland and forest birds near heavily used trails), eventually skewing natural communities in favor of disturbance-tolerant species (Marion et al. 2015). Foot trails located near a habitat edge instead of the interior would cause less disturbance to the sensitive interior wildlife species.

Campsites cause similar disturbances, in addition to the effects of firewood collection, campfires, and improper waste disposal. Intentional or unintentional feeding of wildlife contributes to the dominance of subsidized species at the expense of others, changes ecological relationships, facilitates the spread of diseases, and increases the likelihood of nuisance behavior or attacks on people.

Noise and light pollution associated with recreation activities have greater ecological effects than most people realize. Artificial night lighting can disorient, repel, attract, entrap, or kill a wide range of organisms including moths, other insects, birds, frogs, and fish, and can reduce reproductive success (birds, amphibians) and disrupt communication (fireflies, coyote), bird migration, and predator-prey relationships (Longcore & Rich 2004). Anthropogenic noise alters behavior, reduces habitat quality, and causes physiological impacts across a range of species. Noise levels that are annoying to humans (40-100 dB) also disturb wildlife, and negative health effects occur in both humans and wildlife when levels exceed 52-80 dB. (For comparison, a floor fan can produce about 50 dB, an air conditioning unit 60, conversation 65, a lawn mower 90.) At these levels (well below ATV/motorboat noise), birds, bats, and frogs have been found to suffer effects such as changed vocalization patterns, difficulty locating mates, reduced reproductive success, and altered abundance, distribution, physiology, and development (Shannon et al. 2016).

Shoreline development and motorized watercraft cause the greatest problems for the water quality and ecological integrity of rivers and lakes.

Trails and campsites may be especially damaging when located in riparian zones (contributing to sedimentation, phosphates, and *E. coli* in streams), on rocky ridges or other places with shallow soils, and near other fragile habitats (e.g., acidic bogs) or easily-disturbed species of conservation concern (e.g., nesting raptors or great blue heron). In general, a trail represents a linear corridor of disturbance. The "area of influence" in the vicinity of the trail may extend 300-1000 ft or more from trails in open areas and shorter distances in forest (Taylor & Knight 2003). Motorized vehicle use on trails and access roads usually has larger impacts than other uses in terms of soil disturbance, vegetation damage, noise, air and water pollution, and disturbance of wildlife. For some animals such as raptors, however, a pedestrian can cause more disturbance than a vehicle.

Spent bullets and lost fishing tackle are significant sources of lead released to the environment. Water birds often eat lead tackle, and this is the cause of 49% of known common loon deaths in New Hampshire, for example. Lead bullets fragment on impact, resulting in an average of 235 fragments in an animal carcass and 170 in the viscera. Scavenging birds such as eagles, vultures, and ravens can accumulate sufficient lead during the hunting season to suffer neurological effects and mortality, although it is not known to what extent populations of these species are affected. Lead-free bullets and fishing tackle are available but still not widely used in most parts of the US (Haig et al. 2014).

Additional effects on aquatic systems are associated with water-based recreation. Non-motorized boating may have the least impact on aquatic communities, but even canoeing can cause stress responses in fish and declines in aquatic plant richness. Swimming can introduce chemicals from sunscreens, soaps, and cosmetics, affecting invertebrates; and swimmer presence may change the behavior and physiology of turtles and fishes. Recreational fishing and stocking of non-native fish can severely affect native fish populations as well those of their prey and predators, lowering overall diversity, transmitting fish diseases, and introducing excess nutrients and invasive aquatic species and earthworms (from bait) (Venohr et al. 2018).

Motorized watercraft use and shoreline development cause by far the greatest problems for the water quality and ecological integrity of rivers and lakes. Engine noise, wave action, suspension of sediment, spilled fuel and engine oil, and destruction of aquatic vegetation can pollute water, change behavior and communication in fishes, kill fishes and turtles, disrupt bird nesting, and disperse invasive species—resulting in the disruption of food webs and a decline in diversity of plants and animals. Land development or other significant disturbance to the riparian or shoreline buffer vegetation can have similar effects (Venohr et al. 2018).

Despite these potential adverse impacts of recreation uses, many can be avoided or minimized by public education, good design of recreation amenities, good planning and land management, and monitoring and prompt remediation of problems when they arise. Some mitigating measures are described in the **Conservation Principles and Measures** section below.

Eastern bluebird at Brandow Point.
Photo: Bob Knighton © 2019

CONSERVATION PRINCIPLES AND MEASURES

This section outlines some basic principles and measures for uses and effective conservation of resources of concern, including measures that will help to address anticipated impacts of climate change. Many of these echo and expand on principles and concepts set forth in the 2007 *Greene County Comprehensive Economic Development Plan*. Examples of local policies, procedures, and legislation to implement these measures are in the **Legislative Protections** section below.

Conservation of Mineral Resources

Limestone, sandstone, shale, clay, sand, and gravel have long been mined commercially in Greene County, and all but clay are still mined today. Renewed mining of other materials could occur with changes in domestic or international markets, or if needs for local self-sufficiency become more acute.

These materials are locked up, however, when land is developed with pavement and structures. Municipalities may wish to consider these resources in light of potential future needs and the compatibility of mining with other community goals. Maintaining access to mineral resources would ensure that they are available if needed, and help to avoid the great expense of importing materials from elsewhere for local uses.

Municipalities that are concerned about maintaining access to mineral resources to support local self-sufficiency, local businesses, and local economies may want to proactively designate certain areas as reserves for potential mining uses so that future opportunities for resource extraction are not lost to land development (Kelly 2011).

Soils are a critical resource for ecological communities and for most kinds of agriculture and are capable of storing large amounts of carbon. Soils are regularly lost due to erosion on construction sites and agricultural fields, and inadequate stormwater management in developed areas, and they are damaged by contamination, depletion, and compaction. Eroded sediments that are washed into wetlands and streams degrade the quality of the water and aquatic habitats.

Soils are slow to develop from mineral and organic material, weathering, and organic processes and are slow to recover when damaged, so soil conservation should be a primary objective of land stewardship.

Measures for soil conservation on construction sites include practices such as preserving topsoil; minimizing cutting and filling; minimizing areas of exposed (unvegetated) soils at all times; and stabilizing, seeding, and planting exposed soils immediately upon final grading. Soil conservation on agricultural lands includes practices such as crop rotation, reduced tillage, cross-slope tillage, mulching, cover cropping, minimizing disturbance of wet soils (including from livestock or equipment), and minimizing applications of fertilizers and pesticides.

GENERAL MEASURES FOR CONSERVATION OF MINERAL RESOURCES

- Seek to conserve representatives of all the local bedrock and surficial geology types to ensure that the natural systems supported by those features and materials can persist.
- On construction sites and in developed areas, employ grading, seeding, and mulching practices that reduce soil disturbance and exposure, quickly stabilize soils after disturbance, and prevent erosion and soil loss.
- On agricultural land, avoid overgrazing, minimize soil compaction from vehicles, use cover crops to reduce exposure of bare soils, minimize tillage, and avoid or minimize use of pesticides (including soil fumigants, insecticides, fungicides, herbicides) to reduce harm to soil structure and beneficial soil biota.

Conservation of Water Resources

Forested landscapes are the best insurance for sustaining groundwater supplies, ample water in lakes and ponds, and cool, clean streams with stable banks. Forests with intact canopy, understory, ground vegetation, and floors are very effective at promoting infiltration of precipitation to the soils and preventing rapid runoff of rainwater and snowmelt and the consequent damage to streams, ponds, and wetlands.

> Forested landscapes are the best insurance for sustaining groundwater supplies, ample water in lakes and ponds, and cool, clean streams with stable banks.

Groundwater throughout the county is of conservation concern because it is the source of most of the drinking water for residents and businesses, and is essential to Greene County ecosystems. The unconsolidated aquifers in the county deserve particular attention, as they are important groundwater recharge areas and are the largest and most accessible potential sources for well withdrawals, but are also the most vulnerable to contamination. They are located in permeable glacial deposits (sands and gravels) that can be efficient conduits for contaminants introduced by above-ground human activities. Avoiding both impervious surfaces and potential contamination in these most vulnerable land areas will help to preserve groundwater quality and quanties.

The water quality, flow volumes, and flow patterns of a stream, as well as the types and quality of instream habitats depend to a large extent on characteristics of the stream's watershed—the entire land area that drains into the stream. The condition of the soils and land cover in the watershed determine the quality and quantity of water available to a stream throughout the year. Both surface water and groundwater will best be protected by maintaining forested landscapes wherever possible, minimizing use of agricultural fertilizers, reducing or avoiding use of pesticides and other toxins as much as possible, and carefully designing stormwater management systems to reduce surface runoff and promote infiltration of precipitation and snowmelt to the soils.

Maintaining dense vegetation cover in roadside ditches will reduce soil erosion and reduce sediments carried into streams. Directing ditch flow into vegetated swales or detention basins will further reduce harm to streams from large runoff events.

Maintaining "soft" stream banks and full connectivity between streams and their floodplains allows floodwaters to spread out, thus dampening downstream floodflows, and reducing downstream bank erosion and potential flood damage to property and infrastructure. It also allows movement of organisms and exchange of organic materials and sediments between the stream and floodplain, thus benefiting the habitats of both. Conserving intact habitats in and near flood-prone areas, and removing engineered features, buildings, and other structures, can help reduce local and downstream flood damage while promoting groundwater recharge, improving stream health, and providing valuable wildlife habitats.

Conserving intact habitats in flood-prone areas can help reduce local and down-stream flooding.

Impervious surfaces such as roads, driveways, parking lots, and roofs impede water infiltration to the soils, reduce groundwater recharge, and promote rapid runoff of rainwater and snowmelt into ditches, streams, and wetlands. These effects create "flashy" streams with brief periods of high flow volumes during runoff events followed by prolonged periods of low flow or no flow. The reduced volumes of groundwater recharge reduce the capability of groundwater to support the base flow of streams during dry periods.

The New York Natural Heritage Program published the *New York State Riparian Opportunity Assessment* (Conley et al. 2018,) which identifies and prioritizes riparian restoration projects to improve wildlife habitat, water quality, and climate resiliency, and to provide flood protection during storm events. The assessment promotes science-based decision-making to achieve multiple benefits from improvements, maintenance, or protection of riparian areas.

In anticipation of prolonged droughts, municipalities could establish water conservation programs to harvest rainwater for domestic and agricultural use, increase water usage efficiency, and adopt local legislation and other measures for water source protection. These could include a water source overlay zone (to protect the watersheds of headwater streams), acquisition of key land parcels in the vicinity of unconsolidated aquifers and drinking water reservoirs, use of green infrastructure where appropriate, minimization of impervious surfaces, and strict stormwater management requirements to promote onsite infiltration of rainwater and snowmelt.

Adoption of *Better Site Design* principles and measures can help a municipality achieve some of these goals (Center for Watershed Protection 1998, https://owl.cwp.org/mdocs-posts/better-site-design-part-1/).

Marshy retention pond, Coxsackie. Photo: Jill Knapp © 2019

GENERAL MEASURES FOR WATER RESOURCE CONSERVATION

- Throughout the landscape, maintain forests with intact vegetation and undisturbed forest floors wherever possible.
- Minimize applications of polluting substances, such as de-icing salts to roads, parking lots, and driveways
- Minimize applications of pesticides and fertilizers to lawns, gardens, and agricultural fields.
- In areas of unconsolidated aquifers, minimize impervious surfaces and avoid siting land uses with potential for contaminating soils and water. Educate landowners in these areas about the vulnerability of groundwater resources.
- On development sites, minimize impervious surfaces and manage stormwater in ways that maintain pre-development patterns and volumes of surface runoff and infiltration to the soils. Retrofit existing sites to achieve these goals where possible.
- Site, construct, and maintain septic systems such that septic leachate does not contaminate groundwater or surface water resources.
- Redesign and retrofit roadside ditches and other stormwater systems to maximize water infiltration to the soils, and minimize rapid and direct runoff into streams, ponds, and wetlands.
- Direct runoff from agricultural fields into basins and well-vegetated swales instead of directly into streams or wetlands to prevent sedimentation and the introduction of excess nutrients, pathogens, and toxins to these sensitive habitats.
- Protect wetlands and streams from direct disturbance, and establish and maintain broad buffer zones of undisturbed vegetation and soils along streams, and around wetlands, lakes, and ponds.
- Consider the 500-year flood zone when planning land management and land uses along streams.
- Design new culverts and bridges and retrofit existing ones to maintain the continuity of stream gradients and substrates, and to accommodate storms of 500-year intensity in anticipation of more severe storms in coming decades.
- Keep floodplain meadows well-vegetated. Minimize tillage in floodplains, seed immediately after tilling, and leave abundant thatch to cover exposed soils; use cover crops in winter.
- Prohibit the building of new structures in flood zones, and remove existing structures, pavement, and hazardous materials from flood zones wherever possible.
- In flood zones, shift to resilient land uses that can withstand moderate to severe flooding; for example, parks, ballfields, hiking trails, picnic areas, fishing access sites, pastures, and hayfields.
- Regulate and monitor extractive commercial uses of water to ensure that water withdrawals from groundwater or surface water sources are at sustainable levels.

Conservation of Biological Resources

Most of the land in the county is held by private landowners in thousands of parcels of all sizes from less than ½ acre to hundreds of acres. This is typical of rural areas of the Northeast, but it creates special challenges for maintaining connected landscapes and wildlife travel corridors that must cross multiple property boundaries. The connectivity of habitat areas and the persistence of much of the county's biological diversity depend on the land uses and land management choices of many individual property owners. Educating landowners about the roles their land plays in the larger ecosystem is thus an important component of local conservation.

Greene County has the fortunate distinction of having large areas of intact (undeveloped) land with formal protected status, including areas of great regional and even global significance for biodiversity and for resilience to climate change. Much of the protected land is concentrated in the western half of the county, but there are many other places without formal protected status that are of great importance for plants, animals, and habitats of conservation concern, including stream corridors, limestone landscapes, large grasslands, large forests, rocky barrens, and small wetlands on privately-held lands. Finding ways to protect (formally and informally) the most important and sensitive areas and to maintain intact connections between protected areas will help to ensure that intact ecosystems and the native biological diversity of the county will persist long into the future.

> Educating landowners about the roles their land plays in the larger ecosystem is an important component of local conservation.

For example, maintaining large contiguous areas of intact habitats will help to ensure the persistence of area-sensitive wildlife species that require large habitat patches to fulfill their life history needs, and will also protect the array of natural communities, even those communities of which we are yet unaware. Protecting high-quality representatives of all ecologically significant habitats or communities (such as rocky barrens, calcareous and acidic ledges, upland deciduous forests, conifer swamps, woodland pools, bogs, intermittent streams) and areas with concentrations of unusual and rare habitats will help ensure that the most imperiled biological communities will not disappear.

Many of the basic principles for biological resource conservation, mentioned or hinted at in foregoing discussions, can be summarized as follows (adapted from Kiviat and Stevens 2001):

- Large tracts of undeveloped land and connectivity among diverse habitats are important to many species of rare, declining, and vulnerable plants and animals of Greene County.
- Broad corridors for seasonal or annual migrations and for population dispersal can be just as important to populations of certain mobile species as their primary breeding, foraging, or overwintering habitats.
- Natural disturbances (e.g., wildfires, floods, wind, ice scour, landslides) are essential features of certain habitats and help to create the environmental conditions that allow some species and communities to persist.
- Broad buffer zones of undisturbed vegetation adjacent to streams, woodland pools, other wetlands, lakes, and ponds are important for preserving the integrity of the aquatic, wetland, and upland habitats required by sensitive species of those habitats.
- Old systems, such as mature forests or wetlands with deep organic soil, are less common in the region than young counterparts of those systems (e.g., young forests or recently created marshes) and provide habitat values for biodiversity not duplicated by the younger habitats.

Protecting habitats and habitat complexes critical to particular plant and animal species of conservation concern will provide an umbrella for many other species using the same habitats and landscapes. For example, for the wood turtle, a broad (e.g., 1600-ft wide) zone centered on low-gradient perennial streams with undeveloped riparian habitats would encompass most of the turtle's foraging and nesting migrations, as well as habitat areas for a wide range of other wildlife species of riparian corridors, such as river otter, American mink, and Louisiana waterthrush. For pool-breeding amphibians such as wood frog and Jefferson/blue-spotted salamander, maintaining intact forested connections between clusters of intermittent woodland pools or similar pool-like swamps (within 1500 ft of each other) would protect critical breeding, nursery, foraging, and overwintering habitat and the broad corridors between pools that facilitate population dispersal and genetic exchange. It would also maintain habitat and travelways for the spotted turtle and other animals that use both the pools and forest. For the timber rattlesnake, contiguous habitats within a two-mile radius around rocky barrens habitats and high elevation ledges with southern exposures would encompass the snake's denning, basking, and breeding areas, as well as critical areas for foraging and dispersal migrations. Other ledge-associated snakes of conservation concern would also benefit from protected habitat areas within that zone. While land development is expected to proceed within those zones, siting and designing new development with an eye to the habitat needs and migration corridors of those species will help to ensure that they can continue to thrive in these landscapes.

Below are examples of habitat-specific measures that will help to protect plants and animals of forests and meadows. Many of these measures can be employed voluntarily by individual landowners of small or large parcels.

Conservation of Forests

In forests of any size, maintaining an undisturbed forest floor and retaining understory and ground vegetation, standing snags, downwood, and other organic debris will help to support the forest ecosystem and maintain the resources and microhabitats needed by forest plants and animals. Restoring and maintaining broad landscape connections between forested areas, and between forests and other intact habitat areas, will help to ensure that important ecological interactions can continue to occur, and will help the plants and animals of forests adapt to the many effects of climate change. Where new development is proposed in large forest areas, the forest habitats will be best protected if the developed uses do not encroach on forest interiors but are instead confined to the edges and near existing roads and other development so that forest fragmentation is minimized. A utility corridor, a road, and even a single driveway to a house site deep in the forest interior can be a significant fragmenting feature, disturbing wildlife and inviting invasive plant species, nest predators, and brood parasites.

In addition to fragmentation and the extensive edge effects of land development, forests are subject to multiple other stresses such as excessive deer herbivory; invasive plants, insect pests, and earthworms; acid rain; nitrogen deposition; and ozone pollution. Forest resilience to the effects of climate change will be improved by reducing these non-climate stressors to plants, animals, and habitats as much as possible.

Logging

Adherence to Best Management Practices (NYSDEC 2018) can help avoid some of the adverse ecological impacts of logging. For example:

- Begin with identifying sensitive features—such as steep slopes, streams, wetlands, seeps, highly erodible soils, and known habitats for rare species—and plan the tree harvest to avoid those areas.
- Maintain broad undisturbed forested zones along streams and around wetlands.
- Conduct logging operations when soils are dry, or in winter when soils are deeply frozen and some wildlife are dormant or absent.
- Leave some large trees in place, and maintain trees of diverse ages and species composition.
- Employ temporary soil stabilization measures during logging operations and install permanent measures as soon as work in each area is completed. Grade and seed logging roads and staging areas when no longer in use.

The large deer population is a regional problem needing regional solutions. Site-specific efforts to control deer or reduce their forest impacts are likely to have only minor, local, and temporary effects (see sidebar below).

Invasive plant species are best managed in the early stages of an infestation, when just a few individuals can be successfully removed. Once an infestation has taken hold, removal efforts may be futile and may cause unjustifiable disruption of other biota and the forest soils. Fact sheets on the ecology and management of some of our most widespread non-natives are available at www.hudsonia.org.

Deer Management

Many interests collide around questions of deer management. Some hunters favor higher densities, while many landowners, farmers, and ecologists favor lower densities. Many animal rights advocates oppose sport hunting.

The number of hunters, as well as access to land on which to hunt, continues to decline in New York (NYSDEC 2011) and deer damage to forests, especially in southeastern New York, continues to be severe (Shirer and Zimmerman 2010, Russell et al. 2017).

Recreational hunting is the primary management method for deer in New York. NYSDEC regulates the timing and length of the deer hunting season, the techniques and weapons permitted, and the allowable take per hunter. Exclusion fences, repellents, habitat modification, and frightening devices are also used to reduce deer impacts in some situations, but are impractical for treating large areas. A regulated commercial deer harvest, in which hunters could profit by selling venison, might be an effective control, but would contradict long-standing state and federal laws against buying and selling wildlife (Vercauteren et al. 2011).

Even if control efforts (such as intensive hunting) are temporarily successful at reducing the herd on a single site—say, a 10-acre or 500-acre property—deer mobility and the permeable landscape ensure that deer will quickly repopulate the site once those efforts cease. Programs to reduce the regional deer population will be successful only if implemented region-wide, but practical, ecologically sound, humane, and politically feasible control methods have yet to be discovered.

Conservation of Meadows

Meadows of any size can provide valuable habitat for butterflies, moths, bees, ants, beetles, spiders, and a host of other important invertebrates of above-ground and below-ground meadow microhabitats. While different species and groups have their own particular habitat requirements, many will be served by some general management measures.

Farmers often need to mow hayfields several times per year for economic reasons, but non-farmer landowners have more flexibility in their mowing schedules. Maintaining meadow areas with diverse plant species, diverse vegetation structure, and uncompacted soils, and delaying mowing until fall will accommodate the needs of a wide array of animals. The undisturbed vegetation and soils will provide resting and ground-nest habitat for native bees, ground beetles, and ants, as well as habitats for egg-deposition, pupation, and overwintering of butterflies and moths. Leaving cut vegetation in place provides the thatch ground cover that is important to small mammals and ultimately becomes part of the meadow food web. Avoiding use of broad-spectrum pesticides (herbicides, insecticides, fungicides, algicides, rodenticides) in or near meadows will help to protect the plants and animals of these habitats. Pesticides contaminate the vegetation, pollen, and nectar foods of pollinators and can harm whole populations in the localities where they are used. Promoting the larval host plants for butterfly species of conservation concern, such as milkweeds for monarch and grasses for skippers, and plenty of nectar plants for those and other pollinators will give an extra boost to those groups.

Large meadows (e.g., 10+ acres) have particular value for grassland breeding birds, which are of significant conservation concern in the Northeast. Because many grassland breeding birds nest in the spring and the young do not fledge until late spring or summer, mowing or intensive grazing of meadows in the spring or early summer is likely to be fatal to eggs and nestlings. If nests are destroyed or depredated, some birds will nest again, and the young may not fledge until August, or even later. Delaying mowing until mid- or late summer can significantly improve bird survival rates (Zalik and Perlut 2008), as many of the young will have fledged by mid-July and most will have fledged by mid-August. Sedge wren,[†] however, commonly nests in August or September, so might be harmed by late mowing. (The species is very rare in the Hudson Valley and has not been found recently in Greene County, but has been recorded in northern Dutchess and Albany counties as a "probable" nester in the 1980-1985 or 2000-2005 Breeding Bird Atlas [McGowan and Corwin 2008]). Similarly, rotational grazing that allows for sufficient regeneration of vegetation between grazing periods also improves the survival rates of bird eggs and nestlings.

Delaying mowing until mid- or late summer can significantly improve grassland bird survival rates.

For hayfields, multiple cuttings are essential to the economies of some farm operations, so delayed cutting is not a practical option in those cases. Also, the nutritional quality of forage and hay decreases over the season; hay cut later in the season will tend to have lower protein content. Late-cut hay may therefore be more suitable for beef cows, horses, and sheep whose protein demands are lower, and less suitable for livestock with high protein requirements, such as milking dairy cows (NRCS 2010).

For farm operations that cannot afford to reduce the intensity of mowing or grazing, another alternative is to simply set aside certain areas—perhaps those with poorer soils or wetter soils—to accommodate bird nesting, while maintaining more intensive operations elsewhere. There are other good reasons to delay cutting and grazing of wet areas until late summer when soils may be drier. Compaction of wet soils by farm equipment or grazing livestock can harm the soil structure, impede the root growth of plants, impair plants' ability to take up nutrients and water, and reduce productivity long into the future (Dejong-Hughes et al. 2001). Delayed cutting and grazing in wet meadow areas will help to maintain soil health in addition to maintaining safe bird nesting habitat and supporting pollinators of these habitats.

Another consideration is that some grassland birds return year after year to the same fields for nesting, so it is best to maintain a late-cut schedule in the same general areas over time. Ideally, those areas should be located away from hedgerows and forest edges, which can harbor nest predators such as skunks, raccoons, and black rat snakes, and brood parasites such as the brown-headed cowbird. Best Management Practices for maintaining grassland habitat for nesting birds are described by Atwood et al. (2017).

Permeability and Climate Resilience

Mamy species of plants and animals need to move to adjust to new habitat conditions imposed by climate change. Ecologists and conservationists are seeking ways to identify the most important parts of the landscape to allow safe migrations and to maintain intact habitat areas in the changing environment.

The Nature Conservancy (Anderson et al. 2012) undertook a study to identify key areas for conservation based on landscape characteristics associated with diversity and the ability to buffer against climate effects. Their aim was to identify places that encompass the full spectrum of landscapes and habitats needed to accommodate the safe movements and survival of species, so that conservation efforts can be focused where they will be most effective.

One assumption of the study—based on empirical evidence—is that complex and unfragmented landscapes are most likely to provide the array of habitats and microhabitats needed to support species in a changing climate. "Complex" in this context refers to complexity of landforms, elevation ranges, habitat diversity, and wetland density. Anderson et al. use the term "resilience" to refer to "the capacity of a system to adapt to climate change while still maintaining diversity."

The investigators considered landscape complexity—the number of microhabitats and climatic gradients available within a given area—and landscape permeability, a measure of the freedom from barriers and fragmentation within a landscape. Barriers include roads, developed land, dams, suspended culverts, and other structures that interrupt, redirect, or prevent the movement of organisms and thus lower landscape permeability.

Permeability was assessed according to the hardness of barriers, the connectedness of natural cover, and the arrangement of land uses. The analysis sought to measure the degree to which regional landscapes "will sustain ecological processes and are conducive to the movement of many types of organisms." The intention was to identify the places where conservation of biodiversity and ecosystems is most likely to succeed not just in the near term but over centuries.

After identifying "resilient" sites and areas representing all geophysical settings, and then identifying networks of such sites in the larger landscape, the researchers created maps showing areas with high or low predicted resilience. Figure 35 shows the results of Anderson et al.'s analysis of the Greene County landscape for permeability, and Figure 36 the results for resilience.

Meadow in the Route 9W grassland corridor, Coxsackie.
Photo: Jill Knapp © 2019

In Figure 35, the areas showing the lowest permeability are the "urban" areas of villages and hamlets, the lowland, substantially unforested areas in the Hudson River corridor, and the areas of farmland and small forest patches in the upper Basic Creek and Catskill Creek valleys. Those with the greatest permeability are mostly forested and have few large roads. The high-resilience areas shown in Figure 36 share those characteristics and also have a high degree of topographic complexity.

This analysis provides only a coarse filter for conservation planning. The notions of permeability and resilience are not intended to supersede or outweigh applications of basic conservation principles or the protection of features of local concern—such as riparian corridors, rare or high-quality habitats, or known areas of importance for rare species. But the resilience and permeability maps provide additional perspectives on connectedness and landscape complexity that can help with identifying local and regional conservation priorities.

GENERAL MEASURES FOR BIOLOGICAL RESOURCE CONSERVATION

- Gather information about natural resources and consider environmental concerns early in the planning process for new development projects, and incorporate conservation principles into the choice of development sites, site design, stormwater management, and construction practices.
- Wherever possible, protect habitat areas in large, broad configurations, with broad connections to other habitat areas.
- Protect a diverse array of common and rare habitat types, and those that are in especially good condition.
- Protect habitat complexes used by species of conservation concern wherever possible.
- Maintain broad buffer zones of undisturbed vegetation and soils around ecologically sensitive areas.
- Direct human uses toward the least sensitive areas, and minimize alteration of natural features, including vegetation, soils, bedrock, and waterways.
- Concentrate new development along existing roads; discourage construction of new roads or driveways in undeveloped areas. Avoid fragmentation of large forests or meadows by roads, driveways, and clearings.
- Minimize impervious surfaces and design new land uses (and retrofit existing uses wherever possible) to ensure that surface runoff of precipitation and snowmelt does not exceed pre-development patterns and volumes of runoff.
- Avoid fragmentation of contiguous farmland by roads, driveways, or other non-farm uses.
- Promote wildlife-friendly agricultural practices, such as late mowing to accommodate ground-nesting grassland birds, leaving unmowed strips and fallow rotations to support pollinators and other beneficial invertebrates, and minimizing applications of pesticides and fertilizers.
- Employ sustainable forestry practices in working forests, and sustainable agricultural practices that maintain and build living soils and conserve water.
- Maintain natural disturbances, such as fires, floods, seasonal drawdowns, ice scour, and wind exposure, which help to create and maintain habitat for important components of native biological diversity.
- Encourage pedestrian-centered developments that enhance existing neighborhoods, instead of isolated developments requiring new roads in intact habitat areas and expanded vehicle use.
- Educate municipal agencies, landowners, developers, and the general public about the county's biodiversity to heighten awareness and build support for conservation measures.

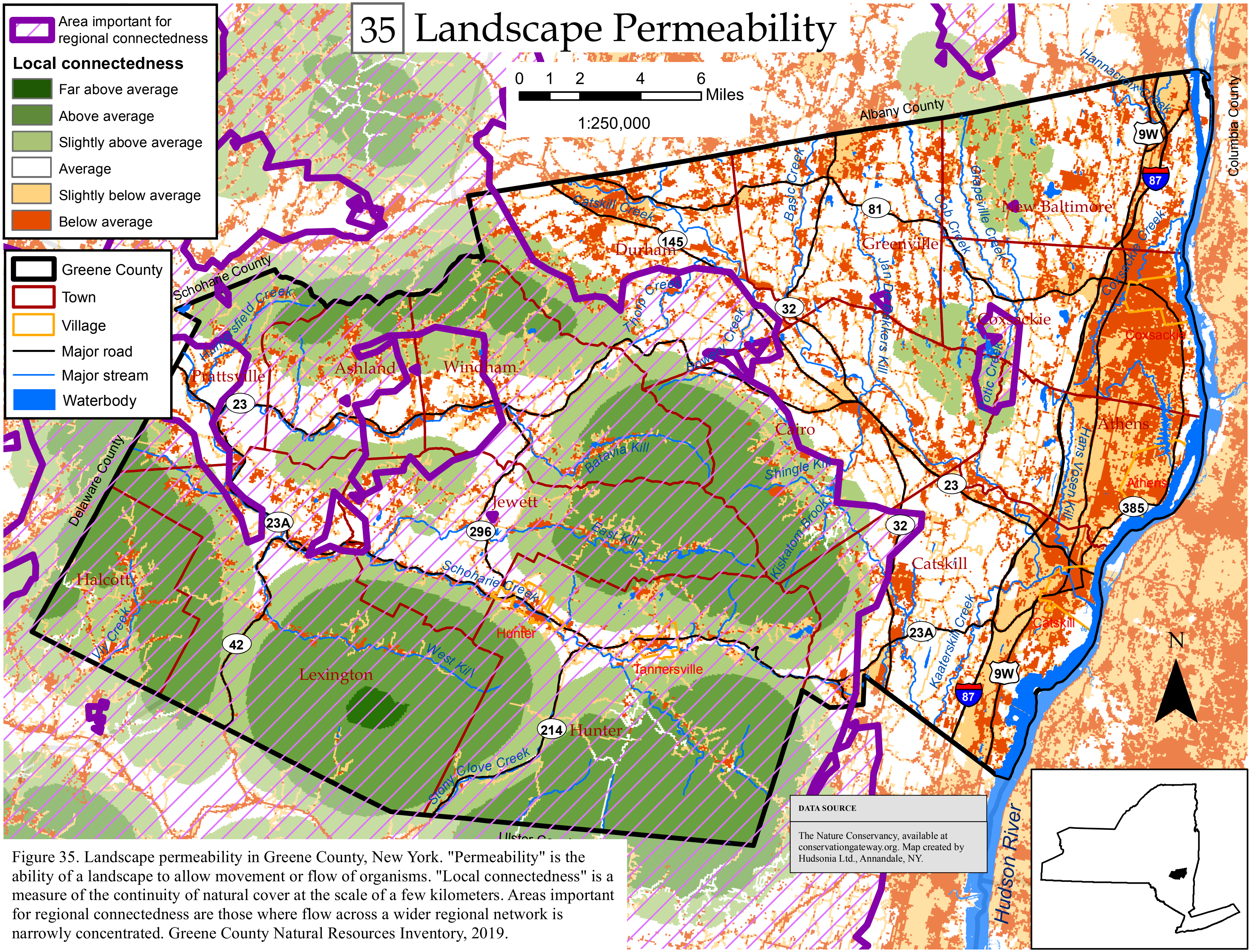

Figure 35. Landscape permeability in Greene County, New York. "Permeability" is the ability of a landscape to allow movement or flow of organisms. "Local connectedness" is a measure of the continuity of natural cover at the scale of a few kilometers. Areas important for regional connectedness are those where flow across a wider regional network is narrowly concentrated. Greene County Natural Resources Inventory, 2019.

36 Landscape Resilience

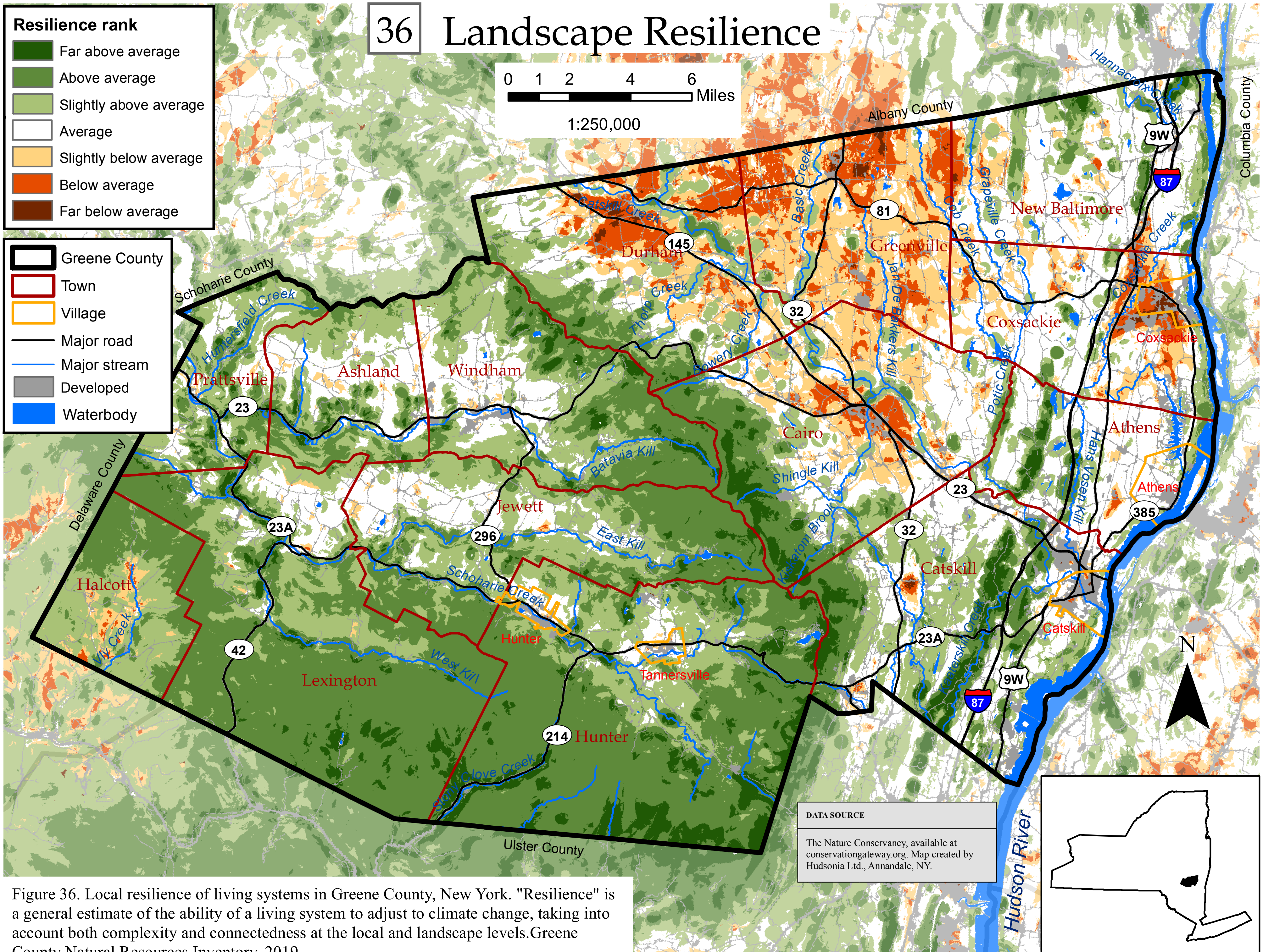

Figure 36. Local resilience of living systems in Greene County, New York. "Resilience" is a general estimate of the ability of a living system to adjust to climate change, taking into account both complexity and connectedness at the local and landscape levels.Greene County Natural Resources Inventory, 2019.

Conservation of Farmland Resources

Maintaining viable local agriculture has obvious large benefits for the local economy, local food security, the scenic character of the landscape, and the culture of the human community of Greene County. Active and abandoned farmland can also contribute significantly to native biodiversity, and intact habitats in the vicinity of farms can, in turn, provide critical and irreplaceable services and resources to farm enterprises—for example, climate moderation, clean and abundant water, flood attenuation, and habitat for pollinators and other beneficial invertebrates.

A strong message from the 2019 United Nations Intergovernmental Panel on Climate Change (IPCC 2019) is that the world's food supply is at great risk from the warming climate. This magnifies the importance of maintaining and expanding the ability to produce food locally. Supporting active farms—for example, by means of reduced property assessments, local right-to-farm laws, allowing onsite farm-related businesses, or assistance with obtaining grants—and protecting the best farmland soils will help to keep present-day farming viable and preserve the potential for future farming in the county. Such local support may nevertheless be insufficient given the fragile economies of small farms and the difficulties of withstanding variable and unpredictable weather, markets, and commodity prices. To ensure the continuing viability of farming in the county, other measures may be necessary to foster the economic success of existing and new farm operations and to pair farmers with available farmland.

Agricultural Value Assessment Program

Farmland that receives a reduced assessment for tax purposes under this program must be actively farmed, and the land generally must consist of seven or more acres that were used in the preceding two years for the production for sale of crops, livestock, or livestock products; in addition, the annual gross sales of agricultural products must average $10,000 or more for those two years. An enterprise on less than seven acres may qualify if average annual gross sales were $50,000 or more. (There are some exceptions to these gross sales requirements.)

Agricultural Districts and Agricultural Assessments

The New York State Agricultural District Program exists to protect current and future farmland from nonagricultural development by reducing competition for limited land resources and helping to prevent adoption of local laws that would inhibit farming and raise farm taxes. The Commissioner of Agriculture is authorized to review local comprehensive plans, legislation, and regulations, and approve or disapprove them according to whether they unreasonably restrict or regulate farm operations within an agricultural district. The commissioner also reviews any purchase by a municipal or state agency of active farmland larger than one acre, or any land over ten acres within an agricultural district, to assess the potential impacts on local agricultural resources. Greene County has just one agricultural district—District 124—(Figure 25) with 286 participating farms as of January 2019.

The Agricultural Value Assessment Program provides property tax relief for landowners by requiring that eligible farmland be assessed based on actual agricultural production value rather than its full market value. The reduced assessment for active farmland results in reduced property taxes for the landowner.

In 2002 the county adopted the Greene County *Agricultural and Farmland Protection Plan* prepared by the Greene County Agricultural and Farmland Protection Board (AFPB) and other county agencies. The *Plan* lays out a program to provide economic and promotional support for farming, to improve the county's agriculture infrastructure, and to promote farmland conservation and agricultural education (GCAFPB et al. 2002). The *Plan* can be viewed and downloaded at https://www.farmlandinfo.org/sites/default/files/GreeneCounty_NY_AgriculturalandFarmlandProtectionPlan.pdf.

Studies conducted during development of the *Plan* found that farming in the county generated $8,781,000 in sales in 1997 (the 2017 Agricultural Census reports sales of $19,761,000) and that farming provides year-round business for other Greene County enterprises that supply the needs of farmers, such as livestock feed, equipment, repairs, and fuel.

The studies found that tax revenues from agriculture go further than those from other sectors in helping the local economy—producing higher economic multipliers than any other sector in the county. (An economic multiplier indicates how many times a dollar of sales recirculates in the local economy for services, labor, and goods from other individuals and businesses.)

The studies also found that farms lower taxes for everyone. Even though many farms receive lower tax assessments than non-farmed properties, they also demand fewer services from a municipality, so farm enterprises usually represent a significant net gain to municipal coffers. The *Plan* reports on studies in western New York that found that agriculture typically requires 15¢ to 40¢ of town and school expenditures for every $1.00 in tax revenue it generates, whereas providing services to residential development costs $1.09 to $1.56 - $2.06 per $1.00 of taxes generated.

The *Agricultural and Farmland Protection Plan* developed an action agenda to improve the profile and success of agriculture in the county, which included initiatives to:

- reduce taxes on active farmland;
- reduce risks and costs associated with the variability and unpredictability of markets;
- encourage incorporation of Right to Farm clauses into municipal ordinances;
- encourage agriculture-related specialty enterprises and improve marketing practices; and
- promote strategic alliances among farmers and with other enterprises (e.g., for sharing equipment, services, and land).

Whatever means are used to promote agriculture in the county, a fundamental need is the protection of high quality farmland and its continued availability for agricultural production. With limited financial resources for conservation, protection efforts should be directed toward working farms and lands that have the greatest potential for successful agriculture over the long term.

The sidebar offers some general measures for supporting agriculture. For more detailed information, the American Farmland Trust published *Planning for Agriculture in New York: A Toolkit for Towns and Counties* (Haight and Held 2011), which describes the many regulatory and non-regulatory means available to municipalities to support and promote agriculture.

General Measures for Farmland Conservation

Municipal Actions

- Adopt municipal right-to-farm legislation in municipalities where it is not already in place.
- Adopt local farm-friendly policies and programs; for example, lowering property tax assessments for active farmland and farm structures, assisting farmers with grant acquisition, and promoting local markets for agricultural products, including uses by restaurants and institutions such as schools.
- Protect active farmland from non-farm development wherever possible.
- Design new subdivisions and other development sites in ways that preserve the areas of Prime Farmland Soils, and Farmland Soils of Statewide Importance intact and unfragmented as much as possible.
- Adopt land use policies that remove barriers to adding farmworker housing to farms.

Farmer Actions

- Where possible, shift tilled land in floodplains to other uses (such as pastures, hayfields) more resilient to flooding.
- Maintain intact habitats in and near cropland, orchards, and pastures to help support pollinators, other beneficial insects, and other wildlife.
- Employ farming practices that conserve water, prevent soil erosion and soil loss, and build living soils.
- Minimize applications of fertilizers and pesticides, especially in the more sensitive areas such as floodplain fields and near streams and wetlands
- Maintain cover crops and thatch to minimize soil loss during heavy precipitation or flood events.

Conservation of Scenic Resources

The scenic beauty of Greene County is inextricably tied to the other resources described in this *NRI*—the hills, valleys, ravines, and cliffs; the streams, lakes, ponds, and the Hudson River; the forests and farmland. Protection of many of those features will help to protect the scenic areas that are so highly valued by the people of the county.

The *Hunter Corridor Regional Planning Study* (GCSWCD et al. 2010) was undertaken to "plan for the long term sustainability of the town and its valuable natural, built and human resources" and already has led to including 26.5 additional miles of roads to the Mountain Cloves Scenic Byway. Scenic Byways are also designated in Durham, and Scenic Roads in New Baltimore and Coxsackie (Figure 28). In 2015 Peckham Industries donated to the Scenic Hudson Land Trust a conservation easement on a mile-long ridgeline in Catskill with a large eastern viewshed extending to east of the Hudson River.

The *Mountain Cloves Scenic Byway Proposed Corridor Management Plan* (Mountain Cloves Scenic Byway Steering Committee 2011) identifies the main threats to the visual quality of those roadways as 1) disruption of the immediate roadside environment; 2) incremental loss of the distinguishing visual character, as by physical alteration of historic structure or by construction of new buildings in prominent viewsheds; and 3) occasional periods of traffic congestion and high use. Scenic protection strategies listed in the *Plan* are applicable to many other scenic places in the county, and include protecting the community's landmarks; promoting conservation of the special features on development sites; cataloguing architectural and cultural resources; supporting education on the town's history; promoting context-sensitive road maintenance and road access management; and considering establishing National Register Districts where applicable.

Such efforts on the part of public and private agencies and organizations are essential to protecting other scenic areas in the county. Many of the scenic viewpoints shown in Figure 28 are on NYSDEC-owned parkland, but most of the land along the Scenic Byways and most of the Scenic Areas of Statewide Significance are on unprotected privately-held land. These and many other scenic places have little or no formal protection despite the documented public interest in the visual landscape of the county. Although Figure 28 shows some of the areas that have been identified by individuals, municipalities, and state agencies for their scenic importance, it provides a very incomplete picture of the scenic resources of the county. Municipalities are encouraged to conduct their own scenic resources surveys, prepare maps, and adopt local measures to protect the areas of greatest importance to the communities.

Winter view from Hunter Mountain. Photo: Andy Reinmann © 2019

GENERAL MEASURES FOR SCENIC RESOURCE CONSERVATION

- Identify and map the places of greatest scenic importance to the local community.
- Enact special protections and/or environmental review procedures that apply in areas of designated scenic importance.
- Maintain intact (i.e., undeveloped) natural areas and farmland visible from public roads and public-access lands wherever possible.
- Maintain intact hilltops and hillsides with large viewsheds wherever possible.
- Minimize outdoor lighting, and design any necessary outdoor lighting to minimize visibility of lights in nearby habitat areas and offsite areas throughout the viewshed.
- Develop municipal policies that support working lands and land-dependent uses (e.g., farming, forestry) that employ sustainable practices and help to maintain the appealing visual landscapes unique to Greene County.

Conservation and Expansion of Recreation Resources

With the large areas of public land in the Catskill Forest Preserve and other state-owned lands in the mountains, public-access sites along the Hudson River, and lands of the Greene Land Trust and Scenic Hudson, and other conservation organizations, Greene County is rich in opportunities for outdoor public recreation. The largest areas of public-access land are in the mountains of the western half of the county. In the eastern tier of towns and villages, numerous small parcels of publicly and privately-held land in the Hudson River corridor provide public access to trails, historic sites, and the river shore. The lowland areas away from the Hudson, however, have few such places for public recreation.

Public recreation opportunities improve the daily lives of residents, attract visitors, benefit businesses, and strengthen people's connections to and appreciation for the land. If designed carefully, monitored, and remediated, recreation tied to the natural landscape can have relatively minor environmental impacts.

Some kinds of public recreation do not require acquisition or development of additional land. For example, development of the Hudson River School Art Trail in the Village and Town of Catskill and the Town of Hunter simply guides visitors to already-protected home sites and natural landscapes that were the subjects of the Hudson River School painters of the 19^{th} century. Another initiative that can expand recreation opportunities without setting aside more land for that purpose is the adoption and implementation (by municipalities and/or the county) of Complete Streets principles (https://www.dot.ny.gov/programs/completestreets/nysdot), which can expand recreation opportunities and transform existing roads into safe and attractive corridors for walking and biking, in addition to their use by motorized vehicles.

When establishing trails and other features for public uses of outdoor spaces, certain practices can help to minimize the adverse effects on plants, animals, and habitats. Trails and access areas located at habitat edges (instead of interiors) and designed to avoid rare and sensitive habitats, wildlife travel corridors, and breeding areas for sensitive species will have fewer impacts on biological resources. Minimizing noise and artificial lights will cause less disruption of wildlife. Managers who identify acceptable and unacceptable levels of impact, and monitor uses and conditions, can take steps to reduce impacts when the resource is threatened by over-use.

The potential for ecological harm is often related more to the spatial extent of public uses than the timing or intensity of use. A spatially extensive network of "social" trails and campsites has a greater impact on wildlife and plants than a few clearly-marked and well-maintained formal trails and campsites, even with more annual visitors (Marion et al. 2015). Predictable disturbances, such as human presence on an established trail, are better tolerated by wildlife than unpredictable ones (Miller 1998). Even low levels of foot traffic or only a few nights of camping in one site can cause lasting changes to soils and vegetation. Visitor education—about wildlife sensitivity to disturbance, the value of staying on trails and using established campsites, proper waste disposal, and other "Leave No Trace" principles (https://lnt.org)—can be very helpful, because many impacts are unintentional and avoidable. Signs alone are sometimes ineffective, but conversation with a ranger or volunteer often changes visitor behavior (Taylor and Knight 2003).

For managers of conservation lands, the different goals of recreation and resource protection should not be confused with each other; they are sometimes but not always compatible. Some areas of conserved land may be inappropriate for public uses, due to the sensitivity of habitats, plants, wildlife, or water, while other sites may be more resilient. Even nonmotorized boating, for example, can damage the rare vegetation on floating mats in a circumneutral bog lake, and even low levels of foot traffic on a rocky crest can destroy its plant community or interfere with the nesting of a sensitive songbird. But good planning and design of infrastructure, trails, and other use areas, along with public education about outdoor etiquette, can improve the compatibility of human recreation and intact habitats and help to protect the natural areas that are so widely valued in Greene County.

MEASURES FOR CONSERVATION, ENHANCEMENT, AND EXPANSION OF OUTDOOR RECREATION RESOURCES FOR THE PUBLIC

- In municipal comprehensive planning, evaluate local needs and opportunities and consider a wide range of recreation types.
- Adopt the Complete Streets approach to enhancing the quality and safety of county and municipal roads for biking, walking, and other uses.
- In existing recreation areas,
    - properly maintain trails, campsites, and picnic areas, and
    - discourage use of informal trails and other non-designated areas;
    - establish thresholds for acceptable and unacceptable levels of impact from public uses, and reduce public access when regular monitoring shows unacceptable levels;
    - design new trails and access areas with the area of influence (e.g., 330 ft from trails) in mind and, when possible, follow existing habitat edges and avoid water resources, rare and sensitive habitats, wildlife travel corridors, and breeding areas for sensitive species;
    - prohibit lead-containing bullets and fishing tackle, and live bait.
- Educate landowners about protection from liability under NYS General Obligations Law.
- Educate the public about ways to avoid disturbing wildlife and Leave No Trace principles (https://lnt.org/learn/7-principles) and following management rules (stay on marked trails; keep dogs on leash, etc.) of public recreation areas.
- Develop additional public access sites for non-motorized boating on lakes and the Hudson River.

PROTECTED LANDS

Greene County has large areas of land with formal protected status, the largest of which is the Catskill Forest Preserve, encompassing over 85,000 acres in the county. Other state-owned lands include six State Forests, three Wildlife Management Units, and State Park land on the Hudson River. As part of the effort to protect the New York City drinking water supply, the NYC Department of Environmental Protection (NYCDEP) owns and protects numerous land parcels, mostly in the western half of the county. Scenic Hudson owns several properties, including the RamsHorn-Livingston Sanctuary, that are managed for conservation, public recreation, and public education. The Catskill Center for Conservation and Development owns and manages the 208-acre Platte Clove Preserve in the Town of Hunter. There are numerous other parcels in private ownership but with conservation easements held by the Greene Land Trust, the Scenic Hudson Land Trust, or NYCDEP. In addition there are county-owned and municipal-owned parcels that are managed for open space and recreation, even though they are not permanently protected from development.

Figure 37 illustrates the pattern of land protection in the county. In all, over 115,000 acres of land in Greene County have some kind of formal conservation status. Together these protected lands contain many of the features of conservation concern outlined in this *NRI*—active farmland, stream corridors, low and high elevations, diverse bedrock types, large forests, large meadows, rare habitats, and habitats for rare species. Many of the protected parcels are isolated from each other, so finding ways to protect connecting corridors would help to further secure habitat options and safe travelways for wildlife.

The persistence of many types of habitat depends on land management decisions by individual landowners, and it would be unreasonable to seek formal conservation status for all of the many places with important habitat or water resources. Most of the kettle wetlands, intermittent woodland pools, floodplain forests, and many of the large forests, large meadows, other unusual habitat areas, and active farms, for example, are on privately-held lands, so are vulnerable to land development and other disturbances. Although many landowners recognize the value of their land for farming, timber production, soil mining, or other income-producing enterprises, they may be unaware of important biodiversity resources. Various means of conferring formal and informal protections for land parcels and natural resources are described in the **Achieving Conservation Goals** section, below.

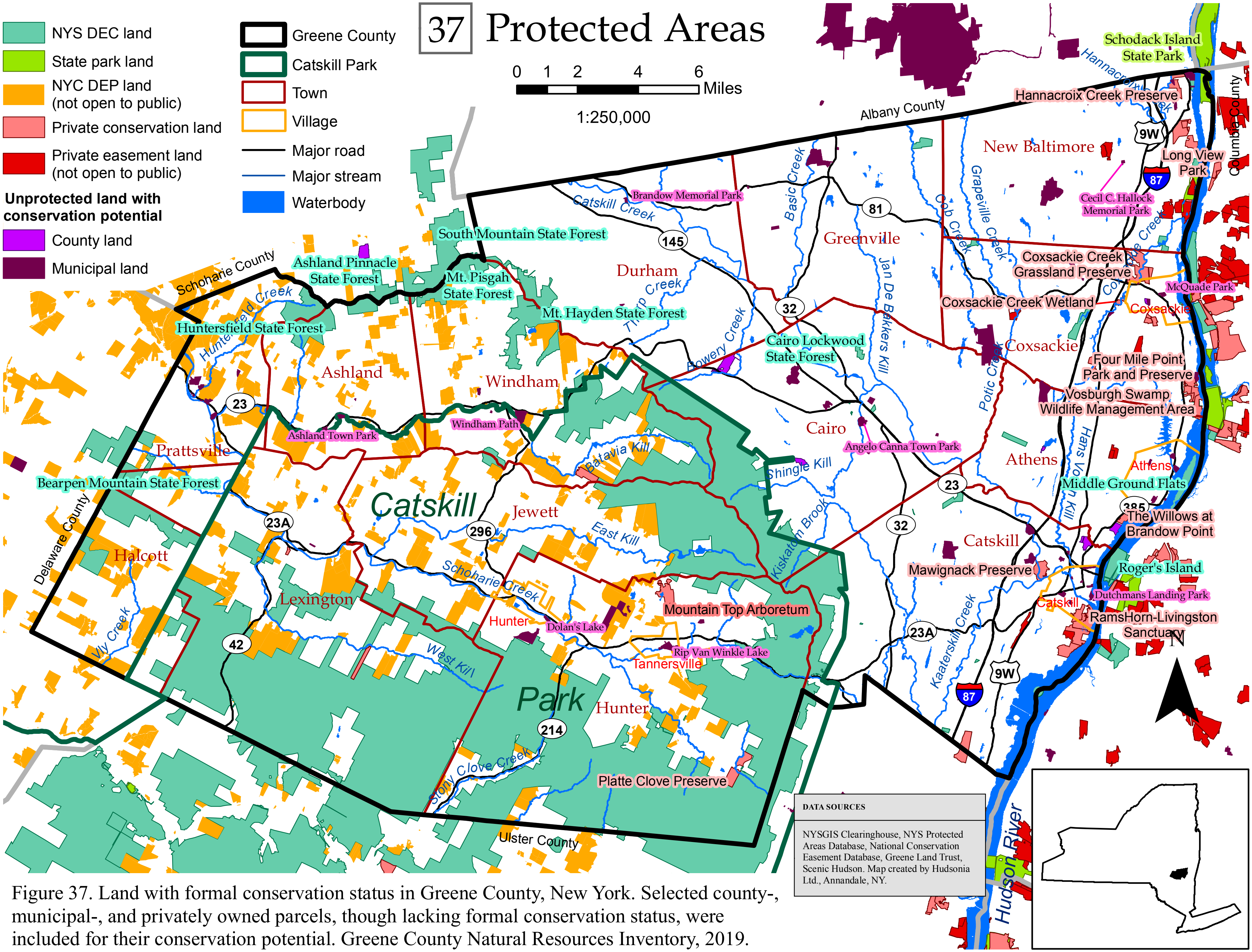

Figure 37. Land with formal conservation status in Greene County, New York. Selected county-, municipal-, and privately owned parcels, though lacking formal conservation status, were included for their conservation potential. Greene County Natural Resources Inventory, 2019.

LEGISLATIVE PROTECTIONS

Federal and state laws provide some protections for certain kinds of resources, and there are additional protections on lands within the watersheds of the New York City drinking water reservoirs (Ashokan, Pepacton, Schoharie), but many resources of great importance to communities have no protection except for those provided by local (municipal) legislation or offered voluntarily by landowners.

Below are outlined some of the existing protections for land areas and species in federal and state laws, and additional protections for lands within the NYC reservoir watersheds. See the **Achieving Conservation Goals** section for ideas for local legislation that can extend protections to other areas and resources of concern.

Wetlands

Federal Wetland Regulatory Program

Section 404 of the federal Clean Water Act is the basis for the federal wetland regulatory program, which is administered by the US Army Corps of Engineers (ACOE), sometimes in consultation with the US Environmental Protection Agency (USEPA) and other federal agencies. The federal government regulates activities in wetlands of any size as long as the wetland is functionally connected to "navigable waters" (see sidebar). The law prohibits certain kinds of activities (especially filling) in jurisdictional wetlands without a permit. It imposes no regulated buffer zone around a wetland, but federal agencies may specify such a zone in permit conditions if they so choose.

> **NAVIGABLE WATERS**
> As defined in Section 404 of the federal Clean Water Act, "navigable waters are…those waters that are subject to the ebb and flow of the tide and/or are presently used or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce."

The criteria and thresholds for federal jurisdiction over wetlands and streams have been in flux in recent decades. For the time being, the definition set forth by the USEPA in the 2015 Clean Water Rule prevails in New York (Federal Register, February 14, 2019), but federal decisions in 2019 could change that. The 2015 rule asserts that wetlands that are "bordering," "contiguous," or "neighboring" traditional navigable waters are jurisdictional (each of these terms is defined in the rule). In effect, these include most wetlands with surface water connections (perennial, intermittent, or ephemeral) to perennial streams, but exclude hydrologically isolated wetlands such as vernal pools unless a convincing case can be made that they will impact the chemical, biological, or physical integrity of downstream navigable waters (https://www.federalregister.gov/documents/2015/06/29/2015-13435/clean-water-rule-definition-of-waters-of-the-united-states). Explanations of the history of jurisdictional decisions for wetlands and descriptions of the new proposed rules are in the Federal Register at https://www.govinfo.gov/content/pkg/FR-2019-02-14/pdf/2019-00791.pdf.

The National Wetland Inventory (NWI) maps (Figure 10a) created by the US Fish and Wildlife Service show many wetlands but show inaccurate wetland boundaries, omit many small wetlands and even some large ones, and include some wetlands that do not fall under federal jurisdiction. The ACOE recognizes these shortcomings, and does not use the NWI maps to determine federal jurisdiction.

Under the ACOE's Nationwide Permit program, certain kinds of activities in jurisdictional wetlands and streams are allowed if the anticipated impacts fall beneath certain thresholds. There are 54 Nationwide Permits described for the New York City ACOE district (which includes Greene County), each for a different kind of activity and with different thresholds of impacts allowed. For example, Nationwide Permit 29, for residential developments, allows filling of up to ½ acre of non-tidal wetland as long as General Permit Conditions are adhered to and "the project is designed and constructed to avoid and minimize adverse effects, both temporary and permanent, to waters of the United States to the maximum extent practicable." The permittee must submit a Pre-Construction Notification to the ACOE, which may impose additional conditions on the project. Nationwide Permits for the New York City district are described at https://www.nan.usace.army.mil/Missions/Regulatory/Nationwide-Permits/.

New York State Wetland Regulatory Program

The New York State Freshwater Wetlands Act (Article 24 of the New York Conservation Law) specifies the kinds of activities that can and cannot legally occur in and near large wetlands (12.4 acres and larger) and in a few smaller wetlands "of unusual local importance." The most typical instances of the latter are wetlands connected to a public drinking water supply, or wetlands known to support a state-listed Threatened or Endangered animal. The law also regulates activities in a 100-foot-wide "adjacent zone" around the perimeter of any state-jurisdictional wetland. Most wetlands in New York do not fall under state jurisdiction, however, because they meet neither the size nor the "unusual local importance" criteria.

Thus, due to their small size or hydrologic isolation, most of our intermittent woodland pools, isolated swamps, and isolated wet meadows receive no protection in federal or state law. Small, isolated wetlands can have great value for biodiversity and for water management, however. Indeed it is often the very isolation that imparts their special value to certain plants or animals. In the case of intermittent woodland pools (vernal pools), for example, the isolation from streams and other wetlands helps to maintain the fish-free environment that is a critical factor for the pool-breeding amphibians of conservation concern. (See discussion of these pools in the **Biological Resources** section, above.)

The New York State Freshwater Wetland Maps show the wetlands that are protected under the NYS Environmental Conservation Law. Like the federal NWI maps, the state wetland maps show inaccurate wetland boundaries and exclude some wetlands that otherwise meet the jurisdictional criteria. NYSDEC relies on on-the-ground delineations, not on the mapped wetland boundaries, to determine the actual extent of jurisdiction.

Many non-jurisdictional wetlands, however, have great ecological value and can still be protected under local (municipal) codes. At present, no Greene County municipalities have yet adopted local wetland laws that would protect these important wetlands, but many other Hudson Valley municipalities have done so.

New York City Watershed Regulations

For land within the watersheds of drinking water reservoirs in the New York City system, the New York City Department of Environmental Protection (NYCDEP) regulates land uses with potential to affect the water quality and quantity in the reservoirs. These include siting of septic systems and sewage treatment systems; impervious surfaces near streams, ponds, or wetlands or near a NYC reservoir; diverting, piping, or crossing of streams; land clearing near reservoirs or on steep slopes; siting and design of landfills; and application or storage of hazardous materials. The regulations impose significant setbacks (e.g., 100-ft and 300-ft) from sensitive water resources, and require stormwater plans for new features in certain settings.

See the **Achieving Conservation Goals** section for discussion of options for local wetland protection legislation.

Streams

Federal Protection of Streams

Under Section 404 of the federal Clean Water Act, the federal government regulates activities in "waters of the United States" defined in the act. These generally include tidal wetlands and streams, and non-tidal wetlands and streams affecting "navigable waters" and interstate waters, but the interpretation has been in flux for many years. See the sidebar and discussion in the previous **Wetlands** subsection.

For the time being, the definition of "waters of the United States" set forth by the USEPA in the 2015 Clean Water Rule prevails in New York (Federal Register, February 14, 2019), but federal decisions in 2019 could change that. The 2015 rule asserts that perennial, intermittent, and ephemeral streams that flow directly or through other streams into traditional navigable waters have a "significant nexus" with navigable waters and are thus jurisdictional under the Clean Water Act. Further directives pertaining to federal jurisdiction of streams and wetlands may be issued in 2019. Explanations of the history of jurisdictional decisions for streams and of the new proposed rules are in the Federal Register at https://www.govinfo.gov/content/pkg/FR-2019-02-14/pdf/2019-00791.pdf.

Where jurisdiction is unclear, determinations are made on a case-by-case basis by the Army Corps of Engineers, sometimes in consultation with the US Environmental Protection Agency or the US Fish and Wildlife Service. As for wetlands, some kinds of stream disturbance may fall under a Nationwide Permit (see above) and thus not require the lengthier "individual permit" process with the ACOE. For residential projects, for example, Nationwide Permit 29 applies to disturbances affecting up to 300 linear feet of a stream bed or banks. The federal government imposes no standard buffer zones along streams but can require a buffer zone on a case-by-case basis.

Among the General Conditions that apply to all Nationwide Permits is a requirement to maintain aquatic connectivity: "[no] activity may substantially disrupt the necessary life cycle movements of those species of aquatic life indigenous to the waterbody, including those species that normally migrate through the area, unless the activity's primary purpose is to impound water. All permanent and temporary crossings of waterbodies shall be suitably culverted, bridged, or otherwise designed and constructed to maintain low flows to sustain the movement of those aquatic species. If a bottomless culvert cannot be used, then the crossing should be designed and constructed to minimize adverse effects to aquatic life movements."

New York State Protection of Streams

A NYS Protection of Waters Permit is required from NYSDEC for disturbing the bed or banks of a stream with a classification of AA, A or B, or with a classification of C with a standard of (T) or (TS) (see the **Water Resources/Surface Water** section for explanation of these classes), whether the disturbance is temporary or permanent. The state law has no setback or buffer zone requirement. No permit is required for disturbance of streams of other classes or for unclassified streams. Small ponds or lakes of ten acres or smaller and located within the course of a stream are considered to be part of the stream and are subject to the same regulations as that reach of the stream.

A Protection of Waters permit is also required for excavating or filling in "navigable waters" of the state and adjacent wetlands. In this case, "navigable waters" include any rivers, lakes, ponds, and streams that can float a watercraft holding one or more persons. Exempted from this requirement are any waterbodies that are entirely surrounded by land held in a single private ownership (http://www.dec.ny.gov/gis/erm/streamsRiversLakesPonds.html).

New York City Protection of Streams

In addition to any state and federal regulations, the New York City Department of Environmental Protection (NYCDEP) has separate regulatory authority over land uses with potential to affect the water quality and quantity in the drinking water reservoirs in the New York City water system. Within the watersheds of those reservoirs, the NYC jurisdiction extends to, for example:

- siting and operation of septic systems and sewage treatment systems;
- impervious surfaces near streams, ponds, wetlands or near a NYC reservoir;
- diverting, piping, or crossing a stream;
- building of structures near a stream;
- land clearing near reservoirs or on steep slopes;
- siting and design of landfills; and
- application or storage of hazardous materials, including fertilizers or pesticides

Details of the NYC watershed regulations are at https://www1.nyc.gov/html/dep/html/watershed_protection/watershed_regulations.shtml.

Water Quality

Certain activities that affect the water quality of streams and lakes require a permit from New York State; for example, constructing or using an outlet pipe for wastewater, a sewage treatment plant, or a concentrated animal feeding operation; construction activities disturbing one or more acres of soil; or stormwater runoff from industry or municipal storm sewers. Siting and design of residential septic systems are subject to municipal review and approval. Pesticides applied to surface waters require a NYSDEC permit and may only be applied by a certified pesticide applicator. The NYCDEP has additional regulatory authority in the reservoir watershed communities for stormwater, septic systems, impervious surfaces, and application and storage of toxic materials (see above).

Rare Species

The federal and New York State governments maintain lists of rare species and have laws intended to prevent harm to individuals and populations of those species. Most places in New York, however, have never been surveyed for rare species, so many of the locations where rare species occur are unknown. Hence, most land disturbance and land development takes place without anyone knowing whether or not rare species occur in the vicinity and could be harmed by the project. Many rare species are also difficult to detect, and determining their presence or absence often requires lengthy surveys conducted by experts during specific seasons.

Most species, however, are associated with particular kinds of habitats, so information on habitats can help determine where particular species are likely to occur. For example, a spotted turtle may use a kettle wetland and nearby deciduous forest but is unlikely to be found on a high-elevation ledge. An eastern meadowlark is likely to nest in a large upland meadow but not in a marsh. In these ways, understanding the kinds of habitats that a rare species uses will help to predict the places where the species might occur in Greene County.

Unfortunately, there is no comprehensive habitat map for the county. Figure 14 gives a rough picture of some of the habitats, based largely on automated remote interpretation of the landscape by the US Geological Survey, but it cannot be relied on for accurate or detailed identification of habitats at a specific location. Thus, an onsite habitat assessment is recommended for municipalities wishing to identify habitats of conservation concern prior to approving new development projects. (See the **Achieving Conservation Goals** section for further explanation of a habitat assessment.)

Below are brief descriptions of some of the federal and state laws, policies, and procedures that can help to protect rare species and their habitats.

<u>Federal Endangered Species Act</u>

The Endangered Species Act of 1973 (16 U.S.C. 1531-1544, 87 Stat. 884) prohibits unauthorized taking, possession, sale, and transport of federally-listed endangered or threatened species of plants and animals. The US Fish and Wildlife Service maintains and revises the list of plant and animal species deemed to be rare nationwide under the law, and assigns a rank of "Endangered" or "Threatened" to each. Only a few species in New York are on the federal list. In Greene County those are Indiana bat,[†] northern long-eared bat,[†] New England cottontail,[†] bog turtle,[†] shortnose sturgeon,[†] and Atlantic sturgeon.[†] (New England cottontail is probably extirpated in Greene County; there are only historical records of its occurrence here.) Land development projects that may interfere with known locations of federally-listed Threatened or Endangered species must be reviewed by the US Fish and Wildlife Service.

New York State Environmental Conservation Law

Animals ranked as Endangered, Threatened, and Special Concern are listed under 6 NYCRR Part 182 of the New York Environmental Conservation Law (ECL) 11-0535. The regulations prohibit the taking of (or engaging in any activity likely to result in the taking of) any species listed as Endangered or Threatened in New York. The regulations also prohibit importing, transporting, possessing, or selling "any endangered or threatened species of fish or wildlife, or any hide or part thereof..."

Plants ranked as Endangered, Threatened, Rare, or Exploitably Vulnerable are listed and regulated under Environmental Conservation Law section 9-1503 Part (f): "It is a violation for any person, anywhere in the state to pick, pluck, sever, remove, damage by the application of herbicides or defoliants, or carry away, without the consent of the owner, any protected plant." ("Exploitably Vulnerable" plants are not rare but are likely to be picked for commercial and personal purposes.) Thus, plants are considered the property of the landowner and are protected only to the degree that the landowner wishes. Under NYS law, any landowner can lawfully remove, damage, or destroy (or grant permission for others to destroy) state-listed rare plants on their own property, but others are not permitted to harm those plants without the landowner's permission.

Wildlife

It is illegal to take (kill, capture, trap, or disturb) many species of wildlife in New York, including listed rare species (discussed above), songbirds, hawks, owls, snakes, lizards, most turtles, and salamanders. Animals considered game in New York can be taken, but only according to specific regulations including permits, bag limits, seasons, and hunting or trapping methods. Game species include deer, bear, bobcat, coyote, red fox, gray fox, raccoon, opossum, skunk, weasel, mink, muskrat, gray squirrel, eastern cottontail, wild turkey, ruffed grouse, ducks, geese, swans, pheasant, shorebirds, blue jay, crows, rails, coots, most fishes, snapping turtle, most frogs, and others. A few species are afforded no protection by the state, including porcupine, red squirrel, woodchuck, English sparrow, starling, rock pigeon, and monk parakeet.

It is also illegal to collect, possess, or sell fish, wildlife, shellfish, crustaceans, aquatic insects, migratory birds, bird nests or eggs, or captive bred or disabled animals without a special license granted for education, exhibition, scientific research, or propagation purposes. (Special protections for rare species of wildlife are described in the **Rare Species** section above.)

Mining

A permit from NYSDEC is required for commercial mining in New York, and mining wastes must be disposed of properly, erosion on mine sites must be controlled, and mined lands must be reclaimed and returned to productive condition according to the mined land reclamation law (Article 23, Title 27 of the Environmental Conservation Law). Regulations (6NYCRR Parts 420-425) and a permitting program designed to achieve these goals have been established by NYSDEC. Exempted from the permit requirements are excavations of less than 1000 tons or 750 cubic yards (whichever is less); or less than 100 cubic yards in or adjacent to any body of water not subject to permitting under the Protection of Waters Program (ECL Article 15); or excavation associated with onsite construction or farming (https://www.dec.ny.gov/lands/24993.html).

Local Legislation

The State of New York grants considerable authority to municipalities to adopt zoning and other laws governing land use. Many provisions in municipal codes are intended to protect important natural resources of conservation concern in a city, town, or village, such as streams, wetlands, aquifers, and scenic areas. For any resource, municipalities may adopt regulations that are equally or more protective than the state regulations of those resources. (See the **Achieving Conservation Goals** section for further discussion of local legislation and other local measures.)

Hudson River cleanup at Brandow Point. Photo: Bob Knighton © 2019

IDENTIFYING LOCAL CONSERVATION PRIORITIES

All places with valuable natural resources cannot be protected from incompatible uses, so municipalities, landowners, developers, and land trusts often need to identify the features and places that seem most important for their conservation efforts. Municipal comprehensive planning, zoning revisions, and environmental reviews of land development projects, as well as landowner decisions about land use and management on their own properties, can benefit from an exercise in identifying conservation priorities. This can help sort out the areas of greater or lesser importance and allow new land use projects to proceed while protecting the most sensitive areas from disturbance.

For identifying local conservation priorities, communities can consider a large array of factors associated with groundwater and surface water resources, good farmland soils and active farms, native biological diversity, and recreational and scenic resources. In addition, there may be other features unique to the locality—such as unusual land formations, caves, springs, waterfalls, and features or landscapes of special cultural or historical significance—that have particular meaning for the community. Landscape features that contribute to the ability of plants, wildlife and people to respond to the effects of climate change can be part of the calculation.

Each community's assessment of conservation priorities will be its own, but below are listed some of the factors that may be relevant to that assessment. Information and maps for many of these factors are included in this *NRI*, and can be expanded by local knowledge of the land and resources. Communities and individuals are strongly encouraged to revise this basic list of factors and develop their own weighting values that reflect a hierarchy of local concerns.

Some of the types of resources that warrant consideration when identifying conservation or restoration priorities are listed below along with sources of relevant information.

- Tidal wetland migration pathways (Figure 30) and predicted flood zones with sea level rise (Figure 32)
- 500-year flood zones, riparian buffer zones (Figure 9a), and Active River Areas (Figure 9b)
- Corridors along all streams, including small unmapped streams (Figure 8 and local knowledge)
- Coldwater streams (Figure 23), and streams with no known impairment (Figure 12)
- Streams that are threatened or impaired (Figure 12), and streams with moderate to severe barriers (Figure 34)

- Unconsolidated aquifers (Figure 8)
- Large forests (Figure 15a)
- Large meadows (Figure 16)
- Known locations and habitats of rare species of plants or animals (from local knowledge, New York Natural Heritage Program, and figures 22a-d)
- Habitats that support rare species of plants or animals (including SGCN animals) (from local knowledge and Figures 15, 16, 17, 18, 19, 20, 21, 22, 23)
- NYSDEC Significant Biodiversity Areas (Figure 24)
- Unusual habitats and high quality examples of common habitats (from local knowledge); examples include the large meadows in the Route 9W corridor and the red cedar forests and calcareous ledges of the Kalkberg
- Wetlands, including those already mapped (Figure 10a), and others not yet mapped (from local knowledge)
- Unusual landforms (caves, cliffs, ravines, etc., from local knowledge) or unusual bedrock types (Figure 4)
- "Prime" and "Statewide Important" farmland soils (Figure 25)
- Active farmland (from local knowledge)
- Sand and gravel deposits (glacial outwash and kames) (Figure 5) or other extractable mineral resources (from local knowledge)
- Broad, intact corridors encompassing low-to-high elevations or south-to-north corridors (figures 2, 14, 15)
- Broad corridors connecting formally protected land parcels (figures 14, 15a, 37)
- Areas with high landscape permeability (Figure 35) or with high climate change resilience (Figure 36)
- Scenic areas (from local knowledge and Figure 28)
- Public recreation areas of recognized importance (from local knowledge and Figure 29) and places where expansion of existing areas or creation of new areas is desirable and anticipated

The kinds of local resources and the values and needs of the community (or organization or landowner) will determine the relative weight given each of those factors. A community may prioritize a subset of those resources because of their importance in the regional landscape, the ecological services that they provide to the community, their local or regional rarity, or their importance to the local economy, identity, or quality of life, for example.

Another kind of analysis could identify the above-listed resources that are located in higher-risk areas, such as:

- Around population centers
- Near fast-growing commercial areas (“strips”)
- In areas at risk for residential development such as recently abandoned farmland, high-elevation areas with good views, land near large streams and waterbodies, or in areas desirable for other reasons (access to schools, amenities, etc.)
- Near potential water pollutant sources such as industry, dense residential or commercial areas, extensive paved or tilled areas, dumps, or landfills

Another, complementary approach would be to focus on general topics of importance to the community (perhaps those identified in a municipal comprehensive plan or in responses to a public survey), such as “maintaining rural character” or “ensuring clean and ample drinking water.” Once some general priorities are set, specific resource information can be brought to bear. For example, some topics to consider:

Reducing flood intensity and flood damage

Protecting drinking water quality/quantity

Protecting or improving stream habitats

Accommodating sea level rise

Conserving biodiversity

Preserving farmland

Protecting mineral resources for local self sufficiency

Maintaining ecosystem stability in the face of climate change

Preserving rural character/scenic beauty

In the *Schoharie Creek Watershed Conservation Assessment* prepared for NYSDEC, The Nature Conservancy (TNC) identified several “priority areas” in the Schoharie Creek watershed to protect and maintain high quality forest and freshwater habitats, conserve habitats for rare species, secure potential climate refugia and resilient landscapes, and protect and restore floodplains and riparian buffers (Shirer et al. 2018). The priority areas identified by TNC in Greene County were 1) the high-elevation West Mountain to Plateau Mountain ridge; 2) the West Kill basin; 3) the Black Dome to South Mountain ridge; 4) the Patterson Ridge to Huntersfield Mountain region; and 5) the Batavia

Kill basin. The special attributes of each area are described by Shirer et al. Parts of these priority areas are in NYSDEC or NYCDEP ownership, but large areas have no formal protection and could be vulnerable to harm from new land uses.

From a survey conducted in 2001, the *Greene County Open Space Plan* (Greene County Planning Department 2002) identified watercourses, mountain tops, and historic sites as the features of greatest importance to the public for open space conservation. The Plan recommends individual landowner actions (e.g., preserving buffer zones along streams and wetlands), adoption of local legislation to discourage new buildings and impervious surfaces near waterbodies and to protect aquifer recharge areas, and attention to scenic impacts in environmental reviews of new projects within Scenic Areas of Statewide Significance and along Scenic Byways.

Municipalities may wish to conduct their own surveys to better understand local conservation concerns. Once identified, the conservation priorities can be incorporated into comprehensive plans or zoning ordinances by means of overlay zones or regulatory setbacks, for example. They can contribute to designation of Critical Environmental Areas or decisions about land acquisition or conservation easements. They can inform individual landowners' management decisions as well as the planning board's requests for information from or recommendations to land use applicants. The section below on **Achieving Conservation Goals** describes some regulatory and non-regulatory tools for protecting areas deemed important for conservation.

The Willows at Brandow Point. Photo: Jill Knapp © 2019

ACHIEVING CONSERVATION GOALS

Conservation Tools

Conservation of natural resources can happen on every land parcel in the county, whether it is a half-acre residential lot, a 50-acre woodlot, or a 200-acre farm. It can happen through a variety of means, including voluntary land management efforts of individual landowners, conservation-minded designs of new development projects, land trust acquisition of land or establishment of conservation easements with willing landowners, or restrictions imposed by municipal policy or legislation.

Landowner Education

Educating landowners about their potential stewardship roles can help raise awareness and support for conservation activities, and inspire voluntary action. This can occur through outreach at community events, through lectures and workshops, or through distribution of educational materials. Some programs of the Cornell Cooperative Extension address these and other issues relevant to land management. Educating landowners about the special natural features of their land, and recruiting landowners as long-term land stewards and conservation partners, is essential for conserving the ecologically significant features of the landscapes of Greene County.

Formal Land Protection

Landowners, conservation organizations, municipal agencies, and state or federal agencies may be involved in formally protecting land. Most often, land protection is undertaken using one of two approaches: land acquisition or perpetual conservation easements. Other legal instruments can confer conservation status for a period of time, such as deed restrictions or term easements (easements that cover a specified period of time).

Land Acquisition

Greene County and local municipalities may only rarely have funds available for acquiring lands for conservation purposes but can nonetheless collaborate with other public and private entities to help with acquisition efforts for lands with special environmental, historic, agricultural, recreational, or scenic importance or lands that are threatened by inappropriate development.

A decision to purchase a property for conservation purposes should be preceded by an assessment of the conservation values of the property in relation to the buyer's goals and priorities, and a determination of the long-term capacity for stewardship of the property. Financial and other forms of collaboration with other agencies, organizations, and landowners can expand the opportunities for and success of land acquisition projects.

Land acquisition is only one of many tools for land conservation, however. The municipalities in the "mountain top" region, where much land is already in state or New York City ownership for conservation purposes, may have little interest in or need for further conservation set-asides, but still have ongoing concern for clean streams, lakes, and ponds, clean and abundant groundwater, and scenic natural landscapes that depend on intact habitats. Other methods for protecting important resources on privately-owned lands without formal conservation status are outlined below.

Conservation Easements

A conservation easement is a legal agreement between a landowner and an entity such as a municipality or a land trust. The easement is developed by the landowner and the receiving agency (such as the land trust), and it restricts the type, location, and amount of development and specifies the types of land uses that can occur on the property so that conservation values—such as wildlife habitat, scenic views, agricultural value, and water resources—are protected. An easement may be in force for a certain amount of time (term easement) or forever. An easement may be donated by the landowner to the receiving agency or may be purchased from the landowner by the receiving agency. Conservation easements may be required under some municipal rules, such as conservation subdivisions.

Easement lands remain in private ownership and on local tax rolls. The landowner retains full title to the land and is free to sell, lease, or mortgage the property or pass it on to heirs. The conservation easement, however, "runs with the land;" that is, the restrictions and responsibilities of the easement are conveyed to all future owners of the property. In this way a conservation easement allows the current landowner to maintain ownership and use of the property, while securing a conservation legacy for future generations.

Conservation easement agreements with a land trust such as the Greene Land Trust or Scenic Hudson are completely voluntary, are developed on the landowner's initiative, and are designed to meet the wishes and long-term needs of landowners while adhering to the conservation principles of the land trust and the rules of the funding program (if state or federal funding is involved). Easements require regular (annual) monitoring to ensure that the terms of the land use agreement continue to be met.

Land Use Legislation & Other Local Measures

Municipalities have considerable authority to establish land use policies and regulations in the public interest through zoning and other mechanisms in the local code. Citizens can make their concerns known to municipal agencies by attending agency meetings and becoming involved in comprehensive planning, open space planning, zoning revisions, and Conservation Advisory Councils. (Conservation Advisory Councils are common in municipalities in other Hudson Valley counties but have yet to be established in Greene.)

The municipal Comprehensive Plan (or Master Plan) sets forth the interests, purposes, and intents of the community for development and conservation; the zoning law establishes rules and procedures to carry out those intents; and municipal agencies (e.g., town board, planning board, zoning board of appeals) implement the local laws when reviewing and ruling on land development projects.

Zoning and other local laws provide legal standards for land development projects and usually strive to balance private property rights with community environmental, health, and safety concerns. Carefully designed legislation and project reviews help to ensure that land use restrictions are applied consistently and fairly and that resources important to municipal interests and public welfare are protected. Below are described some specific regulatory tools that can be employed at the municipal level to govern the uses and conservation of natural resources.

Good land use policies and decisions, however, depend on having good information. This *NRI* provides information on natural resources throughout the county, including resources of conservation concern and particular sensitivity, but does not show parcel-by-parcel details. While this document can alert users to the presence of important resources, on-the-ground observations are still essential to adequately assess the features of concern on any site where new land development is proposed.

Comprehensive Planning

In New York, municipal land-use regulations must be adopted in accordance with a comprehensive plan (Town Law, Section 272-a; Village Law, Section 7-722; or General City Law, Section 28-a). The comprehensive plan, based on the needs and values of the community, is intended to guide long term growth and development and serve as a foundation for all land-use regulations (such as zoning, subdivision, right-to-farm, and flood damage prevention laws). Comprehensive plans are most useful when they include descriptions, locations, and values of local natural resources, along with goals and priorities for resource use and conservation and strategies for furthering those goals.

Watershed Planning

Because streams, watersheds, and aquifers cross political boundaries, cooperation between neighboring communities is often essential for protection of water resources. Through watershed planning, public agencies, conservation NGOs, private landowners, and others can identify threats to water resources and specific actions for watershed management. The Watershed Plans Guidebook (NYSDOS 2009) provides step-by-step guidance on the watershed planning process.

Winter hike at the Mawignack Preserve. Photo: Bob Knighton © 2019

Open Space Planning

Under the broadest definition, "open space" includes all the undeveloped land—both publicly- and privately-owned—in a municipality or other area of interest. The NYS General Municipal Law, Section 247, defines open space as "any space or area characterized by (1) natural scenic beauty or, (2) whose existing openness, natural condition, or present state of use, if retained, would enhance the present or potential value of abutting or surrounding urban development, or would maintain or enhance the conservation of natural or scenic resources." An open space "inventory" simply catalogs and maps the open space resources in a municipality or other area of interest; an open space "plan" identifies priority areas for open space conservation and outlines ways to accomplish open space conservation goals.

The regional NYSDEC office conducts ongoing reviews of potential land protection projects based on priorities identified in the State Open Space Conservation Plan (NYSDEC and OPRHP 2016). Projects that fit the scope of a listed priority conservation project and pass a thorough review process are eligible for funding from the State's Environmental Protection Fund and other state, federal, and local funding sources. Some of the state-identified open space priorities in Greene County include:

Balsam Mountain
Bronck Island
Catskills escarpment
Catskill Mountain unfragmented forests
Coxsackie Flats grassland area
Four Mile Point/Vosburgh Swamp/West Flats
Hudson River Greenway Water Trail Sites
Hunter-West Kill Wilderness
Important farmland
Kaaterskill Rail Trail
Kaaterskill Wild Forest
Lands important to regional adaptation to sea level rise
RamsHorn Marsh
Scenic Areas of Statewide Significance lands
Vosburgh Swamp
Windham High Peak

Zoning and Subdivision Regulations

Landowners have much autonomy in the uses and care of their own land, but municipalities regulate some aspects of land uses and development with potential to affect resources important to the public welfare by means of zoning, subdivision, and site review regulations.

For example, local legislation is the only means for legal protection of the many wetlands and streams that do not fall under state or federal jurisdiction. (Many comprehensive plans and local codes in the county express an intent to protect wetlands and streams but then refer only to existing state and federal regulations.) Local legislation can establish land use restrictions, buffer zones, and other measures for protecting wetlands and streams of any size or in any landscape position. Other Hudson Valley municipalities (e.g., the towns of Clinton, New Paltz, Woodstock, Yorktown) have adopted local laws to protect ecologically important wetlands and streams, but so far in Greene County none have done so.

The statement of purpose in a local zoning law often clearly spells out the public interests to be served by the law and thus the underpinning for regulatory decisions. Below are descriptions of municipal regulations that have been used to protect natural resources in Greene County and elsewhere in the Hudson Valley.

Overlay zoning –Some municipalities have designated "overlay zones" pertaining to certain resources and places of particular conservation concern such as agricultural districts, scenic corridors, ridgeline districts, steep slope districts, stream corridors, and aquifer protection districts. Overlay zones often overlap two or more underlying zones; the existing rules and exemptions for the underlying zones still apply, but additional restrictions may be imposed to protect the sensitive environmental features of the overlay zone.

Performance standard zoning – This zoning establishes restrictions on environmental impacts regardless of use; for example, requiring naturally vegetated buffers of a certain width around waterbodies, wetlands, or streams.

Incentive zoning – In return for maximizing open space or another environmental benefit, a subdivision developer is given an incentive such as permission to build at a higher density.

Special use permit requirement – A municipality may legislate to set standards or impose requirements (furthering natural resource conservation) to avoid or minimize the risks of certain types of uses. For example, a municipality could require special use permits for gas stations in areas of sensitivity for groundwater, making it a condition of approval that fuel storage be above ground.

Conservation subdivision regulations – These can include provisions that explicitly protect open space or natural resources, require cluster development, or impose fees to purchase land for parks or other conservation purposes.

One limitation of "conservation subdivision" laws and similar local laws is that they are usually invoked only for "major" projects (e.g., those involving five or more subdivided lots; the exact threshold is set in the local code). Thus, project sponsors often design smaller projects (e.g., four subdivided lots) to avoid the requirements of a conservation subdivision design. The consequence is that subdivision projects are designed without regard to the habitat fragmentation effects of conventional subdivisions, and rural sprawl proceeds unabated.

Site plan review – A site plan is a scale drawing illustrating the layout and design of a proposed development project or use on a single parcel of land. A zoning ordinance or separate local law may require site plan approval for any development, thus giving some community oversight over how development occurs and how public resources are affected. Municipalities determine what must be shown on a site plan and may require that site plans show various types of natural resources. The reviewing board may impose reasonable conditions or restrictions as part of site plan approval.

Natural Resources and SEQR

Municipalities may require that certain kinds of natural resource information be part of an application to the planning board or building department.

Including natural resource information early in project planning helps the applicant accommodate the important features in the project design right from the start, and helps avoid the expenses of redesign.

Municipalities can recommend or require that land use applicants refer to this *NRI* to bring natural resource information into project design and review, and can require that a **habitat assessment** be prepared by a qualified professional as part of an application for a subdivision or site plan approval.

Model guidelines for such an assessment are at http://hudsonia.org/wp-content/uploads/2018/04/Habitat_Assessment_Guidelines_2013.pdf.

Better Site Design

The Better Site Design approach involves a set of model land development principles to reduce impervious cover, conserve natural areas, and prevent stormwater pollution of streams, ponds, and wetlands from new development (Center for Watershed Protection 1998; https://owl.cwp.org/mdocs-posts/better-site-design-part-1/).

Floodplain Protection

The Floodplain Management Regulations of the Federal Emergency Management and Assistance Law set forth minimum standards for flood protection but encourage communities to adopt more restrictive floodplain management regulations when warranted to better protect people and property from local flood hazards (44 CFR 60.1[d]).

Moreover, under the Community Rating System, insurance premium discounts are available to policy-holders in communities that have enacted floodplain management programs that exceed the standards of the Federal Emergency Management Agency (FEMA). To minimize public hazards, Greene County municipalities may want to adopt improved standards for floodplain management. A model local law provided by NYSDEC is at www.dec.ny.gov/docs/water_pdf/oppaddlang17.pdf.

State Environmental Quality Review (SEQR)

The New York State Environmental Quality Review Act sets forth a formal procedure for assessing potential environmental impacts of proposed projects and integrating environmental concerns into planning and regulatory review at the state and local levels. Most projects proposed by a state agency or a municipality, and all permits from a state agency or unit of local government, require an environmental impact assessment (6 NYCRR Part 617 State Environmental Quality Review). The basic document for this assessment, to be completed in the early stages of a SEQR review, is the Environmental Assessment Form (EAF), designed to help the project applicant and the reviewing agencies gather and assess basic information about the proposed project, the natural and cultural features of the project site, and the potential impacts of the project on resources of concern. SEQR requires the sponsoring or permitting agency (such as a municipal planning board) to identify potentially significant environmental impacts of the activity it is proposing or permitting, and to avoid, minimize, or mitigate those impacts (https://www.dec.ny.gov/permits/6208.html).

As with many such bureaucratic forms, the EAF is often completed in a perfunctory way by the applicant and the lead agency in the environmental review, providing only scant and superficial information about resources at risk and potential impacts to those resources. But applicants, planning boards, and town or village boards that use the EAF and the SEQR process to their fullest potential will find them powerful tools for protecting important resources and sensitive areas. This starts with thorough and informative answers to the EAF questions and analysis of potential impacts.

NYSDEC hosts an online EAF Mapper (http://www.dec.ny.gov/permits/90201.html) designed to answer the place-based questions in Part 1 of the EAF forms. Using the Mapper can greatly hasten and simplify the work of completing the EAF. However, the Mapper uses only existing data in the public domain and thus relies on the state and federal wetland map data (with all their known inaccuracies and omissions), existing rare species data (which are incomplete), and existing flood zone data (which are outdated in some areas of the county). A thorough approach to completing the EAF would include onsite identification and mapping of wetlands and floodplains, and a habitat assessment to determine the potential for species of conservation concern. A fact sheet on using the EAF short form to its fullest potential for identifying sensitive natural resources at risk is at https://hudsonia.org/resources/.

Critical Environmental Areas
Another means of drawing attention to significant natural resources is by establishing a Critical Environmental Area (CEA). A CEA, which can be established by a municipality or a county, is a geographical area with exceptional character with respect to one or more of the following:

- a benefit or threat to human health;
- a natural setting (e.g., fish and wildlife habitat, forest and vegetation, open space and areas of important aesthetic or scenic quality);
- agricultural, social, cultural, historic, archaeological, recreational, or educational values; or
- inherent ecological, geological or hydrological sensitivity that may be adversely affected by any change in land use (http://www.dec.ny.gov/permits/45500.html).

A CEA is a formally-designated area, adopted by the municipality or county and registered with the state, with the purpose of raising awareness of the unusual resource values (or hazards) that deserve special attention during environmental reviews and land use decisions. "Once a CEA has been designated, potential impacts on the characteristics of that CEA become relevant areas of concern that warrant specific, articulated consideration in determining the significance of any Type I or Unlisted actions (in the SEQR process) that may affect the CEA" (http://www.dec.ny.gov/permits/45500.html). In addition, the municipality or county can adopt procedural or regulatory requirements to ensure that the important attributes of the CEA are considered during SEQR review and site plan review in those areas. To date there have been no CEAs established in Greene County.

Habitat Assessment
A "habitat assessment" can be adopted as a standard requirement in the early stages of planning and municipal review of new projects. The purpose is to ensure that the applicant, the planning board, and other reviewing agencies have the information they need to assess potential impacts to habitats and species of concern prior to approval of new projects. A template for habitat assessments is available at: http://hudsonia.org/wp-content/uploads/2018/04/Habitat_Assessment_Guidelines_2013.pdf.

Indian cucumber-root. Photo: Andy Reinmann © 2019

Conservation Partners

The breadth and effectiveness of a municipality's conservation efforts can be greatly extended by collaboration with other entities with shared conservation goals and by marshalling the efforts of active volunteers, willing landowners, and partner organizations and agencies in the town, county, region, and state. Potential partners include:

- federal, state, and county agencies;
- national, statewide, and regional conservation organizations;
- land trusts;
- recreation organizations;
- large and small landowners;
- local businesses; and
- local volunteers.

Federal, State and County Agencies

Natural Resources Conservation Service (NRCS)

The NRCS (of the US Department of Agriculture) collaborates with farmers, communities, and other individuals and groups to protect natural resources on private lands. They identify natural resource concerns related to water quality and quantity, soil erosion, air quality, wetlands, and wildlife habitat, develop conservation plans for restoring and protecting resources, and help to direct federal funding to local conservation projects.

New York State Department of Agriculture and Markets

The agency administers three grant programs focused on farmland protection:

(1) The Farmland Protection Planning Grants Program (FPPG) assists county and municipal (i.e., town, village, city) governments in developing agricultural and farmland protection plans that recommend policies and projects aimed at maintaining the economic viability of the state's agricultural industry and its supporting land base. Greene County used one of these grants to prepare the 2002 Agricultural and Farmland Protection Plan

(2) The Farmland Implementation Grants Program (FPIG) assists counties, municipalities, soil and water conservation districts, and not-for-profit conservation organizations in implementing farmland protection plans, including those created through FPPG.

(3) The Land Trust Grants Program awards grants to land trusts for activities that will assist counties and municipalities with their agricultural and farmland protection efforts.

New York State Department of Environmental Conservation (NYSDEC)

The NYSDEC's mission is "'to conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being." In addition to being a regulatory agency implementing and enforcing environmental regulations to protect clean air and water, NYSDEC has technical assistance, education, and grant programs. NYSDEC owns and manages forest lands, wildlife management areas, and fishing access sites, and sets open space priorities through a statewide planning process (see the 2016 NYS Open Space Conservation Plan). NYSDEC can provide information and technical assistance with stream and lake monitoring, groundwater protection, and floodplain mapping.

The NYSDEC's **Climate Smart Communities** program is a "state-local partnership to meet the economic, social and environmental challenges that climate change poses for New York's local governments." The program supports local governments and communities in their efforts to confront and adapt to climate change, reduce local tax burdens, and advance other community priorities. Participating communities have privileged access to certain state grants and are part of a network of governments working to achieve "climate smart" practices and policies.

The **Hudson River Estuary Program** of NYSDEC has a strong interest in developing municipal capabilities for conserving important resources. It provides educational opportunities and technical assistance for municipal officials, as well as grants to municipalities and nonprofit organizations for local biodiversity conservation projects. The Estuary Program has prepared town-specific reports on habitats, water resources, and climate change for several Greene County towns and funding for the preparation of this *NRI*. The Trees for Tribs program provides training and materials for restoring woody vegetation along streams to improve streambank stability and instream and riparian habitats.

New York State Department of State (DOS)

The DOS offers training, educational publications, and technical assistance for municipal agencies on a variety of topics including the State Environmental Quality Review (SEQR) process and developing local legislation. DOS's Local Government Division offers training and technical assistance for local government in land use and planning. DOS administers the state's Coastal Zone Management Program and Local Waterfront Revitalizations Program which pertain to the Hudson River shoreline and tributary streams that are designated "inland waterways." DOS developed the scenic assessment program that led to the designation of areas of Greene and other counties along the Hudson River as "Scenic Areas of Statewide Significance."

New York State Office of Parks, Recreation, and Historic Preservation (OPRHP)

The OPRHP manages state parks for purposes of conserving natural resources and providing recreational and educational opportunities for the public. The agency is a willing partner providing information, technical assistance, and other support for projects related to biodiversity conservation, water conservation, publicly-accessible trails, and public education on and near state park lands.

Hudson River Valley Greenway

The Greenway offers technical assistance and small grants to municipalities and nonprofit organizations for projects related to community planning, economic development, and protection of open space and of natural, cultural, and scenic resources.

Cornell Cooperative Extension—Columbia and Greene Counties

The Cornell Cooperative Extension (CCE) is part of a statewide program that aims to "put knowledge to work in pursuit of economic vitality, ecological sustainability and social well-being," serving local families, farms, and communities. Their agricultural education programs provide research-based information on production and marketing of agricultural and horticultural products, through workshops, publications, and consultations. The CCE also provides information, workshops, and assistance on forest stewardship, water resource protection, invasive species, and agroforestry. CCE staff have assisted with the preparation of this *NRI*, and the associated public education.

Greene County Soil and Water Conservation District

The District office provides technical assistance and education on matters related to water, soils, and other natural resources to municipalities, farmers, landowners, and residents and promotes resource conservation and environmental stewardship. District staff host educational programs and provide consultations and other services and assist with obtaining funding for projects that enhance environmental quality or economic viability of farm-related projects.

Greene County Department of Planning

The Greene County Department of Planning conducts research and analysis, provides information, data, and technical assistance, and advises the county Board of Supervisors, local governments, and the public on issues related to land use, zoning, environmental quality, agriculture, transportation, open space, and recreation. The Planning Department hosts the Greene County Web Map, an interactive map showing spatial data for (among other features) surface water, bedrock, soil types, flood zones, and state-regulated wetlands (http://gis.greenegovernment.com/giswebmap/).

Greene County Public Health Department

The Department of Health seeks to protect, preserve, and promote the health of the people and natural environment of Greene County. The agency investigates and monitors communicable diseases, including those carried to humans from animal vectors such as Lyme disease and the West Nile virus. They provide materials and services for public education on a wide variety of health issues; respond to spills and other hazardous materials emergencies; and maintain information and resources for emergency preparedness.

Dolans Lake, early spring. Photo: Michelle Yost © 2019

Municipal Agencies

New York City Department of Environmental Protection (NYCDEP)

The NYCDEP owns large areas of land in the watersheds of the city's 19 drinking water reservoirs, and also regulates land uses on privately-held lands that could affect the quality or quantity of water entering the reservoirs. Much of the western half of Greene County lies in the watershed of the Schoharie or Ashokan reservoirs. NYCDEP conducts research on streams and funds programs to improve environmental infrastructure—especially stormwater management and wastewater treatment.

The NYCDEP also works with willing farmers to develop "whole farm plans" that identify land management practices that will help to protect water quality (https://archive.epa.gov/region02/water/nycshed/web/html/protprs.html). As of 2006, 95.7% of commercial farms in the watershed of NYC reservoirs were enrolled in the Watershed Agricultural Program, and 288 of those farms had "whole farm plan" agreements with NYCDEP (https://archive.epa.gov/region02/water/nycshed/web/html/protprs.html#AG).

Town Boards, Village Boards, and Planning Boards

Municipal agencies have the authority and responsibility to uphold policies and practices that protect public health and safety, objectives that are often closely related to protection of natural resources. The Municipal Home Rule Law of the New York State Constitution bestows on town boards, city councils, and village boards of trustees the authority to adopt local legislation that is more protective of resources than the state laws if serving the purpose of public welfare. Planning boards routinely review subdivision proposals and land development projects to ensure that they are in compliance with local laws and policies. Planning boards also have opportunities to educate land use applicants and recommend project designs that further protect, for example, water resources, habitats, and scenic views.

Neighboring municipalities can be valuable partners in land conservation, when shared natural resources straddle municipal boundaries. Adjoining municipalities can collaborate on developing conservation funding, supportive land use ordinances or other regulatory measures, strong open space plans, and ownership and management of conservation lands.

Conservation Advisory Councils

A Conservation Advisory Council (CAC) is a commission appointed by the municipal legislative body (e.g., the Town Board or Village Board) to advise municipal agencies on matters related to natural resources and conservation. CACs typically take on a variety of tasks that may include reviewing development proposals, gathering and distributing natural resource information to municipal agencies and the public (such as natural resource inventories or open space plans), conducting research on local legislation, and public education.

Conservation Organizations

Audubon New York

Audubon New York is a state program of the National Audubon Society. Its mission is to protect birds and their habitats through science, advocacy, education, and on-the-ground conservation programs. The organization manages seven sanctuaries and centers throughout the state, including one in Greene County—the RamsHorn-Livingston Sanctuary in Catskill. It sponsors public education programs, leads public outings, monitors bird populations and trends, promotes conservation legislation, and works with other organizations to promote policies and practices that protect important lands for wildlife.

Catskill Center for Conservation and Development

The mission of the Catskill Center is "to protect and foster the environmental, cultural and economic well-being of the Catskill region." They advocate for land conservation; have many programs for public education; and own and manage several properties for conservation and public education purposes. The Catskill Center collaborates with landowners and with many organizations and agencies to promote conservation throughout the region.

Greene Land Trust

The Greene Land Trust seeks to preserve and protect significant natural and cultural resources in and around Greene County. It is an accredited land trust that owns and manages lands for conservation purposes and for public enjoyment and education, and holds conservation easements on other lands. The GLT initiated this *Natural Resources Inventory* project, obtained the funding, and oversaw the preparation of the *NRI*.

The Nature Conservancy

The Nature Conservancy (TNC) is an international land conservation organization that has worked extensively throughout the state to further land protection (including conservation easements) through partnerships with other organizations and agencies (e.g., NYSDEC, Open Space Institute) and private landowners to prevent further fragmentation of important ecosystems. TNC's conservation targets include matrix forest blocks, wetlands and vernal pools, drinking water sources, rare and endangered plants, and the timber rattlesnake; TNC has a particular interest in helping communities adapt to climate change.

New Baltimore Conservancy

The New Baltimore Conservancy seeks to conserve and enhance the natural, cultural and historic resources in and near the Town of New Baltimore. They sponsor education programs, recreation and social events, and manage several properties owned by the Open Space Institute, Scenic Hudson, and the Town of New Baltimore, designing, constructing, and maintaining trails and other amenities for public uses.

Open Space Institute

The Open Space Institute (OSI) works in the eastern US to protect scenic, natural, and historic landscapes through direct acquisition and conservation easements, and partners with local and state government to expand parklands. OSI's conservation strategy focuses on permanent protection at the landscape-level scale. OSI has protected over 46,000 acres in the Hudson Valley, creating connecting corridors that benefit both recreationists and wildlife and protecting prime farmland.

Preservation League of New York State

The Preservation League of New York State seeks to protect New York's heritage of historic buildings, districts, and landscapes. It leads advocacy, economic development, and education programs, and provides grants, loans, and technical assistance to individuals, organizations, and communities.

Scenic Hudson and Scenic Hudson Land Trust

Scenic Hudson preserves land, creates and manages parks, produces educational publications, and works with communities and conservation NGOs to support conservation efforts throughout the Hudson Valley. Scenic Hudson owns several conservation areas in Greene County, and the land trust holds conservation easements on several parcels of privately-owned land in the county. In their program to Save the Land that Matters Most, Scenic Hudson works to identify and protect the "lands of the highest scenic, ecological, and agricultural significance" throughout the Hudson Valley. Scenic Hudson staff also conduct scientific research and develop plans for responding to climate change in a way that "reduces risks to people, property, and nature, and holds the promise of secure, thriving riverfront communities within a vibrant, healthy ecosystem." They have been working with

Hudson River shoreline communities in the Hudson Valley, including the Village of Catskill, to plan strategically for land uses and infrastructure in the shoreline zone that will be most resilient to sea level rise.

Trout Unlimited

Trout Unlimited (TU) is a national organization whose mission is to conserve, protect, and restore the coldwater streams and fisheries of North America through habitat restoration, land conservation, public education, and legislative advocacy. They have a long history of collaborating with local, county, state and federal government agencies as well as other conservation organizations to achieve shared goals. The local chapter of TU is the Columbia-Greene Chapter #569 (Hudson). The New York State Council Trout Unlimited Conservation Fund provides small grants to local TU chapters for coldwater fisheries conservation projects. Due to the presence of many small and large trout streams, in Greene County the Columbia-Greene chapter may be well-positioned to obtain funding for projects to restore, enhance, or protect the habitat quality of Greene County streams.

Local Businesses

Many local business owners have a deep personal appreciation for and commitment to their community, the county, and the region and also recognize that their business success is closely tied to the natural environment. Contributing to conservation efforts can offer business owners the personal satisfaction that comes with taking care of the places they love, can serve as an investment in the landscape that supports their livelihood, can demonstrate their commitment to conservation and the community as a prominent part of their business profile, and can help build positive relationships with the community. For all these reasons businesses are often enthusiastic partners in conservation initiatives and can often help with funding, publicity, and in-kind assistance for local conservation projects.

Landowners and Others

Private owners of large land parcels or of smaller parcels containing important resources play a critical role in the future of land conservation, and are essential partners in conservation action and funding. Landowners can take specific measures to protect habitats and water resources on their own land, can collaborate with their neighbors to protect and manage resources in nearby areas, and can assist the community with larger conservation efforts. Landowners in the county are diverse and represent a broad spectrum of views on conservation. Municipal conservation efforts can benefit from reaching out to landowners on a regular basis to build partnerships and to understand owners' relationships to their land and their interests, goals, and concerns. Education programs can help landowners understand the role they play in shaping their community's future landscape and the available options for land management and land conservation

Local professionals, such as biologists, ecologists, teachers, environmental engineers, and landscape architects, as well as amateur naturalists often have a wealth of knowledge and expertise related to natural resources. Many have a strong personal interest in resource conservation, and some can offer their volunteer services to the municipality for technical assistance, grant-writing, or public education.

The bald eagle nests in large trees and hunts over large waterbodies. Photo: Larry Federman © 2019

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APPENDICES

APPENDIX A

Glossary

GLOSSARY

Active River Area The area along a stream that is dynamically involved with the physical and ecological processes that drive and sustain the stream (Smith et al. 2008).

aestivation A state of summer dormancy characterized by inactivity and low metabolic process.

allelopathy The chemical inhibition of one species by another. In plants this occurs by release of biochemicals by one species that influence the growth, survival, development, or reproduction of neighboring plants.

alluvium Material, such as sand, silt, clay, and gravel, deposited on land by moving water.

anadromous Migrating from the ocean to spawn in freshwater.

anthropogenic Caused or influenced by human activity.

aquifer A water-bearing formation, e.g., in bedrock fractures or solution cavities, or in unconsolidated surficial material such as sands and gravels.

Area of Known Importance An area deemed to be important for the continued persistence of rare plants, rare animals, and significant ecosystems, identified and delineated through analysis of known occurrences of exemplary ecological communities or rare plants and animals, their life histories and habitats, and the physical and hydrological features of the landscape. Areas of Known Importance are delineated and mapped by the New York Natural Heritage Program.

area-sensitive wildlife Wildlife species that require large contiguous habitat areas to meet their life history needs and maintain local populations. Some of these species have large home ranges; some require a complex of habitats distributed over the landscape; some are especially sensitive to human disturbance or are vulnerable to predators or nest parasites that frequent habitat edges.

asl Above sea level.

aspect The direction that a location faces; for example, a north-facing slope has a northern aspect.

base flow (of a stream) The sustained flow of a stream in the absence of direct precipitation or surface runoff. Natural base flow is sustained largely by groundwater discharges.

bedrock The solid rock either exposed or underlying soil, rock fragments, or other unconsolidated materials.

biodiversity All the variety of plants, animals, and other living things. The term encompasses diversity at all scales, including landscapes, ecosystems, ecological communities, species, and their genes. From a conservation standpoint, ecologists are mainly concerned about native biodiversity—the biota that have established and developed in the region over millennia, but not the recent introductions since European settlement.

bluestone A kind of sandstone with thin horizontal layering (3-20 cm thick) that splits easily into flagstones when quarried. Bluestone may be red, green, brown, gray, or blue.

bog A wetland with permanently saturated soils and receiving most of its water from precipitation instead of groundwater. Bogs often accumulate a deep layer of peat.

calcareous Calcium-rich; containing high concentrations of calcium salts. The term is generally applied to water, soils, and bedrock. The source of calcium in this region is usually calcium carbonate or calcium magnesium carbonate (e.g., limestone or dolostone). Calcareous environments are generally circumneutral (see below) or alkaline.

carbonate bedrock Limestone, dolostone, and related rocks composed largely of calcium carbonate or calcium magnesium carbonate. Carbonates also occur as cementing materials in some sandstones.

carbon sequestration Capture and long-term storage of atmospheric carbon dioxide or other forms of carbon. Carbon sequestration, whether occurring artificially or by natural biological, chemical, and physical processes (such as the growth of a tree, or the accumulation of peat in a wetland), is a means of mitigating or deferring global warming.

catadromous Migrating from freshwater streams to the ocean to spawn.

circumneutral Having a pH at or near 7.0 (approximately 6.6–7.3).

climate change resilience The capacity of a system to adapt to climate change while still maintaining biological diversity and ecosystem function.

conglomerate Gravel-rich sedimentary rocks with grains over 2mm in diameter with relatively rounded, smooth grain margins.

conifer forest A forest dominated by conifer trees; i.e., where conifer tree species constitute $\geq$75% of the forest canopy. Conifers are cone-bearing trees such as white pine, eastern hemlock, tamarack, and eastern red cedar.

conservation easement A voluntary legal agreement drawn up by a landowner and a qualified public or private agency (such as a land trust) that ensures permanent protection of the land. The landowner retains ownership with many of its rights and responsibilities (including property taxes), and can live on, use, or sell the land or pass it on to heirs, but the conservation easement remains attached to the land in perpetuity. The easement is designed to serve the conservation goals of the landowner and easement holder (e.g., the land trust), and describes permissible and impermissible land uses and land management.

Conservation Overlay District A district specified in a municipal zoning ordinance to protect significant habitats, water resources, scenic areas, or other natural feature. The district overlies one or more other zones, and the rules governing the those zones still apply, but the overlay district imposes additional restrictions to protect the sensitive environmental features.

Critical Environmental Area A geographical area with exceptional character with respect to a benefit or threat to human health; a natural setting; agricultural, social, cultural, historic, archaeological, recreational, or educational values; or inherent ecological, geological or hydrological sensitivity that may be adversely affected by any change in land use. A CEA must be formally delineated, mapped, described, and adopted by the municipal legislative body; and registered with the NYS Department of Environmental Conservation (http://www.dec.ny.gov/permits/45500.html).

deciduous forest (Also called a "hardwood forest.") A forest dominated by deciduous trees, i.e., where deciduous tree species constitute ≥75% of the forest canopy. Deciduous trees are those that shed their leaves annually. In this region, deciduous trees include oaks, maples, ashes, cherries, beech, and many others. See "conifer forest" for comparison. (Tamarack is the unusual case of a deciduous conifer.)

denitrification The process by which soil microbes convert nitrate (NO_3) or nitrite (NO_2) to nitrogen gases that are released to the atmosphere.

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distributed wind Small turbines for residential, farm, school, or community that offset some or all grid power usage near the point of end use.

dolomite The mineral calcium magnesium carbonate ($CaMg[CO3]_2$).

dolostone A durable sedimentary rock composed primarily of dolomite (calcium magnesium carbonate); similar to limestone in appearance, hardness, solubility, and human uses.

dredge spoil Sediment material dredged from a waterbody.

ecosystem services The resources and services provided by the natural environment that benefit the human community, such as development of soils, purification of water and air, cycling of nutrients, mitigation of floods, dispersal of seeds, pollination of agricultural crops, control of agricultural pests and human disease organisms, and production of timber, fish, wild game, and other wild foods.

edge effects The influences of habitat edges on interior habitats and species. These may include the effects of noise, light (natural or artificial), wandering pets, accessibility to predators and nest parasites, and pollution introduced from human activities at the habitat edges. Certain edge effects occur at the edges between natural habitats as well as those between natural habitats and human-altered areas.

exposure The degree to which a feature is exposed to elements such as wind, sun, and ice. A high-elevation unforested ledge is an example of a highly "exposed" habitat.

extirpation Local extinction. The term is applied to an organism that ceases to exist in a particular area, although it may still persist elsewhere.

Farmland Soils of Statewide Importance A designation of the Natural Resource Conservation Service for soils that are nearly as productive as "Prime Farmland Soils" (see below) and that produce high yields of crops when properly managed.

flood attenuation The effects of storing and retaining floodwater and slowly releasing it to the groundwater, a stream, or other water body, thereby reducing the peak downstream flows.

floodplain The area bordering a stream that is subject to frequent, occasional, or infrequent flooding.

flood zone The area along a stream that is expected to be inundated by floodwaters at predicted frequencies.

forb A broad-leaved herbaceous (non-woody) plant. (Compare to "graminoid.")

fulling A process in woolen cloth-making in which the material is cleaned and thickened.

glacial outwash Mineral material (gravel, sand, and silt) deposited by a melting glacier.

glacial till Mixed mineral material (clay, silt, sand, rocks) that was transported and deposited by glacial ice or by streams flowing from a melting glacier.

gradient As used in this *NRI*, the slope or degree of slope (e.g., a steep or gentle gradient).

graminoid A grass-like plant. Graminoids includes grasses (Poaceae), sedges (Cyperaceae), and rushes (Juncaceae).

graywacke An impure gray sandstone.

green infrastructure An approach to water management that incorporates natural systems and mimicry of natural systems, sometimes in combination with engineered systems to protect, restore, or maintain water resources and ecosystem functions. Some examples are protection or restoration of floodplains, wetlands, or forests, or use of urban rain gardens, permeable pavement, green roofs, rainwater barrels, graywater retrieval systems, and vegetated swales.

groundwater The water that resides beneath the soil surface in spaces between sediment particles and in rock fissures and seams.

groundwater recharge The process by which water flows or percolates from the ground surface to an aquifer—an underground water-bearing formation in bedrock or loose material such as sand or gravel.

habitat The place or environment where an organism normally spends all or part of its life. A habitat is defined by both the biological (e.g., plants and animals) and the non-biological (soil, bedrock, water, sunlight, temperatures, etc.) components.

habitat assessment As used in this NRI, an appraisal conducted by means of map analysis and field observations to identify and describe the character and condition of habitats and water features on a site, and the implications for land uses and conservation. A habitat assessment should be carried out by biologists familiar with habitats and biota of the region and the life history needs of species of conservation concern.

habitat edge The boundary between two different kinds of habitats or between a natural habitat and a human-altered area.

habitat fragmentation Dividing (by roads, driveways, utility corridors, other developed features) large, continuous habitat areas into smaller areas.

headwaters The upper reaches of a stream, near the stream's origin.

herbaceous Non-woody. Herbaceous plants include, for example, forbs, graminoids (see above), mosses, and liverworts.

herbivory Feeding on plants.

human-subsidized predators Predators that benefit from resources provided by humans—such as food, water, nesting substrates, shelter—and whose populations increase in size and range in the vicinity of human settlements and human-altered landscapes, putting greater predation pressure on native prey populations.

hydric soils Soils formed under conditions of saturation during the growing season long enough to develop anaerobic (oxygen-free) conditions near the ground surface. The presence of hydric soils is one of the three features necessary (along with wetland hydrology and hydrophytic vegetation) for identifying an area as wetland.

hydroperiod The seasonal pattern of inundation or soil saturation.

hydrophytic Adapted to conditions of soil saturation or inundation.

impervious surface Surface such as a roof, pavement, or compacted soils that impedes or prevents the local infiltration of water to the soils or underlying substrate.

intermittent stream A stream that typically flows for only part of the year.

intermittent woodland pool A vernal pool (see below) in a forested setting.

invertebrate An animal that lacks a spinal column. Invertebrates include insects, mollusks, crustaceans, nematodes, annelids, spiders, centipedes, protozoans, and a host of other macroscopic and microscopic organisms.

kame An irregular hill or ridge composed of mineral material deposited by a glacier.

kettle A depression in the ground surface formed by the melting of a stranded block of glacial ice that was buried or partially buried by outwash drift.

lacustrine deposits Sand, silt, and clay particles that settled on the bottom of an ancient lake.

landform A natural feature on the Earth's surface such as a hill, valley, plain, or ravine.

landscape permeability A measure of the freedom from barriers and fragmentation that interrupt, redirect, or prevent the movement of organisms within a landscape.

limestone A fine-grained sedimentary rock composed of calcium carbonate.

liverwort A non-vascular plant, closely related to mosses but differing in leaf characteristics and reproductive structures.

marl A mud or mudstone rich in calcium carbonate with admixtures of clay and silt. It is chemically similar to limestone and may occur as rock or in semi-liquid form. Marl forms from decaying plant and animal material in certain kinds of wetlands.

marsh A wetland that typically has standing water for a prolonged period during the growing season and is dominated by herbaceous (non-woody) vegetation with species such as cattail, bur-reed, pond-lily, and arrowhead.

mesopredator A mid-ranking predator in a food web. Some examples in our habitats are foxes, raccoon, skunk, bobcat, and snakes.

microclimate The climate of a very localized area; for example the hot, dry conditions on a rocky barren in summer, or the cool, moist conditions beneath a rotting log on the forest floor.

microhabitat A very localized habitat with characteristics distinct from those of the larger surrounding habitat; for example, a tree cavity within a deciduous forest, or a woody hummock within a swamp.

mudrock Fine-grained sedimentary rocks with grain diameters less than 1/16 mm, including shale and mudstone, which are composed mainly of microscopic clay minerals.

native species A plant or animal species that is indigenous to the region; that is, a species that arrived here by natural dispersal processes and not by human agency.

NGO Non-governmental organization.

non-native species A plant or animal introduced to the region by human agency, intentionally or unintentionally. (See "native species" for comparison.)

non-point source pollution Pollution emanating from a diffuse source such as unchannelized runoff from a paved parking lot or an agricultural field. (See point-source pollution.)

NYCDEP New York City Department of Environmental Protection.

NYNHP New York Natural Heritage Program, an agency that serves as a repository and clearinghouse for information on the occurrence, distribution, and status of plants, animals, and natural communities in the state.

NYSDEC New York State Department of Environmental Conservation.

odonate An insect in the order Odonata, which comprises dragonflies and damselflies.

old growth forest A forest ecosystem that has attained great age (e.g., 150+ years) without significant disturbance from human activities such as cutting, soil disturbance, or intentional burning. These systems are variable in appearance, structure, and development history, but are often distinguished by old trees, diverse vertical and horizontal vegetation structure, and accumulations of large standing snags and downwood.

organic duff The accumulation of organic matter on the forest floor, usually in many stages of decay.

organic sediments Sediments composed of decaying plant and animal matter.

parasitoids An insect whose larvae live as parasites and eventually kill their hosts.

peat Partially decomposed organic matter that accumulates under conditions of prolonged water saturation.

perennial stream A stream that typically flows year-round.

phyllite A fine-grained metamorphic rock intermediate in grade between slate and schist (Fisher 2006).

pioneering plant species Plant species that are among the first to colonize areas of stripped, disturbed, or damaged soils or other substrate.

point source pollution Pollution emanating from a single point, such as an industrial chimney or discharge pipe from a sewage treatment plant. (See non-point source pollution.)

potamodromous Migrating to and from spawning grounds within freshwater systems; for example, migrating from the freshwater reach of the Hudson into tributary streams to spawn.

Prime Farmland Soils A designation of the Natural Resources Conservation Service for soils that have the best combination of physical and chemical characteristics for producing crops.

propagule Any structure or material (such as a seed, spore, cutting, or root fragment) from which a new plant can develop.

reach (as in "stream reach") A segment of stream or river defined by geographic markers, such as river miles, natural features, or political boundaries.

refugia Plural of refugium: an area in which an organism or a population of organisms can survive through a period of unfavorable conditions.

remote sensing Detecting the physical characteristics of an area from a distance. Typically the term refers to interpretation of satellite or aerial photo imagery and map data to analyze the landscape.

resilience As used in this document, the capacity to withstand, recover from, and adapt to stresses such as those imposed by floods, climate change, or other catastrophic events.

riparian Within or adjacent to a stream or river.

riprap Layer of rock placed along a streambank or shoreline to prevent erosion.

rural sprawl Low-density residential development that is scattered outside hamlets, villages, and cities with the incremental and cumulative effects of fragmenting open spaces, significant habitats, and working landscapes.

sandstone A sedimentary rock composed of sand-size grains of cemented mineral and rock particles.

SAV Submergent aquatic vegetation (see below).

Scenic Areas of Statewide Significance (SASS) Areas identified by the NYS Department of State that encompass "unique, highly scenic landscapes which are accessible to the public and recognized for their scenic quality." The SASS that are partially in Greene County are the Columbia-Greene North SASS and the Catskill-Olana SASS, depicted in Figure 28.

seep Diffuse groundwater discharge to the ground surface. (Compare with "spring.")

SGCN Species of Greatest Conservation Need: a designation NYSDEC assigned to species that are experiencing a population decline or have identified threats that may put them in jeopardy and need timely management or conservation action to restore or maintain stable population levels.

shale A fine-grained thinly layered sedimentary rock derived from silt and clay.

Significant Biodiversity Area Area identified by the New York State Department of Environmental Conservation for especially high concentrations of important, unusual, and vulnerable habitats and rare species. The twenty-three such areas identified in the Hudson Valley are described in Penhollow et al. (2006).

siliciclastic rocks Silica-bearing rocks, typically dominated by quartz, metamorphic and sedimentary rock fragments, and clay minerals.

silviculture Study and management of a forest to control the establishment, growth, and composition of forest vegetation to achieve human objectives.

snag A standing dead tree.

soil Organic material or unconsolidated mineral material that has been acted on by weathering and biological processes.

spring Concentrated groundwater discharge to the ground surface. (Compare with "seep.")

sub-basin The watershed of a tributary to a larger stream.

submergent aquatic vegetation (SAV) Plants that grow beneath the surface in shallow water areas but do not emerge above the water surface.

surficial deposits Loose material transported and deposited over bedrock. Material may be transported by glaciers (e.g., glacial till, glacial outwash) or by moving water (alluvium).

swamp A wetland dominated by woody vegetation (trees or shrubs).

talus Loose rock debris that accumulates below an exposed bedrock ledge.

thatch Undecomposed, dead plant material that accumulates on the soil surface of a meadow or lawn.

tributary A stream that flows into a larger stream, river, or lake.

unconsolidated aquifer Groundwater stored in saturated sand and gravel deposits.

upland In this document, "upland" is equivalent to "non-wetland." The term implies nothing about elevation; upland areas can be at any elevation, low or high or anywhere in between.

vegetation structure The arrangement of vertical layers and horizontal spacing of vegetation.

vernal pool A wetland—usually small—that is isolated from other wetlands or streams, and that holds water in winter and spring, but typically dries up at some time during the growing season. (See "intermittent woodland pool.")

viewshed The entire area visible from a specified location.

watershed The entire land area that drains to a particular place such as a stream, wetland, or pond.

wetland "[An area that is] inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances [does] support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (definition of wetlands regulated under the federal Clean Water Act: at 33 CFR 328.3[c][4]).

wet meadow A wetland that typically has little or no standing water for most of the growing season and is dominated by herbaceous (non-woody) vegetation.

wind farm A utility site with multiple large wind turbines that connect to the grid via high-voltage transmission lines.

APPENDIX B

Water Sampling Data Sheets

Data sheets (unedited) for Greene County waterbodies deemed to have some level of "impacts" or impairment in the NYSDEC Priority Waterbodies inventory program. The program monitors water quality and trends throughout the state, and identifies the impaired streams, lakes, and ponds most in need of improvement. Waterbodies are assessed for invertebrates, water and sediment chemistry, and sediment toxicity.

Basic Creek, Lower, and tribs (1309-0027) NoKnownImpct

Waterbody Location Information

Revised: 11/06/2007

Water Index No: H-193-29 **Drain Basin:** Lower Hudson River
Hydro Unit Code: **Str Class:** C(T)
Waterbody Type: River **Reg/County:** 4/Greene Co. (20)
Waterbody Size: 57.5 Miles **Quad Map:** GREENVILLE (L-24-2)
Seg Description: stream and tribs, from mouth to reservoir

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) survey of Basic Creek at multiple sites between Freehold to Fords Corners was conducted in 1995. Sampling results presented in the Basic Creek Biological Stream Assessment Report (Bode, et al., May 1996) indicated slightly to non-impacted water quality conditions. Two of the three sites located in this reach below the reservoir were found to be non-impacted; the other site was slightly impacted but influenced by impoundment effects from the reservoir. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the portion of the stream and all tribs from the mouth to Basic Creek Reservoir (P950a). The waters of this portion of the stream are Class C(T),C(TS). Tribs to this reach/segment, including Wolf Fly Creek (-10), are Class C,C(T). Upper Basic Creek is listed separately.

Batavia Kill, Upper, and tribs (1202-0059) NoKnownImpct

Waterbody Location Information

Revised: 01/29/2010

Water Index No: H-240- 82-117
Hydro Unit Code: 02020005/020 **Str Class:** C(TS)
Waterbody Type: River (Low Flow)
Waterbody Size: 9.6 Miles
Seg Description: stream and tribs, abv Maplecrest

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20)
Quad Map: HENSONVILLE (L-24-4)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a
Resolution Potential: n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Batavia Kill below Windham (at Route 12) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Though these sampling points are below the described segment, they are considered representative of water quality in the upper reach. Aquatic life community is fully supported. These results are consistent with sampling conducted at this site in 2000 and 2001. (DEC/DOW, BWAM/SBU, January 2010)

Segment Description
This segment includes the portion of the stream and all tribs above unnamed trib (-22a) above Maplecrest. The waters of this portion of the stream are Class C(TS). Tribs to this reach/segment are Class C, C(T), C(TS).

Batavia Kill, Middle, and tribs (1202-0058) MinorImpacts

Waterbody Location Information

Revised: 10/31/2002

Water Index No: H-240- 82-117
Hydro Unit Code: 02020005/020 **Str Class:** A(T)
Waterbody Type: River (Low Flow)
Waterbody Size: 48.1 Miles
Seg Description: stream and tribs, from Windham to near Maplecrest

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20)
Quad Map: ASHLAND (L-23-3)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Habitat/Hydrolgy	Stressed	Known

Type of Pollutant(s)
Known: SILT/SEDIMENT, Problem Species (Japanese knotweed)
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: STREAMBANK EROSION, Habitat Modification
Suspected: - - -
Possible: Construction, On-Site/Septic Syst, Roadbank Erosion

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/NYCW **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in the Batavia Kill is affected by silt/sediment loads from excessive stream bank erosion along the stream. Impacts of the sediment loadings to and the resulting turbidity in the Schoharie Reservoir and the New York City Water Supply System are of particular concern. Habitat/biodiversity issues have also been raised.

Water Quality Sampling
A biological (macroinvertebrate) assessment of Batavia Kill in Windham (at Route 12) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. These results are consistent with results from sampling conducted on the stream in 2000 and 2001. Aquatic life community is fully supported. (DEC/DOW, BWAM/SBU, January 2010)

NYSDEC Rotating Intensive Basin Studies (RIBS) Intensive Network monitoring of the Batavia Kill in Prattsville (at State Route 23A) was conducted in 2001. Sampling of the water column, sediments, and invertebrate tissues was conducted, as well as macroinvertebrate community analysis. While aluminum and lead were elevated in a portion of the water column samples, no metals or organics were detected in the bottom sediments, no organic compounds were found to be elevated over background levels in invertebrate tissues, and no significant mortality or reproductive impairment was found in the three toxicity tests conducted. (DEC/DOW, BWAR/RIBS, April 2003)

A biological survey was also conducted on the Batavia Kill from Hensonville to Windham in June, 1989. The survey included five sampling sites on the main stem, and four on tributaries (Silver Lake Outlet, Lake Heloise Outlet, Mitchell Hollow, and North Settlement tributary). All sites sampled were assessed as non-impacted and water quality was considered to be excellent. (Batavia Kill Biological Assessment Report, Bode et al., DEC/DOW, BWAR/SBU, March 1990)

Routine monitoring by NYCDEP also indicates good water quality with no chronic water quality problems. DEP biological monitoring of two locations on the stream found no impairment to aquatic life. (NYCDEP, October 2002)

Water Quality Management

The Batavia Kill has been identified by NYCDEP as the principal contributor of sediment and turbidity to the Schoharie Reservoir, on of the NYC Water Supply reservoirs. As such, the stream was selected by DEP to pilot both an extensive experiments treatment with natural channel design BMPs and the development of a stream management plan. DEP has been working with the Greene County SWCD to implement these projects. (NYCDEP and Greene County SWCD, October 2002)

Extensive populations of Japanese knotweed also contributes to the streambank erosion problem. This species out competes more beneficial plants, but the shallow root structure provides little or not bank protection. (Greene County SWCD/WQCC, April 2002)

Potential impacts from on-site septic systems in small hamlets along the stream either have been or are being addressed by New York City Watershed protection initiatives. A new wastewater treatment plant and collection systems to serve the Hamlet of Prattsville went on line in 2008. A WWTP and collection system for the Hamlet of Ashland is currently under construction with an anticipated completion date of 2001. (DEC/DOW, NYCW, April 2010)

Segment Description

This segment includes the portion of the stream and all tribs from unnamed trib (-11a) near Windham to/including unnamed trib (-22a) above Maplecrest. The waters of this portion of the stream are Class A(T), A(TS). Tribs to this reach/segment, including Mad Brook (-13), are Class C, C(T), C(TS).

Batavia Kill, Lower, and tribs (1202-0001) MinorImpacts

Waterbody Location Information

Revised: 10/31/2002

Water Index No: H-240- 82-117
Hydro Unit Code: 02020005/020 **Str Class:** C(T)
Waterbody Type: River (Low Flow)
Waterbody Size: 48.2 Miles
Seg Description: stream and tribs, from mouth to Windham

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20)
Quad Map: ASHLAND (L-23-3)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Habitat/Hydrolgy	Stressed	Known

Type of Pollutant(s)
Known: SILT/SEDIMENT, Problem Species (Japanese knotweed)
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: STREAMBANK EROSION, Habitat Modification
Suspected: - - -
Possible: Construction, On-Site/Septic Syst

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/NYCW **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in the Batavia Kill is affected by silt/sediment loads from excessive stream bank erosion along the stream. Impacts of the sediment loadings to and the resulting turbidity in the Schoharie Reservoir and the New York City Water Supply System are of particular concern. Habitat/biodiversity issues have also been raised.

Water Quality Sampling
A biological (macroinvertebrate) assessment of Batavia Kill below Windham (at Route 12) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. These results are consistent with results from sampling conducted at this site in 2000 and 2001. Aquatic life community is fully supported. (DEC/DOW, BWAM/SBU, January 2010)

NYSDEC Rotating Intensive Basin Studies (RIBS) Intensive Network monitoring of the Batavia Kill in Prattsville (at State Route 23A) was conducted in 2001. Sampling of the water column, sediments, and invertebrate tissues was conducted, as well as macroinvertebrate community analysis. While aluminum and lead were elevated in a portion of the water column samples, no metals or organics were detected in the bottom sediments, no organic compounds were found to be elevated over background levels in invertebrate tissues, and no significant mortality or reproductive impairment was found in the three toxicity tests conducted. (DEC/DOW, BWAR/RIBS, April 2003)

Routine monitoring by NYCDEP also indicates good water quality with no chronic water quality problems. DEP biological monitoring of two locations on the stream found no impairment to aquatic life. (NYCDEP, October 2002)

Water Quality Management
The Batavia Kill has been identified by NYCDEP as the principal contributor of sediment and turbidity to the Schoharie Reservoir, on of the NYC Water Supply reservoirs. As such, the stream was selected by DEP to pilot both an extensive experiments treatment with natural channel design BMPs and the development of a stream management plan. DEP has been working with the Greene County SWCD to implement these projects. (NYCDEP and Greene County SWCD, October 2002)

Extensive populations of Japanese knotweed also contributes to the streambank erosion problem. This species out competes more beneficial plants, but the shallow root structure provides little or not bank protection. (Greene County SWCD/WQCC, April 2002)

Potential impacts from on-site septic systems in small hamlets along the stream either have been or are being addressed by New York City Watershed protection initiatives. A new wastewater treatment plant and collection systems to serve the Hamlet of Prattsville went on line in 2008. A WWTP and collection system for the Hamlet of Ashland is currently under construction with an anticipated completion date of 2001. (DEC/DOW, NYCW, April 2010)

Segment Description
This segment includes the portion of the stream and all tribs from the mouth to/including unnamed trib (-11a) near Windham. The waters of this portion of the stream are Class C(T). Tribs to this reach/segment, including Brandow Brook (-2), Lewis Creek (-3) and West Hollow Brook (-6), are Class C, C(T), C(TS).

Catskill Creek, Upper, and minor tribs (1309-0011) NoKnownImpct

Waterbody Location Information

Revised: 11/06/2007

Water Index No: H-193 **Drain Basin:** Lower Hudson River
Hydro Unit Code: **Str Class:** C(T)
Waterbody Type: River **Reg/County:** 4/Greene Co. (20)
Waterbody Size: 228.6 Miles **Quad Map:** FREEHOLD (L-24-3)
Seg Description: stream and select tribs, above Freehold

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted **Severity** **Problem Documentation**
NO USE IMPAIRMNT

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) survey of Catskill Creek at multiple sites between Leeds and Livingstonville was conducted in 1997. Sampling results presented in the Catskill Creek Biological Stream assessment Report (Bode, et al., September 1998) indicated slightly to non-impacted water quality conditions. Water quality throughout the stream was very good, with six of the 8 sites assessed as non-impacted. The other two sites, including one at Preston Hollow in this reach, were assessed as slightly impacted but were very similar to the non-impacted sites. Nonpoint sources of nutrient enrichment were identified as the primary source of the impacts. However, nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the portion of the stream above Basic Creek (-29) in Freehold. The waters of this portion of the stream are Class C(T),C(TS) from Freehold to unnamed trib (-58), Class B to The Vlaie (P960b), and Class C for the remainder of the reach. Tribs to this reach/segment, including Bowry Creek (-31), Potter Hollow Creek (-48), Fox Creek (-50) and Lake Creek (-56), are Class C,C(T),C(TS). Basic Creek (-29), Thorp Creek (-22) and Ten Mile Creek (-41) are listed separately.

Catskill Creek, Middle, and minor tribs (1309-0004) MinorImpacts

Waterbody Location Information

Revised: 06/25/2012

Water Index No:	H-193			**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020006/140	**Str Class:**	B(T)		Middle Hudson River
Waterbody Type:	River			**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	112.1 Miles			**Quad Map:**	LEEDS (L-25-4)

Seg Description: stream and select tribs, from Cautserkill to Freehold

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Public Bathing	Stressed	Known
Aquatic Life	Stressed	Possible
Recreation	Stressed	Known
Aesthetics	Stressed	Known

Type of Pollutant(s)

Known: NUTRIENTS (phosphorus), PATHOGENS, Aesthetics (odors, float.solids)
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)

Known: MUNICIPAL (Catskill (T)), OTHER SANITARY DISCH
Suspected: ON-SITE/SEPTIC SYST
Possible: - - -

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: DOW/Reg4 **Resolution Potential:** High
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in this portion of Catskill Creek are known to experience impacts from pathogens, nutrients and other pollutants due to untreated wastewater discharges and failing and/or inadequate on-site septic systems.

Water Quality Sampling
A biological (macroinvertebrate) assessment of Catskill Creek above Leeds (above Route23B) was conducted as part of the RIBS biological screening effort in 2007. Sampling results indicated the upper range of slightly impacted conditions. In such samples the community is slightly altered from natural conditions. Some sensitive species are not present and the overall abundance of macroinvertebrates is lower. However, the effects on the fauna appear to be (relatively) insignificant and water quality is considered to be good. Aquatic life support is considered to be fully

supported in the stream(, and there are no other apparent water quality impacts to designated uses). (DEC/DOW, BWAM/SBU, January 2010)

A biological survey of Catskill Creek at multiple sites between Leeds and Livingstonville was also conducted in 1997. Sampling results presented in the Catskill Creek Biological Stream assessment Report (Novak, et al., September 1998) indicated slightly to non-impacted water quality conditions. Water quality throughout the stream was very good, with six of the 8 sites assessed as non-impacted. The other two sites, including one at Cairo in this reach, were assessed as slightly impacted but were very similar to the non-impacted sites. Nonpoint sources of nutrient enrichment were identified as the primary source of the impacts. However, nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. (DEC/DOW, BWAM/SBU, June 2005)

Source Assessment

Unpermitted discharges into the creek in the Hamlet of Leeds have been verified during a joint investigation by staff from NYSDEC, NYSDOH, and Town of Catskill in March 2008. Three direct connections (one active sanitary sewer, one inactive sanitary sewer, and two graywater discharges) were found. Although some efforts were made to address these discharges, in 2012 NYSDEC initiated enforcement action against individual dischargers who were found to be discharging wastewater to the waters of the state without a permit. Surveys of the surrounding area suggest that many of the on-site wastewater treatment systems serving homes in the area are quite old and may be in need of repair/maintenance. (DEC/DOW, Region 4, April 2012)

Farther upstream, the Town of Cairo is undergoing an upgrade of its WWTP to address ongoing problems. The Town constructed constructed a WWTP and collection system in 2000 to serve the area. However excessive inflow and infiltration and problems with the sand filters at the WWTP have plagued the collection/treatment system. A Consent Order was issued in 2001 (modified in 2005 and most recently in April 2008) to enforce the installation of new polishing sand filters and other upgrades. Because the design of the small diameter gravity sewer has complicated efforts to locate and address I/I issues, NYSDEC had emphasized efforts to adequately treat the additional wastewater flow conveyed to the WWTP. (DEC/DOW, Region 4, June 2012)

Section 303(d) Listing

This portion of Catskill Creek is not currently included on the NYS Section 303(d) List of Impaired/TMDL Waters. There is currently no data to suggest widespread impairment to the stream, and the nature of the documented problems are likely to be localized and are better addressed through other regulatory measures rather than a TMDL. (DEC/DOW, BWAM, June 2012)

Segment Description

This segment includes the portion of the stream from Kaaterskill Creek (-2) in Cauterskill to Basic Creek (-29) in Freehold. The waters of this portion of the stream are Class B,B(T). Tribs to this reach/segment, including Bell/Little Jones Brook (-16) and Platte Kill (-22), are also/primarily Class C,C(T),C(TS). Kaaterskill Creek (-2), Potic Creek (-9), Jan DeBakkers Kill (-19), Shingle Kill (-20) and Basic Creek (-29) are listed separately.

Coxsackie Creek and minor tribs (1301-0092) MinorImpacts

Waterbody Location Information

Revised: 05/29/2008

Water Index No:	H-208			**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020006/130	**Str Class:**	C		Middle Hudson River
Waterbody Type:	River			**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	55.0 Miles			**Quad Map:**	RAVENA (L-25-2)
Seg Description:	entire stream and select tribs				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Recreation	Stressed	Suspected

Type of Pollutant(s)

Known: - - -
Suspected: ALGAL/WEED GROWTH (odors, aquatic vegetation), Nutrients
Possible: Pathogens

Source(s) of Pollutant(s)

Known: - - -
Suspected: PRIVATE/COMM/INST (trailer park), On-Site/Septic Syst, Urban/Storm Runoff
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 3 (Cause Identified, Source Unknown)
Lead Agency/Office: DOW/Reg4 **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Recreational uses in Coxsackie Creek are thought to experience minor impacts/threats due to aquatic weed growth, nutrient loadings and other pollutants from small private treatment facilities.

Water Quality Sampling
A biological (macroinvertebrate) assessment of Coxsackie Creek in Otter Hook (near Route 61) was conducted in 1998. Sampling results indicated slightly impacted water quality conditions. The fauna was heavily dominated by filter-feeding caddisflies, however the stream substrate was primarily bedrock, suggesting that habitat factors may have influenced the results to some degree. Nutrient biotic evaluation determined these effects on the fauna to be minor. Aquatic life support is considered to be fully supported in the stream. (DEC/DOW, BWAM/SBU, June 2005)

Previous Assessment
Aesthetics in Coxsackie Creek and a tributary, Climax Creek (Trib -4), were previously (1999) reported to be impacted by odors and excessive aquatic weed growth. The suspected cause/source of the problem at the time was a private wastewater system (adsorption bed) serving a trailer park along Climax Creek just above its confluence with Coxsackie Creek. However the extent of the impact on Coxsackie Creek is undetermined and requires further investigation. There have been no recent indications of problems or complaints regarding conditions in the creek. Other on-site and/or private systems may also be affecting water quality in the creek. (DEC/DOW, Region 4, May 2008)

Segment Description

This segment includes the entire stream and selected/smaller tribs. The waters of the stream are Class C. Tribs to this reach/segment, including Sickles Creek (-1), Climax Creek (-4), Coxsackie Reservoir Outlet/Inlet (-4) and Bronks Lake Outlet (-6), are primarily Class C,C(T), with a short trib to Coxsackie Reservoir designated Class A. A short reach of Bronks Lake Outlet (-6) is listed separately. Lower tidal portions of this trib is included with the Hudson Main Stem.

East Kill and tribs (1202-0063) NoKnownImpct

Waterbody Location Information

Revised: 07/02/2010

Water Index No: H-240- 82-133
Hydro Unit Code: 02020005/010 **Str Class:** C(TS)
Waterbody Type: River (Low Flow)
Waterbody Size: 52.6 Miles
Seg Description: entire stream and tribs

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20)
Quad Map: LEXINGTON (M-23-2)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
NYSDEC Rotating Integrated Basin Studies (RIBS) Intensive Network monitoring of East Kill in Jewett Center, Greene County, (at Route 23A) was conducted in 2005 and 2006. Intensive Network sampling typically includes macroinvertebrate community analysis, water column chemistry, toxicity testing, sediment assessment and macroinvertebrate tissue analysis. Biological (macroinvertebrate) sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Aquatic life community is fully supported. These results are consistent with results of a field assessment conducted at this site in 2000 which found a fauna that satisfied field screening criteria indicating non-impacted water quality. Water column chemistry indicates no contaminants to be present in concentrations that constitute parameters of concern. Toxicity testing using water from this location detected no significant mortality or reproductive effects on the test organism. Sediment screening for acute toxicity indicated no sediment toxicity and no porewater toxicity was indicated. Bottom sediments analysis based on sediment quality guidelines developed for freshwater ecosystems revealed overall sediment quality is not likely to cause chronic toxicity to sediment-dwelling organisms. Based on the consensus of these established assessment methods, overall water quality at this site shows that aquatic life and recreational uses are considered to be fully supported in the stream, and there are no other apparent water quality impacts to recreational uses. (DEC/DOW, BWAM/RIBS, January 2010)

Long-tern routine monitoring by NYCDEP on the West Kill also indicates good water quality with no chronic water quality problems. (NYCDEP, October 2002)

Water Quality Management
Excessive stream bank erosion along the stream was raised as a concern in previous assessments. However the East Kill does not seem to be as prone to sediment and turbidity problems as are other Schoharie tribs in the area. Nonetheless the stream is included in the NYCDEP stream management plan for the Schoharie Creek. This management plan is being developed with Greene County SWCD and includes natural channel design demonstration projects. (NYCDEP and Greene County SWCD, October 2002)

Segment Description
This segment includes the entire stream and all tribs. The waters of the stream are Class C(TS). Tribs to this reach/segment are Class C, C(T), C(TS).

Hollster Lake (1309-0007) Need Verific

Waterbody Location Information

Revised: 05/28/2008

Water Index No:	H-193- 1-P913			**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020006/160	**Str Class:**	A		Middle Hudson River
Waterbody Type:	Lake			**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	62.7 Acres			**Quad Map:**	LEEDS (L-25-4)
Seg Description:	entire lake				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Water Supply	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: ALGAL/WEED GROWTH (aquatic vegetation), SILT/SEDIMENT
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: HABITAT MODIFICATION, HYDRO MODIFICATION
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAM **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Water supply uses in Hollister Lake may experience minor impacts due to aquatic weed growth and siltation. Due to the lack of any current information, conditions in the lake need to be verified.

Previous Assessment
Use of Hollister Lake as a water supply for the Village of Athens was previously reported to be stressed by excessive aquatic weed growth and siltation. These conditions were noted during an August 1993 inspection of the lake by the New York State Department of Health. On average the lake is about 3 feet deep and the spillway is in need of repair. The Greene County Soil and Water Conservation District was working with the village to conduct an inventory and evaluation of the reservoir and its watershed. (DEC/DOW, Region 4, 1999)

Huntersfield Creek, Upper, and tribs (1202-0056) NoKnownImpct

Waterbody Location Information

Revised: 02/01/2010

Water Index No:	H-240- 82-116	**Drain Basin:**	Mohawk River
Hydro Unit Code:	02020005/010 **Str Class:** A		Schoharie Creek
Waterbody Type:	River (Low Flow)	**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	9.8 Miles	**Quad Map:**	PRATTSVILLE (L-23-4)
Seg Description:	stream and tribs, above Prattsville Water Supply		

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
NO USE IMPAIRMNT		

Type of Pollutant(s)

Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Hunterfield Creek in Prattsville (at Route 10) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and conditions that reflect a natural community with minimal, if any, human impacts. Aquatic life community is clearly fully supported. (DEC/DOW, BWAM/SBU, January 2010)

Segment Description
This segment includes the portion of the stream and all tribs above the Prattsville Public Water Supply intake. The waters of this portion of the stream are Class A. Tribs to this reach/segment are Class A(T).

Manor Kill and tribs (1202-0017) NoKnownImpct

Waterbody Location Information

Revised: 11/01/2002

Water Index No: H-240- 82-112
Hydro Unit Code: 02020005/030 **Str Class:** C(T)*
Waterbody Type: River (Low Flow)
Waterbody Size: 62.2 Miles
Seg Description: entire stream and tribs

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20)
Quad Map: GILBOA (L-23-1)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Manorkill near the mouth in West Conesville was conducted in 2000. Field sampling results indicated non-impacted water quality conditions. The sample satisfied field screening criteria and was returned to the stream. (DEC/DOW, BWAR/SBU, July 2002)

Routine monitoring by NYCDEP also indicates good water quality with no identified impairments to the stream. The Manor Kill, like may streams in the area, is prone to turbidity problems but is not considered by NYCDEP to be a major source of sediment/turbidity to the Schoharie Reservoir. Though streambank erosion is of some concern, NYCDEP is not involved with the development of a stream management plan for the Manor Kill because the stream clears quickly after storm events and it is not considered a high priority. (NYCDEP, October 2002)

The most recent fishery survey information (1996) indicates that the stream supports a wild trout population. (DEC/DFWMR, Region 4, April 2002)

Water Qaulity Management
Agricultural nonpoint source concerns are being addressed by the New York City Watershed Agricultural Program. Most farms are developing whole farm plans and receiving funding for implementation. (Schoharie County SWCD/WQCC, April 2002)

Segment Description
This segment includes the entire stream and all tribs. The waters of the stream are Class A(T) from the mouth to County Route 39 and Class C(T), C(TS) for the remainder of the reach. Tribs to this reach/segment, including Bear Kill (-5), are primarily Class C, C(T), C(TS); with some tribs designated Class A.

Potic Creek, Lower, and tribs (1309-0019) NoKnownImpct

Waterbody Location Information

Revised: 11/06/2007

Water Index No: H-193- 9 **Drain Basin:** Lower Hudson River
Hydro Unit Code: **Str Class:** C(T)
Waterbody Type: River **Reg/County:** 4/Greene Co. (20)
Waterbody Size: 6.8 Miles **Quad Map:** LEEDS (L-25-4)
Seg Description: stream and tribs, from mouth to Cob Creek

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Potic Creek near Leeds (at Shady Lane Road) was conducted in 2002. Sampling results indicated non-impacted water quality conditions. The fauna was diverse and all screening criteria for waters having no known impacts were met. (DEC/DOW, BWAM/SBU, June 2005)

Segment Description
This segment includes the portion of the stream and all tribs from the mouth to Cob Creek (-2). The waters of this portion of the stream are Class C(T). Tribs to this reach/segment, including Lower Cob Creek (-2), are Class C. Middle/Upper Cob Creek (-2) and Middle/Upper Potic Creek are listed separately.

Potuck (Potic) Reservoir (1309-0024) Threatened

Waterbody Location Information

Revised: 07/25/2008

Water Index No: H-193- 9- 2-P925a
Drain Basin: Lower Hudson River
Hydro Unit Code:
Str Class: A
Waterbody Type: Lake(R)
Reg/County: 4/Greene Co. (20)
Waterbody Size: 53.7 Acres
Quad Map: LEEDS (L-25-4)
Seg Description: entire reservoir

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Water Supply	Threatened	Suspected

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: PATHOGENS

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: AGRICULTURE, Municipal

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/WQCC
Resolution Potential: Medium
TMDL/303d Status: n/a

Further Details

Overview
Water supply uses of Potuck (Potic) Reservoir are thought to experience threats from pathogens due to the level of agricultural pasture lands in the watershed. Current information does not indicate any impacts to water supply or other uses, but the use of the resources as a water supply and the activities in the watershed suggest additional protection efforts are appropriate.

Source (Drinking) Water Assessment
The Potuck (Potic) Reservoir was assessed through the NYSDOH Source Waters Assessment Program (SWAP) which compiles, organizes, and evaluates information regarding possible and actual threats to the quality of public water supply (PWS) sources. The information contained in SWAP assessment reports assists in the oversight and protection of public water systems. It is important to note that SWAP reports estimate the potential for untreated drinking water sources to be impacted by contamination and do not address the quality of treated finished potable tap water. This assessment found substantial potential risks to drinking water quality. The amount of pasture in the assessment area results in high susceptibility for contamination. There is also a medium density of sanitary wastewater discharges which results in medium risks for contamination, but this finding is not fully supported by the cumulative wastewater flow analysis. There are no noteworthy contamination risks associated with other contaminant sources. Finally, it should be noted that reservoirs in general are highly sensitive to phosphorus and microbial contaminants. This water supply reservoir provides water to the Village of Catskill. (NYSDOH, Source Water Assessment Program, 2005)

Schoharie Creek, Upper, Main Stem (1202-0021) MinorImpacts

Waterbody Location Information

Revised: 11/01/2002

Water Index No: H-240- 82 (portion 7)
Drain Basin: Mohawk River
Hydro Unit Code: 02020005/010 **Str Class:** C(T)*
Schoharie Creek
Waterbody Type: River (Low Flow)
Reg/County: 4/Greene Co. (20)
Waterbody Size: 18.3 Miles
Quad Map: PRATTSVILLE (L-23-4)
Seg Description: from Schoharie Reservoir (Prattsville) to Hunter

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
Habitat/Hydrolgy	Stressed	Known

Type of Pollutant(s)
Known: SILT/SEDIMENT
Suspected: - - -
Possible: Problem Species (Japanese knotweed), Thermal Changes

Source(s) of Pollutant(s)
Known: STREAMBANK EROSION
Suspected: Habitat Modification
Possible: Construction, Roadbank Erosion

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/NYCW
Resolution Potential: Medium
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in Upper Schoharie Creek is affected by silt and sediment loadings and modification and erosion of streambanks. Impacts of the sediment loadings to and the resulting turbidity in the Schoharie Reservoir and the New York City Water Supply System are of particular concern.

Source Assessment
The Upper Schoharie Creek is the largest tributary to the Schoharie Reservoir and receives a considerable amount of flow and sediment load from East Kill, West Kill and the Batavia Kill, all of which have been identified by NYCDEP as principal contributors of sediment and turbidity to the Schoharie Reservoir. A section of the Schoharie Creek itself (from the reservoir to Lexington) has also been identified by DEP as a major source of sediment and turbidity to the reservoir. Along this reach riparian cover is inadequate to provide streambank stabilization and shading. Clay soils and exposed banks which contribute significantly to stream turbidity during rainfall runoff events have been documented. The resulting sediment loads and higher summer temperatures in the stream could affect this cold water fishery. Populations of Japanese knotweed which crowd out native plants but provide poor riparian cover are also a concern. (NYCDEP and Greene County SWCD/WQCC, April 2002)

Water Quality Sampling
NYSDEC Rotating Integrated Basin Studies (RIBS) Intensive Network monitoring of Schoharie Creek in Jewett, Schoharie

County, (at Deming Road) was conducted in 2005 and 2006. Intensive Network sampling typically includes macroinvertebrate community analysis, water column chemistry, toxicity testing, sediment assessment and macroinvertebrate tissue analysis. Biological (macroinvertebrate) sampling results indicated non-impacted to slightly impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Water column chemistry indicated only iron to be present in concentrations that constitute a parameter of concern. However the median value is well below the assessment criteria and iron is considered to be naturally occurring and not a source of water quality impacts. Toxicity testing using water from this location detected no significant mortality or reproductive effects on the test organism. Based on the consensus of these established assessment methods, overall water quality at this site shows that aquatic life and recreational uses are considered to be fully supported in the stream, and there are no other apparent water quality impacts to recreational uses. (DEC/DOW, BWAM/RIBS, January 2010)

A biological (macroinvertebrate) assessment of Schoharie Creek in Hunter was conducted in 2000. Field sampling results indicated non-impacted water quality conditions. The sample satisfied field screening criteria and was returned to the stream. (DEC/DOW, BWAR/SBU, July 2002)

These results are consistent with a 1995 macroinvertebrate survey of Schoharie Creek from below Tannersville to below Hunter which found non-impacted conditions and no significant water quality impact at any of the five sampling sites. The survey was done at the request of the Region to determine if there was any significant impact caused by the wintertime withdrawal of water from the Creek to make snow for the ski resort. (Schoharie Creek Biological Assessment Report, Bode et al., DEC/DOW, BWAR/SBU, July 1995)

Routine monitoring by NYCDEP at three locations on the Schoharie (Prattsville, Lexington and Hunter) also indicates good water quality with no chronic water quality problems. DEP biological monitoring of the stream found only occasion slight impacts to aquatic life. (NYCDEP, October 2002)

Watershed Management
DEP (in partnership with Greene County SWCD) is developing a stream management plan for the creek. The management plan will include a natural channel design demonstration project. This plan is scheduled to be completed in 2007. DEP is also assisting Greene County SWCD with streambank stabilization projects and the design of a floodplain restoration project in the Town of Prattsville to help alleviate flooding caused by seasonal ice jams. (NYCDEP and Greene County SWCD/WQCC, April 2002)

Segment Description
This segment includes the portion of the Schoharie Creek from the Schoharie Reservoir above Huntersfield Creek (-116) to unnamed trib (-140) in Hunter. The waters of this portion of the stream are primarily Class C(T), C(TS), with short portions above the reservoir Class A and B(T).

Schoharie Creek, Upper, Main Stem (1202-0023) MinorImpacts

Waterbody Location Information

Revised: 08/21/2002

Water Index No:	H-240- 82 (portion 8)	**Drain Basin:**	Mohawk River
Hydro Unit Code:	02020005/010 **Str Class:** C(T)*		Schoharie Creek
Waterbody Type:	River (Low Flow)	**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	5.5 Miles	**Quad Map:**	PRATTSVILLE (L-23-4)
Seg Description:	from Hunter to near Tannersville		

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Habitat/Hydrolgy	Stressed	Suspected

Type of Pollutant(s)

Known: SILT/SEDIMENT
Suspected: Problem Species (Japanese knotweed)
Possible: - - -

Source(s) of Pollutant(s)

Known: STREAMBANK EROSION
Suspected: Habitat Modification
Possible: Roadbank Erosion

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 4 (Source Identified, Strategy Needed)
Lead Agency/Office: ext/NYCW **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in Upper Schoharie Creek is affected by silt and sediment loadings and modification and erosion of streambanks.

Source Assessment
Riparian cover is inadequate to provide streambank stabilization and shading. The resulting sediment loads and higher summer temperatures in the stream affect this cold water fishery. Clay soils and exposed banks which contribute significantly to stream turbidity during rainfall runoff events have been documented. Populations of Japanese knotweed which crowd out native plants but provide poor riparian cover are also a concern. The local SWCD is working with NYCDEP to implement streambank stabilization projects in the watershed. (Greene County SWCD/WQCC, April 2002)

Water Quality Sampling
NYSDEC Rotating Integrated Basin Studies (RIBS) Intensive Network monitoring of Schoharie Creek in Jewett, Schoharie County, (at Deming Road) was conducted in 2005 and 2006. Intensive Network sampling typically includes macroinvertebrate community analysis, water column chemistry, toxicity testing, sediment assessment and macroinvertebrate tissue analysis. Biological (macroinvertebrate) sampling results indicated non-impacted to slightly impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional

species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Water column chemistry indicated only iron to be present in concentrations that constitute a parameter of concern. However the median value is well below the assessment criteria and iron is considered to be naturally occurring and not a source of water quality impacts. Toxicity testing using water from this location detected no significant mortality or reproductive effects on the test organism. Based on the consensus of these established assessment methods, overall water quality at this site shows that aquatic life and recreational uses are considered to be fully supported in the stream, and there are no other apparent water quality impacts to recreational uses. (DEC/DOW, BWAM/RIBS, January 2010)

A biological (macroinvertebrate) assessment of Schoharie Creek in Hunter was conducted in 2000. Field sampling results indicated non-impacted water quality conditions. The sample satisfied field screening criteria and was returned to the stream. (DEC/DOW, BWAR/SBU, July 2002)

These results are consistent with a 1995 macroinvertebrate survey of Schoharie Creek from below Tannersville to below Hunter which found non-impacted conditions and no significant water quality impact at any of the five sampling sites. The survey was done at the request of the Region to determine if there was any significant impact caused by the wintertime withdrawal of water from the Creek to make snow for the ski resort. (Schoharie Creek Biological Assessment Report, Bode et al., DEC/DOW, BWAR/SBU, July 1995)

A biological (macroinvertebrate) assessment of Shanty Hollow Creek in Hunter (at confluence with Schoharie Creek) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated slightly impacted conditions. In such samples the community is slightly altered from natural conditions. Some sensitive species are not present and a the overall abundance of macroinvertebrates is lower. However, the effects on the fauna are relatively insignificant and water quality is considered to be good. The nutrient biotic index and impact source determination indicate no enrichment in the stream and fauna that is most similar to natural communities with some impoundment influences. Aquatic life support is considered to be fully supported in the stream, and there are no other apparent water quality impacts to designated uses. (DEC/DOW, BWAM/SBU, January 2010)

Segment Description
This segment includes the portion of the Schoharie Creek from unnamed trib (-140) in Hunter to the Tannersville Auxilary Water Supply P656c. The waters of this portion of the stream are primarily Class C(TS), with a short portion in Hunter designated Class B(TS).

Schoharie Creek, Upper, and tribs (1202-0026) NoKnownImpct

Waterbody Location Information

Revised: 02/11/2010

Water Index No: H-240- 82 (portion 9) **Drain Basin:** Mohawk River
Hydro Unit Code: 02020005/010 **Str Class:** A(TS) Schoharie Creek
Waterbody Type: River (Low Flow) **Reg/County:** 4/Greene Co. (20)
Waterbody Size: 21.3 Miles **Quad Map:** HUNTER (M-24-1)
Seg Description: stream and select tribs abv Tannersville water supply

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted **Severity** **Problem Documentation**
NO USE IMPAIRMNT

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
NYSDEC Rotating Integrated Basin Studies (RIBS) Intensive Network monitoring of Schoharie Creek in Jewett, Schoharie County, (at Deming Road) was conducted in 2005 and 2006. Intensive Network sampling typically includes macroinvertebrate community analysis, water column chemistry, toxicity testing, sediment assessment and macroinvertebrate tissue analysis. Biological (macroinvertebrate) sampling results indicated non-impacted to slightly impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Water column chemistry indicated no significant contaminants to be present in concentrations that constitute parameters of concern. Toxicity testing using water from this location detected no significant mortality or reproductive effects on the test organism. Based on the consensus of these established assessment methods, overall water quality at this site shows that aquatic life and recreational uses are considered to be fully supported in the stream, and there are no other apparent water quality impacts to recreational uses. Though this site is downstream of the waterbody segment, is it considered to be representative of water quality conditions in the upper reach. (DEC/DOW, BWAM/RIBS, January 2010)

These results are also consistent with a 1995 macroinvertebrate survey of Schoharie Creek from below Tannersville to below Hunter which found non-impacted conditions and no significant water quality impact at any of the five sampling sites. The survey was done at the request of the Region to determine if there was any significant impact caused by the wintertime withdrawal of water from the Creek to make snow for the ski resort. (Schoharie Creek Biological Assessment Report, Bode et al., DEC/DOW, BWAR/SBU, July 1995)

Source (Drinking) Water Assessment

A source water assessment of Upper Schoharie Creek found only moderate susceptibility to contamination sources. This level of susceptibility is typical of many water supplies that experience no impacts to water supply use and reflects the need to protect the resource. This assessment was conducted through the NYSDOH Source Waters Assessment Program (SWAP) which compiles, organizes, and evaluates information regarding possible and actual threats to the quality of public water supply (PWS) sources. The information contained in SWAP assessment reports assists in the oversight and protection of public water systems. It is important to note that SWAP reports estimate the potential for untreated drinking water sources to be impacted by contamination and do not address the quality of treated finished potable tap water. This water supply source provides water to Tannersville. (NYSDOH, Source Water Assessment Program, 2005)

Segment Description

This segment includes the portion of the Schoharie Creek and all tribs above the Tannersville Auxilary Water Supply P656c. The waters of this portion of the creek are Class A(TS). Tribs to this segment, including Cook Brook (-150) and Roaring Brook (-153) are Class C, C(T), C(TS).

Minor Tribs to Schoharie Creek (1202-0057) MinorImpacts

Waterbody Location Information

Revised: 08/14/2002

Water Index No: H-240- 82-116 thru 140
Drain Basin: Mohawk River
Hydro Unit Code: 02020005/010 **Str Class:** C
Schoharie Creek
Waterbody Type: River (Low Flow)
Reg/County: 4/Greene Co. (20)
Waterbody Size: 58.2 Miles
Quad Map: PRATTSVILLE (L-23-4)
Seg Description: total length of select tribs fr Schoharie Res to Hunter

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Habitat/Hydrolgy	Stressed	Suspected

Type of Pollutant(s)

Known: AESTHETICS (turbidity), SILT/SEDIMENT
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)

Known: STREAMBANK EROSION
Suspected: Habitat Modification
Possible: Hydro Modification

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/WQCC
Resolution Potential: Medium
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in these smaller tribs to Schoharie Creek is thought to be affected by silt/sediment loads from excessive stream bank erosion along the stream. The Little West Kill has been specifically cited. Impacts of the sediment loadings to the Schoharie Reservoir and the New York City Water Supply System are of particular concern.

Source Assessment
Streambank failures/collapses are fairly common in the watershed. These streams have been the focus of significant streambank assessment and restoration activity by both the NYCDEP and the Greene County SWCD. Extensive water quality and erosion rate data is available from the county. (Greene County SWCD/WQCC, April 2002)

Water Quality Sampling
A biological (macroinvertebrate) assessment of Little West Kill in Mosquito Point (at Route 2) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Aquatic life community is fully supported. Though Little West Kill is just one of several streams that make up this waterbody segment, it is considered representative of water quality in the segment as a whole. This segment is listed as being

evaluated rather than monitored. (DEC/DOW, BWAM/SBU, January 2010)

A biological assessment of Hunterfield Creek in Prattsville (at Route 10) was also conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and conditions that reflect a natural community with minimal, if any, human impacts. Aquatic life community is clearly fully supported. (DEC/DOW, BWAM/SBU, January 2010)

Segment Description
This segment includes the total length of selected/smaller tribs to Schoharie Creek between Schoharie Reservoir and unnamed trib (-140) in Hunter. Tribs within this segment, including Lower Huntersfield Creek (-116), Little West Kill (-123), are Class C, C(T), C(TS). Upper Huntersfield Creek (-116), Batavia Kill (-117), West Kill (-128) and East Kill (-133) are listed separately.

Minor Tribs to Schoharie Creek (1202-0066) NoKnownImpct

Waterbody Location Information

Revised: 08/14/2002

Water Index No: H-240- 82-142 thru 147b
Drain Basin: Mohawk River
Schoharie Creek
Hydro Unit Code: 02020005/010 **Str Class:** C
Waterbody Type: River (Low Flow)
Reg/County: 4/Greene Co. (20)
Waterbody Size: 2.3 Miles
Quad Map: HUNTER (M-24-1)
Seg Description: total length of select tribs fr Hunter to Tannersville

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
NO USE IMPAIRMNT		

Type of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a
Resolution Potential: n/a
TMDL/303d Status: n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Gooseberry Creek near Tannersville (at Bloomer Road) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. These results are consistent with results from sampling conducted at this site in 2000. Aquatic life community is fully supported. (DEC/DOW, BWAM/SBU, January 2009)

These results reflect significant improvement from conditions reported in a 1986 biological assessment of Gooseberry Creek. This survey found moderately impacted water quality attributed to chorine toxicity from disinfection at the Tannersville WWTP. This problem has since been addressed. (Gooseberry Creek Rapid Biological Stream Assessment Report, Bode et al., DEC/DOW, BWAR/SBU, October 1986)

A biological assessment of Stoney Grove Creek in Hunter (at Route 214) was also conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. Aquatic life community is fully supported. (DEC/DOW, BWAM/SBU, January 2009)

Though these are just two of several streams that make up this waterbody segment, it is considered representative of water quality in the segment as a whole. This segment is listed as being evaluated rather than monitored.

Segment Description

This segment includes the total length of selected/smaller tribs to Schoharie Creek between unnamed trib (-140) in Hunter and the Tannersville Auxilary Water Supply. Tribs within this segment, including Red Kill (-142) and Gooseberry Creek (-147b), are Class C, C(T), C(TS). Upper Stony Grove Creek (-145) and Tannersville Reservoir Tribs are listed separately.

Schoharie Reservoir (1202-0012) — Impaired Seg

Waterbody Location Information

Revised: 11/13/2002

Water Index No: H-240- 82 (portion 6)/P638a
Hydro Unit Code: 02020005/010 **Str Class:** AA(TS)
Waterbody Type: Lake(R) (Unknown Trophic)
Waterbody Size: 1131.5 Acres
Seg Description: entire reservoir

Drain Basin: Mohawk River
Schoharie Creek
Reg/County: 4/Greene Co. (20) ...
Quad Map: GILBOA (L-23-1)

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
WATER SUPPLY	Impaired	Known
FISH CONSUMPTION	Impaired	Known

Type of Pollutant(s)
Known: METALS (mercury), SILT/SEDIMENT
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: STREAMBANK EROSION
Suspected: ATMOSPH. DEPOSITION, Agriculture
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 4 (Source Identified, Strategy Needed)
Lead Agency/Office: ext/NYCW **Resolution Potential:** High
TMDL/303d Status: 1,4a (Individual Waterbody Impairment Requiring a TMDL, more)

Further Details

Overview
Fish consumption and water supply use in Schoharie Reservoir are impaired due to mercury levels and high turbidity. The mercury is a results of atmospheric deposition. The high turbidity is a result of excessive silt and sediment loadings from streambank erosion and other nonpoint sources in the reservoir watershed.

Water Supply Assessment
Excessive silt and sediment loads to the reservoir from watershed tributaries results in high turbidity in the reservoir. The Schoharie Reservoir is part of the New York City Water Supply's Catskill District, which makes up about 24% of the entire water supply, and which serves nearly half the population of the state. The turbidity in the reservoir is sufficiently high as to limit its use as a drinking water supply. These problems are primarily the result of the erosion of glacial clay deposits indigenous to the watershed. Some in-reservoir processes, such as near shore wave action, can contribute to reservoir turbidity. However the ultimate source of most turbidity in the reservoir is watershed streams. NYCDEP has studied the issue of turbidity in the Catskill Watershed and identified the West Kill, Batavia Kill and Upper Schoharie Creek as major contributors of silt, sediment and turbidity. The water quality problems in these tribs, and NYCDEP's management of these streams, are discussed in further detail on the appropriate individual waterbody segment data sheets. (NYCDEP, October 2002)

Fish Consumption

Fish consumption in Schoharie Reservoir is impaired due to a NYS DOH health advisory that recommends eating no more than one meal per month of walleye because of elevated mercury levels. The source of mercury is considered to be atmospheric deposition, as there are not other apparent sources in the lake watershed. The advisory for this lake was first issued in 2002-03. (2009-10 NYS DOH Health Advisories and DEC/DFWMR, Habitat, December 2009).

Water Quality Sampling

NYCDEP conducts year-round monitoring at 13 stream locations throughout the basin in addition to in-reservoir and aqueduct monitoring. DEP has also conducted biological monitoring at 22 Schoharie watershed stream sites. In spite of the turbidity and atmospheric mercury issues, these monitoring efforts reveal generally high water quality and non-impacted aquatic life in the watershed. (NYCDEP, October 2002)

New York City Watershed

The Schoharie Reservoir is a part of the Catskill/Delaware System of New York City water supply reservoirs. The Catskill/Delaware System provides about 90% of New York City water supply, the other 10% is supplied by the Croton System. The Ashokan Reservoir receives water from the 250 square mile watershed of the Upper Esopus Creek and serves as a collecting reservoir for the water from the other reservoir - Schoharie Reservoir - in the Catskill system. Water quality in this upstream reservoir influences water quality in the Ashokan Reservoir. (Water quality issues in the Ashokan Reservoir and its watershed are discussed more fully in the Mohawk River Waterbody Inventory and Priority Waterbody List.) The capacity of the Catskill water system is 550 MGD. Water from the Schoharie Reservoir travels through the Shandaken Tunnel and the Upper Esopus Creek to the Ashokan Reservoir, and then via the Catskill Aqueduct to the Kensico Reservoir. In order to protect the New York City water supply, a comprehensive long-range watershed protection program is in place. These protections enable the city to receive a series of waivers from a federal requirement to filter water from the Catskill/Delaware supply. (NYCDEP, July 2006)

Water Quality Management

To help protect this resource, NYC DEP has developed and entered into a Watershed Agreement with local Watershed communities. This agreement sets forth protection goals and programs and funding to address water quality issues. Programs to address and improve water quality in the Schoharie Watershed include agricultural BMPs, upgrading of WWTPs, septic system rehabilitation (including remediating failed/inadequate systems and/or connecting failed or marginal systems to WWTPs), improved urban stormwater controls, stream management planning and stream restoration projects. A Phase II TMDL for phosphorus for all the NYC reservoirs including the Schoharie was approved by USEPA in October 2000. Phosphorus levels in the Schoharie do not exceed limits set forth in the TMDL. (NYC DEP, April 2002)

Currently NYCDEP is managing turbidity in the reservoir and its impact on the water supply operationally, by regulating (limiting) the amount of water being diverted from the Schoharie to the Ashokan Reservoir. However this approach represents a trade of water quantity for quality and does not address the underlying sources of turbidity in the watershed. (NYCDEP, October 2002)

Reservoir water is diverted from the Schoharie/Mohawk Basin to the Upper Esopus Creek and the Ashokan Reservoir in the Lower Hudson Basin via the Shandaken Tunnel. The water discharged through the Shandaken Tunnel, has the potential to be a major contributor of suspended sediment to the Esopus Creek. The discharge was a matter of litigation in federal court that resulted in control measures through the SPDES permit process. (DEC/DOW and NYCDEP, January 2010)

Water Quality Management/TMDL

In 2007, The New England Interstate Water Pollution Control Commission (NEIWPCC), on behalf of its member states including New York, submitted and USEPA approved a TMDL to address mercury deposition in lakes throughout the Northeastern United States, including Ferris Lake. The Northeast Regional Mercury TMDL notes that between 1998 and 2002 the Northeast states reduced in-region deposition of mercury by more than 70 percent. In addition these state have enforceable controls in place to meet the remaining reduction goals. Despite these reductions water quality impairment due to mercury still exists and elevated mercury levels in certain fish species remain great concern. The TMDL shows the demonstrates that the need for significant reductions in the mercury reaching waters of the Northeast from sources outside the region by way of atmospheric deposition is essential to restoring these waters. (Northeast Regional Mercury TMDL, NEIWPCC, 2007)

Section 303(d) Listing The reservoir is included on the NYS 2008 Section 303(d) List of Impaired/TMDL Waters. The reservoir was included on Part 1 as an impaired water with high priority for TMDL development due to silt/sediment concerns. The reservoirs was included on previous Section 303(d) List of Impaired Waters due to impairments resulting from fish consumption advisories. However the lake was delisting with regard to this impairment in 2008 due to the Northeast Regional Mercury TMDL. and Part 2b of the List as a Fish Consumption Water.

Segment Description
This segment includes the total area of the entire reservoir.

Minor Tribs to Schoharie Reservoir (1202-0054) Need Verific

Waterbody Location Information

Revised: 11/01/2002

Water Index No:	H-240- 82-110 thru 115			**Drain Basin:**	Mohawk River
Hydro Unit Code:	02020005/010	**Str Class:**	C*		Schoharie Creek
Waterbody Type:	River (Low Flow)			**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	56.6 Miles			**Quad Map:**	GILBOA (L-23-1)
Seg Description:	total length of selected tribs to the reservoir				

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Aquatic Life	Stressed	Possible
Recreation	Stressed	Possible

Type of Pollutant(s)

Known: - - -
Suspected: NUTRIENTS (phosphorus), PATHOGENS
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: AGRICULTURE
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 1 (Waterbody Nominated, Problem Not Verified)
Lead Agency/Office: DOW/BWAR **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Aquatic life support and recreation in some of these tributaries to the Schoharie Reservoir (a New York City Water Supply reservoir) may be affected by nonpoint agricultural runoff. One particular trib that has been previously identified with water quality concerns is Johnson Hollow Brook. Sampling at another trib (Bear Kill) has indicated no water quality impacts.

Water Quality Assessment
Past (1997-2000) routine water quality monitoring of Johnson Hollow Brook by NYCDEP revealed elevated phosphorus concentrations and high "spike" values for coliform. The most likely source of these pollutants is livestock farms adjacent to the stream. To address watershed protection issues throughout the NYC Water Supply System the NYCDEP has entered into a Watershed Agreement with local communities. This agreement outlines the watershed protection goals and funds various watershed protection programs to meet these goals. One such program is the NYC Watershed Agricultural Program. All four farms in the Johnson Hollow Brook watershed have developed Whole Farms Plans that have been approved by this program and BMPs in these plans are currently being implemented. Water quality impacts in the creek need to be verified in light of these efforts. (NYCDEP, October 2002)

Water Quality Sampling

A biological (macroinvertebrate) assessment of Bear Kill below Grand Gorge (at Cottone Road) was conducted as part of the RIBS biological screening effort in 2005. Sampling results indicated non-impacted conditions. Such samples are dominated by clean-water species and are most similar to a natural community with minimal human impacts. Some additional species, including sensitive non-native species, and additional biomass may be present; the samples reveal no, or only incidental, anomalies. These results are consistent with field sampling conducted at the site in 2000 which found a sample that meet field screening criteria for a non-impacted stream. Aquatic life community is fully supported. (DEC/DOW, BWAM/SBU, January 2010)

Segment Description

This segment includes the total length of selected/smaller tribs to the Schoharie Reservoir. Tribs within this segment, including Bear Kill (-113) and Johnson Hollow Brook (-115), are primarily Class C, C(T), C(TS) with some portions designated as Class A, A(T). Manor Kill (-112) is listed separately.

Shingle Kill and tribs (1309-0008) NoKnownImpct

Waterbody Location Information

Revised: 05/29/2008

Water Index No:	H-193-20	**Drain Basin:**	Lower Hudson River
Hydro Unit Code:	02020006/140 **Str Class:** C(TS)		Middle Hudson River
Waterbody Type:	River	**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	25.3 Miles	**Quad Map:**	FREEHOLD (L-24-3)
Seg Description:	entire stream and tribs		

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	**Severity**	**Problem Documentation**
NO USE IMPAIRMNT		

Type of Pollutant(s)

Known: - - -
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)

Known: - - -
Suspected: - - -
Possible: - - -

Resolution/Management Information

Issue Resolvability: 8 (No Known Use Impairment)
Verification Status: (Not Applicable for Selected RESOLVABILITY)
Lead Agency/Office: n/a **Resolution Potential:** n/a
TMDL/303d Status: 3a->n/a

Further Details

Water Quality Sampling
A biological (macroinvertebrate) assessment of Shingle Kill in Cairo (at Route 23B) was conducted in 2002. Sampling results indicated non-impacted water quality conditions. The fauna was diverse and all screening criteria for waters having no known impacts were met. (DEC/DOW, BWAM/SBU, June 2005)

Previous Assessment
Recreational uses and aesthetics of the Shingle Kill were previously reported to be affected by raw sewage discharges from private and on-site wastewater treatment systems. However the Village of Cairo has constructed a community wastewater treatment system that now serves most of the homes in the area. (DEC\DOW, Region 4, June 1998)

Section 303(d) Listing
Shingle Kill is currently included on the NYS 2008 Section 303(d) List of Impaired Waters. The waterbody is included on Part 3a of the List as a Water Requiring Verification of Impairment, however this updated assessment suggests that the previous impacts to water quality have been addressed and that more recent monitoring results find conditions are fully supporting of uses are continued listing is not warranted. (DEC/DOW, BWAM, May 2008)

Segment Description
This segment includes the entire stream and all tribs. The waters of the stream are Class C(TS), with portions in the

forest preserve.   Tribs to this reach/segment, including Trout Creek (-3), are Class C,C(T),C(TS), with portions in the forest preserve.

South Lake, North Lake (1309-0017) Impaired Seg

Waterbody Location Information

Revised: 05/28/2008

Water Index No: H-193- 2-P921,P922
Drain Basin: Lower Hudson River
Hydro Unit Code:
Str Class: B
Waterbody Type: Lake
Reg/County: 4/Greene Co. (20)
Waterbody Size: 80.3 Acres
Quad Map: KAATERSKILL (M-24-2)
Seg Description: total area of both lakes

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
FISH CONSUMPTION	Impaired	Known

Type of Pollutant(s)
Known: METALS (mercury)
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)
Known: - - -
Suspected: ATMOSPH. DEPOSITION
Possible: - - -

Resolution/Management Information

Issue Resolvability: 1 (Needs Verification/Study (see STATUS))
Verification Status: 4 (Source Identified, Strategy Needed)
Lead Agency/Office: ext/EPA
Resolution Potential: Medium
TMDL/303d Status: 4a (TMDL Complete, Being Implemented, Not Listed)

Further Details

Overview
Fish consumption use in North and South Lakes is impaired by mercury contamination attributed to atmospheric deposition.

Fish Consumption Advisories
Fish consumption in North, South Lakes is impaired due to a NYSDOH health advisory that recommends eating no more than one meal per month of larger (over 15 inches) largemouth bass because of elevated mercury levels. The source of mercury is considered to be atmospheric deposition, as there are not other apparent sources in the lake watershed. The advisory for this lake was first issued in 2005-06. (2006-07 NYSDOH Health Advisories and DEC/DFWMR, Habitat, December 2006).

Section 303(d) Listing
North,South Lakes are included on the NYS 2006 Section 303(d) List of Impaired Waters. The lake is included on Part 2b of the List as a Fish Consumption Water/Atmospheric Deposition (Acid Rain). However, the mercury impairment was addressed in the Northeast Regional Mercury TMDL that was established in 2007. Therefore the listing for mercury for the lake are not included in the 2008 NYS Section 303(d) List of Impaired/TMDL Waters. (DEC/DOW, BWAM/WQAS, March 2008)

West Kill and tribs (1202-0062) MinorImpacts

Waterbody Location Information

Revised: 11/01/2002

Water Index No:	H-240- 82-128	**Drain Basin:**	Mohawk River
Hydro Unit Code:	02020005/010 **Str Class:** C(TS)		Schoharie Creek
Waterbody Type:	River (Low Flow)	**Reg/County:**	4/Greene Co. (20)
Waterbody Size:	46.6 Miles	**Quad Map:**	WEST KILL (M-23-1)
Seg Description:	entire stream and tribs		

Water Quality Problem/Issue Information

(CAPS indicate MAJOR Use Impacts/Pollutants/Sources)

Use(s) Impacted	Severity	Problem Documentation
Habitat/Hydrolgy	Stressed	Known

Type of Pollutant(s)

Known: AESTHETICS (turbidity), SILT/SEDIMENT
Suspected: - - -
Possible: - - -

Source(s) of Pollutant(s)

Known: STREAMBANK EROSION
Suspected: Habitat Modification
Possible: Construction, Hydro Modification

Resolution/Management Information

Issue Resolvability: 3 (Strategy Being Implemented)
Verification Status: 5 (Management Strategy has been Developed)
Lead Agency/Office: ext/NYCW **Resolution Potential:** Medium
TMDL/303d Status: n/a

Further Details

Overview
Natural resources (fishery) habitat in the West Kill is thought to be affected by silt/sediment loads and turbidity from excessive stream bank erosion along the stream. Impacts of the sediment loadings to the Schoharie Reservoir and the New York City Water Supply System are also of particular concern.

Source Assessment
The West Kill has been identified by NYCDEP as a principal contributor of sediment and turbidity to the Schoharie Reservoir. Along this reach riparian cover is inadequate to provide streambank stabilization and shading. Clay soils and exposed banks which contribute significantly to stream turbidity during rainfall runoff events have been documented. In fact much of the streambank destabilization began with a major flooding event in 1987. As a result, DEP (in partnership with Greene County SWCD) is developing a stream management plan for the creek. The management plan will include two natural channel design demonstration projects. This plan is scheduled to be completed in 2005. In association with these BMP projects, DEP has also entered into a SWDA funded research project with Penn State University to assess the performance of these BMPs and conduct an erosion and scour study which will include at least one site on the West Kill. (NYCDEP and Greene County SWCD, October 2002)

Water Quality Sampling
A biological (macroinvertebrate) assessment of West Kill in West Kill was conducted in 2000. Field sampling results indicated non-impacted water quality conditions. The sample satisfied field screening criteria and was returned to the stream. (DEC/DOW, BWAR/SBU, July 2002)

Routine monitoring by NYCDEP on the West Kill also indicates good water quality with no chronic water quality problems. DEP biological monitoring of the stream found no impacts to aquatic life. (NYCDEP, October 2002)

Segment Description
This segment includes the entire stream and all tribs. The waters of the stream are Class C(TS). Tribs to this reach/segment are Class C, C(T), C(TS).

APPENDIX C

Plants and Animals

Table C-1. Common and scientific names of vascular plants mentioned in the Greene County *Natural Resources Inventory*. Scientific nomenclature follows Weldy et al. (2019).

Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
alder	*Alnus*	blueberry, highbush	*Vaccinium corymbosum*
apple	*Malus*	blueberry, hillside	*Vaccinium pallidum*
arrow-arum	*Peltandra virginica*	blueberry, late low	*Vaccinium angustifolium*
arrowhead, grass-leaved	*Sagittaria graminea* ssp. *graminea*	bluegrass, Kentucky	*Poa pratensis*
arrowhead, spongy	*Sagittaria montevidensis* ssp. *spongiosa*	bluestem, little	*Schizachyrium scoparium* var. *scoparium*
arrowhead, stiff	*Sagittaria rigida*	boxelder	*Acer negundo* var. *negundo*
arrowhead, strapleaf	*Sagittaria subulata*	bracken	*Pteridium aquilinum* ssp. *latiusculum*
arrowwood, northern	*Viburnum dentatum* var. *lucidum*	brome, smooth	*Bromus inermis*
ash	*Fraxinus*	bulrush, soft-stemmed	*Schoenoplectus tabernaemontani*
ash, black	*Fraxinus nigra*	bulrush, river	*Bolboschoenus fluviatilis*
ash, green	*Fraxinus pennsylvanica*	bur-reed	*Sparganium*
ash, white	*Fraxinus americana*	bur-reed, large	*Sparganium eurycarpum*
aspen, quaking	*Populus tremuloides*	buttercup, swamp	*Ranunculus caricetorum*
aster	*Symphyotrichum*	buttonbush	*Cephalanthus occidentalis*
azalea, early	*Rhododendron prinophyllum*	canary-grass, reed	*Phalaris arundinacea*
baneberry, red	*Actaea rubra*	cancer-root, one-flowered	*Orobanche uniflora*
barberry, Japanese	*Berberis thunbergii*	cattail	*Typha*
basswood, American	*Tilia americana* var. *americana*	cedar, eastern red	*Juniperus virginiana* var. *virginiana*
bearberry	*Arctostaphylos uva-ursi*	cedar, northern white	*Thuja occidentalis*
beech, American	*Fagus grandifolia*	cherry, black	*Prunus serotina* var. *serotina*
beechdrops	*Epifagus virginiana*	cherry/plum	*Prunus*
beggarticks	*Bidens*	cinquefoil, three-toothed	*Sibbaldia tridentata*
beggarticks, estuary	*Bidens bidentoides*	cliffbrake, purple	*Pellaea atropurpurea*
bentgrass	*Agrostis*	clover	*Trifolium*
birch, black	*Betula lenta*	columbine, wild	*Aquilegia canadensis*
birch, gray	*Betula populifolia*	cottonwood, eastern	*Populus deltoides* ssp. *deltoides*
birch, yellow	*Betula alleghaniensis*	cranberry, large	*Vaccinium macrocarpon*
bittersweet, oriental	*Celastrus orbiculatus*	cranberry, small	*Vaccinium oxycoccos*
blackberry, northern	*Rubus allegheniensis*	creeper, Virginia	*Parthenocissus quinquefolia*
blueberry	*Vaccinium*	daisy, ox-eye	*Leucanthemum vulgare*

(continued)

Table C-1. (cont.)

Common Name	Scientific Name	Common Name	Scientific Name
deerberry	*Vaccinium stamineum*	hickory	*Carya*
dogwood, gray	*Cornus racemosa*	hickory, pignut	*Carya glabra*
dogwood, red-osier	*Cornus sericea*	hickory, shagbark	*Carya ovata* var. *ovata*
dogwood, silky	*Cornus amomum* ssp. *amomum*	holly, winterberry	*Ilex verticillata*
dragon, green	*Arisaema dracontium*	honeysuckle, Bell's	*Lonicera* x *bella*
duckweed	*Lemna* or *Spirodela*	hornbeam, American	*Carpinus caroliniana* ssp. *virginiana*
elm, American	*Ulmus americana*	horsetail, field	*Equisetum arvense*
elm, slippery	*Ulmus rubra*	horseweed	*Erigeron canadensis*
false-nettle	*Boehmeria cylindrica*	huckleberry, black	*Gaylussacia baccata*
fern, cinnamon	*Osmundastrum cinnamomeum* var. *cinnamomeum*	iris, yellow	*Iris pseudacorus*
fern, maidenhair	*Adiantum pedatum*	jewelweed, common	*Impatiens capensis*
fern, marsh	*Thelypteris palustris* var. *pubescens*	Joe-Pye-weed, spotted	*Eutrochium maculatum* var. *maculatum*
fern, royal	*Osmunda regalis* var. *spectabilis*	knapweed	*Centaurea*
fern, sensitive	*Onoclea sensibilis*	knotweed, Japanese	*Reynoutria japonica* var. *japonica*
fern, walking	*Asplenium rhizophyllum*	lady's-slipper, pink	*Cypripedium acaule*
fir, balsam	*Abies balsamea*	larch, European	*Larix decidua*
flag, blue	*Iris versicolor*	laurel, sheep	*Kalmia angustifolia* var. *angustifolia*
flatsedge, Schweinitz's	*Cyperus schweinitzii*	leatherleaf	*Chamaedaphne calyculata*
garlic-mustard	*Alliaria petiolata*	locust, black	*Robinia pseudoacacia*
ginger, wild	*Asarum canadense*	loosestrife, purple	*Lythrum salicaria*
goldenclub	*Orontium aquaticum*	lousewort, swamp	*Pedicularis lanceolata*
goldenrod	*Solidago*	lovegrass	*Eragrostis*
goldenrod, smooth	*Solidago gigantea*	madder, wild	*Galium album*
grape, river	*Vitis riparia*	mannagrass	*Glyceria*
grass, deer-tongue	*Dichanthelium clandestinum*	maple	*Acer*
grass, orchard	*Dactylis glomerata*	maple, red	*Acer rubrum*
grass, poverty	*Danthonia spicata*	maple, silver	*Acer saccharinum*
gum, black	*Nyssa sylvatica*	maple, sugar	*Acer saccharum*
hackberry, American	*Celtis occidentalis*	marigold, marsh	*Caltha palustris*
hairgrass, common	*Avenella flexuosa*	meadowsweet	*Spiraea alba* var. *latifolia*
hawthorn	*Crataegus*	milkweed	*Asclepias*
hemlock, eastern	*Tsuga canadensis*	monkeyflower, winged	*Mimulus alatus*
hepatica	*Hepatica*	mud-plantain, kidney-leaved	*Heteranthera reniformis*

(continued)

Table C-1. (cont.)

Common Name	Scientific Name	Common Name	Scientific Name
naiad	*Najas*	rice, wild	*Zizania aquatica* var. *aquatica*
nettle	*Urtica*	rose, multiflora	*Rosa multiflora*
nightshade, enchanter's	*Circaea canadensis*	rose, swamp	*Rosa palustris*
ninebark	*Physocarpus opulifolius*	rosemary, bog	*Andromeda polifolia* var. *latifolia*
oak	*Quercus*	rose-of-Sharon	*Hibiscus syriacus*
oak, black	*Quercus velutina*	rush, soft	*Juncus effusus* ssp. *solutus*
oak, chestnut	*Quercus montana*	saxifrage, golden	*Chrysosplenium americanum*
oak, pin	*Quercus palustris*	sedge, cattail	*Carex typhina*
oak, red	*Quercus rubra*	sedge, clustered	*Carex cumulata*
oak, scarlet	*Quercus coccinea*	sedge, false hop	*Carex lupuliformis*
oak, scrub	*Quercus ilicifolia*	sedge, Fernald's	*Carex merritt-fernaldii*
oak, swamp white	*Quercus bicolor*	sedge, lakeside	*Carex lacustris*
oak, white	*Quercus alba*	sedge, Pennsylvania	*Carex pensylvanica*
orchid, lesser purple-fringed	*Platanthera psycodes*	sedge, Sprengel's	*Carex sprengelii*
pear	*Pyrus*	sedge, tussock	*Carex stricta*
pickerelweed	*Pontederia cordata*	sedge, weak stellate	*Carex seorsa*
pine	*Pinus*	serviceberry	*Amelanchier*
pine, eastern white	*Pinus strobus*	shadbush, dwarf	*Amelanchier spicata*
pine, pitch	*Pinus rigida*	skunk-cabbage	*Symplocarpus foetidus*
pine, red	*Pinus resinosa*	spatterdock	*Nuphar advena* ssp. *advena*
pine, Scotch	*Pinus sylvestris*	spicebush	*Lindera benzoin*
pitcher-plant	*Sarracenia purpurea*	spikerush, ovate	*Eleocharis ovata*
plantain, heartleaf	*Plantago cordata*	spleenwort, maidenhair	*Asplenium trichomanes*
poison-ivy	*Toxicodendron radicans*	spruce	*Picea*
pond-lily, fragrant	*Nymphaea odorata* ssp. *odorata*	spruce, black	*Picea mariana*
pond-lily, yellow	*Nuphar variegata*	spruce, Norway	*Picea abies*
pondweed, curly	*Potamogeton crispus*	spruce, red	*Picea rubens*
pondweed, horned	*Zannichellia palustris*	spruce, white	*Picea glauca*
pondweed, clasping	*Potamogeton perfoliatus*	stiltgrass, Japanese	*Microstegium vimineum*
pondweed, sago	*Stuckenia pectinata*	sundew, round-leaved	*Drosera rotundifolia*
primroses	*Oenothera*	swallow-wort, black	*Vincetoxicum nigrum*
raspberry	*Rubus*	sweetfern	*Comptonia peregrina*
reed, common	*Phragmites australis*	sweetflag	*Acorus*

(continued)

Table C-1 (cont.)

Common Name	**Scientific Name**
switchgrass	*Panicum virgatum*
sycamore, American	*Platanus occidentalis*
tearthumb	*Persicaria*
three-square	*Schoenoplectus pungens* var. *pungens*
timothy	*Phleum pratense* ssp. *pratense*
tree-of-heaven	*Ailanthus altissima*
turtlehead, white	*Chelone glabra*
viburnum, maple-leaf	*Viburnum acerifolium*
violet	*Viola*
wall-rue	*Asplenium ruta-muraria*
water-celery, American	*Vallisneria americana*
water-chestnut	*Trapa natans*
watermilfoil, Eurasian	*Myriophyllum spicatum*
water-plantain	*Alisma*
water-shield	*Brasenia schreberi*
waterwort, American	*Elatine americana*
weed, mile-a-minute	*Persicaria perfoliata*
willow	*Salix*
willow, pussy	*Salix discolor*
witch-hazel	*Hamamelis virginiana*
woodsia, rusty	*Woodsia ilvensis*
woolgrass	*Scirpus cyperinus*

Table C-2. Vascular plants of conservation concern in Greene County, New York.

Occurrence data are from the New York Natural Heritage Program (NYNHP). Rarity ranks were current as of August 2019. Habitat data are from the NYNHP Online Conservation Guides, New York Flora Atlas, Gleason and Cronquist (1991), and Hudsonia observations. Scientific nomenclature follows Weldy et al. (2019).

Common Name	Scientific Name	NYS Rank[1]	NYNHP Rank[2]	Habitat
arrowhead, spongy	*Sagittaria montevidensis* ssp. *spongiosa*	T	S2	intertidal mudflat
arrowhead, strap-leaf	*Sagittaria subulata*	R	S3	intertidal mudflat
aster, northern bog	*Symphyotrichum boreale*	T	S2	calcareous fen, swamp, & shoreline
aster, smooth blue	*Symphyotrichum laeve* var. *concinnum*	E		open, dry area
avens, rough	*Geum virginianum*	T	S2	woodland edge; roadside
beggar-ticks, Delmarva	*Bidens bidentoides*	R	S3	intertidal shore, mudflat & marsh
beggar-ticks, estuary	*Bidens hyperborea* var. *hyperborea*	E		intertidal shore & marsh
birch, river	*Betula nigra*	R	S3	stream bank & terrace
bittercress, Long's	*Cardamine longii*	T		intertidal shore, mudflat, & swamp
bittersweet, American	*Celastrus scandens*	R		forest, thicket, roadside
bulrush, Georgia	*Scirpus georgianus*	E	S1S2	wet meadow
bur-marigold, smooth	*Bidens laevis*	T	S2	intertidal marsh
bur-reed, small	*Sparganium natans*	T	S2	still, open water
club, golden	*Orontium aquaticum*	T	S2	intertidal shore, mudflat, marsh & creek
comfrey, northern wild	*Andersonglossum boreale*	E	S1S2	wood & thicket edge, sandy or rocky soil
corn-salad, navel-fruited	*Valerianella umbilicata*	E	SH	wet meadow
dodder, southern	*Cuscuta obtusiflora* var. *glandulosa*	E	S1S2	marsh at edge of Hudson River bay
dropseed, northern	*Sporobolus heterolepis*	T	S2	dry, open ground
elm, cork	*Ulmus thomasii*	T	S2S3	calcareous forest, meadow, ledge
firmoss, Appalachian	*Huperzia appressa*	R	S3	high-elevation ledge
fern, Appalachian bristle	*Crepidomanes intricatum*	E	S1	rock crevice, cave, moist overhang
fern, blunt-lobe grape	*Botrychium oneidense*	T	S2S3	rich, lowland, mesic forest
fern, climbing	*Lygodium palmatum*	E	S1	moist thicket, forest on acid soils
fern, fragrant cliff	*Dryopteris fragrans*	E	S1S2	cliff face by waterfall
fern, rugulose grape	*Botrychium rugulosum*	E	S1	active or old field, meadow
fern, smooth cliff	*Woodsia glabella*	E	S1	cool, seepy, calcareous ledge
flatsedge, rusty	*Cyperus odoratus*	R	S3	shoreline, tidal marsh, meadow
flatsedge, Schweinitz's	*Cyperus schweinitzii*	R	S3	exposed, sandy soil
goldenrod, stiff-leaf	*Solidago rigida* var. *rigida*	T	S2	old field, woodland edge
gypsy-wort	*Lycopus rubellus*	E	S1	marsh, fen, flooded swamp

(continued)

Table C-2. (cont.)

Common Name	Scientific Name	NYS Rank[1]	NYNHP Rank[2]	Habitat
hatpins, estuary	*Eriocaulon parkeri*		SX	tidal flat, muddy shore
knotweed, erect	*Polygonum erectum*		S2S3	disturbed habitats, lakeshore, stream edge
knotweed, slender	*Polygonum tenue*	R	S3	dry, acidic soil
lousewort, swamp	*Pedicularis lanceolata*	T	S2S3	intertidal marsh & swamp, roadside edge
milkweed, purple	*Asclepias purpurascens*	T	S2S3	old field, calcareous soils
mud-plantain, kidneyleaf	*Heteranthera reniformis*	R	S3	shallow water, mudflat
mudwort	*Limosella australis*	R	S3	intertidal mudflat
orchid, Hooker's	*Platanthera hookeri*	E	S1	woodland or forest, open understory
plantain, heartleaf	*Plantago cordata*	R	S3	intertidal shore, mudflats, & marsh
quillwort, large-spored	*Isoetes lacustris*	R	S3	cold pond, lake, stream
quillwort, riverbank	*Isoetes septentrionalis*	E	S1	shoreline, tidal mudflat
rock-cress, Drummond's	*Boechera stricta*	T	S2	ledge, dry-to-mesic forest
rock-cress, purple	*Boechera grahamii*	T	S2	rocky ledge, cliff, ravine
root, musk	*Adoxa moschatellina*	E	S1	cool talus slope
roseroot	*Rhodiola rosea*	E	S1	cliff face by waterfalls
running-pine, northern	*Diphasiastrum complanatum*	E	S1S2	openings, upland forest, rocky slope
sandwort, Appalachian	*Mononeuria glabra*	R	S3	pitch pine-oak-heath rocky summit
sedge, Bush's	*Carex bushii*	R	S3	wet meadow; esp. on clayey soils
sedge, clustered	*Carex cumulata*	T	S2S3	open ledge
sedge, Davis'	*Carex davisii*	T	S2	wrack line along shore
sedge, Emmons'	*Carex emmonsii*	R	S3	acidic soil
sedge, false hop	*Carex lupuliformis*	T	S2	old farm wetland
sedge, Fernald's	*Carex merritt-fernaldii*	T	S2S3	rock ledge, sandy or rocky soil, acidic
sedge, glaucous	*Carex glaucodea*	T	S2	dry-to-mesic forest, oldfield, trail edge
sedge, reflexed	*Carex retroflexa*	T		dry-mesic to mesic forest opening or edge, rocky ledge
sedge, Schweinitz's	*Carex schweinitzii*	T	S2S3	calcareous fen, marsh, swamp
sedge, straw	*Carex straminea*	E	S1	marsh & swamp edge, acidic soil
spikerush, ovate	*Eleocharis ovata*	E	S1S2	marsh
spikerush, tidal	*Eleocharis aestuum*	E	S1	intertidal mudflat & marsh
twayblade, large	*Liparis liliifolia*	E	S1	northern hardwood forest
wand, fairy	*Chamaelirium luteum*	E	S1S2	calcareous soils
water-nymph, Hudson River	*Najas muenscheri*	E	S2	shallow water, Hudson River tidal mudflat

(continued)

Table C-2. (cont.)

Common Name	Scientific Name	NYS Rank[1]	NYNHP Rank[2]	Habitat
waterwort, American	*Elatine americana*	E	S1	Hudson River intertidal mudflat & marsh
wood-mint, downy	*Blephilia ciliata*	E	S1	calcareous oldfield, mowed hay field
woodrush, hairy	*Luzula bulbosa*	R	S3	woodland, thicket

[1] New York State ranks are explained in Appendix D:
E = endangered; T = threatened; R = Rare SC = special concern
[2] New York Natural Heritage Program ranks (S1, S2, S3) are explained in Appendix D.

Table C-3. Prominent non-native invasive plants of Greene County and the region.

Species are listed and ranked for management priority (tiers) by the Capital-Mohawk Partnership for Invasive Species Management (Cap-Mo PRISM) and the Catskill Region Invasive Species Partnership (CRISP). Updated lists of invasive species are at the websites of those organizations. The Cap-Mo region includes the Greene County area east of the Catskill escarpment, and the CRISP region includes the area west of the escarpment. The status of each species is denoted by "&" for both regions, "#" for the CRISP region only, and "X" for the Cap-Mo region only.

Common Name (*Scientific Name*)	**Tier 2**[1]	**Tier 3**[1]	**Tier 4**[1]	**Tier 5**[1]	**Habitat**
alder, black (*Alnus glutinosa*)			X	#	wetland, shoreline
aralia, five-leaved (*Eleutherococcus sieboldianus*)	X			#	swamp
autumn-olive (*Elaeagnus umbellata*)			&		forest edge, meadow
barberry, European (*Berberis vulgaris*)		X			forest, meadow
barberry, Japanese (*Berberis thunbergii*)			&		forest, shrubland, meadow, floodplain
beautybush (*Kolkwitzia amabilis*)				#	forest edge
bedstraw, sweet (*Galium odoratum*)				#	forest edge, meadow
berry, porcelain (*Ampelopsis glandulosa*)	&				forest, meadow
bittercress, hairy (*Cardamine hirsuta*)				#	meadow, waste ground
bittercress, narrowleaf (*Cardamine impatiens*)	#		X		forest
bittersweet, Asian (*Celastrus orbiculatus*)			&		forest, shrubland, waste ground
bower, Japanese virgin's (*Clematis terniflora*)	&				forest, shrubland, meadow
brome, smooth (*Bromus inermis*)				#	meadow, field
buckthorn, common (*Rhamnus cathartica*)			&		forest, shrubland, meadow
buckthorn, glossy (*Frangula alnus*)		#	X		forest,shrubland, meadow, swamp
bush, burning (*Euonymus alatus*)			&		forest, shrubland
butter-bur, purple (*Petasites hybridus*)				#	meadow, shoreline
butterfly-bush, orange-eye (*Buddleja davidii*)				#	forest, forest edge
canary-grass, reed (*Phalaris arundinacea*)			&		wetland, shoreline, meadow
carpetgrass, small (*Arthraxon hispidus*)	X				forest, floodplain, swamp
catalpa, northern (*Catalpa speciosa*)				#	forest edge, floodplain, meadow, shrubland
cattail, hybrid (*Typha* x *glauca*)				#	shoreline, marsh, wetlands
celandine, lesser (*Ficaria verna*)	&				forest, floodplain, shoreline
chervil, wild (*Anthriscus sylvestris*)			&		forest edge, meadow

(continued)

Table C-3. (cont.)

Common Name (*Scientific Name*)	**Tier 2**[1]	**Tier 3**[1]	**Tier 4**[1]	**Tier 5**[1]	**Habitat**
crabapple, Siberian (*Malus baccata*)				#	forest edge, meadow
crabapple, Toringo (*Malus toringo*)	X				forest, shrubland
crabgrass, hairy (*Digitaria sanguinalis*)				#	meadow, waste ground, lawn
crabgrass, smooth (*Digitaria ischaemum*)				#	meadow, waste ground, lawn
cranesbill, Siberian (*Geranium sibiricum*)				#	meadow, waste ground
cup-plant (*Silphium perfoliatum* var. *perfoliatum*)	X				shrubland
daphne (*Daphne mezereum*)	#				forest edge, shrubland
dayflower, Asiatic (*Commelina communis*)				#	forest edge, meadow
daylily, orange (*Hemerocallis fulva*)				#	forest edge, floodplain
didymo (*Didymosphenia geminata*)			#	X	stream
elm, Siberian (*Ulmus pumila*)	X				forest edge, meadow, shoreline
elodea, Brazilian (*Egeria densa*)	X				lake, pond, stream
fanwort (*Cabomba caroliniana*)	#				lake, pond, stream
fern, European water (*Marsilea quadrifolia*)				#	lake, pond, shoreline
floating-heart, yellow (*Nymphoides peltata*)	&				lake, pond, stream
foxglove, Grecian (*Digitalis lanata*)				#	meadow
frogbit, European (*Hydrocharis morsus-ranae*)	X				lake, pond, stream
garlic, wild (*Allium vineale*)				#	meadow, field, waste ground
garlic-mustard (*Alliaria petiolata*)			&		forest, floodplain
globethistle, great (*Echinops sphaerocephalus*)				#	meadow
goutweed, bishops (*Aegopodium podagraria*)	X				forest, floodplain, meadow
grass, Chinese silver (*Miscanthus sinensis*)	&				meadow
hawkweed, tall (*Pilosella piloselloides*)				#	meadow
hawthorn (*Crataegus monogyna* var. *monogyna*)				#	forest edge, meadow, hedgerow
hedge-parsley, erect (*Torilis japonica*)				#	forest, meadow
Himalayan-balsam (*Impatiens glandulifera*)	X	#			meadow
hogweed, giant (*Heracleum mantegazzianum*)	X	#			road bank, forest, oldfield
honeysuckle, Amur (*Lonicera maackii*)	X	#			forest, shrubland
honeysuckle, Bell's (*Lonicera* x *bella*)			&		forest, shrubland, meadow
honeysuckle, European fly (*Lonicera xylosteum*)			#		forest edge
honeysuckle, Japanese (*Lonicera japonica*)			&		forest, shrubland, meadow
honeysuckle, Morrow's (*Lonicera morrowii*)			&		forest, shrubland

(continued)

Table C-3. (cont.)

Common Name (*Scientific Name*)	**Tier 2[1]**	**Tier 3[1]**	**Tier 4[1]**	**Tier 5[1]**	**Habitat**
honeysuckle, Tartarian (*Lonicera tatarica*)			&		forest, shrubland, meadow
hops, Japanese (*Humulus japonicus*)	&				meadow, waste ground
hyacinth, water (*Eichhornia crassipes*)	#				lake, pond, stream
iris, yellow (*Iris pseudacorus*)		#	X		wetland, shoreline
ivy, English (*Hedera helix*)	X				forest
jetbead, black (*Rhodotypos scandens*)	&				forest edge
Johnsongrass (*Sorghum halepense*)				X	meadow
knapweed, spotted (*Centaurea stoebe* ssp. *micranthos*)			&		meadow
knapweed, Tyrol (*Centaurea nigrescens*)				#	meadow, oldfield
knotweed, bohemian (*Reynoutria* x *bohemica*)	#		X		shoreline, floodplain, waste ground
knotweed, giant (*Reynoutria sachalinensis*)				X	meadow, shoreline, waste ground
knotweed, Japanese (*Reynoutria japonica* var. *japonica*)			&		forest, shoreline, floodplain, waste ground
lettuce, wall (*Mycelis muralis*)				#	meadow
lilac, Japanese tree (*Syringa reticulata*)	&				forest, meadow
locust, black (*Robinia pseudoacacia*)			&		forest, floodplain, meadow
locust, bristly (*Robinia hispida*)				#	road bank, meadow
loosestrife, purple (*Lythrum salicaria*)			&		wetland, shoreline, meadow
loosestrife, yellow garden (*Lysimachia vulgaris*)	X	#			meadow
lupine, giant (*Lupinus polyphyllus* var. *polyphyllus*)				#	meadow
maple, Japanese (*Acer palmatum*)	X				forest, meadow
maple, Norway (*Acer platanoides*)			&		forest
maple, sycamore (A*cer pseudoplatanus*)	&				forest, floodplain
mint, crested late-summer (*Elsholtzia ciliata*)				#	waste ground
morning-glory, ivy-leaved (*Ipomoea hederacea*)				#	oldfield, waste ground
mugwort (*Artemisia vulgaris* var. *vulgaris*)			&		forest, meadow, waste ground
mulberry, white (*Morus alba*)			X		forest edge, meadow
naiad, brittle (*Najas minor*)			X		lake, pond, stream, river
parsnip, wild (*Pastinaca sativa*)			&		meadow
pepper-grass, field (*Lepidium campestre*)				#	meadow
pepperweed, common (*Lepidium densiflorum* var. *densiflorum*)				#	meadow
periwinkle (*Vinca minor*)			X		forest, meadow
pondweed, curly leaf (*Potamogeton crispus*)			&		lake, pond, stream, river

(continued)

Table C-3. (cont.)

Common Name (*Scientific Name*)	**Tier 2**[1]	**Tier 3**[1]	**Tier 4**[1]	**Tier 5**[1]	**Habitat**
privet, border (*Ligustrum obtusifolium*)		#	X		forest, shrubland, meadow
purse, common shepherd's (*Capsella bursa-pastoris*)				#	meadow, waste ground
reed, common (*Phragmites australis*)			&		wetland, shoreline
rose, dog (*Rosa canina*)				#	meadow, hedgerow
rose, multiflora (*Rosa multiflora*)			&		forest, shrubland, meadow, shoreline
rush, flowering (*Butomus umbellatus*)		X			shoreline, marsh
smartweed, Nepal (*Persicaria nepalensis*)				#	road bank, shoreline
spurge, cypress (*Euphorbia cyparissias*)		#	X		meadow
spurge, leafy (*Euphorbia virgata*)		&			forest edge, meadow, waste ground
star-of-Bethlehem, common (*Ornithogalum umbellatum*)				#	forest edge, meadow
stiltgrass, Japanese (*Microstegium vimineum*)			&		forest, meadow, shoreline, floodplain
stonecrop, garden (*Hylotelephium telephium*)				#	forest, floodplain, meadow
stonecrop, showy (*Hylotelephium spectabile*)				#	meadow
stonecrop, stringy (*Sedum sarmentosum*)				#	forest
stonewort, starry (*Nitellopsis obtusa*)		#			lake, river
strawberry, Indian (*Potentilla indica*)				#	forest edge, meadow
swallow-wort, black (*Vincetoxicum nigrum*)		#	X		forest, meadow, shoreline
swallow-wort, pale (*Vincetoxicum rossicum*)			X		forest, meadow, shoreline
sweetpea (*Lathyrus odoratus*)				#	meadow
teasel, cut-leaf (*Dipsacus laciniatus*)	#		X		meadow, waste ground
thistle, bull (*Cirsium vulgare*)			X		meadow
thistle, Canada (*Cirsium arvense*)			&		meadow
thistle, Carline (*Carlina vulgaris*)	#			X	meadow
thistle, European marsh (*Cirsium palustre*)			#		marsh, swamp, wetland edge
thistle, yellow star (*Centaurea solstitialis*)				#	meadow
tree, Japanese angelica (*Aralia elata*)	#				forest edge, meadow, shoreline
tree, princess (*Paulownia tomentosa*)	#				forest, waste ground
tree, wayfaring (*Viburnum lantana*)	X				forest, meadow
tree-of-heaven (*Ailanthus altissima*)			&		forest, shrubland, waste ground
trefoil, slender (*Lotus tenuis*)				#	road bank, marsh
viburnum, European cranberry (*Viburnum opulus* var. *opulus*)	X				meadow, wetland, shoreline
vine, China fleece (*Fallopia baldschuanica*)				X	forest edge

(continued)

Table C-3. (cont.)

Common Name (*Scientific Name*)	**Tier 2[1]**	**Tier 3[1]**	**Tier 4[1]**	**Tier 5[1]**	**Habitat**
vine, chocolate (*Akebia quinata*)	#				forest, meadow, ledge
vine, mile-a-minute (*Persicaria perfoliata*)	&				forest, meadow
water-chestnut (*Trapa natans*)		#	X		lake, pond, stream, river
watermilfoil, Eurasian (*Myriophyllum spicatum*)			&		lake, pond, stream
water-primrose, floating (*Ludwigia peploides* ssp. *glabrescens*)	#				pond
waterwheel (*Aldrovanda vesiculosa*)	#			X	lake, pond
willow, basket (*Salix purpurea*)				#	meadow, shoreline, wetland edge
willow, crack (*Salix fragilis*)				#	shoreline
willow, rusty (*Salix cinerea* ssp. *oleifolia)*	X				forest edge, meadow, shoreline
willow, Wisconsin weeping (*Salix* x *pendulina*)				#	shoreline
wineberry (*Rubus phoenicolasius*)	&				forest, meadow, rocky slope
wisteria (*Wisteria* spp.)	X				forest
wormwood, common (*Artemisia absinthium*)				#	meadow

[1]**Tier 2: Eradication is recommended**. High and very high impact species with low enough abundance to make eradication feasible within the Mohawk-Hudson PRISM region. Highest level of response efforts.

Tier 3: Containment is recommended. High and very high impact species that are likely too widespread for eradication, but low enough abundance to think about regional containment. Target strategic management to slow the spread since many surrounding regions could be at risk if left unattended.

Tier 4: Local control is recommended. Well-established species with high and very high impacts. Eradication efforts not feasible; only localized management over time to contain, exclude, or suppress, if justified to meet local management goals.

Tier 5: More research is needed. Species in or surrounding the PRISM region that need more research, mapping, and monitoring to understand invasiveness and impacts**.**

Table C-4. Dragonflies and damselflies of Greene County.

Data are from the NYSDEC 2005-2009 statewide odonate survey (White et al. 2010), with additional 2018 observations from the Mountain Top Arboretum by the Farmscape Ecology Program (Stevens et al. 2018). Habitats are from Dunkle (2000), Abbott (2006-2018), and Vispo (2017).

Common Name	Scientific Name	Habitat	Statewide Status[1]
AESHNIDAE			
darner, black-tipped	*Aeshna tuberculifera*	over meadow; along edge of water	
darner, Canada	*Aeshna canadensis*	over meadow; along shore of slow-moving water	
darner, common green	*Anax junius*	over small pond; skimming lake edge; over meadow	
darner, fawn	*Boyeria vinosa*	forested swamp; over shaded stream	
darner, green-striped	*Aeshna verticalis*	over meadow	
darner, harlequin	*Gomphaeschna furcillata*	edge of forest	
darner, lance-tipped	*Aeshna constricta*	over meadow; pond	
darner, ocellated	*Boyeria grafiana*	rocky forested stream; rocky lake edge	
darner, shadow	*Aeshna umbrosa*	along forest edge; shaded area	
darner, spatterdock	*Rhionaeschna mutata*	pond, lake	S2, SGCN
darner, swamp	*Epiaeschna heros*	wooded pond; wooded stream (incl. ephemeral pool)	S3
CALOPTERYGIDAE			
jewelwing, ebony	*Calopteryx maculata*	shaded area; along small stream	
rubyspot, American	*Hetaerina americana*	stream; river	S3, SGCN
COENAGRIONIDAE			
bluet, azure	*Enallagma aspersum*	near most slow-moving water	
bluet, big	*Enallagma durum*	around swampy pond; slow-moving river	S3
bluet, familiar	*Enallagma civile*	around large, slow-moving water body	
bluet, Hagen's	*Enallagma hageni*	along edge of pond	
bluet, marsh	*Enallagma ebrium*	around wetland; open swamp	
bluet, orange	*Enallagma signatum*	near still water	
bluet, skimming	*Enallagma geminatum*	around edge of water	
bluet, stream	*Enallagma exsulans*	alongside stream; lake	
bluet, taiga	*Coenagrion resolutum*	pond; marsh; *Sphagnum* pool	S3
damsel, aurora	*Chromagrion conditum*	near most water; esp. slow-moving or stagnant pond	
damsel, eastern red	*Amphiagrion saucium*	around stationary water	
dancer, powdered	*Argia moesta*	around medium to large river; pond; lake	
dancer, variable	*Argia fumipennis violacea*	around edge of slow or still water	
forktail, eastern	*Ischnura verticalis*	wide variety incl. pond; edge of slow-moving river; meadow	
forktail, fragile	*Ischnura posita*	wide variety incl. pond edge; forested swamp; stream; meadow	
forktail, lilypad	*Ischnura kellicotti*	pond; lake; marsh with pond-lilies	S3

(continued)

Table C-4. (cont.)

Common Name	Scientific Name	Habitat	Statewide Status[1]
COENAGRIONIDAE (cont.)			
sprite, sedge	*Nehalennia irene*	wet, grassy, mostly open area	
sprite, sphagnum	*Nehalennia gracilis*	*Sphagnum* bog; fen	
CORDULEGASTRIDAE			
spiketail, delta-spotted	*Cordulegaster diastatops*	unshaded seep; small stream	
CORDULIIDAE			
baskettail, beaverpond	*Epitheca canis*	bog pond; slow-moving stream; marshy lake	
baskettail, common	*Epitheca cynosura*	around pond; nearby meadow	
baskettail, prince	*Epicordulia princeps*	tree-top	
emerald, American	*Cordulia shurtleffii*	near still pond; bog; fen; marsh; small lake; over meadow	
emerald, brush-tipped	*Somatochlora walshii*	slow-moving clear stream through bog; fen; marsh	S3
emerald, clamp-tipped	*Somatochlora tenebrosa*	edge of meadow; along shady tree line	
emerald, forcipate	*Somatochlora forcipata*	bog	S1, SPCN
emerald, mocha	*Somatochlora linearis*	forested stream	S1, SGCN
emerald, petite	*Dorocordulia lepida*	marsh; bog lake; pond	S3
emerald, racket-tailed	*Dorocordulia libera*	over pond; bog; along edge of forest	
emerald, ski-tipped	*Somatochlora elongata*	slow stream; marsh; beaver pond	
sundragon, Uhler's	*Helocordulia uhleri*	clean, slow, forested stream	S3
GOMPHIDAE			
clubtail, beaverpond	*Gomphus borealis*	mud-bottomed pond; slow stream; lake	
clubtail, dusky	*Gomphus spicatus*	over slow-moving or still water	
clubtail, lancet	*Gomphus exilis*	over meadow; road; on rock near water	
clubtail, least	*Stylogomphus albistylus*	around rocky stream	
clubtail, lilypad	*Arigomphus furcifer*	around still water; slow-moving stream	
clubtail, northern pygmy	*Lanthus parvulus*	over small shaded stream	S3
clubtail, russet-tipped	*Stylurus plagiatus*	river	S1, SGCN
clubtail, unicorn	*Arigomphus villosipes*	around pond; lake	
snaketail, riffle	*Ophiogomphus carolus*	near swift stream; small river	S2S3
spinyleg, black-shouldered	*Dromogomphus spinosus*	around clear rocky stream	
LESTIDAE			
spreadwing, common	*Lestes disjunctus*	slow-moving stream with emergent vegetation, marsh; swamp; bog	
spreadwing, slender	*Lestes rectangularis*	around forested pool; small clearing	
spreadwing, spotted	*Lestes congener*	around still, marshy water	
spreadwing, swamp	*Lestes vigilax*	near still, swampy body of water	
LIBELLULIDAE			
amberwing, eastern	*Perithemis tenera*	around still water; in nearby meadow	
corporal, chalk-fronted	*Ladona julia*	near pond; small lake	
dasher, blue	*Pachydiplax longipennis*	over still pond	
glider, wandering	*Pantala flavescens*	over meadow; wide open area	

(continued)

Table C-4. (cont.)

Common Name	Scientific Name	Habitat	Statewide Status[1]
LIBELLULIDAE (cont.)			
meadowhawk, band-winged	*Sympetrum semicinctum*	in meadow	
meadowhawk, cherry-faced	*Sympetrum internum*	around small pond; nearby meadow	
meadowhawk, ruby	*Sympetrum rubicundulum*	around swamp; wet meadow; wetland	S3
meadowhawk, saffron-winged	*Sympetrum costiferum*	marsh-bordered pond esp. in sandy, gravelly deposit	S3S4
meadowhawk, yellow-legged	*Sympetrum vicinum*	near still water; meadow	
pennant, calico	*Celithemis elisa*	around pond; in nearby meadow	
pennant, Halloween	*Celithemis eponina*	in meadow; around pond	
pondhawk, eastern	*Erythemis simplicicollis*	around pond or (for females esp.) in meadow	
saddlebags, black	*Tramea lacerata*	over meadow	
skimmer, four-spotted	*Libellula quadrimaculata*	around pond; swamp; marshy stream	
skimmer, slaty	*Libellula incesta*	around edge of pond; edge of lake	
skimmer, spangled	*Libellula cyanea*	around pond; stream	
skimmer, twelve-spotted	*Libellula pulchella*	near water; over meadow	
skimmer, widow	*Libellula luctuosa*	near pond; lake; meadow	
whiteface, dot-tailed	*Leucorrhinia intacta*	around small stagnant body of water	
whiteface, frosted	*Leucorrhinia frigida*	mud-bottomed lake or pond with emergent vegetation; pool in fen; bog	
whiteface, Hudsonian	*Leucorrhinia hudsonica*	marshy pond; sand-bottomed lake; bog	
whitetail, common	*Plathemis lydia*	near water (slow or still); meadow	

[1] Criteria for statewide rarity status are explained in Appendix D.

S1, S2, S3 = New York Natural Heritage Program ranks

SGCN = Species of Greatest Conservation Need

SPCN = Species of Potential Conservation Need

Table C-5. Butterflies of Greene County, New York.

Data are from Butterflies and Moths of North America (Lots and Naberhaus 2018; http://www.butterfliesand moths.org), with a few additions from the Farmscape Ecology Program (FEP) observations at the Mountain Top Arboretum (Stevens et al. 2018). Flight time, foods, and habitats from Cech and Tudor (2005) and FEP observations in the Hudson Valley region.

Common Name	**Statewide Status[1,2]**	**Flight Time**	**Caterpillar Food**	**Habitat**
HESPERIIDAE				
broken-dash, northern		early Jun-mid Aug	panic grasses	oldfield
cloudywing, northern		late May-early Jul	clovers & other legumes	oldfield, utility corridor
dash, black		late Apr-early Jun	sedges	sedgy wetlands
dash, long		early Jun-early Jul; Aug	grasses	open grassy meadow, often moist
duskywing, columbine		May-June, Jul	columbine	calcareous ledge
duskywing, dreamy		mid-May-Jun	willows, aspen, black locust	open forest & edges
duskywing, Juvenal's		late Apr-early Jun	oaks	open upland habitats, usually not disturbed
duskywing, mottled	SC, S1, SGCN[HP]	May-Jun, July-Aug	New Jersey tea	open, dry forest
edge, hoary		Jun-Jul	legumes, e.g., tick trefoil	oldfield & field edge
glassywing, little		late Jun-Jul	purple top & other grasses	oldfield & pasture
skipper, arctic		late May to mid-Jun	grasses	grasses near forest
skipper, Delaware		mainly Jul	little bluestem, switchgrass, other grasses	open habitats, dry to wet
skipper, Dion	S3	Jul	sedges	wetlands
skipper, dun		Jul-Aug	sedges, maybe grasses	oldfield
skipper, Hobomok		late May-early Jul	grasses	oldfield
skipper, Indian		May-Jun	grasses, e.g., bluestem	dry, often shrubby, meadows
skipper, least		Jun-Oct	grasses	wet meadow, grassy marsh
skipper, Leonard's		end of Aug/early Sep	native grasses, e.g., little bluestem	dry upland grassland near wet area

(continued)

Table C-5. (cont.)

Common Name	Statewide Status[1,2]	Flight Time	Caterpillar Food	Habitat
HESPERIIDAE (cont.)				
skipper, Peck's		late May-Sep	grasses	meadow
skipper, roadside		late May-mid Jun	grasses	forest openings
skipper, silver-spotted		June-Aug	black locust	shrubby meadow
skipper, tawny-edged		late May-mid Jul; early Aug-Sep	grasses	grassy, often moist
skipper, Zabulon		late May-mid Jun; mid Aug-mid Sep	grasses	shrubby meadow, roadside
wing, mulberry		mid Jul-early Aug	sedges	sedgy wetland
LYCAENIDAE				
azure, Appalachian		May-Jun	bugbane	rich forest, esp. near streams
azure, spring		May-Aug	flowering dogwood, New Jersey tea, meadowsweet, other woody shrubs	openings & edges of deciduous forest, oldfield, forested swamp
azure, summer		Apr-Sep	(various)	mainly meadow
blue, eastern tailed		May-Sept	legumes	open, disturbed, low growth
blue, silvery		Apr-Jun	legumes	opening in moist forest
copper, American		May-Sep	*Rumex* (docks)	drier meadow
copper, bronze		mid Jun-mid Jul; early Aug-mid Sep	*Rumex* (docks)	wetland around pond or stream
elfin, brown		May	heaths	barrens, dry forest
elfin, eastern pine		May-Jun	pines	near pine woods
elfin, frosted	T, SGCN[HP]	May-Jun	legumes	open forest, forest edge, meadow, shrubland
hairstreak, Acadian		Jul	willows	shrubby wet meadow & swamp
hairstreak, banded		May-Aug	oaks, hickories	edges, open habitats
hairstreak, coral		Jun	cherries, plums	oldfield, second growth
hairstreak, early		May-Jun, Jul-Aug	beechnuts	beech forest

(continued)

Table C-5. (cont.)

Common Name	Statewide Status[1,2]	Flight Time	Caterpillar Food	Habitat
LYCAENIDAE (cont.)				
hairstreak, gray		early May-mid Jun	various meadow & shrubland plants	open, weedy, disturbed
hairstreak, hickory		late Jun-early Aug	hardwood trees	edge of rich, deciduous forest
hairstreak, juniper		mid May-Jun; Aug	eastern red cedar	open upland with red cedar
hairstreak, striped		late Jun-mid Jul	roses, cherries, hawthorns, heaths, American hornbeam	forest opening & edge
NYMPHALIDAE				
admiral, red		May-Oct	nettles	moist forest & meadow, esp. floodplain forest
admiral, white		mid Jun-early Aug; mid Aug-mid Sep	cherries	forest, edge, shrubland
brown, eyed		late Jun-early Aug	sedges	sedgy habitats
checkerspot, Baltimore		mid Jun-mid Jul	turtlehead, English plantain	meadow
checkerspot, Harris'		Jun-Jul	flat-topped white aster	wet, open habitats
cloak, mourning		year around; most common in summer	willows, other trees	wanders among many habitats
comma, eastern		3 flights, Apr-Sep?	elms, nettles, wood nettle, hops	forest, especially floodplain forest
comma, green		3 flights, Apr-Sep?	gooseberries, currants, elms	forest
crescent, pearl		mid May-early Sep	asters	meadow
crescent, tawny	SH, SC	Jun-Jul	certain asters	rocky, scrubby area
emperor, hackberry	S3S4	Jul-Aug	hackberry	floodplains with hackberry
fritillary, Aphrodite		late Jun-early Sep	violets	upland habitats on acidic soils, moist grassland
fritillary, Atlantis		mid Jun-mid Sep	northern blue violet	forest opening
fritillary, great spangled		late Jun-early Sep	violets	forest edge
fritillary, meadow		May-Sep	violets	moist meadow

(continued)

Table C-5. (cont.)

Common Name	**Statewide Status**[1,2]	**Flight Time**	**Caterpillar Food**	**Habitat**
NYMPHALIDAE (cont.)				
fritillary, regal	E, SH	late Jun-mid Sep	violets	extensive open area, somewhat wet
fritillary, silver-bordered		Jun-Sep	wetland violets	overgrowing wet habitats, marsh, bog
lady, American		mid May-late Oct	composites (asters, goldenrods, etc.)	(various)
mark, question		late Jun-Oct	elms	forest & edge
monarch	SPCN	mid Jun-Sep	milkweeds	oldfield, edge
nymph, common wood		Jul-early Sep	grasses	meadow with shrubs or other tall vegetation
pearly-eye, northern		late Jun-early Aug	grasses	forest, often near water
purple, red-spotted		mid Jun-early Aug; mid Aug-mid Sep	cherries	near deciduous, often moist forest
ringlet, common		late May-early Jul; late Jul-Aug	grasses	oldfield
satyr, little wood		late May-early Aug	grasses	forest edge or opening
tortoiseshell, Milbert's		mid Jun-Oct?	nettles	wet or moist habitat near forest
viceroy		late May-early Oct	willow	moist, shrubby habitat
PAPILIONIDAE				
swallowtail, black		May-Sep	parsley, carrot, & related plants	mainly open meadow
swallowtail, Canada		May-early Jun?	birches, aspens, cherries	near deciduous trees
swallowtail, eastern tiger		late May-Oct	black cherry, tulip tree, ashes	near deciduous trees
swallowtail, giant		May-Sep	plants in the Rutaceae family, esp. prickly-ash	various habitats, often semi-open
swallowtail, spicebush		May-Aug	spicebush	various open habitats, usually near forest

(continued)

Table C-5. (cont.)

Common Name	Statewide Status[1,2]	Flight Time	Caterpillar Food	Habitat
PIERIDAE				
orange-tip, falcate	S3S4	May	mustards, rock cresses, two-leaved toothwort	open woodland, rocky hill
sulphur, clouded		May-mid Oct	legumes	open habitat
sulphur, orange		mid May-early Oct	alfalfa & other legumes	open habitat, weedy, alfalfa meadow
white, cabbage		May-Oct	mustards	pasture or cultivated meadow
white, checkered	S1, SC, SGCN	late Aug-Sep	mustards	weedy, open habitat
white, mustard		as early as late Apr-Aug	mustards, e.g., *Dentaria*, *Arabis*, *Cardamine*	edge, streamside habitat, oldfield
white, West Virginia	S3	early Apr-late May	mainly *Dentaria* & *Cardamine diphylla*	rich moist forest

[1] New York Natural Heritage Program ranks (S1, S2, S3, SH) are explained in Appendix D.
[2] New York State Ranks are explained in Appendix D:

SC = Special Concern (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html)
SPCN = Species of Potential Conservation Need

Table C-6. Mollusks of Greene County: A. Aquatic mollusks and B. Land snails.

Occurrence and habitat data for aquatic mollusks are from Strayer (1987) and Coote (2015), updated by David Strayer in 2019. Occurrence and habitat data for land snails are from Hotopp et al. (2018), compiled by Kathleen A. Schmidt.

A. Aquatic mollusks

Scientific Name	Habitat	Native (Y/N)	Statewide Status[1,2]
ANCYLIDAE			
Ferissia fragilis[3]	quiet water	Y	
Ferrissia rivularis	quiet waters, streams & rivers, freshwater tidal Hudson River	Y	
Laevapex fuscus	quiet waters of lakes, impoundments, & streams	Y	
BITHYNIIDAE			
Bithynia tentaculata	freshwater tidal Hudson River	N	
HYDROBIIDAE			
Amnicola limosa[3]	freshwater tidal Hudson River	Y	
Birgella subglobosa	streams & freshwater tidal Hudson River	N	S3, SPCN
Floridobia winkleyi[3]	freshwater tidal Hudson River	Y	
Gillia altilis	freshwater tidal Hudson River	Y	SC, S1, SPCN
Littoridinops tenuipes[3]	freshwater tidal marsh	Y	
Probythinella lacustris[3]	freshwater tidal Hudson River	Y	
LYMNAEIDAE			
Fossaria humilis	brooks, streams, freshwater tidal Hudson River, lakes, ponds & temporary pools	Y	
Pseudosuccinea columella	quiet waters	Y	
Stagnicola catascopium	streams, intertidal zone of Hudson River, & lakes	Y	
Stagnicola elodes	ponds (incl. temporary), canals, & marshes	Y	
PHYSIDAE			
Aplexa hypnorum[3]	shallow ponds, wetlands, vernal pools	Y	
Physa acuta[3]	lakes, ponds, ditches	Y	
Physa gyrina[3]	lakes, streams, Hudson River	Y	
Physa vernalis[3]	wetlands, vernal pools, ditches	Y	
PLANORBIDAE			
Gyraulus circumstriatus[3]	temporary waters	Y	
Gyraulus deflectus	lakes, ponds, stream backwaters, Hudson River	Y	
Gyraulus parvus	streams, freshwater tidal Hudson River, lakes, ponds	Y	
Helisoma anceps	streams, freshwater tidal Hudson River, lakes, & ponds	Y	
Menetus dilatatus	streams, freshwater tidal Hudson	Y	
Planorbella campanulata	lakes & ponds	Y	
Planorbella trivolvis	streams, freshwater tidal Hudson River, & ponds	Y	
Planorbula armigera[3]	temporary waters, marshes, ponds	Y	
Promenetus exacuous	freshwater tidal Hudson River, marshes, & ponds	Y	

(continued)

Table C-6.A. (cont.)

Scientific Name	Habitat	Native (Y/N)	Statewide Status[1,2]
PLANORBIDAE (cont.)			
Gyraulus parvus	streams, freshwater tidal Hudson River, lakes, ponds	Y	
Helisoma anceps	streams, freshwater tidal Hudson River, lakes, & ponds	Y	
Menetus dilatatus	streams, freshwater tidal Hudson	Y	
Planorbella campanulata	lakes & ponds	Y	
Planorbella trivolvis	streams, freshwater tidal Hudson River, & ponds	Y	
Planorbula armigera[3]	temporary waters, marshes, ponds	Y	
Promenetus exacuous	freshwater tidal Hudson River, marshes, & ponds	Y	
PLEUROCERIDAE			
Pleurocera acuta	freshwater tidal Hudson River	N	S3
Pleurocera livescens	streams & freshwater tidal Hudson River	N	
Pleurocera virginica	freshwater tidal Hudson River	Y	S3
POMATIOPSIDAE			
Pomatiopsis lapidaria	in and near wetlands & moist ground, freshwater tidal Hudson River	Y	
SPHAERIIDAE			
Pisidium spp.[3]	many habitats		
Sphaerium occidentale[3]	temporary ponds	Y	
Sphaerium simile[3]	streams	Y	
Sphaerium striatinum[3]	streams	Y	
UNIONIDAE			
Anodonta implicata	freshwater tidal Hudson River	Y	S1S2, SGCN[HP]
Elliptio complanata	streams, freshwater tidal Hudson River & lakes	Y	
Lampsilis radiata	streams, freshwater tidal Hudson river, & lakes	Y	
Leptodea ochracea[3]	tidal Hudson River	Y	S1, SGCN[HP]
Pyganodon cataracta	streams, freshwater tidal Hudson River, lakes, & ponds	Y	
VALVATIDAE			
Valvata sincera	freshwater tidal Hudson River	Y	S1, SC, SPCN
Valvata tricarinata	streams, freshwater tidal Hudson River, lakes, & ponds	Y	
VIVIPARIDAE			
Campeloma decisum	streams, freshwater tidal Hudson River, lakes, & ponds	Y	
Cipangopaludina chinensis	quiet waters	N	
Lioplax subcarinata	freshwater tidal Hudson River	Y	
Viviparus georgianus[3]	rivers, permanent ponds, & lakes	N	

[1] New York Natural Heritage Program ranks (S1, S2, S3) are explained in Appendix D.
[2] NY State Ranks are explained in Appendix D:
SC = Special Concern (Environmental Conservation Law 6NYCRR Part 182.[g]
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need
SPCN = Species of Potential Conservation Need
[3] Documented nearby and almost surely occurring in Greene County (David Strayer, pers. comm.)
[4] Historic record only (1936).

(continued)

Table C-6. (cont.)

B. Land Snails

Scientific Name	Common Name	Habitat	Native (Y/N)
AGRIOLIMACIDAE			
Deroceras laeve[1]	meadow slug	open & developed areas, yards, fields, shrubs, young woods	Y
Deroceras reticulatum[1]	gray fieldslug	gardens & fields (a pest of crops)	N
ARIONIDAE			
Arion circumscriptus[1]	brown-banded arion	leaf litter; lowland deciduous forests	N
Arion fasciatus[1]	orange-banded arion	near human habitation, gardens, fields, dumps, cemeteries,	N
Arion hortensis[1]	garden arion	nurseries & farmland	N
Arion intermedius[1]	hedgehog arion	disturbed & developed habitats, yards, farms, woods, wetlands	N
CIONELLIDAE			
Cochlicopa lubrica	glossy pillar	open habitats, wetlands, grasslands, roadsides	Y
Cochlicopa lubricella[1]	thin pillar	colonies on developed sites, lawns, driveways	N
Cochlicopa morseana[1]	Appalachian pillar	deep leaf litter; cool mature forests	Y
DISCIDAE			
Anguispira alternata	flamed disk	leaf litter around logs, bark, rocks; hardwood or mixed forests	Y
Discus catskillensis	angular disk	among logs, stumps, rock talus, dead leaves; forests or old fields	Y
Discus patulus[1]	domed disk	stumps, logs, or in deep layers of moist leaves; mature forests	Y
Discus rotundatus	rotund disk	among herbaceous vegetation, leaf litter, rocks; damp habitats, woods	N
Discus whitneyi[1]	forest disk	moist habitats, near springs, wetlands, low-lying meadows, roadsides	Y
ELLOBIIDAE			
Carychium exiguum[1]	obese thorn	damp calcium-rich environments	Y
Carychium exile[1]	ice thorn	leaf piles, fallen tree pits on wooded slopes & talus	Y
Carychium nannodes[1]	file thorn	leaf piles, fallen tree pits on wooded slopes & talus	Y
EUCONULIDAE			
Euconulus chersinus	wild hive	moist leaf litter on wooded hillsides & steep valleys	Y
Euconulus dentatus[1]	toothed hive	dry leaf litter & around logs	Y
Euconulus fulvus egena[1]	brown hive	moist leaf litter	Y
Euconulus polygyratus	fat hive	leaf litter	Y
GASTRODONTIDAE			
Gastrodonta interna[1,2]	brown bellytooth	deep piles of wet leaf litter & rotting wood debris in damp woods	Y
Striatura exigua[1]	ribbed striate	leaf litter in mesic forests	Y
Striatura ferrea[1]	black striate	leaf litter in hardwood forests	Y
Striatura milium[1]	fine-ribbed striate	leaf litter; mesic upland woods, acidic wooded wetlands, fens	Y
Ventridens intertextus[1]	pyramid dome	leaf litter in acidic woods	Y

(continued)

Table C-6.B. (cont.)

Scientific Name	**Common Name**	**Habitat**	**Native (Y/N)**
GASTRODONTIDAE (cont.)			
Ventridens ligera[1]	globose dome	richer soils; open weedy forest, floodplains, meadows, roadsides	Y
Zonitoides arboreus	quick gloss	common and widespread; forest leaf litter, logs, snags	Y
Zonitoides nitidus	black gloss	floodplains, streamsides, & wetlands	Y
HAPLOTREMATIDAE			
Haplotrema concavum[1]	gray-foot lancetooth	forest leaf litter	Y
HELICIDAE			
Cepaea nemoralis[1]	grovesnail	early successional habitats; roadsides, urban forests, floodplains	N
HELICODISCIDAE			
Helicodiscus parallelus	compound coil	decaying wood, leaf matter; floodplains, uplands, grassland, roadsides	Y
Helicodiscus shimeki[1]	temperate coil	leaf litter in upland woods; acidic environments	Y
Lucilla singleyana[1]	smooth coil	urban terrain, open land, dry grasslands, bare rock & talus, roadsides	Y
HYGROMIIDAE			
Trochulus hispidus[1]	hairy helicellid snail	damp, shady, weedy places	N
LIMACIDAE			
Limax flavus	yellow gardenslug	under logs & waste piles; disturbed habitats, gardens,	N
Limax maximus[1]	giant gardenslug	wooded areas near houses, gardens, yards, sidewalks	N
OXYCHILIDAE			
Oxychilus alliarius[1]	garlic glass-snail	disturbed areas, yards, gardens, roadsides, abandoned lots	Y
Oxychilus cellarius[1]	cellar glass-snail	anthropogenic shaded habitats, forests, gardens, brushpiles, caves	N
Oxychilus draparnaudi[1]	dark-bodied glass-snail	moist shaded habitats in yards, gardens, woods	N
PHILOMYCIDAE			
Megapallifera mutabilis[1]	changeable mantleslug	upland forest, human habitations; moist areas around trees, under bark	Y
Pallifera dorsalis[1]	pale mantleslug	leaf litter; old growth & secondary upland forests	Y
Philomycus carolinianus[1]	Carolina mantleslug	wooded floodplains	Y
Philomycus flexuolaris[1]	winding mantleslug	on logs, snags, tree trunks; upland hardwood forests	Y

(continued)

Table C-6.B. (cont.)

Scientific Name	Common Name	Habitat	Native (Y/N)
POLYGYRIDAE			
Euchemotrema fraternum	upland pillsnail	leaf litter & logs in woods, sometimes climbing on beech & maple trunks	Y
Euchemotrema leai	lowland pillsnail	lowlands, marshes, swamps, floodplains, grassy meadows	Y
Inflectarius inflectus[1]	shagreen	leaf litter & under logs, rocks, & trash; wooded areas	Y
Mesodon thyroidus	white-lip globe	rich soil; lowlands, limestone ledges; oak & maple wood, gardens	Y
Neohelix albolabris	whitelip	leaf litter, logs, woody debris; forests, damp rich lower forest slopes	Y
Neohelix dentifera[1]	big-tooth whitelip	upland forest, acidic, damp rocky slopes near streams, glacial talus, rhododendrons	Y
Neohelix solemi[1]	coastal whitelip	leaf litter & woody debris; open habitats, forests	Y
Patera appressa[1,2]	flat bladetooth	rocky areas of hardwood forests, roadsides, urban terrains	Y
Stenotrema hirsutum	hairy slitmouth	leaf litter under rocks; vine-covered talus, niches; rich soils	Y
Triodopsis juxtidens[1]	Atlantic threetooth	leaf litter & under logs & rocks in rich, hilly forests	Y
Triodopsis tridentata	northern threetooth	leaf litter, under logs; mixed hardwood forests, roadsides, meadows, urban areas	Y
Xolotrema denotatum	velvet wedge	near big logs, fallen trees, & snags; damp steep slopes, floodplains	Y
POMATIOPSIDAE			
Pomatiopsis lapidaria	slender walker	mud or debris near streams; riparian forests, calcareous habitats	Y
PRISTILOMATIDAE			
Hawaiia minuscula	minute gem	leaf litter; wooded slopes, open ground on floodplains & roadsides	Y
Paravitrea multidentata[1]	dentate supercoil	moist leaf litter in rocky forests	Y
PUNCTIDAE			
Punctum minutissimum[1]	small spot	leaf litter; calcium-rich habitats	Y
PUPILLIDAE			
Pupilla muscorum	widespread column	roadsides, quarries, old fields, carbonate cliffs, glades, grasslands	Y
Pupoides albilabris	white-lip dagger	under stones, leaf litter, thatch; rock outcrops, bedrock glades, dry prairie, old fields; calcareous habitats	Y

(continued)

Table C-6.B. (cont.)

Scientific Name	Common Name	Habitat	Native (Y/N)
STROBILOPSIDAE			
Strobilops aeneus[1]	bronze pinecone	in old logs & leaf litter	Y
Strobilops affinis[1]	eightfold pinecone	on logs & in leaf litter; mixed hardwood forests	Y
Strobilops labyrinthicus[1]	maze pinecone	leaf litter, on old logs, & at the base of trees	Y
SUCCINEIDAE			
Catinella vermeta[1]	suboval ambersnail	around lowland streams & wetlands	Y
Novisuccinea ovalis	oval ambersnail	among herbaceous veg.; ditches, along streams, rivers, hillside woods	Y
Oxyloma retusum[1]	blunt ambersnail	on plants; damp fields, shoreline habitats	Y
Succinea putris[1]	European ambersnail	common around ponds, swamps, wet meadows, streams	N
VALLONIIDAE			
Planogyra asteriscus[1]	eastern flat-whorl	wetlands & occasionally upland woods	Y
Vallonia costata	costate vallonia	calcium-rich habitats; forest gaps, dry open places	Y
Vallonia excentrica	iroquois vallonia	grassy places, roadsides, lawns	N?
Vallonia perspectiva[1]	thin-lip vallonia	talus slopes in woods, broken rock areas, railroad tracks; calcareous habitats	Y
Vallonia pulchella	lovely vallonia	grassy places, meadows, roadsides, lawns	Y
VERTIGINIDAE			
Columella simplex	high-spire column	leaf litter, on leaves; various habitats, forests, open, acidic, calcareous	Y
Gastrocopta contracta	bottlenose snaggletooth	leaf litter, under logs; various habitats: wet, dry, forests, open	Y
Gastrocopta corticaria	bark snaggletooth	wooded calcareous ledges; in soil under e. red cedar; in wetlands	Y
Gastrocopta pentodon[1]	comb snaggletooth	various habitats; dry, damp, open, forested, rich, acidic	Y
Gastrocopta procera[1]	wing snaggletooth	leaf litter, thatch, under stones; exposed (unforested) sites; calcareous habitats	Y
Gastrocopta tappaniana[1]	white snaggletooth	leaf litter in flooplains, swamps, mesic & wet prairies, fens, bogs	Y
Vertigo bollesiana[1]	delicate vertigo	mesic upland forests under shrubs, cliff ledges, boulder tops	Y
Vertigo gouldi	variable vertigo	decomposed leaf litter; shaded calcareous ledges, forests	Y

(continued)

Table C-6.B. (cont.)

Scientific Name	Common Name	Habitat	Native (Y/N)
VERTIGINIDAE (cont.)			
Vertigo milium[1]	blade vertigo	decomposed leaf litter; mesic, rocky, riparian woodland; cliffs; roadsides; swamps	Y
Vertigo morsei[3]	six-whorl vertigo	decomposed leaf litter, esp. in calcareous open wetlands, moist meadows	Y
Vertigo ovata[1]	ovate vertigo	graminoid litter, cattail leaves; swamps, wet or mesic, calcareous, sedge meadows; woods	Y
Vertigo pygmaea	pygmy vertigo	graminoid thatch, leaf litter; disturbed areas, grasslands, roadsides, old fields, quarries	Y
VITRINIDAE			
Vitrina angelicae[1]	eastern glass-snail	beneath wood or rocks; damp, grassy, wetlands, streams, rivers	Y
ZONITIDAE			
Glyphyalinia indentata	carved glyph	leaf litter; forests, open lots, roadsides, railways	Y
Glyphyalinia rhoadsi[1]	sculpted glyph	leaf litter; upland forests	Y
Glyphyalinia wheatleyi[1]	bright glyph	leaf litter; ravines, moist hillsides	Y
Mesomphix cupreus	copper button	damp leaf litter & around logs; mature upland forests	Y
Mesomphix inornatus[1]	plain button	under leaves & dead wood; upland forests	Y
Nesovitrea binneyana[1]	blue glass	leaf litter; upland mixed hardwood forests	Y
Nesovitrea electrina	amber glass	wet habitats, lake margins, freshwater marshes, wet prairies, forests	Y

[1] Documented nearby and almost surely occurring in Greene County (Kathy Schmidt, pers. comm.)
[2] Unlikely in Greene County
[3] Provisional in Greene County

Table C-7. Fishes of Greene County, New York.

Data are from the New York State Fish Atlas, 1934-2011. Hudson River fishes are listed only if they are documented in the Greene/Columbia County reach of the river.

Common Name (statewide status[1])	**Scientific Name**	**Native (Yes/No)**	**Hudson River**	**Other Streams**	**Ponds/ Lakes**
alewife (SGCN)	*Alosa pseudoharengus*	Y	x	x	x
American eel (S2S3, SGCN[HP])	*Anguilla rostrata*	Y	x	x	x
American shad (SGCN[HP])	*Alosa sapidissima*	Y	x		
Atlantic sturgeon (E, S1, SGCN[HP])	*Acipenser oxyrinchus*	Y	x		
Atlantic tomcod (S3, SGCN[HP])	*Microgadus tomcod*	Y	x		
banded killifish	*Fundulus diaphanus*	Y	x	x	x
black crappie	*Pomoxis nigromaculatus*	N	x	x	x
blueback herring (S3)	*Alosa aestivalis*	Y	x	x	
bluegill	*Lepomis macrochirus*	N	x	x	x
bluntnose minnow	*Pimephales notatus*	Y		x	x
brassy minnow	*Hybognathus hankinsoni*	Y	x		
bridle shiner (S2?, SGCN)	*Notropis bifrenatus*	Y		x	x
brook stickleback (S3)	*Culaea inconstans*	Y		x	
brook trout (SGCN)	*Salvelinus fontinalis*	Y	x	x	x
brown bullhead	*Ameiurus nebulosus*	Y	x	x	x
brown trout	*Salmo trutta*	N	x	x	x
central mudminnow	*Umbra limi*	N	x	x	
central stoneroller	*Campostoma anomalum*	Y		x	
chain pickerel	*Esox niger*	Y	x	x	x
channel catfish	*Ictalurus punctatus*	N	x	x	
comely shiner (S2?, SGCN[HP])	*Notropis amoenus*	N	x	x	
common carp	*Cyprinus carpio*	N	x	x	x
common shiner	*Luxilus cornutus*	Y		x	x
creek chub	*Semotilus atromaculatus*	Y		x	x
cutlip minnow	*Exoglossum maxillingua*	Y		x	
eastern blacknose dace	*Rhinichthys atratulus*	Y		x	
eastern creek chubsucker	*Erimyzon oblongus*	Y		x	
eastern silvery minnow	*Hybognathus regius*	Y	x	x	
emerald shiner	*Notropis atherinoides*	N	x	x	
fallfish	*Semotilus corporalis*	Y	x	x	
fathead minnow	*Pimephales promelas*	N		x	x
fourspine stickleback (SGCN[HP])	*Apeltes quadracus*	Y	x	x	
freshwater drum	*Aplodinotus grunniens*	Y	x		
gizzard shad (S3)	*Dorosoma cepedianum*	N	x	x	
golden shiner	*Notemigonus crysoleucas*	Y	x	x	x
goldfish	*Carassius auratus*	N	x	x	x
grass carp	*Ctenopharyngodon idella*	N	x	x	x
green sunfish (S3)	*Lepomis cyanellus*	N	x	x	x
largemouth bass	*Micropterus salmoides*	N	x	x	x

(continued)

Table C-7. (cont.)

Common Name (statewide status[1])	**Scientific Name**	**Native (Yes/No)**	**Hudson River**	**Other Streams**	**Ponds/ Lakes**
logperch (S3)	*Percina caprodes*	Y	x	x	
longnose dace	*Rhinichthys cataractae*	Y		x	
longnose sucker (S3, SGCN)	*Catostomus catostomus*	Y		x	
margined madtom	*Noturus insignis*	Y		x	
mummichog (S3, SGCN)	*Fundulus heteroclitus*	Y	x	x	
northern hog sucker	*Hypentelium nigricans*	Y	x	x	
northern pike	*Esox lucius*	N	x	x	
pumpkinseed	*Lepomis gibbosus*	Y	x	x	x
rainbow trout	*Oncorhynchus mykiss*	N		x	x
redbreast sunfish (S3)	*Lepomis auritus*	Y	x	x	
redfin pickerel	*Esox americanus americanus*	Y	x	x	
rock bass	*Ambloplites rupestris*	N	x	x	x
rosyface shiner	*Notropis rubellus*	Y		x	
rudd	*Scardinius erythrophthalmus*	N	x	x	
satinfin shiner (S3)	*Cyprinella analostana*	Y		x	
sea lamprey	*Petromyzon marinus*	Y	x	x	
shortnose sturgeon (E, S1, SGCN)	*Acipenser brevirostrum*	Y	x		
slimy sculpin	*Cottus cognatus*	Y		x	
smallmouth bass	*Micropterus dolomieu*	N	x	x	
splake	*Salvelinus fontinalis* x *namaycush*	N			x
spotfin shiner	*Cyprinella spiloptera*	Y	x	x	
spottail shiner	*Notropis hudsonius*	Y	x	x	
striped bass	*Morone saxatilis*	Y	x	x	
tadpole madtom (S3)	*Noturus gyrinus*	Y		x	
tessellated darter	*Etheostoma olmstedi*	Y	x	x	
threespine stickleback	*Gasterosteus aculeatus*	Y		x	
tiger musky	*Esox lucius* x *masquinongy*	N			x
walleye	*Sander vitreus*	N	x	x	x
white catfish	*Ameiurus catus*	Y	x	x	
white crappie	*Pomoxis annularis*	N	x	x	
white perch	*Morone americana*	Y	x	x	x
white sucker	*Catostomus commersonii*	Y	x	x	x
yellow bullhead	*Ameiurus natalis*	Y		x	
yellow perch	*Perca flavescens*	Y	x	x	x

[1] New York Natural Heritage Program ranks (S1, S2, S3) are explained in Appendix D.
New York State ranks are explained in Appendix D:
E = endangered; T = threatened (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need

Table C-8. Greene County birds of conservation concern: A. Breeding birds, B. Winter birds

Data are from the NYS *Breeding Bird Atlas* (BBA) (Andrle and Carroll 1988, McGowan and Corwin 2008). Species are listed if they were documented in *Atlas* blocks that were more than 50 percent within the county.

A. Breeding birds of conservation concern

Group	**Species**	**General Habitat Type for Nesting**	**NYNHP Rank**[1]	**NYS Rank**[2]	**BBA 1980-85**[3]	**BBA 2000-05**[3]	**Trend**[4]
WATERFOWL							
	blue-winged teal	marsh	S2S3B	SGCN	y	n	d
	American black duck	marsh	S3B	SGCN[HP]	y	y	d
	red-breasted merganser	marsh edge, streambank	S3		y	n	s
GALLINACEOUS BIRDS							
	ruffed grouse	forest		SGCN	y	y	d
CUCKOOS							
	black-billed cuckoo	forest		SGCN	y	y	s
NIGHTJARS							
	whip-poor-will	forest	S3B	SC,SGCN[HP]	y	y	d
SHOREBIRDS							
	upland sandpiper	upland meadow	S3B	T,SGCN[HP]	y	n	d
	American woodcock	shrubland, forest		SGCN	y	y	s
RAPTORS							
	osprey	open area		SC	n	y?	?
	bald eagle	forest (near water)	S2S3B, S2N	T,SGCN	n	y	i
	northern harrier	meadow	S3B, S3N	T,SGCN	n	y	s
	sharp-shinned hawk	forest		SC	n	y	i
	Cooper's hawk	forest		SC	y	y	i
	northern goshawk	forest	S3S4B,S3N	SC,SGCN	y	n	d

(continued)

Table C-8. A. (cont.)

Group	Species	General Habitat Type for Nesting	NYNHP Rank[1]	NYS Rank[2]	BBA 1980-85[3]	BBA 2000-05[3]	Trend[4]
RAPTORS (cont.)							
	red-shouldered hawk	forest		SC,SGCN	n	y	i
	American kestrel	meadow		SGCN	y	y	d
	peregrine falcon	cliff, high bridge, tall building (near open habitat)	S3B	E,SGCN	n	y	i
OWLS							
	northern saw-whet owl	forest	S3		n	y	s
WOODPECKERS							
	red-headed woodpecker	forest (& various other)	S2?B	SC	y	y	d
PERCHING BIRDS							
	olive-sided flycatcher	forest	S3B	SGCN[HP]	y	n	d
	yellow-bellied flycatcher	forest	S3B		y	y	s
	Bicknell's thrush	forest	S2S3B	SC,SGCN[HP]	y	y	s
	wood thrush	forest		SGCN	y	y	d
	brown thrasher	shrubland	S3S4B	SGCN[HP]	y	y	d
	vesper sparrow	meadow	S3B	SC,SGCN[HP]	y	n	d
	grasshopper sparrow	meadow	S3B	SC,SGCN[HP]	y	y	s
	bobolink	meadow		SGCN[HP]	y	y	s
	eastern meadowlark	meadow		SGCN[HP]	y	y	d
	worm-eating warbler	forest		SGCN	y	n	d
	Louisiana waterthrush	streamside		SGCN	y	y	d
	golden-winged warbler	shrubland	S3B	SC,SGCN[HP]	y	y	d
	blue-winged warbler	shrubland		SGCN	y	y	s
	cerulean warbler	forest	S3?B	SC,SGCN	y	n	d
	northern parula	forest	S3S4B		y	n	s
	blackpoll warbler	forest	S3B		y	y	s

(continued)

Table C-8. A. (cont.)

Group	Species	General Habitat Type for Nesting	NYNHP Rank[1]	NYS Rank[2]	BBA 1980-85[3]	BBA 2000-05[3]	Trend[4]
PERCHING BIRDS (cont.)							
	black-throated blue warbler	forest		SGCN	y	y	s
	prairie warbler	meadow		SGCN	y	y	i
	Canada warbler	forest		SGCN[HP]	y	y	d
	scarlet tanager	forest		SGCN	y	y	s

[1] New York Natural Heritage Program ranks (S1, S2, S3) are explained in Appendix D.
[2] New York State ranks are explained in Appendix D:
E = endangered; T = threatened; SC = special concern (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html)

[3] NYS Breeding Bird Atlas data for survey periods 1980-85 and 2000-05: y = recorded in Greene County; n = not recorded in Greene County
[4] Trend in BBA data between the two survey periods: i = increasing; d = declining; s = similar; ? = trend uncertain

(continued)

Table C-8. (cont.) B. Winter birds of conservation concern

Data are from eBird archives, December –March, 1966 – 2019.

Group	Species	Where Seen in Winter[1]	NYNHP Rank[2]	NYS Rank[3]
WATERFOWL				
	blue-winged teal	Hudson River, swamp	S2S3B	SGCN
	northern shoveler	lake	S2	
	American wigeon	Hudson River	S3	
	American black duck	marsh	S3B	SGCN[HP]
	northern pintail	Hudson River, lake	S1B, S3N	SGCN
	green-winged teal	Hudson River, lake	S3	
	greater scaup	Hudson River, lake		SGCN
	lesser scaup	Hudson River, lake		SGCN
	white-winged scoter	Hudson River		SGCN
	black scoter	Hudson River		SGCN
	long-tailed duck	lake		SGCN
	common goldeneye	Hudson River, lake	S3	SGCN
	red-breasted merganser	Hudson River	S3	
	ruddy duck	lake	S1	SGCN
GALLINACEOUS BIRDS				
	ruffed grouse	forest		SGCN
GREBES				
	pied-billed grebe	pond, marsh	S3B, S1N	T,SGCN
	horned grebe	Hudson River, lake		SGCN
RAILS & CRANES				
	American coot	lake	S3	
SHOREBIRDS				
	American woodcock	meadow		SGCN

(continued)

Table C-8.B. (cont.)

Group	Species	Where Seen in Winter[1]	NYNHP Rank[2]	NYS Rank[3]
SHOREBIRDS (cont.)				
	Bonaparte's gull	Hudson River		SGCN
	laughing gull	Hudson River	S1	SGCN
	common tern		S3B	T,SGCN
LOONS				
	common loon	Hudson River, lake		SC,SGCN
CORMORANTS				
	double-crested cormorant	Hudson River	S3	
IBIS & HERONS				
	black-crowned night-heron		S3	SGCN
	glossy ibis		S2	SGCN
RAPTORS				
	osprey			SC
	bald eagle	forest (near water)	S2S3B, S2N	T,SGCN
	golden eagle		SHB, S1N	E
	northern harrier	marsh, meadow	S3B, S3N	T,SGCN
	sharp-shinned hawk	meadow		SC
	Cooper's hawk	various		SC
	northern goshawk	forest	S3S4B,S3N	SC,SGCN
	red-shouldered hawk	forest		SC,SGCN
	American kestrel	meadow		SGCN
	merlin	meadow	S3?B	
	peregrine falcon	cliff, high bridge, tall building (near open habitat)	S3B	E,SGCN
OWLS				
	barn owl		S1S2	SGCN[HP]
	long-eared owl		S2S3B	SGCN

(continued)

Table C-8.B. (cont.)

Group	Species	Where Seen in Winter[1]	NYNHP Rank[2]	NYS Rank[3]
OWLS (cont.)				
	short-eared owl	meadow	S2	E,SGCN[HP]
	northern saw-whet owl		S3	
PERCHING BIRDS				
	loggerhead shrike		S1B	E,SGCN[HP]
	horned lark	meadow	S3S4B	SC,SGCN[HP]
	boreal chickadee		S3	
	red crossbill		S2S3	
	white-winged crossbill		S2S3	
	eastern meadowlark	meadow		SGCN[HP]
	rusty blackbird		S2B	SGCN[HP]
	palm warbler		S2S3B	

[1] Winter habitats are given only as reported in eBird or by other observers; habitats were often not reported.
[2] New York Natural Heritage Program ranks are explained in Appendix D.
[3] New York State ranks are explained in Appendix D:
E = endangered; T = threatened; SC = special concern (Environmental Conservation Law 6NYCRR Part 182.[g])
SGCN = Species of Greatest Conservation Need
SGCN[HP] = Highest Priority Species of Greatest Conservation Need (http://www.dec.ny.gov/animals/9406.html)

APPENDIX D

Explanation of Rarity Ranks

EXPLANATION OF RARITY RANKS

A. ANIMALS

The explanation below is from the New York Natural Heritage Program Rare Animal Status List (Schlesinger 2017). Explanation of all NYNHP ranks are given here, but the NRI lists none of the global (G) ranks and considers only the ranks of S1, S2, and S3 to denote species of conservation concern.

STATE & FEDERAL LISTINGS

NY Natural Heritage tracks a selected subset of New York's animals. The species tracked are chosen based on their degree of rarity or imperilment within the state, and as new information comes in, new species are sometimes added while others are discontinued. Information on the species and communities tracked by NY Natural Heritage are used for conservation, research, and regulatory purposes.

Many of the species tracked by NY Natural Heritage are listed as "endangered" or "threatened" under the state Environmental Conservation Law (ECL). Listing is a legal process that is conducted by the state agency with authority over the species in question, and for animals confers important protection requirements. See http://www.dec.ny.gov/animals/7494.html for all state-listed animals.

The NYSDEC Division of Fish, Wildlife, and Marine Resources has jurisdiction over rare animal species listed as "endangered," "threatened," or of "special concern" under ECL §11-0535. Animals listed as endangered or threatened receive notable legal protection, as it is illegal to take or possess any of these species or their parts without a permit from NYSDEC. Species of special concern warrant attention and consideration but current information does not justify listing them as either endangered or threatened.

A subset of the animal species listed under New York state law is also recognized under federal law. These species are so seriously imperiled across their entire range that they face the very real prospect of extinction. Species are listed as federally endangered or threatened by the US Fish and Wildlife Service in consultation with state agencies and other experts, and the Service works closely with NYSDEC on the protection of federally listed species in New York.

Ultimately, protection of New York's biodiversity lies with landowners and land managers regardless of state or federal listings. How private and public landowners manage their properties will determine what species and natural communities persist into the future. This situation is both a great opportunity and a serious challenge.

(continued)

A. ANIMALS (cont.)

State legal listings are identified with the following codes:

- **E** endangered
- **T** threatened
- **SC** special concern

Federal legal listings are identified with the following codes:

- **E** listed endangered
- **T** listed threatened
- **C** candidate

NY Natural Heritage tracks all species listed as endangered and threatened. While they track many of the species listed as being of special concern, a subset of special concern species are currently not rare or imperiled enough to merit tracking at our precise scale. In addition, they track many species that are biologically rare and imperiled but that have not gone through the review process necessary for state listing.

Active Inventory and Watch List

The NY Natural Heritage Program keeps two lists of rare animal species: the Active Inventory List and the Watch List. Species on the Active Inventory List are ones they currently track in our database; for the most part these are the most rare or most imperiled species in the state. Species on the Watch List are those that could become imperiled enough in the future to warrant being actively inventoried, or are ones for which the Heritage Program does not have enough data to determine whether they should be actively inventoried. Species are moved between lists, or off the lists entirely, as available information warrants.

Global and State Status Ranks

NY Natural Heritage's statewide inventory efforts revolve around lists of rare species and all types of natural communities known to occur, or to have historically occurred, in the state. These lists are based on a variety of sources including museum collections, scientific literature, information from state and local government agencies, regional and local experts, and data from neighboring states.

Each rare species is assigned a rank based on its rarity, population trends, and threats. Like those in all state Natural Heritage Programs, NY Natural Heritage's ranking system assesses rarity at two geographic scales: global and state. The global rank (G-rank) reflects the status of a species or community throughout its range, whereas the state rank (S-rank) indicates its status within New York. Global ranks are maintained and updated by NatureServe, which coordinates the network of Natural Heritage programs. Both global and state ranks are usually based on the range of the species or community, the number of occurrences, the viability of the occurrences, and the vulnerability of the species or community around the globe or across the state. As new data become available, the ranks may be revised to reflect the most current information. Subspecific taxa are also assigned a taxon rank which indicates the subspecies' rarity rank throughout its range.

(continued)

A. ANIMALS (cont.)

For the most part, global and state ranks follow a straightforward scale of 1 (rarest/most imperiled) to 5 (common/secure). The Greene County NRI refers only to the three ranks—S1, S2, S3—that indicate rarity or limited occurrence in the state, as follows:

- **S1** Critically imperiled in New York State because of rarity (5 or fewer occurrences, or few remaining acres or miles of stream) or factors making it especially vulnerable to extinction rangewide (global) or in the state;
- **S2** Imperiled in New York State because of rarity (6-20 occurrences, or few remaining acres or miles of stream) or factors demonstrably making it very vulnerable to extinction (global) or extirpation from New York (state);
- **S3** Either uncommon or local in New York State, typically with 21 to 100 occurrences, limited acreage, or miles of stream rangewide (global) or in New York (state).

Additional species lists and codes are at https://www.acris.nynhp.org/.

Codes sometimes have qualifiers attached:

- **T1**, **T2**, etc. These ranks, which like global and state ranks run from 1 (rarest/most imperiled) to 5 (common/secure), are attached to global ranks to indicate the status of a subspecies or variety.
- **Q** Indicates that the species, subspecies, or variety is in taxonomic dispute.
- **?** Indicates that the state or global rank is uncertain and more information is needed.
- **N** Indicates the migratory status of a migratory species when it is not breeding in NY (for example, populations that are overwintering in the state).
- **B** Indicates the state status of a migratory species when it has breeding populations in NY.

Species of Greatest Conservation Need

The list of Species of Greatest Conservation Need was developed for the *New York State Wildlife Action Plan* (NYSDEC 2015).

High-Priority Species of Greatest Conservation Need

The status of these species is known, and conservation action is needed in the next ten years. These species are experiencing a population decline, or have identified threats that may put them in jeopardy and are in need of timely management intervention, or they are likely to reach critical population levels in New York.

Species of Greatest Conservation Need

The status of these species is known and conservation action is needed. These species 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.

Species of Potential Conservation Need

The status of these species are poorly known, but there is an identified threat to the species or features of its life history that make it particularly vulnerable to threats. The species may be declining or begin to experience declines within the next ten years, and studies are needed to determine their actual status.

B. PLANTS

New York State Legal Status

The following categories are defined in regulation 6NYCRR part 193.3 and apply to New York State Environmental Conservation Law section 9-1503. Part (f) of the law reads as follows: "It is a violation for any person, anywhere in the state to pick, pluck, sever, remove, damage by the application of herbicides or defoliants, or carry away, without the consent of the owner, any protected plant. Each protected plant so picked, plucked, severed, removed, damaged or carried away shall constitute a separate violation." Violators of the regulation are subject to fines of $25 per plant illegally taken. The list and contact information for questions about the list may be accessed at the DEC Protected Plants website. This list is updated only every 10 years so legal status ranks may not reflect the current Heritage rank.

E = Endangered Species: listed species are those with
1) 5 or fewer extant sites, or
2) fewer than 1,000 individuals, or
3) restricted to fewer than 4 U.S.G.S. 7 1/2 minute topographical maps, or
4) species listed as endangered by the U. S. Department of Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

T = Threatened: listed species are those with
1) 6 to fewer than 20 extant sites, or
2) 1,000 to fewer than 3,000 individuals, or
3) restricted to not less than 4 or more than 7 U.S.G.S. 7 1/2 minute topographical maps, or
4) listed as threatened by the U. S. Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

R = Rare: listed species have
1) 20 to 35 extant sites, or
2) 3,000 to 5,000 individuals statewide.

(continued)

B. PLANTS (cont.)

New York Natural Heritage Program Ranks

The explanation below is from the New York Natural Heritage Program Rare Plant Status Lists (Young 2017). The Greene County NRI refers only to the three ranks —S1, S2, S3—that indicate rarity or limited occurrence in the state, as follows:

- **S1** Critically imperiled in New York State because of extreme rarity (5 or fewer sites or very few remaining individuals) or extremely vulnerable to extirpation from New York State due to biological or human factors.
- **S2** Imperiled in New York State because of rarity (6 - 20 sites or few remaining individuals) or highly vulnerable to extirpation from New York State due to biological or human factors.
- **S3** Vulnerable in New York State. At moderate risk of extinction or elimination due to very restricted range, very few populations (usually 21 - 35 extant sites), steep declines, or other factors.

Double Ranks (S1S2, S2S3, S1S3)

The first rank indicates rarity based upon current documentation. The second rank indicates the probable rarity after all historical records and likely habitat have been checked. Double ranks denote species that need additional field surveys.

Codes sometimes have qualifiers attached, such as “Q” or “?”:

- **Q** indicates a question exists whether or not the taxon is a good taxonomic entity.
- **?** indicates that an identification question exits about known occurrences. It also indicates the rank presumably corresponds to actual occurrences even though the information has not yet been documented in heritage files or historical records. It serves to flag species that need more field studies or specimen identification.