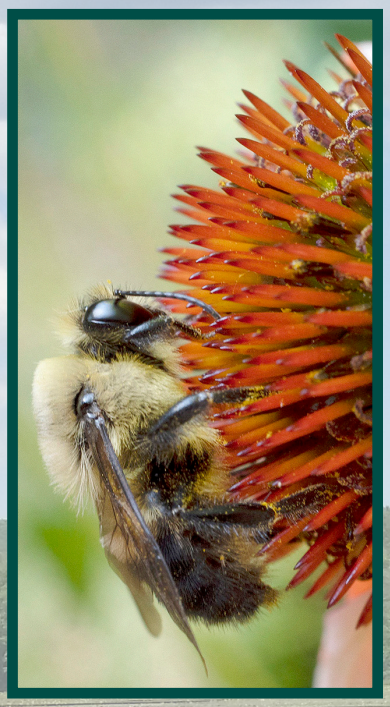
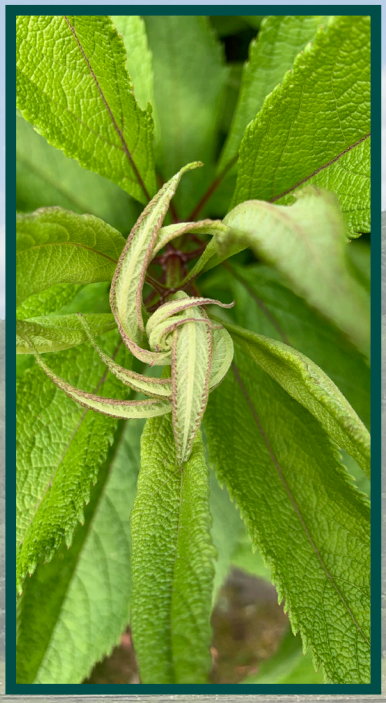


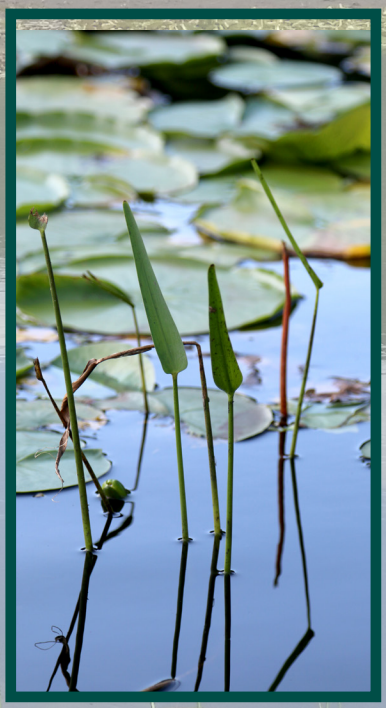
TOWN OF

WOODSTOCK, NY

Natural Resources Inventory

2020





On the cover: Photo of Yankeetown Pond by Maxanne Resnick. Close-up images, clockwise from top left: fiddlehead fern by Bennet Ratcliff; brown trout by Bennet Ratcliff; Joe pye weed by Alex Bolotow; lily pads by Erik Kiviat; grasshopper by Fionn Reilly; river birch by Alex Bolotow; bee on echinacea by Fionn Reilly; and eastern box turtle by Ingrid Haeckel. Cover design by Naomi Graphics.

Town of Woodstock, NY
Natural Resources Inventory

**Prepared by the DEC Hudson River Estuary Program and Cornell University,
the Ashokan Watershed Stream Management Program, Cornell Cooperative Extension
of Ulster County, and Ulster County Department of the Environment,
with assistance from the Town of Woodstock Environmental Commission
and the Woodstock Land Conservancy**

2020

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Acknowledgments

The Town of Woodstock Natural Resources Inventory was created with technical assistance from Cornell University, the NYS DEC Hudson River Estuary Program, Ulster County, and the Ashokan Watershed Stream Management Program.

We deeply appreciate the leadership and many contributions of our project coordinator, Ingrid Haeckel. We are also grateful for the expertise, input and mapping contributions of Nate Nardi-Cyrus, Tim Koch and Ben Ganon. Further, we'd like to thank Bill McKenna, Town Supervisor, for his support, and Peter Cross, Planning Board Chair, for his insights and advice. Finally, we are grateful to Ashley Slovensky, Assistant to the Town Supervisor, for her help with website and administrative matters.

Section 1: Introduction

The evolution of the Town of Woodstock is intimately tied to its natural resources. From the original Munsee Lenape inhabitants, to the Dutch and English colonizers, to the generations of artists and counter-culture pioneers who have passed through these 67 square miles, the natural beauty and ecological wealth of our town has long been a draw to visitors and residents alike. Often called "the most famous small town in the world," Woodstock is known for its breathtaking scenery, art, music, outdoor recreation, spirituality, and quality of life—all due in large part to the abundance of natural resources that grace this community.

More than fifty years ago town historian Alf Evers began to express concerns about the potential for overbuilding, and he encouraged town leaders to develop land use ordinances. In 1982 Alf was quoted as saying,

> *The reawakening of Americans to the importance of personal contact with the world of nature is an encouraging development, but new ways of relating to nature must become accepted on our crowded earth if areas of natural beauty and usefulness like the Catskills are not to be destroyed.*[1]

This statement rings evermore true today. With changing demographics and pressures for new development, along with the challenges of climate change, protecting our natural resources is increasingly critical.

View of Mt Guardian and Overlook from Comeau. Maxanne Resnick

[1] Cited in Heppner, Richard. *Woodstock: Everyday History*, CreateSpace, 2015.

Our Natural Resources Inventory (NRI) provides a baseline of information for helping government officials, developers, land trust planners, and residents make informed and environmentally sound land use decisions. This information can serve as a guide in the development of policies, the identification of areas for natural resource conservation and management, and the education of residents. We want our community to be even more effective stewards of its natural beauty and assets.

What is a Natural Resources Inventory?

Woodstock's NRI is comprised of a series of maps and data sets, and an accompanying narrative. Together they document and highlight the many natural assets with which our town is blessed.

Our forests, meadows, wetlands, and streams are not only habitat for abundant wildlife and fish, but they also provide many vital benefits to humans. These ecosystems help to keep drinking water and air clean, to moderate temperature, to filter pollutants, to absorb floodwaters, and to provide for pollination of agricultural crops. They also present opportunities for outdoor recreation and education, and they create the scenery and sense of place that is unique to our community.

Land-use planning seeks to balance future growth and development with the protection of natural resources. Identifying important natural resources is the first step in proactive environmental planning and informed decision-making. This NRI identifies and describes the naturally occurring resources located in the Town of Woodstock, including topography, geology and soils, water resources, and habitat, as well as recreation and scenic areas, land uses, and climate conditions and projections. By bringing this information together in one place, the NRI can cultivate a better understanding and appreciation of the community's natural resources and set the stage for a wide range of planning and conservation applications. The NRI provides a foundation for comprehensive and open space planning, zoning updates, identification of critical environmental areas, climate adaptation strategies, and other municipal plans and policies for the Town of Woodstock. The NRI can also inform land stewardship and conservation in our town.

Data and Methods

Mapping for the Woodstock NRI was completed in 2020 through technical assistance from Cornell University, the NYS DEC Hudson River Estuary Program, Ulster County, and the Ashokan Watershed Stream Management Program. The maps were created by Ingrid Haeckel, Tim Koch, and Ben Ganon, with input from the Woodstock NRI committee. The maps display data from federal, state, city, and county agencies; non-profit organizations including The Nature Conservancy; and prior planning efforts by the Town. The original source and publication year of data sets are included on each map and are described in the report.

All maps were produced using ESRI ArcGIS 10.6 Geographic Information Systems (GIS) software and data in the NAD 1983 State Plane New York East FIPS 3101 Feet coordinate system. Information on the maps comes from different sources, produced at different times, at different scales, and for different

purposes. Most of the GIS data were collected or developed from remote sensing data (i.e., aerial photographs, satellite imagery) or derived from paper maps. For these reasons, GIS data often contain inaccuracies from the original data, plus any errors from converting it. Therefore, maps created in GIS are approximate and best used for planning purposes. They should not be substituted for site surveys. Any resource shown on a map should be verified for legal purposes, including environmental review. Information provided by the maps can be enhanced by local knowledge, and the NRI should be updated every 10 years as new data become available.

The NRI report was written based on a template from the Hudson River Estuary Program, with assistance from Julia Blelock and Jim Hanson (Introduction and other introductory material), Erin Moran (Climate and Agricultural Resources), Ken Panza (Aquifers, Drinking Water Resources and Stream Management), Grant Jiang (Drinking Water Resources), Tim Koch (Watersheds, Special Flood Hazard Areas, and Stream Management), Arlene Weissman and Maxanne Resnick (Zoning and Conservation and Public Lands), and Ingrid Haeckel (Physical Setting, Stream Habitat, Wetlands, Water Quality Monitoring and Assessment, plus Habitats and Wildlife).

The NRI incorporates information and insights from Woodstock's *Comprehensive Plan 2018*; water district maps; "Wellhead Protection Area Delineation," Horsley & Witten, Inc. (April 1995); "Summary of Findings for the Woodstock Aquifer and Proposed Water Supply Overlay District," Steven Winkley of the New York Rural Water Association (circa 2002); the *Sawkill Creek Stream Corridor Assessment Report* (May 2007); AWSMP culvert assessments and stream management plans (*Beaver Kill Stream Management Plan*, and the forthcoming *Little Beaver Kill Stream Management Plan*); and the 2012 Hudsonia study, *Significant Habitats in the Town of Woodstock, Ulster County, New York*.

During the NRI project, NRI committee members reached out regularly to Woodstock's municipal leaders and citizens for their input and review. The project was presented via Zoom meetings to the Town Board on June 16th and to the Planning Board on October 29th, and to the public on October 5th.

How to Use this Report

The NRI is a valuable land use planning tool as well as an educational resource that documents aspects of the town's diverse natural and cultural resources. The inventory provides an essential tool for the local Planning and Zoning Boards, Environmental Commission, and Building Department by officially identifying sensitive land and water resources. It discusses development considerations for the Planning and Zoning Boards, laying a foundation for land use planning and decision-making, zoning considerations and municipal policy guidance, as well as environmental conservation. In addition, the NRI provides property owners, developers and their consultants with information they may need in considering the impact their project may have on the town's natural resources. It can be used to address natural resources during project planning and design and to help expedite review and approval of their endeavors. It can also be used as a general reference for landowners to understand resources that may occur on their property, and to inform stewardship. Organizations that have drafted conservation easements can use the NRI to identify potential conservation values on a given property and then include

restrictions in the easement to protect those values.

It is important to keep in mind that the NRI is best suited for municipal-scale planning but may be used as a screening tool at the site-scale to raise questions or identify the need for additional site assessment. The maps are not intended to provide site-specific accuracy and should not be used as a primary source for land use decision-making but may identify where further site assessments are needed.

The NRI maps are available as PDFs on the Town website at the Woodstock Environmental Commission's webpage. These maps allow for ease of navigation, with the ability to zoom in to an area of interest. In addition, a separate set of maps with tax parcel boundaries is available.

Many of the data sets shown in the NRI maps are available for more detailed viewing through online interactive maps. These include:

- Ulster County Parcel Viewer
- Hudson Valley Natural Resource Mapper
- DECinfo Locator
- Discover GIS Data NY
- National Map
- Web Soil Survey
- TNC Resilient Land Mapping Tool

Cooper Lake. Matt Jones

Geographic Location
Base Map (Map 1) and Aerial View (Map 2)

The Town of Woodstock is located in northern Ulster County in the mid-Hudson Valley region of New York State. It is approximately 67.5 square miles in area and has a population of 5,884 according to the 2010 US Census. The entire Town is within the "blue line" of the New York State Catskill Park. Woodstock's location at the abrupt transition from the Catskill foothills to the steep escarpment presents a dramatic landscape and has resulted in a diversity of natural environments and resources spanning the transition from Hudson Valley to Catskill Mountain physiographic regions.

The Base Map (Map 1) is the foundation for the Natural Resources Inventory map series. It shows municipal boundaries, roadways, topographic relief, streams, and waterbodies. Woodstock is bounded on the north by the Town of Hunter in Greene County; on the east by the Town of Saugerties; southeast by Ulster, and Kingston; on the south by the Towns of Hurley and Olive; and on the west by the Town of Shandaken (all in Ulster County). State Routes 212 and 375 are the main gateways to the Town, the latter connecting to State Route 28 with access to Kingston and NYS Thruway Exit 19. State Route 212 connects Woodstock with Saugerties and provides access to NYS Thruway Exit 20. Local roads are also shown and labeled on the map. Tax parcel data shown in the Natural Resources Inventory map series were published in 2019 by Ulster County.

The Aerial View Map (Map 2) gives a bird's-eye view of Woodstock, showing 0.5-ft resolution 2016 orthoimagery from New York State[2] delivered through ESRI Base Map services. Orthoimagery is aerial imagery that has been georeferenced and digitally corrected to remove geometric distortion due to ground relief and camera position.[3] The resulting imagery is proportionally accurate and can be overlaid onto maps. The aerial imagery was taken in early spring prior to the leaf out of deciduous trees, resulting in a detailed view of vegetation types, land uses, and development. It can serve as a reference for comparison with features shown on other maps in the Natural Resources Inventory.

For interactive viewing of New York State's orthoimagery dating back to 1994, users can visit the Discover GIS Data NY website at https://orthos.dhses.ny.gov/.

[2] Ulster County 2016 Orthoimagery is available for download at http://gis.ny.gov/gateway/mg/2016/ulster/

[3] "Frequently Asked Questions – Digital Orthoimagery Information." NYS GIS Program Office. http://gis.ny.gov/gateway/mg/faq.htm

Section 2: Climate

What Is Climate Change?

Climate change is a long-term change in the average weather patterns. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report states that there is a greater than 95 percent chance that rising global average temperatures observed since the mid-20th century are primarily due to human activities.[4] The principal driver of recent climate change has been increasing levels of atmospheric greenhouse gases associated with fossil-fuel combustion, changing land-use practices, and other human activities. Atmospheric concentrations of the greenhouse gas carbon dioxide are now approximately 40 percent higher than in preindustrial times. This has resulted in changes to the average temperature and precipitation patterns of regional climates around the world.

Climate is the long-term average of weather, typically averaged over a period of 30 years. Woodstock is already experiencing the effects of rapid climate change.

Forest. Fionn Reilly

[4] IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp. https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf

Why Is Understanding Climate Change Important?

The changing climate is causing rising sea levels as glaciers and polar ice melt, changing temperature and precipitation patterns, and increasing frequency of extreme weather events, including heat waves, droughts, and floods. This already impacts how and where we live, from farmers growing different crops to people leaving their no-longer-habitable homes. It also contributes to species' relocation or demise. In addition, warmer temperatures can have adverse effects on health by increasing plants' pollen production and the formation of ground-level ozone, which in turn can worsen respiratory conditions such as asthma and allergies. The warming climate is also creating a more hospitable environment for disease-carrying insects such as mosquitoes and ticks.

Much of New York's coastline including Long Island, New York City, and the Hudson River estuary is less than 10 feet above sea level and vulnerable to coastal flooding from coastal storm surges, as experienced during Hurricane Sandy. Hurricane Irene and Tropical Storm Lee revealed that inland flood risks associated with extreme rainfall can be significant in high-elevation regions away from the coast, such as the Catskills. Heavy rains from these storms were part of a broader wet-weather pattern – rainfall totals for August and September exceeded 25 inches across much of the Northeast – that left the Catskills and Hudson Valley region predisposed to extreme flooding.[5]

Regional weather data show steady and rapid changes in our climate that reflect global trends. It is vital for local decision-makers to understand these trends and the related climate hazards facing the region and to plan for future conditions. Many of the natural resources described throughout this inventory contribute to the community's safety and ability to adapt to the impacts of climate change. Natural areas like forests and wetlands furthermore help to sequester and store carbon, offsetting some of the impacts of local greenhouse gas emissions. This section presents general climate information prepared for Hudson Valley communities by the DEC Hudson River Estuary Program.[6]

Climate Projections

Responding to Climate Change in New York State (the ClimAID Report), written in 2011 and updated in 2014, is the current authoritative source for climate projections for New York State.[7] ClimAID translated Intergovernmental Panel on Climate Change (IPCC) scenarios into more robust regional-scale predictions incorporating local data inputs and expert knowledge. The Town of Woodstock is located within the ClimAID climate region 2. ***Note that models are inherently uncertain and simply present a range of possible scenarios to assist people and communities plan for the future***. Future climate changes in the Town of Woodstock could exceed or fall short of these projections.

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

[6] Zemaitis, L. *Working Toward Climate Resilience: General Climate Information Prepared for Hudson Valley Communities*. NYS DEC Hudson River Estuary Program, 2018.

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

Looking towards the future there are three prominent climate trends that will affect the Town of Woodstock and the region: increasing temperatures, shifting precipitation patterns, and sea level rise.

Temperature

New York has experienced particularly rapid changes to the regional climate in the last century and this trend is projected to continue through the 21st century. Global average temperature has been rising in unison with increasing input of insulating greenhouse gases, driving changes to regional and local climate. Warming atmospheric temperature alters the water cycle, leading to more extreme precipitation, short-term drought and severe storms. Since 1970 the Town of Woodstock has seen a 2°F increase in average annual temperature and a 5°F winter temperature increase. These increases are above both the national and global increase in annual temperature during the same period. Current projections see an additional increase of about 4-6°F in the coming decades and up to 11°F by 2100.

AIR TEMPERATURE PROJECTIONS FOR REGION 2

	Baseline 1971-2000	2020s	2050s	2080s	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

Increasing annual temperatures will lead to more frequent, intense, and long-lasting heat waves during the summer, posing a serious threat to human health and increased electricity demand from air conditioning. By mid-century, The Town of Woodstock could annually experience five to twelve days above 95 degrees, and five to six heat waves that last one to two days longer than average. Increasing temperature not only affects human health and ecosystems but can impact the electrical needs of a community putting strain on both budgets and the grid, while creating more challenges in agriculture and other industries.

Warming temperatures are already impacting species and ecosystems, whose preferred climate conditions may no longer exist locally within a few decades. Modeling for climate resilient lands that are likely to continue to support native species, ecosystems, and biodiversity is presented in the Climate Resilience section of the report under Habitats and Wildlife.

HEAT WAVE PROJECTIONS FOR REGION 2

	Baseline 1971-2000	2020s	2050s	2080s	2100
# Days per year above 90°F	12	19 - 25	31 - 47	38 - 77	*
# Days per year above 95°F	2	2 - 5	5 - 12	7 - 28	*
# Heat waves per year	2	3	4 - 6	5 - 9	*
Average # days of each heat wave	4	5	5 - 6	5 - 7	*
# Days per year ≤ 32°F	138	108 - 116	86 - 100	65 - 89	*

*Projections not available at this time

Precipitation

Precipitation has become more variable and extreme, whereas total rainfall has changed only marginally. The amount of rain falling in heavy downpour events increased 71% from 1958 to 2012 in the Northeast.[8] Projections indicate total annual precipitation could increase as much as 11% by mid-century and 18% by 2100. Overall, New York State models project more dry periods intermixed with heavy rain and decreased snow cover in winter. However, precipitation is considered more uncertain since it is difficult to model. In addition to elevating flood risk, infrastructure such as roads and the town's wastewater system can become strained during heavy rains.

PRECIPITATION PROJECTIONS FOR REGION 2

	Baseline 1971-2000	2020s	2050s	2080s	2100
Total annual precipitation	48"	48.5" - 52"	49.5" - 53.5"	51" - 54.5"	48.5" - 56.5"
% Increase in annual precipitation	-	1 - 8%	3 - 11%	6 - 14%	1 - 18%
# Days with precipitation > 1"	12	12 - 13	13 - 14	13 - 15	*
# Days with precipitation > 2"	2	2	2 - 3	2 - 3	*

*Projections not available at this time

Sea Level Rise

Global sea level is rising due to various factors, including thermal expansion from warmer water temperatures and melting of land-based ice. The Hudson River is connected to and influenced by the sea; therefore, it experiences tides and is rising with global sea level. Since 1900, sea level in New York Harbor has risen 13 inches. More concerning, the rate at which it is rising is increasing (from 2000 to 2014 the average rate was 6.8 millimeters per year compared to 4.6 millimeters per year from 1990 to 2014). Projections for additional sea level rise along the Hudson River range from one to 9 inches by year 2020 and five to 27 inches by mid-century. It is possible that New York City and nearby Kingston, NY could experience as much as 71 inches of sea-level rise by the end of the 21st century if rapid ice melt from the Greenland ice sheet occurs.

DEC officially adopted sea-level rise projections in 2017 under 6 NYCRR Part 490. "Low" signifies the lower end of model forecasts, while "high" signifies the upper end over the range of different model formulations and initialization scenarios.

New York State Sea Level Rise Projections for the Mid-Hudson region (Kingston to Troy)

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

[8] Melillo, J. M., T.C. Richmond, and G. W. Yohe. *Climate Change Impacts in the United States: The Third National Climate Assessment*. 841 pp. doi:10.7930/J0Z31WJ2, 2014. https://nca2014.globalchange.gov/

Although Woodstock will not be directly influenced by sea level rise, its impacts on New York City and other coastal urban centers like Kingston will likely have many indirect impacts. More frequent flooding after major storms may drive more residents of coastal areas to relocate to inland communities such as Woodstock. There are many additional potential ramifications of sea level rise to the regional infrastructure and economy that will likely impact Woodstock, as well.

High water in the Sawkill Creek in spring.

Climate Smart Community Certification

The Climate Smart Communities program is a New York State program that helps local governments take action to reduce greenhouse gas emissions and adapt to a changing climate.[9] The Woodstock Climate Smart Task Force is leading local efforts to engage and educate residents and to reduce carbon emissions and be more prepared for climate change. The Town achieved Climate Smart Bronze certification in 2020. Some of the actions completed to date include:

- Government operations greenhouse gas inventory
- Comprehensive Plan update with sustainability elements
- LED streetlight replacement
- Shift to clean, renewable energy at town buildings
- Geothermal installation at the highway garage and town hall
- PV solar array installation at the highway garage and town hall
- EV charging station installation

[9] For more information, visit https://climatesmart.ny.gov

Section 3: Physical Setting

Topography (Map 3)

The variation in the Town's topography reflects differences in the underlying geology and has been an important factor influencing the location of development. For visual display purposes, the Topography Map shows 50-ft contours derived from 2-ft contours developed by Ulster County.[10] The original contours were produced using 1-meter resolution elevation data from the US Geological Survey (USGS).[11] The detailed 2-ft contours may be downloaded for site-level analysis from the County website but require special software for viewing.

The highest elevation in Woodstock is located on the southern shoulder of Olderbark Mountain at just over 3,300 ft. Other notable elevation points include Overlook Mountain at 3,136 ft.

The Woodstock 2018 Comprehensive Plan describes the Town's topography:[12]

> The natural terrain of the land has restricted and shaped the settlement and development of Woodstock since its earliest days. Even today, with powerful and efficient transportation and construction equipment, building activity must respect the hills and valleys if it is to be economical and in harmony with nature.
>
> The town is located directly on the abrupt eastern escarpment of the Catskill Mountains. To the east extends the broad Hudson Valley starting with rolling foothills and gradually flattening out near the river itself.
>
> The Zena section of Woodstock is within the foothill band and is characterized by relatively mild topography of low hills with only scattered areas of steep slopes. The general elevation here ranges

View from Overlook Mountain fire tower. Ingrid Haeckel

[10] Ulster County 2-ft Contours are available at https://ulstercountyny.gov/ucis/gis-data. Due to the size of the dataset, it has been broken into small shapefile tiles available for download at http://ulstercountyny.gov/maps/contours/. These files can be used in any GIS application and imported into AutoCAD.

[11] USGS 1-meter DEMs are available from the NY GIS Clearinghouse at https://gis.ny.gov/elevation/metadata/Ulster-Dutchess-Orange-Counties-NY-DEM-UTM.xml

[12] Town of Woodstock, New York Comprehensive Plan 2018, pg. 10. https://townwoodstock.digitaltowpath.org:10111/content/Generic/View/46

from 400 to 500 feet above mean sea level. The lowest point of the town is also found here—250 feet above sea level—in the Sawkill bed.

In the western portion of the town there are [narrower] valleys…bordered by steep escarps. These principal or collector valleys join the broader Sawkill Valley at Bearsville. The first crosses the Sawkill/Beaver Kill watershed divide with the Beaver Kill flowing generally west to the Esopus Creek water gap at Mount Tremper. This is generally the path of Route 212 connecting Bearsville with the upper valley hamlets of Shady, Lake Hill, and Willow. Principal peaks to the north include Olderbark Mountain (3,350 feet), and Carl Mountain (2,840 feet). To the south are Mount Tobias (2,550 feet), Beetree Hill (1,820 feet), and Roundtop Mountain (1,980 feet).

To the other side of these elevations is the Wittenberg Valley comprising the southwest area of the town. This valley extends along the Wittenberg-Mount Tremper Road west of Bearsville across the Sawkill/Little Beaver Kill watershed divide, following the Little Beaver Kill on to its confluence with Esopus Creek. The hamlet of Wittenberg is the only settlement in this valley, with Yankeetown Pond, the Riverby development and Wilson State Park being other significant features. To the south, Ticetonyk Mountain (2,502 feet) and Tonshi Mountain (2,020 feet) define the Wittenberg Valley.

Farther east extends the broad and flat Sawkill valley (about 3 miles long and 1 mile wide) at a general elevation of 500 to 700 feet. The main development of the town—the hamlets of Woodstock and Bearsville—is located within this area. The valley is open to the east but is bounded on the other three sides by high hills: Ohayo Mountain (1,380 feet), Beetree Hill (1,820 feet), Mount Guardian (2,100 feet), and Overlook Mountain (3,140 feet) with a truly magnificent view.

Smaller valleys abound throughout the northern and western sections of Woodstock. Each is typically narrow, steep sided and drained by a mountain brook. Several of these are found in the northern section of the town: Hoyt Hollow, Lewis Hollow, Silver Hollow, Mink Hollow, the upper reaches of Sawkill, et al.

Scenic Overlay District

The Town of Woodstock Scenic Overlay (S-O) District (Chapter 260, §260-6) provides for special permit review of all development at an elevation greater than 1,200 feet above sea level, as delineated on USGS maps, to mitigate the visual impact of such development to the extent practicable. USGS topographic maps are available for viewing using the USGS National Map Viewer (https://viewer.nationalmap.gov/advanced-viewer/) or using TopoView (https://ngmdb.usgs.gov/topoview/viewer).

The Topography Map shows a more detailed delineation of the 1,200-ft elevation zone based on the County's 2-ft contour data. Elevations above 365.76 meters (1,200 ft) were selected and geo-processed using the ArcMap "Raster to Polygon" tool to create a polygon coverage.

Steep Slopes (Map 4)

Slope is defined as the vertical change in elevation over a given horizontal distance. For example, a 10% slope is one that rises 10 feet over a horizontal distance of 100 feet. The Steep Slope map is derived from 1-meter resolution digital elevation models from the U.S. Geological Survey and should be considered an approximate depiction of steeply sloped areas in the Town of Woodstock.[13]

Steep slopes pose significant limitations to development and are among the most sensitive environmental features in the landscape.

The Steep Slopes Map includes the following slope classes, based on the national Soil Survey Manual:[14]

<10% (nearly level to gently sloping)
10 – 15% (strongly sloping)
15 – 20% (steep)
20 – 25% (steep)
Over 25 % (very steep)

The Woodstock 2018 Comprehensive Plan describes steep slopes in the Town:[15]

> In general, the steepest slopes are found in the mountainous areas of Mount Tobias, Overlook Mountain, Tremper Mountain and the north face of Ticetonyk Mountain. Many of the slopes in these areas are in excess of 15%, making development very costly and difficult to contemplate. Some areas of steep slopes have been a constraint to development and have remained classified as vacant. In fact, when a steep slopes map is overlaid upon a land use map, approximately 3,000 acres of undeveloped land has slopes in excess of 15%. In addition, when these maps are compared it becomes apparent that slope has helped divert human settlement into the flatter areas of the community. As can be expected from the above description, large areas of the Town consist of steep mountainsides ill-suited for farming or building. Brown and Anthony, for the purposes of their Growth Plan in 1962, classified the land within Woodstock according to the steepness of slopes.
>
> The areas from 0% to 10% are usable for most any purpose without difficulties as far as the topography is concerned. Slopes of 10% to 15% require considerable site improvements—grading of lots, road approaches, etc.—that make large-scale developments of limited lot size in many cases uneconomical. Areas of slopes above 15% can, of course, also be built upon, but at greater expense, greater risk of storm water runoff problems, and compromise to the aesthetics of the area since such development may be prominently exposed. Large lots and expensive houses are prerequisites in order to make building feasible in these areas, and the Town's decision in the early 2000s to regulate

[13] USGS 1-meter DEMs are available from the NY GIS Clearinghouse at https://gis.ny.gov/elevation/metadata/Ulster-Dutchess-Orange-Counties-NY-DEM-UTM.xml

[14] Ditzler, C., K. Scheffe, and H.C. Monger (eds.). *Soil Survey Manual. USDA Handbook 18.* Government Printing Office, 2017, Washington, D.C.

[15] Town of Woodstock, New York Comprehensive Plan 2018, pg. 11.

development on steep slopes recognizes the potential environmental problems, including proper septic installations, aesthetic considerations and erosion, inherent in such development.

The Comprehensive Plan notes that only a relatively limited portion of the Town can be considered for further intensive development, as just 30% of the land occurs on level or gently sloping land.

Several significant habitats are associated with steep slopes, as well. Thinly soiled steep slopes may support rocky crests, ledges and talus, which are used for denning, shelter, foraging, and basking by various wildlife species, including NY-threatened timber rattlesnake.[16] Extensive ledges on the Catskill escarpment are often at least 20 feet tall and alternate with steep forested slopes, forming a 'stair-step' pattern. These habitats are shown on the Habitat Map and described in further detail in the accompanying report.

§260-58 of Town Code prohibits development on slopes greater than 50% or on slopes of 33% or greater with "severe" soil limitations, with some exceptions.

Catskill Escarpment. Ingrid Haeckel

[16] Haeckel, I.B., O. Vazquez Dominguez, and G. Stevens. *Significant Habitats in the Town of Woodstock, Ulster County, New York: Report to the Town of Woodstock, the New York State Department of Environmental Conservation, the Ashokan Watershed Stream Management Program, and the Catskill Watershed Corporation*, 2012. https://townwoodstock.digitaltowpath.org:10111/content/Generic/View/24

Bedrock Geology (Map 5)

Bedrock is the solid rock that lies beneath the soil and subsoil.[17] The geology of the Catskills has had a profound influence on the topography, soils, water resources, ecological communities, and economy of Woodstock and the surrounding region. The Bedrock Geology Map (Map 5) shows generalized mapping at a 1:250,000 scale published by the New York State Museum.[18] Table 1 describes geology units shown on the map.

Geology influences many environmental factors, including topography, groundwater and mineral resources, and the establishment of natural communities.

Table 1. Bedrock Geology in the Town of Woodstock

Code	Formation	Bedrock Unit	Primary Materials	Geologic Age
Dhmo	Moscow Formation	Hamilton Group	Sandstones and shales	Middle Devonian
Dhpl	Plattekill Formation	Hamilton Group	Sandstones and shales	Middle Devonian
Dww	Upper Walton Formation	lower West Falls Group	Shales and sandstones	Upper Devonian
Dsw	Lower Walton Formation	Sonyea Group	shale, sandstone, conglomerate	early Upper Devonian
Dgo	Oneonta Formation	Genesee Group and Tully Limes	shale, sandstone, conglomerate	early Upper Devonian

Bob Titus Geology Walk. Maxanne Resnick

Woodstock is underlain primarily by sandstones and shales, with more erosion-resistant conglomerate forming the Town's higher peaks and ridges (Overlook Mountain, Ticetonyk, Mount Tobias, Carl Mountain, Olderbark Mountain, and Twin Mountain). Sediments in the bedrock can be traced to origins in the Devonian period, about 400-350 million years ago, when a great delta formed from numerous streams draining the now-vanished Acadian Mountains to the east of the present-day Hudson River. Over millions of years, eroded sediments from the Acadian Mountains were deposited into a shallow sea, accumulating in a giant sedimentary wedge as thick as 7,000 feet. Eventually, the

[17] Rafferty, J. "Bedrock." Encyclopedia Britannica, 2019.

[18] Fisher, D. W., Y. W. Isachsen, and V. L. Rickard. *Geologic Map of New York: Hudson-Mohawk Sheet*. New York State Museum and Science Service, Map and Chart Series No. 15, 1970. http://www.nysm.nysed.gov/research-collections/geology/gis.

delta formation was buried and transformed into bedrock.

During the Appalachian Revolution in the Permian period around 280 to 230 million years ago, the delta was thrust upward, folded, and tilted, forming part of the present-day Appalachian mountain system.[19] Over time, flowing water and other erosional forces have dissected the present-day Catskills region, carving river valleys through fine-grained shales and leaving remnants of coarser sandstone and conglomerate on the summits.

zAround 2.6 million years ago, the Quaternary Period ushered in a series of ice ages, with giant ice sheets advancing and retreating over the Northern Hemisphere. The most recent advance was the Wisconsin glaciation, which reached its greatest extent around 21,750 years ago and covered the region with as much as 1-2 miles of ice. These glacial periods further rounded the summits and ridges of the Catskills and scoured the valleys, and the retreat of the Wisconsin glacier left behind glacial deposits described in the following Surficial Geology section of this report.

Bluestone Quarry. Ingrid Haeckel

Thinly laminated sandstone originating from the Catskill Delta, known as "bluestone," is an even-textured sandstone that is an attractive and durable paving stone. Bluestone was first discovered in Ulster County and was quarried heavily during the 1800s.[20] Workers cut slabs of rock, leaving behind large piles of discarded stone. Most such quarries were abandoned by the late 19th century, and many have since reverted to forest. Where exposed, such abandoned bluestone quarries are mapped as "waste ground" in the town Habitat Map but are noted to provide habitat similar in value to crest, ledge, and talus. The largest concentration of abandoned bluestone quarries in Woodstock is found in the Catskill foothills around Zena and along the escarpment.

Bedrock exposures are common along the Catskill escarpment and on many steep slopes in the Town. Most bedrock in Woodstock is acidic in reaction, but some sandstones and shales may be mildly calcareous (calcium-rich), a condition that often supports rare plants and uncommon habitats. Occurrences of calcareous ledges were identified on the basis of plant communities in several areas of the Town by Hudsonia biologists, particularly in the Catskill foothills around Zena.

[19] Bierhorst, J. *The Ashokan Catskills: A Natural History.* Purple Mountain Press, Fleischmanns, 1995, pg. 16

[20] Evers, A. *The Catskills: From Wilderness to Woodstock*. Doubleday, Garden City, NY, 1972.

Surficial Geology and Glacial Deposits (Map 6)

Surficial geology refers to unconsolidated sediments lying above the bedrock. The weathering of both bedrock and surficial deposits along with organic matter, water, and air is responsible for the slow process of soil formation and the properties of these "parent materials" strongly influence resulting soil chemistry, nutrients, and texture. The surficial geology of Woodstock largely reflects the retreat of the Wisconsin glacier, beginning around 21,750 years ago, depositing boulders, sand, and gravel in its path. The Catskills were ice-free by approximately 13,000 to 14,000 years ago.[21]

Surficial deposits are unconsolidated sediments primarily resulting from deposits left behind as glaciers retreated at the end of the last ice age. They are important sources of sand, gravel, and crushed stone.

The Surficial Geology Map (Map 6) displays information from statewide maps produced by the New York State Geological Survey.[22] This map, like the one for bedrock geology, was developed at a scale of 1:250,000 and is best used as a general reference. There are nine types of surficial materials mapped in Woodstock:

- Bedrock (exposed bedrock, typically within 1 meter of the soil surface)
- Till (dense, unsorted clay, silt, sand, gravel, boulders)
- Till Moraine (an accumulation of till deposited by direct glacial action)
- Outwash Sand and Gravel (sand and gravel deposits from glacial meltwater streams)
- Kame Deposit (mound-like hill of poorly sorted drift, mostly sand and gravel, deposited at or near the terminus of a glacier)
- Fluvial Sand and/or Gravel (occasional laterally continuous lenses of silt, deposition farther from glacier than outwash)
- Alluvial Fan (poorly stratified silt, sand, and boulders, fan shaped accumulations, at bottoms of steep slopes)
- Lacustrine Sand (fine to medium sand often underlain by silt or clay deposits)
- Colluvium (sediments transported downslope by gravity/mass wasting)

The distribution of glacial deposits—or absence thereof—in Woodstock follows the path of the retreating glaciers. Exposed bedrock predominates at higher elevations on the Town's mountain slopes and summits, while glacial till was deposited along lower elevation slopes. Outwash sand and gravel as well as kame deposits are found in the valleys along the major streams. Fluvial sand and/or gravel underlies the Sawkill valley from Bearsville to the hamlet. An alluvial fan is present where the Beaver Kill enters the valley floor in Lake Hill. An area of lacustrine sand occurs in the lower reaches of the Sawkill valley in Zena. Colluvium deposits also occur in the Catskill foothills near Zena.

[21] Kudish, M. *The Catskill Forest: A History.* Purple Mountain Press, Fleischmanns, 2000.

[22] Caldwell, D. H., and R. J. Dineen. *Surficial Geologic Map of New York, Hudson-Mohawk Sheet.* New York State Geological Survey, 1987.

Note that fluvial or outwash sand and gravel and kame deposits hold Woodstock's major aquifers, contributing to the Town's public water supply (see the Aquifer Map and the Drinking Water Resources Map). These deposits may also be an important source of sand, gravel, and crushed stone for building and road construction.

Beaver Kill alluvial fan at State Route 212 (see MU6 description in Stream Management section). Ingrid Haeckel

Soils (Map 7)

Soils determine the suitability of an area for particular land uses and are the foundation for the establishment of natural communities of plants and animals.

Soils are the foundation for the establishment of natural communities of plants and animals as well as for critical ecological processes from decomposition and nutrient cycling to the water cycle. Soil characteristics including reaction (acidity or alkalinity), drainage, soil texture, depth to bedrock, and slope inform the natural habitats that become established in a particular area.[23] Soils also play a fundamental role in determining suitability for land uses. Soil characteristics determine potential for agricultural production as well as vulnerability to flooding, soil erosion or instability, and efficiency at filtering pollutants and wastes. Consideration of soil properties is important for planning and designing drainage systems; siting of structures; evaluating the potential for septic systems; assessing requirements for constructing foundations, basements, and roads; and determining the feasibility of excavation; among other uses.[24]

The Soil Survey of Ulster County, New York[25] includes detailed soil maps for the entire county along with descriptions of soil types and tables of chemical, hydrologic, and structural characteristics of the soils for various human uses. It is important to note that county soil maps are only approximate; any soil unit may contain "inclusions" of up to 2 acres of soil types different from the mapped unit. The soil data may also be viewed online using the USDA Natural Resources Conservation Service (NRCS) Web Soil Survey.[26] Table 2 lists soil types found in Woodstock along with selected soil characteristics based on tabular information provided in the county soil survey and through the NRCS Soil Data Viewer.[27]

The Soils Map (Map 7) shows the soil units from the county *Soil Survey* symbolized by erosion hazard rating, calculated using the NRCS Soil Data Viewer. Refer to Table 2 for additional characteristics associated with each soil unit. Soil erosion hazard rating is defined as the hazard of soil loss from off-road and off-trail areas, where 50 to 75 percent of the surface has been exposed by logging, grazing, mining, or other kinds of disturbance. The erosion hazard rating can inform planning and sediment and erosion control measures in areas where clearing and grading is proposed for land development. A rating of "slight" indicates that erosion is unlikely under ordinary climatic conditions; "moderate" indicates that some erosion is likely and that erosion-control measures may be needed; "severe" indicates that erosion is very likely and that erosion-control measures, including revegetation of bare areas, are advised; and

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[23] Heady, L., and G. Stevens. *Biodiversity Assessment Guidebook*, Hudsonia Ltd, 2018.

[24] Haeckel, I., and L. Heady. *Creating a Natural Resources Inventory: A Guide for Communities in the Hudson River Estuary Watershed.* New York State Department of Environmental Conservation and Cornell University, 2014.

[25] Tornes, L.A. *Soil Survey of Ulster County, New York*. USDA Soil Conservation Service in cooperation with Cornell University Agricultural Experiment Station, Ithaca, 1979. https://www.blogs.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/new_york/ulsterNY1979/ulster.pdf

[26] NRCS Web Soil Survey is available online at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

[27] NRCS Soil Data Viewer documentation is available online at https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/soils/survey/geo/?cid=nrcs142p2_053620

"very severe" indicates that significant erosion is expected, loss of soil productivity and off-site damage are likely, and erosion control measures are costly and generally impractical. Soil erosion hazard ratings are closely tied to slope values, with the greatest hazards found in mountainous terrain.

Soil drainage class can indicate the possible presence of wetlands and is a particularly important factor to consider in the evaluation of proposed development. Somewhat poorly drained soils are good indicators of possible wetland areas and poorly drained and very poorly drained soils are indicators of probable wetland areas.[28] They are also shown on Map 15 (Wetlands). In addition to drainage classification, hydric class is often used to identify wetland areas.

Depth to bedrock influences suitability for septic and other wastewater treatment systems, as well as the siting of buildings and roads. Shallow soils (<20 inches to bedrock) are often associated with steep slopes, increasing susceptibility to erosion. Shallow soils are also less capable of filtering pollutants draining to surface and groundwater supplies.

Farmland soil classifications are defined by NRCS and are described and discussed in relation to Map 22, Agriculture and Forestry Resources.

Soil reaction refers to the acidity or alkalinity of the soil, expressed in pH values.[29] Soil chemistry exerts a strong influence on plant and animal communities, and can be a useful predictor for certain habitats, from acidic bogs to calcareous wet meadows. Calcareous or alkaline soils often support disproportionately high numbers of rare plants, animals, and natural communities.

Table 2. Soils in the Town of Woodstock

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
AA	Alluvial land	Poorly drained	partially hydric	>60	Slight	Not prime farmland	6.5	slightly acidic
AcB	Arnot channery silt loam, 0 to 8 percent slopes	Somewhat excessively drained	nonhydric	<20	Slight	Farmland of statewide importance	5.2	strongly acidic
ARD	Arnot-Lordstown-Rock outcrop complex, moderately steep	Well drained	nonhydric	<20	Moderate	Not prime farmland	4.8	very strongly acidic

[28] Kiviat, E. and G. Stevens. *Biodiversity Assessment Manual for the Hudson River Estuary Corridor.* New York State Department of Environmental Conservation, 2001.

[29] Heady, L., and G. Stevens. *Biodiversity Assessment Guidebook*, Hudsonia Ltd, 2018.

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
ARF	Arnot-Oquaga-Rock outcrop complex, very steep	Well drained	nonhydric	<20	Very severe	Not prime farmland	4.8	very strongly acidic
At	Atherton silt loam	Poorly drained	predominantly hydric	>60	Slight	Farmland of statewide importance	6.6	neutral
Ba	Barbour loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	5.4	strongly acidic
Be	Basher silt loam	Moderately well drained	predominantly nonhydric	>60	Slight	All areas are prime farmland	5.2	strongly acidic
BP	Borrow pit	Moderately well drained	predominantly nonhydric	>60	Not rated	Not prime farmland	0.0	
Cc	Canandaigua silt loam	Very poorly drained	predominantly hydric	>60	Slight	Farmland of statewide importance	7.3	neutral
Cd	Canandaigua silt loam, till substratum	Very poorly drained	predominantly hydric	>60	Slight	Farmland of statewide importance	7.1	neutral
CgA, CgB	Castile gravelly silt loam	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	5.9	moderately acidic
CF	Cut and fill land	Somewhat excessively drained	predominantly nonhydric	>60	Slight	Not prime farmland	6.5	slightly acidic
Du	Dump		nonhydric	>60	Not rated	Not prime farmland	0.0	
FW	Fresh water marsh	Very poorly drained	hydric	>60	Slight	Not prime farmland	0.0	
GP	Gravel pit	Somewhat excessively drained	predominantly nonhydric	>60	Not rated	Not prime farmland	0.0	
Ha	Hamlin silt loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	6.4	slightly acidic
He	Haven loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	5.3	strongly acidic
HfA	Hoosic cobbly loam, 0 to 3 percent slopes	Somewhat excessively drained	nonhydric	>60	Slight	Farmland of statewide importance	5.2	strongly acidic

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
HgD	Hoosic gravelly loam, 15 to 25 percent slopes	Somewhat excessively drained	nonhydric	>60	Moderate	Not prime farmland	5.2	strongly acidic
HSF	Hoosic soils, very steep	Somewhat excessively drained	nonhydric	>60	Severe	Not prime farmland	5.2	strongly acidic
HwD	Hudson and Schoharie soils, 15 to 25 percent slopes	Moderately well drained	nonhydric	>60	Moderate	Not prime farmland	6.9	neutral
HXE	Hudson and Schoharie soils, steep	Moderately well drained	nonhydric	>60	Severe	Not prime farmland	6.9	neutral
LCD	Lackawanna and Swartswood soils, moderately steep, very bouldery	Well drained	nonhydric	>60	Moderate	Not prime farmland	5.1	strongly acidic
LEE	Lackawanna and Swartswood soils, steep, extremely bouldery	Well drained	nonhydric	>60	Moderate	Not prime farmland	5.1	strongly acidic
LCF	Lackawanna and Swartswood soils, very steep, very bouldery	Well drained	nonhydric	>60	Severe	Not prime farmland	5.1	strongly acidic
LaB	Lackawanna flaggy silt loam, 3 to 8 percent slopes	Well drained	nonhydric	>60	Slight	All areas are prime farmland	5.1	strongly acidic
LaC	Lackawanna flaggy silt loam, 8 to 15 percent slopes	Well drained	nonhydric	>60	Slight	Farmland of statewide importance	5.1	strongly acidic
LnB	Lordstown channery silt loam, 3 to 8 percent slopes	Well drained	nonhydric	20-40	Slight	All areas are prime farmland	5.2	strongly acidic
LOC	Lordstown-Arnot-Rock outcrop complex, sloping	Well drained	nonhydric	20-40	Slight	Not prime farmland	5.3	strongly acidic
ML	Made land	Somewhat excessively drained	predominantly nonhydric	>60	Slight	Not prime farmland	6.5	slightly acidic
Mn	Menlo silt loam	Very poorly drained	hydric	>60	Slight	Not prime farmland	5.7	moderately acidic

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
MO	Menlo very bouldery soils	Very poorly drained	hydric	>60	Slight	Not prime farmland	5.7	moderately acidic
Mr	Middlebury silt loam	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	6.4	slightly acidic
MTB	Morris-Tuller complex, gently sloping, very bouldery	Poorly drained	predominantly nonhydric	>60	Slight	Not prime farmland	5.4	strongly acidic
OdA, OdB	Odessa silt loam	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Prime farmland if drained	7.7	mildly alkaline
OlC	Oquaga and Lordstown channery silt loams, 8 to 15 percent slopes	Well drained	nonhydric	20-40	Slight	Farmland of statewide importance	5.3	strongly acidic
OgB	Oquaga channery silt loam, 3 to 8 percent slopes	Well drained	nonhydric	20-40	Slight	Farmland of statewide importance	5.1	strongly acidic
ORC, ORD	Oquaga-Arnot-Rock outcrop complex	Well drained	nonhydric	20-40	Moderate	Not prime farmland	4.8	very strongly acidic
Pa	Palms muck	Very poorly drained	hydric	>60	Slight	Not prime farmland	7.3	neutral
Pb	Palms muck, bedrock variant	Very poorly drained	hydric	20-40	Slight	Not prime farmland	7.3	neutral
Pt	Pompton fine sandy loam	Somewhat poorly drained	nonhydric	>60	Slight	All areas are prime farmland	5.0	very strongly acidic
QU	Quarry		predominantly nonhydric	20-40	Not rated	Not prime farmland	0.0	
Ra	Raynham silt loam	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Prime farmland if drained	6.4	slightly acidic
Re	Red Hook gravelly silt loam	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Prime farmland if drained	6.5	slightly acidic
RXE, RXF	Rock outcrop-Arnot complex, >15 percent slopes	Somewhat excessively drained	nonhydric	>60	Not rated	Not prime farmland	0.0	

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
RXC	Rock outcrop-Arnot complex, 3 to 15 percent slopes	Somewhat excessively drained	nonhydric	>60	Slight	Not prime farmland	0.0	
SaB	Schoharie silt loam, 3 to 8 percent slopes	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	7.8	mildly alkaline
SaC	Schoharie silt loam, 8 to 15 percent slopes	Moderately well drained	nonhydric	>60	Moderate	Farmland of statewide importance	7.8	mildly alkaline
Sc	Scio silt loam	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	5.5	strongly acidic
SdB	Scriba and Morris soils, 0 to 8 percent slopes	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Farmland of statewide importance	6.2	slightly acidic
SGB	Scriba and Morris soils, gently sloping, extremely bouldery	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Not prime farmland	6.2	slightly acidic
SEB	Scriba and Morris soils, gently sloping, very bouldery	Somewhat poorly drained	predominantly nonhydric	>60	Slight	Not prime farmland	6.2	slightly acidic
STD	Stockbridge-Farmington-Rock outcrop complex, hilly	Well drained	nonhydric	<20	Moderate	Not prime farmland	6.7	neutral
Su	Suncook loamy fine sand	Excessively drained	nonhydric	>60	Slight	Farmland of statewide importance	5.5	strongly acidic
Tg	Tioga fine sandy loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	6.4	slightly acidic
TkA, TkB	Tunkhannock gravelly loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	4.8	very strongly acidic
TuD	Tunkhannock gravelly loam, clayey substratum, 15 to 25 percent slopes	Well drained	nonhydric	>60	Moderate	Not prime farmland	6.5	slightly acidic

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
TuB	Tunkhannock gravelly loam, clayey substratum, 3 to 8 percent slopes	Well drained	nonhydric	>60	Slight	All areas are prime farmland	6.5	slightly acidic
TuC	Tunkhannock gravelly loam, clayey substratum, 8 to 15 percent slopes	Well drained	nonhydric	>60	Slight	Farmland of statewide importance	6.5	slightly acidic
TkC	Tunkhannock gravelly loam, rolling	Well drained	nonhydric	>60	Slight	Farmland of statewide importance	4.8	very strongly acidic
Un	Unadilla silt loam	Well drained	nonhydric	>60	Slight	All areas are prime farmland	5.7	moderately acidic
VAB	Valois very bouldery soils, gently sloping	Well drained	nonhydric	>60	Slight	Not prime farmland	5.2	strongly acidic
VAD	Valois very bouldery soils, moderately steep	Well drained	nonhydric	>60	Moderate	Not prime farmland	5.2	strongly acidic
W	Water		nonhydric	>60	Not rated	Not prime farmland	0.0	
Wc	Wayland mucky silt loam	Very poorly drained	hydric	>60	Slight	Not prime farmland	6.9	neutral
Wb	Wayland soils complex, non-calcareous substratum, 0 to 3 percent slopes, frequently flooded	Very poorly drained	predominantly hydric	>60	Slight	Not prime farmland	5.7	moderately acidic
WOB	Wellsboro and Wurtsboro soils, gently sloping, extremely bouldery	Moderately well drained	nonhydric	>60	Slight	Not prime farmland	5.3	strongly acidic
WLB	Wellsboro and Wurtsboro soils, gently sloping, very bouldery	Moderately well drained	nonhydric	>60	Slight	Not prime farmland	5.3	strongly acidic
WeB, WeC	Wellsboro flaggy silt loam	Moderately well drained	nonhydric	>60	Slight	Farmland of statewide importance	5.3	strongly acidic

Map Unit Code*	Soil Unit Name	Drainage Class	Hydric Class	Depth to Bedrock (inches)	Erosion Hazard Rating	Farmland Class	pH	Reaction
WsA	Williamson silt loam, 0 to 3 percent slopes	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	5.5	strongly acidic
WsB	Williamson silt loam, 3 to 8 percent slopes	Moderately well drained	nonhydric	>60	Slight	All areas are prime farmland	5.5	strongly acidic

* The final letter in each soil unit code (i.e., the "B" in "AcB") refers to slope. Slopes are given letter codes A-F, with "A" signifying the gentlest slopes and "F" the steepest. The absence of a final uppercase letter indicates more-or-less flat terrain.

A	0-3%	level to gently sloping
B	3-8%	gently sloping
C	3-15%	gently to strongly sloping
D	15-35%	strongly sloping to steep, or hilly
E	25-45%	moderately steep to very steep

Zena Cornfield. Maxanne Resnick

Section 4: Water Resources

Aquifers (Map 8)

Major Aquifers are unconsolidated deposits of sand and gravel that are capable of storing large quantities of water.

Unconsolidated aquifers are deposits of sand and gravel that can store large quantities of water. These aquifers also provide important base flow to streams during dry periods of the year. The map displays unconsolidated aquifers that were mapped at a scale of 1:250,000 by the US Geological Survey in partnership with the NYS DEC. The mapping is based on the New York State Museum maps of surficial and bedrock geology shown in previous sections of this report. Confined aquifers (not shown) have layers of impermeable material above and below the aquifer and are under pressure so water will rise when punctured by a well.[30] Mapping of consolidated aquifers is not currently available. A summary of deposit type and yield for the mapped unconsolidated aquifers is shown in Table 3. Note that a more detailed delineation of the Woodstock drinking water aquifer was completed in the early 2000s by Steve Winkley of the New York Rural Water Association and is shown and described in the Drinking Water Resources section that follows.[31]

Table 3. Unconsolidated Aquifers in the Town of Woodstock

Location	Type	Yield
Sawkill Upper - Shady	Unconfined, Mid Yield	10-100 gal/min
Sawkill Upper - Terrace - Mt Guardian	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Sawkill Terrace - Glasco Tpk-Bearsville_Broadview Rd	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Sawkill - Mainstem - Comeau	Lacustrine or Eolian	Probably <10 gal/min
Sawkill - Rt 212 and Rt 375	Unconfined, Mid Yield	10-100 gal/min
Sawkill - Music Hill Rd	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Sawkill - Zena Rd	Lacustrine or Eolian	Probably <10 gal/min
Sawkill Lower - Sawkill Rd	Unconfined, Mid Yield	10-100 gal/min

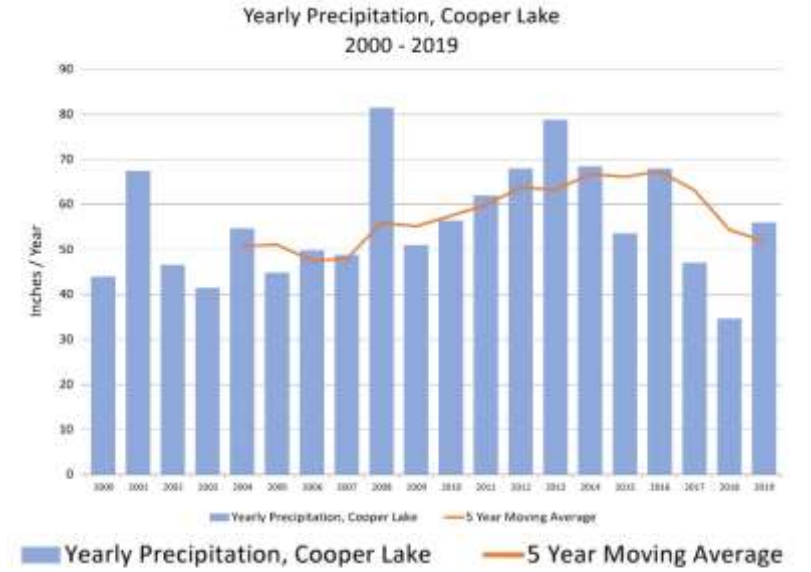
[30] "What is the difference between a confined and an unconfined aquifer?" United States Geological Survey, 2018. https://www.usgs.gov/faqs/what-difference-between-a-confined-and-unconfined-water-table-aquifer?qt-news_science_products=0#qt-news_science_products.

[31] Steven Winkley, "Summary of Findings for the Woodstock Aquifer and Proposed Water Supply Overlay District," New York Rural Water Association, Undated (est. 2002)

Location	Type	Yield
Sawkill Lower Tribs - Town of Ulster	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Sawkill/Plattekill - Bluestone Forest - Eastwoods Dr - Church Rd	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Plattekill - Purdy Hollow Rd	Unconfined, Mid Yield	10-100 gal/min
Beaver Kill - Silver Hollow - Willow	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Beaver Kill - Rt 212 and Willow Flats	Unconfined, Mid Yield	10-100 gal/min
Little Beaver Kill - Upper - Yankeetown Pond	Unconfined, Mid Yield	10-100 gal/min
Little Beaver Kill Terrace - Jonet Ln - Baker Rd	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown
Little Beaver Kill - Lower - Wittenberg Rd - Kenneth Wilson	Kame, Kame Terrace, Kame Moraine, Outwash or Alluvium	Unknown

Drinking Water Resources (Map 9)

Woodstock typically receives over 50 inches of precipitation in a year; the source of Woodstock's drinking water and water for the City of Kingston and for New York City. Rainfall and snowmelt recharge the Woodstock aquifers homeowners use for well water and that supply the wells of the Woodstock Water District.



Source: City of Kingston Water Department

Over 750 households and businesses depend on water provided by the Woodstock Water District. Water is sourced from two wellfields located near the Sawkill Creek in the Bearsville Flats that draw from the underlying aquifer. Rainfall and snowmelt recharge the aquifer. Groundwater is purified naturally as it filters through layers of soil, clay, rock and sand, a process known as percolation. As a result, groundwater requires less treatment than surface water. Woodstock's seven wells are drilled to a depth of 20 feet and yield approximately 300,000 gallons per day. The wells are plumbed through two pump houses and then into storage tanks with a total capacity of 1.3 million gallons. To comply with State regulations the Woodstock Water District annually issues a report describing the quality of the drinking water and to raise awareness of the need to protect drinking water sources.[32]

Protecting the Sawkill Watershed Recharge Area

The upper Sawkill watershed is the primary source of water that recharges the aquifers used by Woodstock's water wells. To preserve the integrity of Woodstock's watersheds and streams, the Town adopted a Wetland and Watercourse Law designed to protect unregulated areas. The Town regulations extend the stream bank buffer area from 30 to 100 feet depending on the upstream drainage area and the slope of the land. A permit is required for all activities listed in §260-34C of the Town code.

The Sawkill's headwaters originate at Echo Lake on the northern shoulder of Overlook Mountain at an elevation of 2,075 feet. The upper Sawkill is characterized by steep rocky headwaters between Echo Lake and Shady, gradually widening and softening in slope as it leaves the mountains and enters the broader valley and widening floodplain. The milder gradient as the Sawkill reaches the base of the mountains in Bearsville reduces the stream's sediment transport capability and is thus a natural deposition zone, that is, an area where sediment naturally accumulates. In aggregate, this is the area that recharges the Woodstock aquifer and is the source of water for the Woodstock Water District.

[32] Woodstock Water and Sewer Department, "Annual Drinking Water Quality Report," Available at https://townwoodstock.digitaltowpath.org:10111/content/Departments/View/3

Water quality is dependent not only on the amount of rain and snowmelt in the Sawkill watershed, but also on ground-source contamination. The Town engaged consultants and engineers to study the Town's water supply and to recommend actions that would ensure its integrity. The resulting reports and maps are filed in the Town offices and key information from them is presented here. The Drinking Water Resources Map provides a single reference showing the boundaries of the Woodstock Water District and identifies areas deemed important by the consultants for protecting the integrity of the Town's water supply.

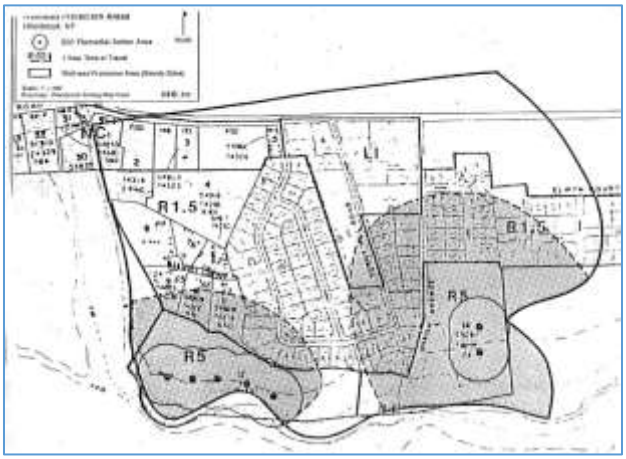
Woodstock Water District Boundaries

The water district has been extended several times to include new neighborhoods and developments. In 2011, before authorizing a permit for including Woodstock Commons in the water district, the DEC required the Town to perform a stress test on the water wells and to create a new, up-to-date map combining all the previous district expansions. The Town's engineers prepared a legal description and map for the water district, which was then submitted to the DEC. The Woodstock Drinking Water Resources Map shows the boundaries of the Water District as delineated by the Town's engineers in 2014.

Draft Wellhead Protection Area

In 1994, the hydrogeological consulting firm of Horsley & Whitten, Inc. defined a Wellhead Protection Area, an area considered to directly contribute ground water to the district's production wells. [33] The draft Horsley & Whitten Wellhead Protection Area is shown on the Woodstock Drinking Water Resources Map but has not yet been formally adopted by the Town.

The wellhead protection area was delineated according to DEC regulations that called for a 200-ft Remedial Action Area, a 1-year time of travel zone for rainwater to reach the wells, and to identify the complete capture zone under steady state conditions. The delineation under steady state conditions is bordered to the west and south by the Sawkill, to the north by the mapped extent of the aquifer and extends to the east almost to Spear Road.[34]



Wellhead Protection Area
Horsley & Whitten, Figure 2

A common threat to ground water quality is an elevated nitrate-nitrogen level caused primarily by private septic systems. Nitrates are the primary contaminant of concern for Woodstock's drinking water system; however, periodic testing for nitrates at the Town's two wellfields dating back to 2007 have consistently remained below concentration levels that would suggest contamination. Other potential threats to ground water include businesses that utilize materials that may generate hazardous waste,

[33] Horsley & Witten, Inc., "Wellhead Protection Area Delineation," April 1995

[34] Note: these boundaries do not follow property boundaries or topographic boundaries. The most accurate way to incorporate these protection areas is to use the modeled boundaries, which are based on concrete scientific evidence.

including such varied uses as automotive repair, manufacturing, and agricultural operations. Accidental or inappropriate disposal of hazardous wastes, even in small quantities, can result in ground water contamination exceeding state and federal drinking water standards.[35] At this time there is no known contamination of the public drinking water supply.

The Aquifer Protection Working Group, appointed by the Town Board in September 2019, studied the question of nitrate contamination and concluded that nitrate concentrations in Woodstock's water supply and aquifer are low and corrective action is not warranted.[36]

Draft Water Supply Protection Overlay District

In 2002, the Town engaged hydrogeologist Steven Winkley of the New York Rural Water Association to delineate a draft Water Supply Protection Overlay District, which has two purposes.[37] First, it is designed to protect those areas of the Woodstock aquifer identified by Horsley & Whitten that directly influence the Town's wells. This is the Wellhead Protection Area described above. The second purpose is to protect portions of the aquifer that could realistically support additional production wells for the Water District.

Variables considered in mapping areas suitable for future ground water supply development include distance from the existing water system, distance from the Sawkill and other streams, distance from potential contaminant sources, distance from roads, distances from houses, floodplains, parcel size, land use, and finally, the hydrogeological potential.

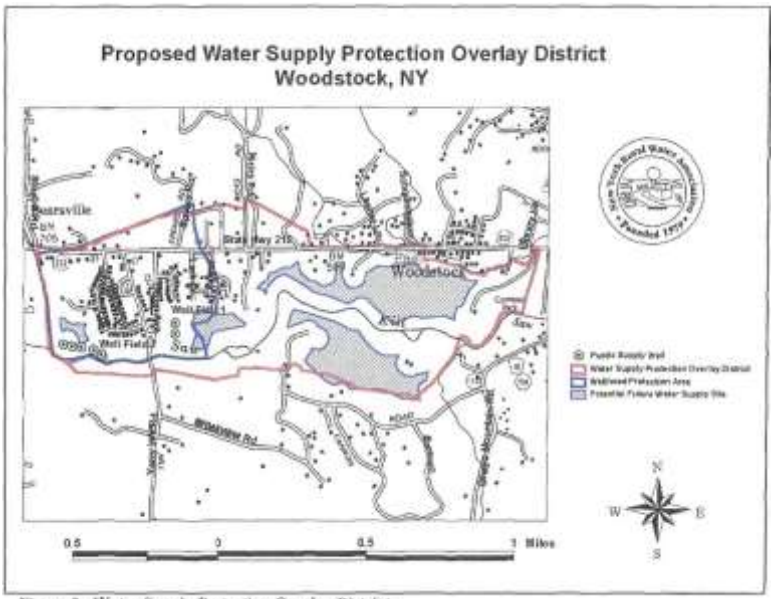


Figure 2. Water Supply Protection Overlay District

Water Supply Protection Overlay District
Winkley Figure 2

It includes all areas within 1,500 feet of the existing water distribution system, a distance that represents the realistic extent of a new water main that the Water District could economically afford to construct in order to tap a new source of supply. The area outlined in blue in Winkley's Figure 2 is the Horsley & Whitten draft Wellhead Protection Area judged to supply groundwater to the water district wells.

[35] Horsley & Whitten, page 7

[36] Kenneth S. Panza to Woodstock Town Board, "Report of the Aquifer Protection Working Group, Review of Nitrate Concentration," March 20, 2020

[37] Steven Winkley, "Summary of Findings for the Woodstock Aquifer and Proposed Water Supply Overlay District," New York Rural Water Association, Undated (est. 2002)

Parcel boundaries used by Winkley to delineate the Water Supply Protection Overlay District are identified on the Woodstock Drinking Water Resources Map. At the time of writing, the draft Wellhead Protection Area and the draft Water Supply Protection Overlay District have not yet been formally adopted by the Town.

Woodstock Aquifer and Surficial Geology

The Woodstock Aquifer, as described in the Winkley report, is shown on the Drinking Water Resources Map.[38] The aquifer underlies Bearsville and the area east of Bearsville identified by the Water Supply Protection District. The aquifer also extends upstream along the Sawkill through Shady.

There are two distinct types of surficial deposits that comprise portions of the so-called Woodstock Aquifer. Ice-contact deposits[39] overlie the area to the west and northwest of Bearsville. As the name implies, ice-contact deposits were laid down next to melting ice as glaciers melted and receded northward. Ice-contact deposits display a high degree of lateral variability in sorting, texture, and thickness. These deposits generally range in size from boulders to sand. Boulders are particularly characteristic of the local ice-contact deposits as evidenced by drilling logs. Hydraulically, ice contact deposits are highly heterogeneous. Permeabilities are highly variable due to their complex depositional setting. The saturated thickness ranges widely, and well logs reveal that deposits are sometimes unsaturated.

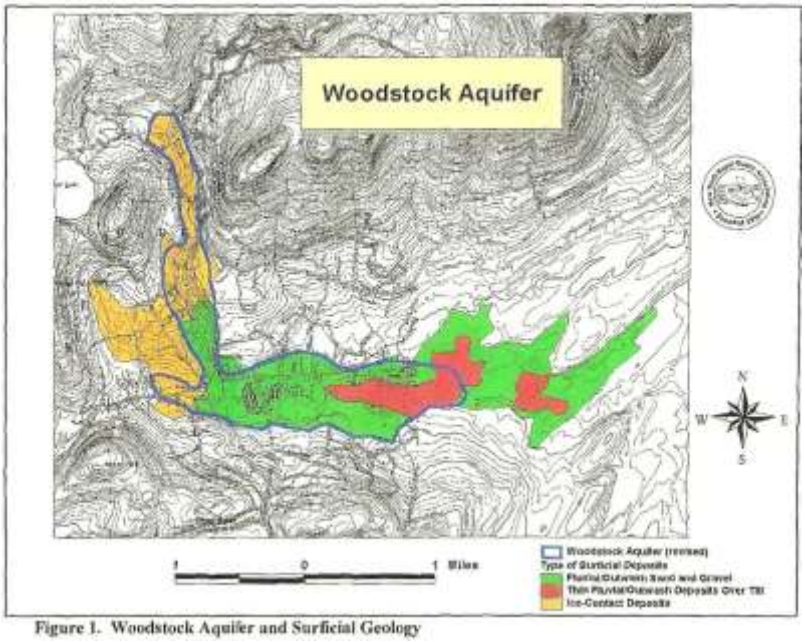


Figure 1. Woodstock Aquifer and Surficial Geology

Woodstock Aquifer and Surficial Geology
Winkley Figure 1

Other deposits comprising the Woodstock Aquifer are fluvial sand and gravel or outwash sand and gravel. These proglacial deposits were laid down by glacial meltwater in advance of the glacial ice margin and are comprised of coarse-to-fine gravel and sand. The Water District's wells tap proglacial deposits. Laterally continuous layers of silt are sometimes present, indicating a fluctuating depositional environment. These layers of finer-grained material are evident on several of the logs and are characteristic of these proglacial deposits.[40]

[38] Ibid.

[39] Ice-contact deposits is another term for kame or esker deposits. This area is mapped as kame deposits in the state Surficial Geology map.

[40] Ibid.

Private Wells

All properties outside of the Town Water District rely on individual private wells drawing on water from aquifers as well as other groundwater stored in the cracks and fractures of bedrock. Whereas public water wells are routinely monitored according to state regulations, private well owners are responsible for the safety of their water. Homeowners with private wells should test their water on a regular basis. There are three certified drinking water laboratories in Ulster County: Kingston Water Department Lab Inc. (Kingston), Environmental Labworks, Inc. (Marlboro) and Gentech Environmental Services (Stone Ridge).

The U.S. Environmental Protection Agency (EPA) has identified common conditions or nearby activities that well owners should be aware of and the substance(s) that should be tested for to ensure well safety.[41] If you suspect your drinking water well may have been contaminated after a flood or another natural disaster, contact the Ulster County Health Department or New York State Department of Environmental Conservation for additional advice on inspecting and testing your well.

Mink Hollow. Bennet Ratcliff

Homeowners should carefully manage activities near private wells to protect drinking water quality. This includes keeping contaminants away from the well itself, keeping hazardous chemicals out of septic systems and not mixing or using pesticides, fertilizers, herbicides, degreasers, fuels, and other pollutants near the well. The integrity of any above ground and underground storage tanks that hold home heating oil, diesel, or gasoline should also be monitored. Additional information about maintenance of drinking water wells appears on the Ulster County Cornell Cooperative Extension website.[42] The US Geological Survey publication *Groundwater and the Rural Homeowner*[43] discusses common well contamination problems and provides guidance to property owners, as well.

[41] https://www.epa.gov/privatewells/protect-your-homes-water#welltestanchor

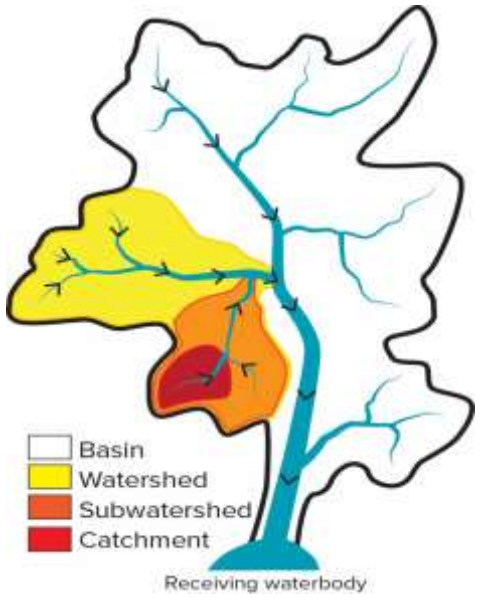
[42] http://ulster.cce.cornell.edu/environment/emergency-preparedness/water-septic-issues

[43] US Geological Survey, *Groundwater and the Rural Homeowner,* 1994. pubs.usgs.gov/gip/gw_ruralhomeowner/.

Watersheds (Map 10)

A watershed is an area where water, including groundwater, drains to its lowest point, such as a stream, river, or lake. Watersheds are divided by high points on the land such as ridges, mountains, and hills, and are nested, with smaller watersheds often referred to as catchments. Catchments are nested within subwatersheds, which are in turn nested within larger watersheds, often called basins. Healthy watersheds with a high percentage of forested land cover and intact stream buffers can recharge groundwater, minimize erosion and flooding impacts, and reduce the need for public infrastructure—ecosystem services that translate to economic benefits.[44] They are also likely to be more resilient to the effects of climate change.

Nested Watersheds



Source: NYS DEC

Major watersheds in Woodstock are shown on the Watersheds Map. Watershed boundaries are provided from the United States Geologic Survey (USGS) National Hydrography Dataset and the Ashokan Watershed Stream Management Program.[45] Streams and waterbodies on this and other maps in the inventory are from the Ulster County Department of Environment and were developed based on an analysis of 1-meter elevation data. More information about stream condition and management are provided in the Stream Management section of this report.

Woodstock Watershed Context

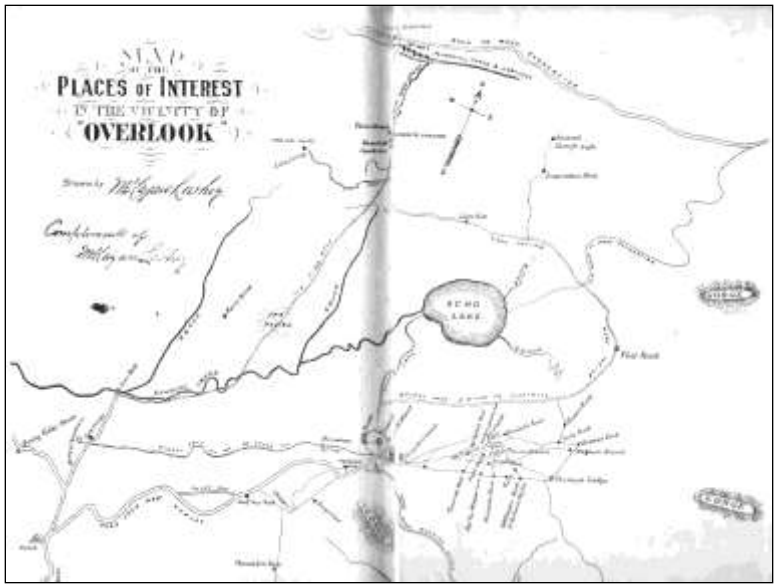
There are three major watersheds in Woodstock: the Sawkill, the Beaver Kill, and the Little Beaver Kill (kill is a Dutch word for creek or stream). The Beaver Kill and Little Beaver Kill drain the western half of the Town and form part of the basin for the Ashokan Reservoir, a major component of New York City's public water supply. Water that flows into the reservoir is either diverted to the City via the Catskill Aqueduct or is released into lower Esopus Creek, which ultimately drains to the Hudson River in Saugerties. The City of Kingston also diverts water from the Beaver Kill to Cooper Lake, which is then piped to Kingston. The Sawkill watershed covers most of eastern Woodstock, with the stream starting at Echo Lake and eventually flowing into the lower Esopus Creek below the Ashokan Reservoir in the Town of Ulster. In addition to these major watersheds, small portions of the Town drain via Warner Creek to Stony Clove and Upper Esopus Creek and via tributaries to the Plattekill and Stony Creek to lower Esopus Creek. All streams in Woodstock eventually flow into the Hudson River Estuary except for the noted drinking water diversions.

[44] "The Economic Benefits of Protecting Healthy Watersheds." US Environmental Protection Agency, 2015. https://www.epa.gov/sites/production/files/2015-10/documents/economic_benefits_factsheet3.pdf

[45] The USGS StreamsStats tool can be used to delineate watersheds at a finer scale where desired.

Sawkill Watershed

The Sawkill watershed drains 41.8 mi^2 of land in Ulster and Greene Counties. Approximately 29.8 mi^2 or 71% of the Sawkill watershed is within the Town of Woodstock. The northern headwaters of the Sawkill are in the Greene County town of Hunter. The main stem of the Sawkill is about 20 miles long and falls 1,950 feet in elevation along its course. Approximately 15.8 stream miles are within the Town of Woodstock, 2.5 stream miles are in the Town of Kingston, and the last 1.8 stream miles are in the Town of Ulster.[46]



Echo Lake and Sawkill Creek headwaters
Alf Evers, *Woodstock, History of an American Town*

Map drawn by M. Hazzard Lasher around 1874 intended to point out to visitors the various features close to the Overlook Mountain House, then under lease to the mapmaker's father, John E. Lasher.

Echo Lake on the northern shoulder of Overlook Mountain, 2,075 feet above sea level, is the source of the Sawkill, which is a tributary of Lower Esopus Creek. The Sawkill is characterized by steep rocky headwaters between Echo Lake and Shady, then gradually widening and softening in slope as it enters the broader valley and floodplain in Bearsville. This area reduces the stream's sediment transport capability and is a natural deposition zone, an area where sediment accumulates.

There are approximately 62 secondary stream tributaries draining to/feeding the Sawkill, ranging from small intermittent drainages to moderately sized streams. The stream meanders through the central hamlet of Woodstock before flowing into the Town of Kingston near Morey Hill Road. The Sawkill flows into the Esopus Creek in the Town of Ulster at the elevation of 135 feet above sea level.

Cooper Lake lies at the western edge of the Sawkill watershed and serves as the main reservoir for the City of Kingston's public water supply. The original dam impounding the lake was constructed in the mid to late 1800's and underwent several modifications through the early 1900's. In general, the current configuration is as constructed during the 1927 rehabilitation, which included raising of the Main Dam (along the

The Legend of Echo Lake was inspired by *The New Times* of July 19, 1874. According to the legend, "It seems an Indian girl was in the habit of meeting her lover along its shores." Her disapproving father, a chief, murdered the intrepid youth, and she followed by throwing herself from the cliffs. It was reported by the *Times* that her spirit haunts the lake as an echo. Guests from the nearby Overlook Mountain House, who had been told of this remarkable echo, would row out on the lake at night and shout "Hello!"

- Alf Evers, *Woodstock, History of an American Town*, Overlook Press, Woodstock, NY, 1987, pg. 303

[46] The term stream or river mile is the distance from the mouth of the creek or river to an upstream reference point.

northeastern shoreline) and construction of the West Dike (along the western shoreline). The reservoir has been enlarged over the years to increase storage capacity. At the time of writing the Cooper Lake dam is being repaired, which should not change the storage capacity or footprint of Cooper Lake. Water from the Mink Hollow section of the Beaver Kill is diverted to Cooper Lake to supply the system. The Watersheds Map shows the approximate drainage area contributing to this diversion. A fish ladder was installed by Kingston Water Works in 2012 at the Cooper Lake water diversion on the Beaver Kill to improve aquatic organism passage to the upper reaches of the stream. The Kingston public water system supplies approximately 24,000 people in the City with, on average, over 4 million gallons of water per day.[47] The City of Kingston Water Department owns and manages land along the Beaver Kill and surrounding Cooper Lake. The City of Kingston also owns land around Reservoirs 1, 2, and 4 along the Sawkill, which serve as an emergency water source. Kingston Water Department also now connects to the Ashokan Reservoir as a backup source.

Beaver Kill Watershed

The Beaver Kill watershed drains 25 mi^2 of land in Ulster and Greene Counties. Approximately 17.5 mi^2 or 70% of the Beaver Kill watershed lies in the Town of Woodstock. The northern headwaters of the Beaver Kill are in the Greene County town of Hunter. The watershed continues from Woodstock into the neighboring Ulster County town of Shandaken.

According to the Ashokan Watershed Stream Management Program:

> The Beaver Kill begins on the slopes of Plateau and Sugarloaf mountains and runs for 12.5 miles south-southeast, through the hamlet of Willow and ends at its confluence with the Esopus in Mt. Tremper. The Beaver Kill has three distinct geomorphic sections. From the headwaters and down through Mink Hollow, the Beaver Kill is a steep, narrow mountainous stream. The middle section near Willow flattens out drastically [(aptly named the "Willow Flats")]. The valley is broad and the stream is highly sinuous with many adjacent wetlands. After Willow, the Beaver Kill regains its steeper slope, flowing through a narrow valley adjacent to State Route 212 until it joins the Esopus Creek at Mt. Tremper.[48]

The United States Geological Survey (USGS) operates a stream gage at the downstream end of the Beaver Kill in Mt. Tremper.[49] This gage has been collecting continuous stream flow data since 2010.

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[47] "Annual Drinking Water Quality Report," Kingston Water Department, 2019.

[48] Ashokan Watershed Stream Management Program, "Beaver Kill," Available at https://ashokanstreams.org/exploring-the-watershed/beaverkill-2/

[49] USGS Stream Gauge Data, Beaver Kill at Mt. Tremper, https://waterdata.usgs.gov/ny/nwis/uv?site_no=01362487

Note that the upper portion of the Beaver Kill in Mink Hollow is sometimes referred to inter-changeably as Mink Hollow Stream, but this report uses the name Beaver Kill for consistency.

Little Beaver Kill Stream and Watershed

The Little Beaver Kill watershed covers approximately 17 mi^2 of land in Ulster County. Most of the watershed is in the Town of Woodstock with small sections extending into the neighboring towns of Olive and Hurley. The last 0.5 miles of the Little Beaver Kill prior to its confluence with the Esopus Creek is outside of Woodstock and forms the boundary between the towns of Olive and Shandaken.

According to the Ashokan Watershed Stream Management Program:[50]

> The Little Beaver Kill is a 9.8-mile stream, flowing east to west in southern Woodstock. … [It] is the last tributary to join Esopus Creek before it enters the Ashokan Reservoir. …The Little Beaver Kill headwaters start with two forks: a south fork that flows from Ohayo Mountain and a north fork that drains Roundtop, Tobias, and Beetree mountains. …The Little Beaver Kill is considered one of the more geomorphically stable tributaries in the Ashokan watershed due to a lack of infrastructure influencing the creek along most of its length taken together with its comparatively gentle slope from headwaters to mouth.
>
> Unique features of the Little Beaver Kill include two, large in-stream ponds and a high occurrence of wetlands. These water bodies provide valuable habitat and flood storage, but negatively affect sediment transport and may lead to increased water temperatures in the warmer months. On the south fork of the headwaters, the Little Beaver Kill flows through Yankeetown Pond and an associated wetland complex. [Further downstream], the Little Beaver Kill flows through a wetland complex and pond at the NYS DEC Kenneth L. Wilson Day Use Area and Public Campground.
>
> The United States Geological Survey (USGS) operates a stream gage at the downstream end of the Little Beaver Kill at Beechford. This gage has been collecting continuous stream flow data since 1997. The stream gauge collects water stage (height) and relates it to discharge.[51]

Watershed Land Cover and Land Use

Land cover is closely linked to the health of a watershed and the quality of its surface and subsurface

[50]Ashokan Watershed Stream Management Program, "Little Beaver Kill," Available at https://ashokanstreams.org/exploring-the-watershed/little-beaver-kill/

[51] USGS Stream Gauge Data, Little Beaver Kill at Beechford, https://waterdata.usgs.gov/ny/nwis/uv?site_no=01362497

waters. Watersheds with a high percentage of forest cover are generally associated with higher water quality and can produce significant savings on drinking water treatment costs.[27] The expansion of impervious surfaces in a watershed such as roofs, pavement, and other development is conversely associated with stream degradation.[52] Even low amounts of impervious cover can result in impacts. Research undertaken in Dutchess County found impacts to nutrient levels in streams in watersheds with less than 5% impervious cover.[53] Table 4 summarizes watershed land cover and land protection efforts in the Town's major watersheds.

Areas draining to the Ashokan Reservoir including the Beaver Kill and the Little Beaver Kill watersheds comprise 52% of the Town of Woodstock's territory and are highly protected through public ownership—43.9% and 38.8%, respectively—primarily as a result of investments by New York City Bureau of Water Supply, City of Kingston Water Department, and New York State's Catskill Forest Preserve lands. All of the Town's major watersheds are significantly forested, most notably the Beaver Kill watershed, which is over 95% forested. Development and impervious surfaces remain limited in the Town and are most concentrated in the hamlet of Woodstock and along State Route 375, though they make up a small percentage of overall land cover in the Sawkill watershed. For further discussion of land conservation efforts, see the Conservation and Land Use section of the report.

Table 4. Watershed Land Cover and Land Use, Land Protection, and Ownership in the Town of Woodstock

Land Cover/Land Use	Sawkill	Beaver Kill	Little Beaver Kill
Deciduous Forest	50.2%	55.2%	33.8%
Evergreen Forest	6.8%	19.7%	28.8%
Mixed Forest	26.8%	19.4%	27.4%
Shrub/Scrub	0.1%	1.2%	1.9%
Percent Impervious Cover	1.0%	0.3%	0.3%
Developed, Open Space/ Very Low Density	8.0%	1.8%	4.0%
Developed, Low Intensity/ Low Density	1.4%	0.9%	1.5%

[52] National Research Council, Committee on Reducing Stormwater Discharge Contributions to Water Pollution. 2008. Urban Stormwater Management in the United States. Water Science and Technology Board, Division of Earth and Life Studies of the National Research Council. National Academies Press, Washington D.C., pp 529. http://www.epa.gov/npdes/pubs/nrc_stormwaterreport.pdf

[53] Cunningham M.A., C.M. O'Reilly, K.M. Menking, D.P. Gillikin, K.C. Smith, C.M Foley, S.L Belli, A.M. Pregnall, M.A. Schlessman, and P. Batur. 2009. The Suburban Stream Syndrome: Evaluating Land Use and Stream Impairments in the Suburbs. Physical Geography. 30, 3, pp 269-284.

Land Protection and Ownership	Sawkill	Beaver Kill	Little Beaver Kill
Total public or protected land	29.1%	43.9%	38.8%
New York State	19.2%	13.2%	13.0%
New York City	0.6%	25.6%	21.2%
City of Kingston	3.2%	4.9%	0%
Town of Woodstock	3.3%	0.0%	0%
Woodstock Land Conservancy	0.8%	0%	0.2%
Privately-owned land with conservation easement	1.9%	0.2%	4.4%
Privately-owned land	70.9%	56.1%	61.2%

Watershed land cover for the Ashokan Reservoir watersheds is based on a high-resolution land use/land cover dataset generated by the DEP using LiDAR, leaf-off imagery and leaf-on imagery from 2009. Statistics for the Sawkill watershed are based on the 2016 National Land Cover Dataset.

Beaver lodge, Yankeetown Pond. Erin Moran

Stream Management (Map 11)

Local governments are often on the front lines of stream management. Construction and maintenance of stream-related infrastructure such as culverts, bridges, and roads that share valley bottoms with streams are costly and labor-intensive operations. Stream management techniques that "fight" the stream often succumb to the immense power of a flood and require repair or replacement. Management strategies that work with the natural tendencies of the stream often fare better. In order to implement effective management strategies, the tendencies and processes at play in the stream need to be understood. Stream management plans (SMPs) are the mechanism by which communities can understand the forces at play in the stream channels and develop effective management strategies.

The Ashokan Watershed Stream Management Program (AWSMP) was established as a joint effort between Cornell Cooperative Extension of Ulster County and the Ulster County Soil and Water Conservation District, with funding provided by the New York City Department of Environmental Protection, to maintain and improve the health and stability of streams in the Ashokan Reservoir Watershed.

Communities with SMPs in place to manage and maintain their stream channels and corridors (including riparian areas and floodplains) are better able to proactively plan for and to react appropriately to flood events. SMPs identify areas at high risk for erosion and inundation by floodwaters, which gives private landowners and local stakeholders time to prepare for the next flood. Communities with prioritized management recommendations in place through SMPs are also better able to secure funding for emergency response operations, to address erosion threats, infrastructure needs, and maintain the health and integrity of their streams and rivers.

In a SMP, the length of the main channel is broken into management units (MUs) based on valley characteristics, stream morphology, and tributary influence. Data and observations collected during field assessments are presented in the MU description. Management recommendations are made for areas that currently are or could become management issues, such as sites of high erosion or high flood hazard.

The Town of Woodstock has three primary stream networks, each comprised of a main channel and several tributaries, the Sawkill, Beaver Kill, and Little Beaver Kill. The Sawkill and Beaver Kill both have published stream management plans and/or stewardship manuals. The Sawkill *Stream Corridor Assessment* and the *Sawkill Stewardship Manual* were published in 2007 by Integrated Rivers Solutions, Inc. and the Beaver Kill SMP in 2015 by the Ashokan Watershed Stream Management Program (AWSMP). A management plan for the Little Beaver Kill is currently in publication and expected to be published by AWSMP at the end of 2020. These plans provide a wealth of information and insight into the challenges faced by streamside residents and municipalities. SMPs identify these challenges and provide recommendations for best management practices that aim to mitigate hazards and improve stream health and channel stability.

Brief descriptions of channel morphology and management recommendations based on the full text of the SMPs are provided below. However, it is recommended that the original SMPs be consulted for more information and prior to implementing any stream management activities. The AWSMP is available for

technical assistance and funding for stream-related projects in the Ashokan watershed portion of Woodstock. For the remainder of the Town, several potential sources of funding for stream-related projects are available including grants from the New York State DEC's Hudson River Estuary Program.

Digital versions of the Beaver Kill Stream Management Plan and Sawkill Assessment and Stewardship Manual are available for download here:
Sawkill: https://townwoodstock.digitaltowpath.org:10111/content/Generic/View/44
Beaver Kill: https://ashokanstreams.org/publications-resources/stream-management-plans/

Map 11 displays Stream Management Units for the Beaver Kill. A similar map has been prepared for the Little Beaver Kill and should be appended to the NRI with SMU descriptions when the Stream Management Plan is published.

Sawkill MU Descriptions and Management Recommendations:

Sawkill Creek Management Units

The Town of Woodstock, on behalf of the Town of Ulster and the Town of Kingston, applied for a grant from the NYS Department of Environmental Conservation's Hudson River Estuary Program to fund a Sawkill Watershed Stewardship and Education project. In December 2002 the town was awarded a grant of $15,000 with a $5,000 in-kind match required from the participating Sawkill watershed communities. Integrated River Solutions, Inc. (IRS) of Ulster Park, NY was hired to conduct a stream corridor assessment and develop a preliminary management plan.

Sawkill Creek Management Units

In 2007, IRS delivered two documents: *Stream Corridor Assessment*[54] and *Sawkill Stewardship Manual.* [55] The corridor assessment is a complete inventory of the stream's physical condition, berms, banks, bridges and culverts. The stewardship manual summarizes the findings of the assessment, provides recommendations, and is the source for much of the information in this section of the NRI report. The IRS work was intended to complement a previous study conducted by the Ulster County Soil and Water Conservation District on the upper Sawkill corridor, extending from its headwaters at Echo Lake to the Bearsville Flats. [56] Combined, these two assessments provide a complete inventory of the Sawkill Creek.

[54] Integrated River Solutions, Inc., "Sawkill Creek, Stream Corridor Assessment Report," May 2007
[55] Integrated River Solutions, Inc., "Sawkill Stewardship Manual," December 2007
[56] Ulster County Soil and Water Conservation District, "Upper Sawkill Creek Erosion and Stabilization Assessment," Preliminary Report 1999-2002.

Following the example of the Beaver Kill Stream Management Plan, management units (SMU) were identified for the Sawkill in Woodstock in 2020 for the Natural Resources Inventory based on the 2007 assessment and stewardship manual.

Headwaters and Wilderness Area (SMU0)
Starting at Echo Lake, there is a steep descent between steep banks with the rocky creek bed.
No major concerns.

Keefe Hollow Area (SMU1)
Clay soils with significant bank collapse are largely responsible for turbidity after rainfall and sediment deposits downstream.
Major concern: ongoing bank collapse.

Keefe Hollow to the Intersection of State Route 212 and Wittenberg Rd (SMU2)
There is significant downward flow with generally rocky stream bed and banks.
Should be monitored for changes.

From Bearsville Corner to Eastward Bend at the South Side of Comeau (SMU3)
A relatively flat area with clay banks; stream has a history of meandering.
Concern: large woody material from bank erosion (both from the headwaters and SMU3) can cause large wood jams that cause directional change in flow leading to further bank erosion and loss of streambank trees. Should be monitored for changes that harm property and infrastructure.

Area from center of Comeau to State Route 375 (SMU4)
Stream drops in elevation through generally rocky area with a series of small waterfalls/rapids.
No concerns noted.

Area from State Route 375 to Kingston Reservoir #1 in Zena (SMU5)
General flow is through somewhat flat area with major drop at reservoir #2 dam. There are several floodplains in this area.
Concern: Potential for serious flooding at John Joy Road.


Big Deep. Kelly Sinclair

Area from Kingston Reservoir #1 to Town Line at Morey Hill Rd. (SMU6)
Moderate drop with rocky streambed.
No concerns noted.

Turbidity
A distinctive characteristic of the Sawkill during high flow events is its muddy brown color,

predominantly the result of fine sediment particles (clay and silt) carried by the water. Naturally occurring turbid waters are characteristic of eastern Catskill mountain streams. Clay-rich sediments are common in Catskill valleys and stream channels, and the Sawkill is no exception. Fine sediments were deposited in the ancient Catskill delta and later glaciated. The result of this geologic history is that highly turbid water, caused by high flows, mobilizes larger sediments (boulders, gravels) and erodes the clay-rich streambeds and banks.

In 2001 to 2002, the Ulster County Soil and Water Conservation District inventoried the condition of the Sawkill headwaters beginning at Echo Lake through Keefe Hollow near Alf Ever's home at the intersection of Hutchin Hill Road and Reynolds Lane. Their findings were surprising and explained, in large part, the source of the Sawkill's chronic turbidity; some 30 woody debris jams associated with failing hillslopes and eroding streambanks in the clay-rich headwaters.

IRS described the headwaters of the Sawkill as a source of sediment—above and beyond the fine sediments that contribute to turbidity. The headwaters produce a tremendous volume of larger sediments and transport them to the lower reaches of the Sawkill. The source is the mountains themselves—boulders, cobbles and gravels contained in streambanks, the streambed and adjacent hillslopes. Their forceful transport to lower stream reaches is a result of the steep streambed in these headwaters. Along with the sediment transported to the lower reaches of the Sawkill, the trees and woody material are also carried, especially in flood events. This exacerbates erosion of streambanks in the lower reaches especially SMU3.

These reaches of the Sawkill are largely inaccessible, making any treatment or intervention to improve water quality an expensive and challenging proposition, and visual documentation indicates that these sites are unlikely to stabilize on their own. There should be no expectation that the Sawkill's turbidity will naturally resolve.

Beaver Kill MU Descriptions and Management Recommendations (see Map 11):
(Note: the Sawkill MU descriptions start in the headwaters and go with the flow downstream. The Beaver Kill MUs are arranged from downstream to the headwaters.)

MU-1 – Vicino Road to Esopus Creek

Description: This unit has been heavily managed and maintained to provide private property and highway infrastructure protection. This MU is characterized by very dynamic and unstable conditions. The valley is wide and gently sloping, naturally serving as a sediment storage location. Access to floodplains along most of this unit is poor with both natural features (abandoned terraces) and management features such as berms and road embankments. Numerous bank failures were observed along this reach which add to the excessive bedload being sourced from upstream.

Management: Watershed planning efforts should take into account that this MU is a sediment storage location, which is dynamic in nature and should be given room to change. Explore opportunities to re-vegetate stream banks and riparian areas. This will help regain some level of sediment stability through the unit. Where feasible allow the active channel corridor to widen. This is a natural process of re-establishing floodplains within the existing channel.

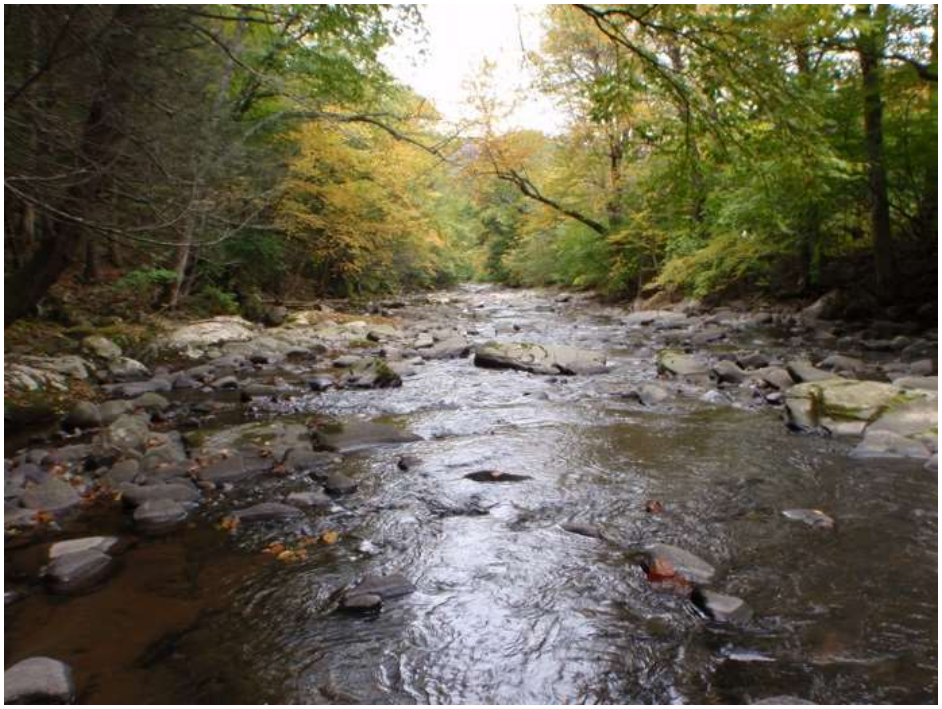
MU2 – Confluence of Grog Kill to Vicino Road

Description: This section is in varying condition ranging from relatively stable to unstable. It is within a narrow, terraced valley and the stream is relatively steep and confined (entrenched), often laterally constrained by Route 212. Transportation infrastructure and channel interactions, fine sediment loading, geotechnical bank failures, and hydraulic erosion were the primary concerns for stability in this unit. The riparian buffer is generally in good condition with sporadic revetment placed to protect Route 212.

Management: Adequately size material used in stabilization of road embankments to ensure stability. Interplant riprap with suitable species to provide shade and bank stability. Use low growing native species to reduce obstructions to line-of-sight along roadways. Maintain channel roughness when performing post-flood work. Leave large boulders in the bottom of the streambed. Boulders are extremely important for stability in MU-2. Assess coarse sediment input and impact on downstream areas to help support the development of a sediment budget for the Beaver Kill.

MU3 – 550 ft. downstream of Rt. 212 crossing to confluence of Grog Kill

Description: MU-3 encompasses complex geologic boundaries creating both stable and unstable characteristics. The S-turn site in the upstream portion contained the majority of bank erosion in MU-3, including several high bank geotechnical failures and fine sediment exposures. Concerns in the upstream portions include risks to public and private infrastructure, as well as contribution of suspended sediments that may degrade water quality.



The lower portion of Beaver Kill MU3 is a natural, stable, fully functioning reach of stream. Tim Koch

Management: The upstream portion of MU-3 demonstrated potential for reach scale remediation or restoration. Leave detached pieces of large riprap in the stream channel as it stabilizes the toe of previously eroding banks and provides channel roughness. Remove dump site of yard waste and non-natural material along stream as this discourages natural vegetation establishment. Improve (introduce and/or widen) streamside vegetated buffers. Protect the downstream portion of the unit, between stream stations 34400-36000, as a stable reference reach for future restoration designs in the watershed.

MU4 – Confluence of Silver Hollow Brook to 550 ft. downstream of Rt. 212 crossing.

Description: MU-4 was identified as a stable section of stream. The valley is gently sloping at 1-1.5%. Floodplains in this section were accessible, riparian buffers were healthy, and infrastructure had little negative influence on channel processes. The stream had plenty of room to meander throughout its extensive forested floodplains.

Management: Focus on preservation. Interplant slope stone revetment downstream of Route 212 bridge to increase bank strength and durability which increases the value and function of the riparian buffer.

MU5 – Sickler Road to the confluence of Silver Hollow Brook.

Description: This portion of the Beaver Kill flows through the Willow Flats area, a low gradient section of the stream that leads to a highly sinuous planform. In such an open valley setting, flood flows would naturally spill across the broad flood plain, reducing in-channel erosive power. However, in MU-5 the stream has downcut, making the sandy stream banks especially prone to erosion and the channel prone to lateral migration. Historic channel migration in this area has led to the formation of oxbows and vernal pools which are valuable habitat.

Management: If merited, reduce erosion with bioengineering techniques. Allow woody material to remain in the channel wherever possible. Woody material serves as grade control and reduces erosion on the outside of meander bends.

MU6 – Where stream pulls away from Mink Hollow Road to Sickler Road

Description: MU-6 is broken into sub-units 6A upstream, and 6B downstream, due to a change in valley type and sediment dynamics. Upstream, MU-6A was a section of stream with little to no floodplain access and a high percentage of bedrock channel boundaries. This combination led to high water velocity and high sediment transport through the reach during high flow events. Downstream of the State Route 212 crossing, the valley broadened, the stream regained access to a floodplain, and the resulting decrease in stream power led to sediment deposition. A history of post-flood stream excavation in the downstream reach has led to over-widening of the stream channel. This has resulted in a loss of streamflow during the low flow period in the summer months and periodic inability to support aquatic life.

Management: The mid-unit change in valley slope means sub-unit 6B is a natural depositional area that will tend towards a wide, multi-thread channel. To maintain a single-thread channel and protect nearby properties and infrastructure, upstream sources of coarse sediment need to be reduced. Following flood events, this reach should be monitored, and technical assistance sought from the AWSMP to help properly size the channel should it be needed.

MU7 – Mink Hollow Road bridge to where stream pulls away from Mink Hollow Road

Description: The Beaver Kill is MU-7 is partially stable with discontinuous access to floodplains as it flows along Mink Hollow Road. Hard bank revetments and side-case berms are common in areas where the stream runs close to the road but disconnect the stream from the floodplain. Stable sections were

observed where cross-channel bedrock exposures provided grade control, and where the stream had access to narrow, forested floodplains.

Management: Changes in diversion rates related to Kingston Water Supply transfers to Cooper Lake should be evaluated for downstream consequences. Maintain channel roughness when performing post-flood work. Leave large boulders in the bottom of the stream bed. Utilize stream dimensions (ideally bankfull dimensions) when re-constructing channels.

A stable section of stream in Beaver Kill MU7. Tim Koch

MU8 – Confluence of east and west branches to Mink Hollow Road bridge

Description: MU-8 is one of the most unstable reaches in the Beaver Kill watershed. Hillslope failures, stream bank erosion, infrastructure threats, accumulations of large woody material, and flood hazards have all been identified by various stakeholders in this unit. The stream is confined between high valley walls and abandoned terraces along the left bank and a road on the right bank. Due to the steep slope and confined nature of the valley, channel stability in this reach relies on channel roughness from large sediments and the roots of woody vegetation.

Management: Utilize stream dimensions (ideally bankfull dimensions) when reconstructing channels. Incorporate in-stream grade controls when stabilizing stream banks.

MU-9 – Upstream of Mink Hollow Trail trailhead to confluence of east and west branches

Description: This unit contains the lower headwater section of the west branch of the Beaver Kill. It is moderately entrenched with a steep slope of 2-4% and characterized by large cobble and boulder material in the bed. There is discontinuous floodplain access on forest preserve land in the upper extents, but this access is blocked in the lower portion where the stream flows adjacent to the road. Extensive channel work following Tropical Storm Irene have exacerbated channel instabilities.

Management: Discontinue regular channel maintenance (e.g., removing sediment and filling eroding banks with channel material). Incorporate in-stream grade controls when stabilizing stream banks. Utilize stream dimensions (ideally bankfull dimensions) when re-constructing channels. Maintain channel roughness when performing post-flood work. Leave large boulders in the bottom of the streambed. Where feasible allow the active channel corridor to widen. This is a natural process of re-establishing floodplains within the existing channel.

Little Beaver Kill:
The Little Beaver Kill Stream Management Plan is anticipated to be completed at the end of 2020.

Kenneth L. Wilson Public Campground Unit Management Plan
Downstream from the hamlet of Wittenberg, the Little Beaver Kill flows through Kenneth L. Wilson Day Use Area and Public Campground. A dam created a six-acre impoundment known as Wilson Lake. The dam is a gabion drop structure with a concrete spillway that was modified with steel sheet piling.


Kenneth Wilson Campground pond. Ingrid Haeckel


Wetlands around Kenneth Wilson Campground pond. Ingrid Haeckel

The pond at Kenneth Wilson Campground provides excellent fishing access for warmwater fish, including largemouth bass, chain pickerel, yellow perch, sunfish, and bullheads. For many years, DEC maintained a beach and swimming area on the pond, which were moderately popular among campers and day-use visitors. Over time, the accumulation of silt and the presence of aquatic vegetation resulted in poor water visibility. In addition, poor water quality resulted from a resident population of Canada geese which frequented the beach area. In 2002/03, DEC temporarily lowered the water level of the lake during the winter in hopes that an extended freeze would kill the undesirable aquatic vegetation, but that approach proved to be ineffective. Continued unfavorable conditions resulted in DEC closing the beach and swimming area in 2004. In 2016, DEC proposed a feasibility study to assess conditions and explore options to reestablish the beach and swimming area at or near its original location at the south end of the lake. The study would address water quality, lake bottom condition, waterfront safety and wildlife concerns, among other issues, and upon completion, would consider the feasibility of reopening a swimming beach at the facility.[57]

Following Tropical Storm Irene in 2011, the Catskill Streams Buffer Initiative restored a section of the riparian buffer along the campground parking area.

[57] New York State Department of Environmental Conservation, "Kenneth L. Wilson Public Campground Unit Management Plan, Town of Woodstock, Ulster County, New York," December 2016, https://www.dec.ny.gov/docs/permits_ej_operations_pdf/klwpublicfinalump.pdf

Water Quality Classifications and Assessment (Map 12)

The DEC designates the "best uses" that a waterbody should be supporting. Waterbodies are classified by the letters A, B, C, or D for freshwater. The letter classifications and their best uses are described in regulation NYS regulation 6 NYCRR Part 701.[58] For each class, the designated best uses are defined as follows:

Activities allowed in and around waterbodies are regulated by the DEC based on their classification and standard.

- Class A, AA-water supply, primary and secondary contact recreation and fishing
- Class B-primary and secondary contact recreation and fishing
- Class C-fishing, suitable for fish propagation and survival
- Class D-fishing

Brown trout. Bennet Ratcliff

Waterbodies classified as A, B, or C may also have a standard of (T), indicating they are trout waters, or (TS), indicating they are trout spawning waters. The Water Quality Classifications Map shows the water quality classifications of surface waters in Woodstock. Official descriptions for the classifications and standards of waterbody segments in the Lower Esopus Creek drainage (including the Sawkill) are found in 6 CRR-NY 861.4 Table 1 and Upper Esopus Creek drainage segments (including the Beaver Kill and the Little Beaver Kill) are listed in 6 CRR-NY 862.6 Table 1.[59] Note that the waterbody classification does not necessarily indicate good or bad water quality—it relates simply to the designated "best uses" that should be supported. DEC recognizes that some waterbodies have an existing quality that is better than their assigned classification and uses an anti-degradation policy to protect and maintain high-quality streams.

Note that not all waterbodies appear on classification maps. However, the missing waterbodies will always have a classification. Waterbodies that do not appear on classification maps and have flow all year (perennial flow) have the classification of the waterbody into which they flow. Waterbodies that do not appear on these maps and have seasonal or intermittent flow seasonally have a classification of "D." DEC has the final authority to determine if a waterbody has perennial or intermittent flow.

[58] "Water Quality Standards and Classifications." NYS Department of Environmental Conservation. https://www.dec.ny.gov/chemical/23853.html
[59] https://www.dec.ny.gov/regs/2485.html

DEC also establishes water quality standards, specific for particular parameters and pollutants, to protect the uses associated with these classifications. These standards are found in NYS regulation 6 NYCRR Part 703. Standards can be numerical or narrative. For example, dissolved oxygen has a numerical standard of no less than 7.0 mg/l in trout spawning waters. Turbidity has a narrative water quality standard which states there should be "no increase that will cause a substantial visible contrast to natural conditions." Information on surface water and groundwater quality standards can be found at Surface Water and Groundwater Quality Standards.[60] If waterbodies are not supporting the standards for their best uses, they may be listed on the Priority Waterbody List as impaired.

Activities allowed in and around waterbodies are regulated based on their classification and standard. C(T), C(TS) and all types of B and A streams—as well as waterbodies under 10 acres located in the course of these streams—are collectively referred to as "protected streams." C streams are not protected. In situations where streams are unmapped in DEC databases, perennial streams share the classification of the receiving stream, while intermittent streams become Class D. Protected streams are subject to the provisions of the Protection of Waters regulations in Article 15 of the Environmental Conservation Law.[61] DEC regulates the bed and banks of protected streams, defined as the areas immediately adjacent to and sloping toward the stream. Activities that excavate, fill or disturb these beds or banks require a DEC permit.[62] DEC water quality certification permits and U.S. Army Corps of Engineers (ACOE) permits may also be required for work involving streams; contact the DEC Region 3 biologist responsible for applying state regulations in the protection of surface water resources for information regarding specific projects.

In 2009, Woodstock adopted local wetland and watercourse protection standards (§260-34) to promote comprehensive watershed protection in the Town, including protection for streams and stream buffer areas not currently regulated (and are therefore unprotected) under state and federal laws. Under Woodstock's standards, regulated watercourses include any natural, artificial, permanent, seasonal, or intermittent, public or private water segment, such as rivers, streams, brooks, or other waterways that are contained within, flow through, or border on the Town of Woodstock. A watercourse is defined as containing a discernible channel, bed, and/or banks and usually flows in a particular direction. Artificial water segments, such as swales and ditching shall not be considered a regulated watercourse, provided they do not discharge directly into a naturally occurring wetland, water body or watercourse. Town regulations extend from the stream bank to an adjacent buffer area ranging from 30 to 100 ft depending on the upstream drainage area and the slope of the land and are specified in the "Applicable Watercourse Buffer" map (with a default of 30 ft in all other cases). A permit is required for all activities listed in §260-34C of the Town code, including:

[60] "Surface Water and Groundwater Quality Standards." NYS Department of Environmental Conservation. http://www.dec.ny.gov/regs/4590.html
[61] "Protection of Waters Program." NYS Department of Environmental Conservation. https://www.dec.ny.gov/permits/6042.html
[62] "Protection of Waters: Disturbance of the Bed or Banks of a Protected Stream or Other Watercourse." NYS Department of Environmental Conservation. https://www.dec.ny.gov/permits/6554.html

1. Any form of mining, dredging or excavation and any grading or removal of soil, mud, sand, gravel, peat, silt or any other earth material, either directly or indirectly.
2. Any form of dumping, filling or depositing of any soil, stones, sand, gravel, mud, rubbish or fill of any kind, either directly or indirectly.
3. Construction or enlargement of any building or structure except as allowed by § 260-34D (13) and (14), whether or not the same affects the ebb and flow of water.
4. Construction of any road, driveway or parking facility, or paving, or establishment of trails consisting of impervious surfaces for vehicles, whether or not the same affects the ebb and flow of water.
5. Placement of any obstructions within a wetland, water body and/or watercourse, whether or not the same affect the ebb and flow of water.
6. Draining or ditching with the intent of mosquito control.
7. Creation of a diversion of water flow on any watercourse, including but not limited to constructing dams, docks (pilings), or bridges.
8. Timber harvesting or clearing of vegetation, except as allowed without a wetland and watercourse permit pursuant to § 260-34D of this chapter.
9. Commercial use or storage of any chemicals, dyes, fertilizers, fuels, herbicides, pesticides, petroleum products, de-icing materials, or similar materials in any regulated area, such that the same may cause pollution of waters.
10. Introduction of any influents of high thermal content to a wetland, water body or watercourse, as may be capable of causing deleterious ecological effect. Deleterious effects shall be defined in accordance with the New York State Department of Environmental Conservation, Chapter X, Division of Water, Part 704 regulations, or its successor.
11. Installation of septic disposal systems or swimming pool drainage systems; discharging sewage treatment effluent or other liquid wastes; construction of wells; or installation of any pipe or other conduit in a regulated area; whether or not said activities affect the ebb and flow of water.
12. Withdrawal of ground or surface water in excess of 2,500 gallons per day for more than seven days in the course of one year which may cause an increase or decrease in the flow, velocity or volume of water in any watercourse or water body (excluding the natural seasonal fluctuations of said watercourse or water body and controlled dam releases).
13. Interbasin transfers of water (such as water supply distribution systems and sewer systems) of more than 10,000 gallons per day from one watershed to another watershed.
14. Any other activity which impairs the function of a wetland, water body or watercourse as defined in § 260-34B of this chapter, unless said activity is allowed without a wetland permit under § 260-34D.

Water Quality Monitoring and Assessment (not mapped)

DEC monitors water quality through several routine statewide monitoring programs and publishes assessments that describe the quality of water resources. A waterbody's assessment results, compared with its classification, provides an understanding of its health and can lead to the designation of a stream or waterbody as impaired. A waterbody's level of impairment influences which programs, opportunities, and responsibilities the community has for addressing problems.

The NYS Waterbody Inventory/ Priority Waterbodies List (WI/PWL) is a document that lists New York State waterbodies and information about water quality in relation to the state's waterbody classifications.

Water Quality Assessments

DEC's Stream Biomonitoring Unit conducts biomonitoring sampling throughout New York State on an approximately 10-year rotating basis. Based on the number and kinds of macroinvertebrates, each sample receives a water quality score. DEC biomonitoring data collected in 2009 at the mouth of the Beaver Kill and Little Beaver Kill found non-impacted conditions. Sampling on the lower Sawkill in 2012 just downstream of Kingston Reservoir 2 found slightly impacted conditions. Full reports with the results of biomonitoring sampling along the Upper and Lower Esopus Creek describe the macroinvertebrate communities and drivers of water quality conditions.[63]

DEC Division of Water also runs a citizen monitoring program for biomonitoring called Water Assessments by Volunteer Evaluators (WAVE). Citizen monitors visit a stream and collect and identify stream organisms. WAVE data is included in federal and state water quality reports and will be used to focus DEC assessments and local restoration efforts to where they are most needed. WAVE is particularly useful for unassessed waterbodies (see assessment status under the Impairment section).

Impairment

The Waterbody Inventory/Priority Waterbodies List (WI/PWL) is a document that lists New York State waterbodies and information about their water quality. The WI/PWL documents support (or impairment) of water uses, overall assessment of water quality, causes and sources of water quality impact/ impairment, and the status of restoration, protection and other water quality activities and efforts. WI/PWL information is used to identify those water quality issues and specific waterbodies where efforts will have the greatest impact and benefit, objectively evaluate needs for project funding, monitor water quality improvement, and record and report changes over time. The WI/PWL includes waterbody fact sheets outlining the most recent assessment of support for best uses, identification of water quality problems and sources, and a summary of activities to restore and protect each individual waterbody.

[63] DEC Division of Water Stream Biomonitoring Unit, Upper Esopus Creek Biological Assessment, 2013, available online at https://www.dec.ny.gov/docs/water_pdf/barupperesopuscreek09.pdf; DEC Division of Water Stream Biomonitoring Unit, Lower Esopus Creek Stream Assessment, 2015, available online at https://www.dec.ny.gov/docs/water_pdf/lowesocree15.pdf

Table 5. Waterbody Assessment in the Town of Woodstock
(Source: Waterbody Inventory/Priority Waterbodies List)

Waterbody Name	Description	Assessment
Beaver Kill and tribs	stream and tribs, mouth to Lake Hill	No Known Impact
Little Beaver Kill and tribs	entire stream and tribs	Unassessed
Sawkill, upper and tribs	stream and tribs, above Shady	Unassessed
Sawkill, middle and tribs	stream and tribs, from Zena to Shady	Unassessed
Sawkill, lower and tribs	stream and tribs, from mouth to Zena	No Known Impact
Stony Clove Brook and tribs	entire stream and tribs	No Known Impact
Cooper Lake		No Known Impact
Echo Lake		Unassessed
Yankeetown Pond		Unassessed
Kingston Reservoirs 1, 2, and 4		Unassessed

No known impacts have been reported from Woodstock's streams in the NYS Waterbody Inventory/ Priority Waterbodies List to date, though slight impacts were found along the lower Sawkill in the most recent DEC biomonitoring samples.

Cooper Lake is the only lake that has been formally assessed in Woodstock to date and has no known impacts. It 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 source water catchment area contains no discrete potential contaminant sources, and land cover suggests susceptibility to contaminants is low.

Cooper Lake. Arlene Weissman

Special Flood Hazard Areas (Map 13)

Locations within the "100-year" (1% annual chance) flood zone have at least a 1 in 4 (25%) chance of flooding during over the course of a 30-year mortgage.

Special Flood Hazard Areas (SFHAs) are regulatory boundaries generated by the Federal Emergency Management Agency (FEMA) in order to set policy rates for the National Flood Insurance Program. SFHA boundaries delineate areas deemed at the highest risk of flooding during a 1% annual chance flood event, or what has been referred to as the "100-year flood." Regulatory agencies and flood mitigation experts are discouraging the use of the "100-year flood" moniker as it is statistically misleading and can lead to a false sense of security. The 1% annual chance flood is a specific discharge has a 1% probability of occurring in any given year, regardless of any floods or droughts in previous years. In fact, the 1% annual chance flood can happen multiple times with a single calendar year. SFHA maps also delineate the 0.2% annual chance flood hazard areas ("500-year flood") and the regulatory floodway. Areas outside the SFHA can still be at risk of flooding. While SFHAs are delineated topographically, they are not synonymous with natural floodplains.

Floodplains are an integral, morphological part of streams and rivers. They are low-lying areas next to streams and rivers that are inundated during overbank flows that result from heavy precipitation or snowmelt events. Floodplains are built by the river over time via point bar accretion or sediment deposition during floodwater recession. Streams of all sizes can have floodplains at various locations along their length. Floodplains can extend far from a stream or river and aren't necessarily found alongside of them. Successful stream management done on a watershed scale must include the condition and connection of a stream to its floodplain.

Little Beaver Kill in flood. Ingrid Haeckel

Floodplains provide many critical functions for a healthy stream and its watershed. When left in a natural state, floodplains provide a buffer between people and infrastructure and the damaging waters of a flood. They provide the space streams need to expand, contract, and sometimes change course. Floodplains are part of the river, thus any structures built there are at risk of significant property damage, and residential development in the floodplain puts the lives of residents at risk. The extent of floodplains

as well as SFHA boundaries can change over time. Those changes can be in response to changes in land use in the stream and floodplain and the surrounding watershed, major flood events and/or obstructions in the stream or its floodway (defined below), stream projects (including dams and levees), and natural stream processes. Climate change models predict that New York's wet periods will be wetter in the future, and this is expected to increase the frequency of flood events and their magnitude, making the protection of existing floodplains more important than ever.

The Special Flood Hazard Areas Map shows SFHAs mapped by the Federal Emergency Management Agency (FEMA) where the National Flood Insurance Program's (NFIP's) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies to homes purchased with a federally backed mortgage.[64] Flood insurance rate maps (FIRMs) show areas estimated to have a 1% chance (1 in 100) or greater probability of being inundated in any given year, areas commonly referred to as the "100-year" floodplain. Some additional flood hazard areas are mapped by FEMA with a 0.2% chance (1 in 500) or greater probability of flooding in any given year—referred to as the "500-year flood"—though these areas are not subject to the same regulations as the 1% flood hazard areas. The floodway is the channel of a stream or river that carries the deepest, fastest water downstream and is a distinct sub-area within the boundaries of the 1% annual flood hazard area. The floodway is the area "that must be reserved in order to discharge the base flood (100 year or 1% annual chance flood) without cumulatively increasing water surface elevation more than a designated height."[65] Thus, the floodway is the most heavily regulated of the SFHAs. The FIRMs for Woodstock were recently updated with an effective date of 2016.

Woodstock's Flood Damage Prevention Law (Chapter 82 of Town code) regulates activities within the 1% flood hazard area in accordance with NFIP in order to minimize flood damage. Within the regulatory floodway, all encroachments, including fill, new construction, substantial improvements, and other development, are prohibited unless a technical evaluation demonstrates that such encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge (flow and its associated depth). Town Building Department staff are the designated floodplain administrators for Woodstock and are responsible for issuing floodplain development permits and enforcing the Flood Damage Prevention Law.

It is important to note that FIRMs are only estimates based on the data and modeling technology available at the time of mapping. Due to the unpredictable nature of some kinds of floods, they often omit many areas subject to flooding from localized drainage problems, including undersized culverts, ice or wood jams or sheet flooding down a slope. Climate change is furthermore changing precipitation patterns and increasing the frequency and magnitude of floods in the Hudson Valley. Annual rainfall occurring in heavy downpour events across the Northeast increased 74% between the periods of 1950-

[64] "National Flood Insurance Program." Federal Emergency Management Agency. https://www.fema.gov/national-flood-insurance-program
[65] https://www.fema.gov/glossary/floodway

1979 and 1980-2009.[66] See the Climate section for more information.

The Stream Management section of this report describes some of the locations along the Town's major tributaries to the Ashokan Reservoir where flood-related problems are most acute, as well as management recommendations that have been identified.

Priority Road-Stream Crossings

Undersized, poorly designed, and improperly installed culverts or bridges can cause localized flooding, stream channel instability, negatively impact water quality, and fragment aquatic habitat. Flooded streams flowing into undersized culverts can create backwater flooding upstream and, in some cases, overtop and wash out a road during heavy precipitation or snowmelt. Improperly designed culverts do not account for natural stream processes such as sediment transport and can set off a cascading series of geomorphic adjustments in the stream channel. Culverts can also fragment a long, linear stream into short segments damaging habitat needed to support local fish and other species.

In 2018, the Ashokan Watershed Stream Management Program (AWSMP) developed a new Multi-Objective Stream Crossing Assessment Protocol (MOSCAP). The MOSCAP was piloted that year in the Ashokan Reservoir Watershed portion of the Town of Woodstock. The MOSCAP is a holistic assessment protocol that evaluates culverts and bridges in terms of 1) geomorphic compatibility with the stream channel, 2) structural condition, 3) aquatic organism passage (AOP), and 4) flood flow capacity. The flow capacity objective is assessed using a GIS based hydrology and hydraulics model. Current and predicted future rainfall values from NOAA are used to generate peak flow estimates that are compared to each structure's calculated hydraulic capacity. Road-stream crossings shown on the Special Flood Hazard Areas Map are classified according to priority for flood flow capacity. "High" priority crossings are those modeled to have hydraulic capacity insufficient for passing the estimated 10-year return interval discharge.

A comprehensive MOSCAP assessment of the lower Esopus Creek watershed in Woodstock is underway in 2020 through a partnership among Ulster County Department of the Environment and Cornell Cooperative Extension of Ulster County. When completed, all county and town road crossings in Woodstock will have been assessed with MOSCAP. The assessment data, scoring strategy, and prioritization algorithm will be used to develop town-wide, municipal road-stream crossing management plan for Woodstock to identify priority culvert replacement projects that will improve flood resiliency, road infrastructure condition, and remove barriers to fish and wildlife passage.

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

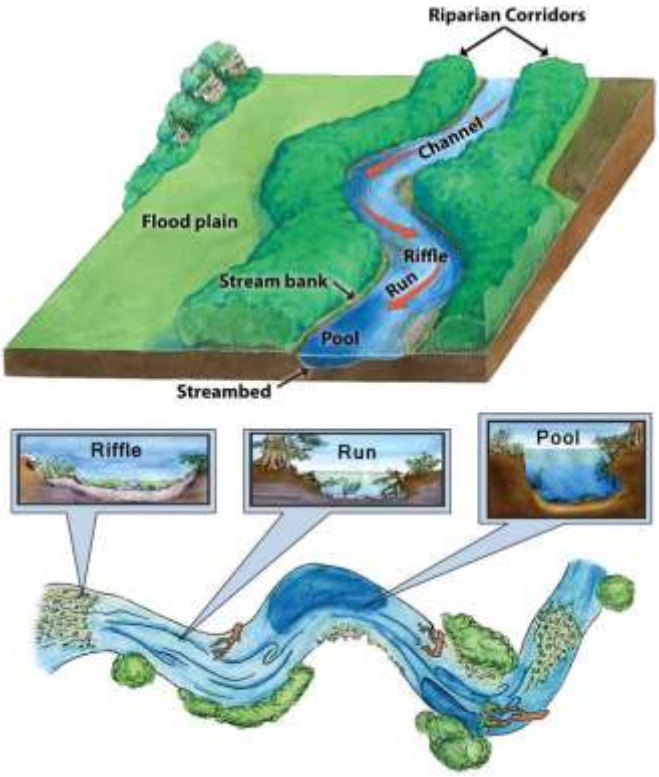
Stream Habitats (Map 14)

From mountain headwater creeks to meandering valley streams, a variety of streams and related habitats are found in Woodstock. The Town's streams are an important water resource and support diverse aquatic life, as well as recreational activities like fishing and swimming. Stream infrastructure such as dams and culverts play an important role in determining connectivity and access to stream habitat for fish and other aquatic species.

Intermittent stream. Ingrid Haeckel

Types of Streams and Stream Habitats

Streams shown on this map are from the Hudsonia Habitat Map for Woodstock and are classified based on estimated duration of flow. Intermittent streams only flow during certain times of the year, fed by seasonally high groundwater and runoff from rainfall and snowmelt. Some headwaters are ephemeral, only flowing after rainfall. Perennial streams and rivers flow year-round, with most water fed by smaller upstream intermittent and ephemeral streams or groundwater. Intermittent and epehmeral streams make up 50-80% of stream miles in a river system.[67]



Source: https://texasaquaticscience.org/streams-and-rivers-aquatic-science-texas/

This vast network of small streams in the landscape provide many of the same functions and values as larger perennial streams. Intermittent streams provide seasonal refuge and spawning habitat for small fish, habitat for macroinvertebrates that drift downstream to feed larger fish and organisms, and support nutrient cycling and flood control processes, among other benefits. Ephemeral streams provide floodwater and sediment storage and are often hydrologically linked to headwater wetlands and vernal pools. However, both

[67] https://www.americanrivers.org/conservation-resource/small-streams-wetlands/

intermittent and ephemeral streams are often unmapped, underappreciated, and overlooked.

Streams share some common habitat features. Many streams have alternating deep and shallow areas called pools and riffles. The deep, slow water in pools provides shelter and resting areas for fish. Shallow, swift water in the riffles adds oxygen to the water and provides fish with spawning and feeding areas. The fast moving water between riffle areas and pools is called a run. Some streams also form natural meanders or curves that slow down the water and absorb energy. These curves produce erosion such as cut banks and depositional areas like gravel bars where sediments are deposited. Large woody material such as logs, trees, and branches is an important component of in-stream habitat that supports the capture of sediment, gravel, and organic matter, prevents streambank erosion, and decreases water temperature—all factors that enhance habitat for fish and other organisms.

Riparian Areas

Beyond the stream channel and banks, riparian areas (often called stream buffers) and floodplains support unique soil and vegetation that are strongly influenced by proximity to water and frequent flooding. Riparian areas are located adjacent to streams, ponds, wetlands, and other waterbodies. They are sensitive transition zones between land and water and are vital to stream physical processes, habitat, and water quality. Riparian areas help clean water by intercepting runoff and filtering sediment and nutrients. They can attenuate flooding by slowing down and absorbing floodwaters. Riparian trees are especially important for providing shade, bank stabilization, woody material, and nutrients that benefit fish and other aquatic life. Many terrestrial wildlife species also depend on riparian habitats and use them as travel corridors. Some animals are even considered "riparian species" because of their dependence on the unique ecological characteristics of riaprian areas.

From the standpoint of stream protection, naturally vegetated riparian buffers provide different functions depending on width.[68] In general, wider buffers provide better habitat connectivity and more protection to the water quality of streams and other waterbodies. Recent studies recommend 100 feet as the minimum buffer width to improve wildlife habitat, water quality and storm resiliency. Riparian buffers of 300 feet or more provide the greatest opportunity for natural functions to benefit ecological and human communities. While narrower buffers might help maintain some stream functions, protecting wider buffers and restoring degraded ones can help enhance those functions.

The Stream Habitats Map shows potential riparian areas mapped by the New York Natural Heritage Program for the Statewide Riparian Opportunity Assessment.[69] They are delineated around streams based on digital elevation data, known wetlands, and modeling for the 50-year flood zone. Note that the riparian areas were developed through modeling and have not been field verified. They may not be vegetated nor functional but represent areas that are most likely to provide riparian area functions if left

[68] Sweeney, B.W. and Newbold, J.D. "Streamside forest buffer width needed to protect stream water quality, habitat, and organisms: a literature review." JAWRA Journal of the American Water Resources Association, 50(3), pp.560-584, 2014.

[69] Conley, A., T. Howard, and E. White. *New York State Riparian Opportunity Assessment*. New York Natural Heritage Program, State University of New York College of Environmental Science and Forestry, 2018, Albany, NY. http://nynhp.org/files/TreesForTribs2017/Statewide_riparian_assessment_final_jan2018.pdf

in a natural state or restored. There are likely many additional riparian areas along unmapped streams that occur throughout the Town. Nevertheless, the mapped riparian areas can provide a starting point to inform land use and stream protection efforts. The Hudson River Estuary Program's "Trees for Tribs" program offers free consultation and native trees and shrubs for qualifying streamside buffer planting projects in the estuary watershed.[70] Areas within the Ashokan Reservoir watershed are also eligible for the Catskill Stream Buffer Initiative (CSBI) Program through the Ashokan Watershed Stream Management Program. This program provides funding, guidance, and technical assistance for streamside landowners to improve their riparian buffers.

Trees for Tribs planting at the Thorn Preserve. Maxanne Resnick

Coldwater Stream Habitat

Trout are valuable indicators of healthy aquatic ecosystems because of their habitat requirements of cold and high-quality water. Trout become thermally stressed when the water temperature rises above 70°F. They typically inhabit clear, cool, well-oxygenated streams and lakes and depend on clean gravel areas for spawning. DEC's Water Quality Standards provide a starting point for identifying trout or trout-spawning stream habitat and suggest there is coldwater habitat suitable for trout throughout many of Woodstock's streams, and for trout-spawning along the Beaver Kill and upper Sawkill. Among trout species, native brook trout are the most highly sensitive to increases in water temperature and sedimentation of stream habitats. The Stream Habitats Map identifies important areas for coldwater stream habitat mapped by the New York Natural Heritage Program based on known populations of wild brook trout. The Beaver Kill and its tributaries and Warner Creek are mapped as sensitive coldwater stream habitat supporting populations of wild brook trout.

[70] "Hudson River Estuary Trees for Tribs Program." NYS DEC Hudson River Estuary Program. http://www.dec.ny.gov/lands/43668.html

Coldwater streams are in decline region-wide due to habitat loss, degradation, and fragmentation from stream barriers. Other threats to wild brook trout include the introduction of exotic species such as smallmouth bass and non-native trout, which are better adapted to warm water temperatures. Mapped areas include lands most likely to contribute to the continued presence and quality of coldwater stream habitat supporting brook trout. Note that this map does NOT indicate areas with public fishing rights, and many areas are unsuitable for recreational trout fishing due to small fish populations and small fish size.

Dams and Culverts

Infrastructure in streams, such as dams and culverts, can create barriers that isolate and severely limit the range of fish and other aquatic organisms that use stream corridors. Dams and culverts can present physical barriers to passage, and these structures can also become impassable by changing water quality (e.g. temperature) and hydraulics (e.g. high velocity). Dams can also cut off streamflow to downstream reaches during dry periods, especially common when the water behind the dam is used, consumed, or diverted for other purposes (e.g., drinking water supply). Stream barriers disconnect and decrease available habitat to aquatic organisms. Protecting and restoring free-flowing streams where possible generally benefits stream habitat value. Bridges, open-bottom culverts and similar structures that completely span the waterway and associated floodplain/riparian area generally have the least potential impacts on stream hydrology, floodplains, and habitat.

Dam locations shown on the map are provided from the New York State Inventory of Dams. While the DEC tries to maintain an accurate inventory, this data should not be relied upon for emergency response decision-making. Note that assessments by the DEC Hudson River Estuary Program in trial watersheds indicate that perhaps two to three times as many barriers exist than are recorded in the NYS Inventory of Dams.

Road-stream crossings are provided for the Ashokan watershed from the Ashokan Watershed Stream Management Program and are classified according to aquatic organism passage (AOP) rating as developed by the North Atlantic Aquatic Connectivity Collaborative. Assessment of stream crossings in the lower Esopus Creek watershed portion of the Town is underway in 2020 and is described further under the Special Flood Hazard Areas section of this report.

Wetlands (Map 15)

Wetlands are areas saturated by surface or groundwater sufficient to support distinctive vegetation adapted for life in saturated soil conditions.[71] There are many types of freshwater wetlands in Woodstock, including wet meadows, emergent marsh, forested and shrub swamps, intermittent woodland pools (vernal pools), constructed ponds, a circumneutral bog lake, and open water. In addition to providing critical habitat for many plants and animals, wetlands help to control flooding and reduce damage from storm surge, recharge groundwater, filter and purify surface water, and provide recreation opportunities. The buffer area surrounding a wetland is essential to its survival and function. When natural wetland buffers are encroached on by development including buildings, lawns, and pavement, the habitat quality and other values of the wetland are often degraded.[72]

Wetlands:

- provide critical habitat
- control flooding
- reduce damage from storm surge
- recharge ground water
- filter and purify surface water
- store carbon
- provide recreational opportunities

The Wetlands Map shows information from the town-wide Habitat Map completed by Hudsonia in 2012 (see Habitats, Map 17 for detail).[73] Open water habitats are symbolized in blue as waterbodies. New York State Regulated Freshwater Wetlands are typically limited to wetlands larger than 12.4 acres. The Habitat Map was developed based on remote interpretation of air photos, soil and topographic maps, as well as extensive field verification. It is likely to be much more accurate than the NYS regulatory wetlands map or other maps such as the National Wetlands Inventory. Nevertheless, it should be considered approximate and is not a substitute for field verification and professional wetland delineation.

County soil maps are also a good source for predicting the location of potential wetlands. Soils classified in the county soil survey as very poorly drained or poorly drained are good indicators of probable wetland areas, and soils classified as somewhat poorly drained may indicate possible wetland areas (see Soils section for further discussion of soil properties).[74] The probable and possible wetland areas cover a greater area than Hudsonia and NYS regulatory wetland layers. Note that soil units are only mapped to an approximate area of about two acres, and that soils within the unit may not be homogeneous. Areas

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[71] "Wetlands." NYS Department of Environmental Conservation. https://www.dec.ny.gov/lands/305.html

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

[73] Haeckel, I.B., O. Vazquez Dominguez, and G. Stevens. *Significant Habitats in the Town of Woodstock, Ulster County, New York: Report to the Town of Woodstock, the New York State Department of Environmental Conservation, the Ashokan Watershed Stream Management Program, and the Catskill Watershed Corporation, 2012*. https://townwoodstock.digitaltowpath.org:10111/content/Generic/View/24

[74] Kiviat and Stevens, 2001.

shown as supporting probable or possible wetlands should always be verified in the field for the purposes of environmental review.

Woodstock's Wetlands

A variety of wetlands large and small are found throughout Woodstock. Riverine wetlands are common and occur within the floodplains of the Sawkill, Beaver Kill, and Little Beaver Kill and their tributaries. The largest contiguous wetlands area in the Town extends from Yankeetown Pond west along the Little Beaver Kill, an area that has been shaped by extensive beaver activity resulting in a diversity of swamps, marshes, open water, and wet meadow habitats. A large wetland complex is also located in the floodplain along the Beaver Kill between Route 212 and Sickler Road. East of the Woodstock hamlet, a high density of small wetlands in a relatively connected landscape also forms a number of wetland complexes. NY-Special Concern spotted turtle was observed in Woodstock by Hudsonia biologists and is a species that moves seasonally between nearby wetland and upland habitats and is thus highly dependent on connectivity of the complex. It is described as a focal species for conservation of wetland complexes. The Habitat Map report provides recommendations for conserving the viability of wetland complexes for spotted turtle and other wildlife.

A **wetland complex** is a group of nearby wetlands connected by intact upland habitats. Such complexes are important for many wildlife that rely on movement between different wetland and upland habitats throughout the year.

While the Town's larger wetlands are confined to valley bottoms, many additional small wetlands and seepage areas occur on mountain slopes in places where topography and geology result in a discharge of groundwater to the land surface, or in small topographic basins found on slope terraces or saddles. These wetlands are commonly small swamps embedded in large forest landscapes. Where groundwater-fed, they may serve as important water sources for a variety of wildlife during droughts and cold winters, when other water sources dry or freeze over. The Habitat Map shows mapped springs and seeps in addition to wetlands.

The Habitat Map identifies many high-quality examples of common wetland types as well as some occurrences of uncommon wetlands in Woodstock. Perhaps the most unusual, Yankeetown Pond is identified as a circumneutral bog lake (CBL). A preliminary biodiversity assessment of the pond was completed in 2019.[75] CBLs are spring-fed, calcareous waterbodies with floating peat rafts or mats supporting vegetation of acidic bogs and surrounding vegetation typical of calcareous marshes. It is an unusual habitat complex that commonly supports rare plants and animals. The pools and channels of Yankeetown Pond support an abundance of white water lilies, as well as numerous peat rafts. Kiviat states "Typically, peat rafts rise to the surface in spring or summer, buoyed by gases of decomposition in the white water-lily beds, and sink again in the fall when the water cools. Some peat rafts remain at the

[75] Kiviat, E., *Preliminary Biodiversity Assessment of Yankeetown Pond*, Town of Woodstock, Ulster County, New York. Hudsonia, Ltd., 2019.

Wetland habitat, Yankeetown Pond. Erik Kiviat

surface and develop vegetation of larger plants in subsequent years. Yankeetown Pond has peat rafts with a variable degree of vegetation development."[76] Vegetation of acidic bogs such as large cranberry and round-leaved sundew is present in the pond. Kiviat notes the potential for wildlife such as northern cricket frog, spotted turtle, musk turtle, American black duck, king rail, and pied-billed grebe. There have been no detailed surveys of the pond's flora and fauna, however. Beaver activity in Yankeetown Pond causes fluctuating water levels and has been the subject of some local controversy, as has the question of managing the abundant water lilies.

A heath swamp in Zena. Ingrid Haeckel

The Town Habitat Map also identifies 75 examples of intermittent woodland pools in Woodstock, though more likely exist.[77] An intermittent woodland pool is a small, isolated wetland in a forested setting, with standing water during winter and spring that dries up by mid- to late summer during a normal year. It is synonymous with the term "vernal pool" when located in a forested setting. Seasonal drying and the lack of a stream connection prevent establishment of fish populations, which are major predators on amphibian eggs and larvae. The pools provide important breeding habitat for a group of amphibians that spend most of their lives in the surrounding upland forest floor habitat. Some additional types of swamps were mapped with characteristics similar to intermittent woodland pools. The study mapped 27 examples of heath swamps, described as isolated wetlands with seasonal or permanent deep standing water, moss-covered woody

[76] Ibid., pg. 3.
[77] Haeckel et al., 2012.

hummocks, and a well-developed, diverse shrub layer. Three buttonbush pools were also found. They are seasonally or permanently flooded pools with abundant buttonbush growth. Wildlife records from the *NY Amphibian and Reptile Atlas* and Hudsonia biologists indicate that spotted salamander and wood frog occur in Woodstock; other vernal pool wildlife may also be present. Lyre-tipped spreadwing, a rare damselfly, has also been documented from vernal pools in Woodstock. Specific development and management recommendations are available to minimize impacts to vernal pools and associated wildlife.[78] [79]

The Wetlands Map also shows Intermittent Woodland Pool Conservation Zones recommended in the Habitat Map report. To protect pool-breeding amphibians and the habitat complex they require, Hudsonia recommends the following measures:[80]

1. Protect the intermittent woodland pool depression
2. Protect all upland forest within 100 ft of the intermittent woodland pool
3. Maintain critical terrestrial habitat within 750 ft of the pool
4. Do not channel runoff from roads and developed areas into the pool

Within the 750-ft conservation zone, Hudsonia recommends that proposed development activities:

1. Avoid or minimize the potential adverse effects of roads to the greatest extent possible
2. Maintain woodland pool water quality and quantity at pre-disturbance levels
3. Avoid creating stormwater detention basins and other artificial basins that artificially hold water
4. Modify potential pitfall hazards such as swimming pools to prevent entrapment
5. Schedule construction activities to occur outside the peak amphibian movement periods of spring and early summer

Wetland Protection

State and federal laws protect some but not all wetlands. The New York State Freshwater Wetlands Act generally regulates activities in and around large wetlands, including a 100-foot adjacent area.[81] To be protected, a wetland must be at least 12.4 acres or considered of unusual local importance, and appear on the NYS Freshwater Wetlands Map. Wetlands are classified from Class I to Class IV according to their ability to perform wetland functions and provide wetland benefits, with Class I Wetlands having the highest rank. There are four DEC mapped wetlands in Woodstock, which are also designated Critical Environmental Areas by the Town:[82]

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[78] Morgan, D. and A. Calhoun. *The Maine Municipal Guide to Mapping and Conserving Vernal Pools*. University of Maine, Sustainability Solutions Initiative, 2012, Orono, ME. http://www.vernalpools.me/wp-content/uploads/2015/06/Maine-Municipal-Guide-to-Mapping-and-Conserving-Vernal-Pool.pdf

[79] Calhoun, A. and M. Klemens. *Best development practices: Conserving pool-breeding amphibians in residential and commercial developments in the northeastern United States*. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, 2002, Bronx, New York. https://www.nae.usace.army.mil/Portals/74/docs/regulatory/VernalPools/BestDevelopmentPractices20Oct2014.pdf.

[80] Haeckel et al., 2012, pgs. 88-90.

[81] "Freshwater Wetlands Program." NYS Department of Environmental Conservation. http://www.dec.ny.gov/lands/4937.html

[82] "Critical Environmental Areas." NYS Department of Environmental Conservation.

- Yankeetown Pond
- Little Beaver Kill
- Bradley Meadows
- Wittenberg Sportsmen's Club Pond

The U.S. Army Corps of Engineers regulates wetlands of all sizes in New York under section 404 of the Clean Water Act.[83] However, to be protected, wetlands must generally have a surface water connection to a navigable waterway. Since federal wetlands do not appear on any regulatory maps, it is incumbent on the landowner and the Building Inspector's office to identify the potential presence of a wetland during the review process for a development proposal. Where a federal wetland is indicated, notification to the Corps is required and delineation and a permit may be necessary.

Vernal pools and other isolated wetlands less than 12.4 acres are generally unprotected by state or federal wetland regulations.[84]

In 2011, Woodstock adopted local wetland and watercourse protection regulations (§260-34) to promote comprehensive watershed protection in the Town, including protection for wetlands and wetland buffer areas not currently regulated under state and federal laws. A permit is required for all activities listed in §260-34C of the Town code. Wetland buffer areas are also subject to the regulations. A buffer of 100 feet from the wetland boundary is regulated for wetlands greater than 1/10 of an acre; smaller wetlands have a 50-ft regulated buffer area. Artificial ponds of less than 1/10 of an acre are exempt from the regulations provided that their creation/ maintenance does not interfere with existing wetlands, waterbodies, or watercourses. Individuals wishing to conduct an activity in or near a regulated area under these standards must file a request for a wetland and watercourse permit determination with the Town of Woodstock Building Department or Planning Board Office. Based on this form and a site visit if needed, the Town Wetland Inspector will determine whether a permit is needed.

https://www.dec.ny.gov/permits/6184.html

[83] "Section 404 of the Clean Water Act." United States Environmental Protection Agency. https://www.epa.gov/cwa-404

[84] "Woodland Pool Conservation." NYS Department of Environmental Conservation. https://www.dec.ny.gov/lands/52325.html

Section 5: Habitats and Wildlife

Landscape Context (Map 16)

The first step to understanding habitats in Woodstock is to consider the Town's larger ecological context. The Landscape Context Map helps illustrate the major ecological features in Woodstock extending beyond the Town's borders, including habitat areas that have been identified as significant at inter-municipal, regional, and statewide level.

Significant Biodiversity Areas

Most of Woodstock north and west of the hamlet lies within the Catskill Mountains, a Significant Biodiversity Area (SBA) recognized in DEC's *Hudson River Estuary Wildlife and Habitat Conservation Framework.*[85] SBAs are areas with a high concentration of biological diversity or value for regional biodiversity.

> The ecological significance of the Catskill Mountains relates to its large, continuous forest and pristine headwater stream habitats, and the species dependent on these habitats.

According to the *Framework,* "the Catskill Mountains contain major unfragmented forests, including first growth forest, as well as alpine communities, gorges, pristine headwater streams, and reservoirs; the area supports regionally significant populations of forest interior nesting birds, bald eagle, large mammals, coldwater fish, reptiles, and rare communities and plants…. Exemplary occurrences of a number of significant communities can be found in the Catskills. Examples include many ecologically significant cliff and ledge communities associated with steep-sided ravines, and exemplary occurrences of red maple-tamarack peat swamp and hemlock hardwood swamp…. The Catskills are home to more than 120 species of breeding birds including the rare Bicknell's thrush and several regionally rare raptors.... Other important animals that live in the Catskills include regionally rare reptiles and amphibians such as timber rattlesnake, eastern hognose snake, spotted turtle, wood turtle and spotted salamander, and several large mammals such as black bear, bobcat, and fisher. Black bear and bobcat depend on the large tracts of unbroken forest that this region provides."[86]

The *Framework* identifies the protection of riparian and upland habitat in the valleys, old growth forests, and habitats of rare plants and animals as the highest conservation priorities in the Catskills.

Matrix Forests

Over 63,000 acres of forest span the Indian Head range in Woodstock and neighboring Hunter. These are some of the largest intact areas of forest in New York and are considered globally significant. The Nature Conservancy and New York Natural Heritage Program have also identified these areas as "matrix

[85] Penhollow, M., P. Jensen, and L. Zucker. *Wildlife and Habitat Conservation Framework: An Approach for Conserving Biodiversity in the Hudson River Estuary Corridor.* New York Cooperative Fish and Wildlife Research Unit, Cornell University and New York State Department of Environmental Conservation, Hudson River Estuary Program, 2006, Ithaca, NY. https://www.dec.ny.gov/docs/remediation_hudson_pdf/hrebcf.pdf

[86] Ibid., pp 63-66

forests," large enough to withstand major natural disturbances, maintain important ecological processes, and support populations of forest-interior wildlife and plants.[87] These attributes are discussed further in the Large Forests section.


Forest. Kelly Sinclair

Important Bird Area

The National Audubon Society has identified the 300,000-acre Catskill Peaks area including northern Woodstock as an area of global importance for forest birds.[88] An ornithological summary of the area from Audubon states: "The Catskill peaks over 3,000 feet support a distinctive sub-alpine bird community including breeding Yellow-bellied Flycatchers, Swainson's Thrushes, Hermit Thrushes, Magnolia Warblers, Yellow-rumped Warblers, White-throated Sparrows, and Dark-eyed Juncos. Peaks over 3,500 feet support breeding Bicknell's Thrushes and Blackpoll Warblers. This is the southernmost extension of the breeding range of these two species.… Other at-risk species found at the site include the American Black Duck (breeds), Osprey (breeds), Bald Eagle (observed in breeding season), Sharp-shinned Hawk (breeds), Cooper's Hawk (breeds), Northern Goshawk (breeds), Red-shouldered Hawk (breeds), Peregrine Falcon (breeds), American Woodcock (breeds), Olive-sided Flycatcher (breeds), Wood Thrush (breeds), Cerulean Warbler (breeds), and Canada Warbler (breeds)."

Scarlet Tanager. Ed Lam

By visualizing how natural resources extend beyond political boundaries, local leaders can better understand the context and potential implications of local decisions on the larger landscape. Consideration of habitat connectivity and potential for wildlife corridors during local planning and review can help ensure that plants and animals will be able to respond to shifting habitat suitability in response to climate change, habitat fragmentation, and other human disturbance. Whether at the site scale or town-wide level, understanding a site's landscape context can help guide new development to avoid impacts to major ecological features.

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[87] Anderson, M. and S. Bernstein (editors). *Planning methods for ecoregional targets: Matrix forming ecosystems.* The Nature Conservancy, Conservation Science Support, Northeast & Caribbean Division, 2003, Boston, MA.

[88] Audubon Society. Catskill Peaks Important Bird Area, http://www.audubon.org/important-bird-areas/catskills-peaks-area

Habitats (Map 17)

From 2011-2012, biologists with Hudsonia Ltd. mapped ecologically significant habitats in the Town of Woodstock.[89] The project report describes each of the 22 mapped habitat types, including their ecological attributes, some of the species of conservation concern they may support, and their sensitivities to human disturbance. The report also addresses conservation issues related to the habitats and provides conservation recommendations. Guidance is provided for how to use the habitat information to review site-specific proposals and for town-wide planning and decision-making.

Red-Spotted Newt. Bennet Ratcliff

The project used a combination of map analysis (including topographic, geology, and soil maps), aerial photo interpretation, and field observations to map habitats. Approximately 20,800 acres in Woodstock were field checked during the project, representing over half of the undeveloped land in the Town. Field visits were used to verify the presence, general characteristics, quality, and extent of habitats, and to identify habitats that could not be identified remotely. Some basic field notes are embedded in the GIS data from the project, and field work contributed to the general habitat descriptions in the report. Although the habitat map was carefully prepared and extensively field-checked, there are inevitable inaccuracies in the final map. Because of this, the map is considered suitable for general land-use planning, but not suitable for detailed planning and site design, or for jurisdictional determinations (e.g., for wetlands). Boundaries of wetlands and other habitats depicted are only approximate.

Eastern Box Turtle. Daniella DeCaro

The Habitat Map is far more detailed and accurate than any other existing land cover data for Woodstock. The study found that approximately 12% of the Town is developed, while 79% is covered in upland forests, and 3% is upland meadow (including hayfields and unmanaged grassland

Monarch Butterfly. Ingrid Haeckel

[89] Haeckel, I.B., O. Vazquez Dominguez, and G. Stevens. *Significant Habitats in the Town of Woodstock, Ulster County, New York: Report to the Town of Woodstock, the New York State Department of Environmental Conservation, the Ashokan Watershed Stream Management Program, and the Catskill Watershed Corporation, 2012*. https://townwoodstock.digitaltowpath.org:10111/content/Generic/View/24

habitats). Hardwood and shrub swamps comprise 2.5% of the Town's land area. Notable findings from the project included extensive areas of unfragmented forest, examples of acidic and calcareous ledges, oak-heath barrens, a circumneutral bog lake, extensive wetlands and wetland complexes, numerous intermittent woodland pools, and miles of previously unmapped intermittent streams. Table 6 lists and describes the habitat types and corresponding acreage mapped in Woodstock. Refer to the Hudsonia report for more detailed descriptions of each habitat and associated wildlife species.

The report also identifies priority habitats for conservation and recommends conservation zones to focus protection or management efforts.[90] These include large forests >100 acres, oak-heath barrens and a 1.5-mile adjacent area, large meadows >25 acres, intermittent woodland pools and a 750-ft adjacent area, circumneutral bog lake and the 3,300-ft adjacent area, wetland complexes and a 390-ft adjacent area, and the 660-ft adjacent area along perennial streams.

Table 6. Significant Habitats in the Town of Woodstock

Name	Description	Acres
Upland Habitats		
upland hardwood forest	non-wetland forest dominated by hardwood trees (conifers make up < 25% of canopy).	18,011
upland conifer forest	non-wetland forest dominated by conifer trees (>75% of canopy).	5,698
upland mixed forest	non-wetland forest with a mix of hardwoods and conifers (conifers make up 25-75% of canopy).	10,478
crest/ledge/talus	partially or fully exposed bedrock on a summit or knoll (crest) or slope (ledge). Talus occurs where rock fragments accumulate at the base of ledges and cliffs.	19,031
oak-heath barren	open woodland with a sparse and often stunted canopy of pitch pine, oaks, and scrub oak, occurring on mountain summits or slopes with exposed bedrock and thin soils, maintained by wildfire.	31
orchard/plantation	actively maintained or recently abandoned fruit orchards, tree farms, or plant nurseries.	5
upland shrubland	open (non-forested) area with shrubs making up > 20% of ground cover.	255
upland meadow	open area dominated by herbaceous vegetation (shrubs and saplings < 20% ground cover; may have scattered trees) and either unmowed or mowed infrequently (up to a few times a year, such as a hayfield); includes pasture, cropland, abandoned fields.	1,320
cultural	open area (may have scattered trees) mowed frequently or otherwise managed in an intensive way (lawn, playing field, golf course, garden, park, cemetery).	177

[90] Ibid. See Table 2, pg. 71.

Name	Description	Acres
waste ground	land that has been severely altered by human activity but lacks pavement or structures. Gravel mines, quarries, dumps, wetland fill, abandoned lots, or construction sites. Places where soil has been removed, and sometimes replaced with fill.	59
Wetland Habitats		
hardwood & shrub swamp	wetland (identified by predominance of hydrophytic vegetation) dominated by trees and/or shrubs. (conifers make up < 25% of canopy).	701
conifer swamp	wetland dominated by conifer trees or shrubs (>75% of canopy).	54
mixed forest swamp	wetland with a mix of hardwood and conifers trees and/or shrubs (conifers make up 25-75% of canopy).	315
intermittent woodland pool	small, isolated, seasonally flooded pool, generally with an open basin, surrounded by forest.	6
circumneutral bog lake	spring-fed, calcareous waterbody with floating peat mats supporting vegetation of acidic bogs and surrounding vegetation typical of calcareous marshes.	131
marsh	wetland dominated by hydrophytic herbaceous vegetation that stays saturated/flooded most of the time.	26
wet meadow	area of seasonally saturated or flooded soils dominated by hydrophytic herbaceous vegetation.	194
calcareous wet meadow	a wet meadow strongly influenced by calcareous groundwater or soils favoring establishment of a calcicolous plant community.	13
constructed pond	manmade body of water with a mostly managed shoreline (bordered by developed or cultural areas).	300
open water	body of water (natural or manmade) with a mostly undeveloped shoreline.	21
spring/seep	places where groundwater discharges to the surface at a single point (spring) or diffusely (seep).	360
intermittent stream	stream that has flow at least part of the year, including man-made ditches.	n/a
perennial stream	stream that generally flows year-round.	n/a

Important Biodiversity Areas (Map 18)

The Important Biodiversity Areas Map highlights the most significant ecological features in Woodstock based on existing records of rare species and significant natural communities from the New York Natural Heritage Program (NYNHP). NYNHP is a partnership between NYS DEC and SUNY ESF, with a mission to monitor and conserve New York State's rare plants, animals and habitats. Note that many areas have yet to be formally surveyed, and additional study may reveal other important occurrences in the Town.

Timber rattlesnake is a NY-Threatened species that inhabits rocky summits and surrounding forests of Woodstock. During summer months, males travel 1.3 to 2.5 miles from den sites. The species is imperiled due to loss and disturbance of habitat, illegal collection, and malicious killing.

Contrary to popular opinion, a rattlesnake will not pursue or attack a person unless threatened or provoked.

Significant Biodiversity Areas

Most of Woodstock north and west of the hamlet lies within the Catskill Mountains Significant Biodiversity Area, described under the Landscape Context section of this report. The extensive forests and pristine headwater streams of the Catskills support regionally significant populations of forest interior nesting birds, bald eagle, large mammals, coldwater fish, reptiles, and rare communities and plants.

Timber Rattlesnake on Overlook Mountain. Catskill Mountaineer

Significant Natural Communities

NYNHP has mapped several occurrences of high quality and/or uncommon natural communities in Woodstock. These are based on a more detailed classification of habitats than used in the Hudsonia habitat study. A large swath of chestnut oak forest is mapped along the Catskill escarpment and Mount Guardian in Woodstock, with noted excellent habitat and species diversity. An excellent example of cliff community is also found along the escarpment, known locally as "the Minister's Face." Chestnut oak transitions to a high-quality beech-maple mesic forest heading west into the interior Catskills. Hemlock-northern hardwood forest is interspersed and found predominantly in steep ravines up to the mid-slope of associated mountains. Pitch pine-oak-heath rocky summits are present on the summits of Ticetonyk and Tonshi mountains, primarily in the neighboring Town of Olive. A moderate-size complex of vernal pools in good condition is also mapped in the Bluestone forest. Additional vernal pools mapped by Hudsonia are also shown on the preceding Habitat Map. The following list of mapped communities includes links to online conservation guides:

- Beech-Maple Mesic Forest - https://guides.nynhp.org/beech-maple-mesic-forest/
- Chestnut Oak Forest - https://guides.nynhp.org/chestnut-oak-forest/
- Cliff Community - https://guides.nynhp.org/cliff-community/
- Hemlock-Northern Hardwood Forest - https://guides.nynhp.org/hemlock-northern-hardwood-forest/
- Pitch Pine-Oak-Heath Rocky Summit - https://guides.nynhp.org/pitch-pine-oak-heath-rocky-summit/
- Vernal Pool - https://guides.nynhp.org/vernal-pool/

Known Important Areas for Rare Animals

Woodstock is home to abundant wildlife common to the temperate northeastern United States, such as deer, wild turkey, bears, and coyotes. The Town also supports populations of several rare animals of conservation concern in New York. NYNHP has identified important areas for sustaining populations of the animals listed below based on documented occurrences in the Town.[91] These areas include the specific locations where a species has been observed, the adjacent habitat, as well as areas critical to maintaining the quality or integrity of the animal's habitat. Proactive planning that considers how species move across the landscape, with careful attention to maintaining connected habitat complexes, will contribute to the long-term survival of rare species. A complete list of species of conservation concern known from Woodstock is shown in Table 7. To request more information about rare species occurrences, visit http://www.dec.ny.gov/animals/31181.html or e-mail NaturalHeritage@dec.ny.gov.

Lyre-tipped spreadwing is a rare damselfly known to inhabit small ponds, marshy wetlands, and vernal pools, and has been documented in the Bluestone forest.

NY-Endangered **peregrine falcon** was extirpated from the state in the 1960s by DDT and PCB poisoning but has been steadily recovering in New York since 1983. Nesting is documented in Woodstock. Threats include habitat disturbance and loss, human recreation disturbance near nests, nest poaching, shooting by hunters, and effects of contamination.

NY-Threatened **timber rattlesnake** inhabits forests in mountainous terrain with rock outcroppings, steep ledges, and rockslides. They migrate widely from their dens in summer to forage in the forest surrounding den sites. Extensive forest, ledges, and rocky barrens of the Catskill Mountains provide habitat for timber rattlesnakes, which occur in several areas of the Town. Timber rattlesnakes are threatened due to habitat loss and fragmentation, illegal collecting, and malicious killing.

NY-Special Concern **wood turtle** lives primarily along low gradient perennial streams and may spend time in adjacent forests and grasslands. Wood turtle has been documented in riparian settings in Woodstock and is threatened by habitat loss, stream degradation, nest predation, and the pet trade.

[91] New York Natural Heritage Program and New York State Department of Environmental Conservation, Biodiversity Databases [Accessed July 1, 2020], Important Areas Digital Data Set, 2018, Albany, NY.

NY-Endangered **Indiana bat** and other at-risk bats may travel long distances from their winter hibernacula during the summer months, using forested areas and stream corridors for shelter and foraging for insect prey. Female bats roost in trees and snags in maternity colonies to raise their young. Existing restrictions on tree cutting aim to protect threatened bat species, especially during the period when mothers are birthing and raising pups. Rare bat foraging areas depict potential Indiana Bat summer habitat areas in Woodstock. DEC recommends restricting any tree-cutting activities to the winter months (November 1-March 31) in areas occupied by protected bats to avoid direct impacts to the species.

In addition to these mapped important areas for rare animals, Hudsonia biologists also identified occurrences in Woodstock of NY-Special Concern eastern box turtle and spotted turtle. Hudsonia recommended a 390-ft conservation zone for spotted turtle around wetland complexes to protect potential nesting habitat.[92]

Note: Rare animals may occur in more locations than are currently known. Contact the DEC Region 3 Office at 845-256-3098 with any concerns or questions about protected species in Woodstock.

Wood turtle. Ingrid Haeckel

Spotted turtle. Laura Heady

[92] Haeckel et al. *Significant Habitats in the Town of Woodstock, Ulster County, New York, 2012*, pg. 96.

Table 7. Species of Conservation Concern in the Town of Woodstock

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

			NYS Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Hudson River Valley Priority Bird	Species of Greatest Conservation Need xx = high priority	Special Concern	Threatened	Endangered	**Data Source**
Mammals								
Indiana bat	*Myotis sodalis*	cave, forest		xx			US NY	NYNHP
little brown bat	*Myotis lucifugus*	cave, forest, wetland		xx				DEC
northern long-eared bat	*Myotis septentrionalis*	cave, forest		xx		US NY		DEC
tri-colored bat	*Perimyotis subflavus*	cave, forest, stream		xx				DEC
Birds								
American black duck	*Anas rubripes*	wetland	x	xx				NYBBA
American goldfinch	*Spinus tristis*	young forest, shrubland	x					NYBBA
American kestrel	*Falco sparverius*	meadow	x	x				NYBBA
American redstart	*Setophaga ruticilla*	forest	x					NYBBA

			NYS Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Hudson River Valley Priority Bird	Species of Greatest Conservation Need xx = high priority	Special Concern	Threatened	Endangered	**Data Source**
American woodcock	*Scolopax minor*	young forest, shrubland	x	x				NYBBA
bald eagle	*Haliaeetus leucocephalus*	lake, stream, forest	x	x		NY		NYBBA
Baltimore oriole	*Icterus galbula*	forest	x					NYBBA
belted kingfisher	*Megaceryle alcyon*	lake, stream	x					NYBBA
black-and-white warbler	*Mniotilta varia*	forest	x					NYBBA
black-billed cuckoo	*Coccyzus erythropthalmus*	young forest, shrubland	x	x				NYBBA
Blackburnian warbler	*Dendroica fusca*	forest	x					NYBBA
black-throated blue warbler	*Dendroica caerulescens*	forest	x	x				NYBBA
black-throated green warbler	*Dendroica virens*	forest	x					NYBBA
blue-winged warbler	*Vermivora pinus*	young forest, shrubland	x	x				NYBBA
broad-winged hawk	*Buteo platypterus*	forest	x					NYBBA
brown thrasher	*Toxostoma rufum*	young forest, shrubland	x	xx				NYBBA
cerulean warbler	*Dendroica cerulea*	forest	x	x	x			NYBBA
chestnut-sided warbler	*Setophaga pensylvanica*	young forest, shrubland	x					NYBBA
chimney swift	*Chaetura pelagica*	urban	x					NYBBA
common nighthawk	*Chordeiles minor*	mixed/urban	x	xx	x			NYBBA
Cooper's hawk	*Accipiter cooperii*	forest	x		x			NYBBA

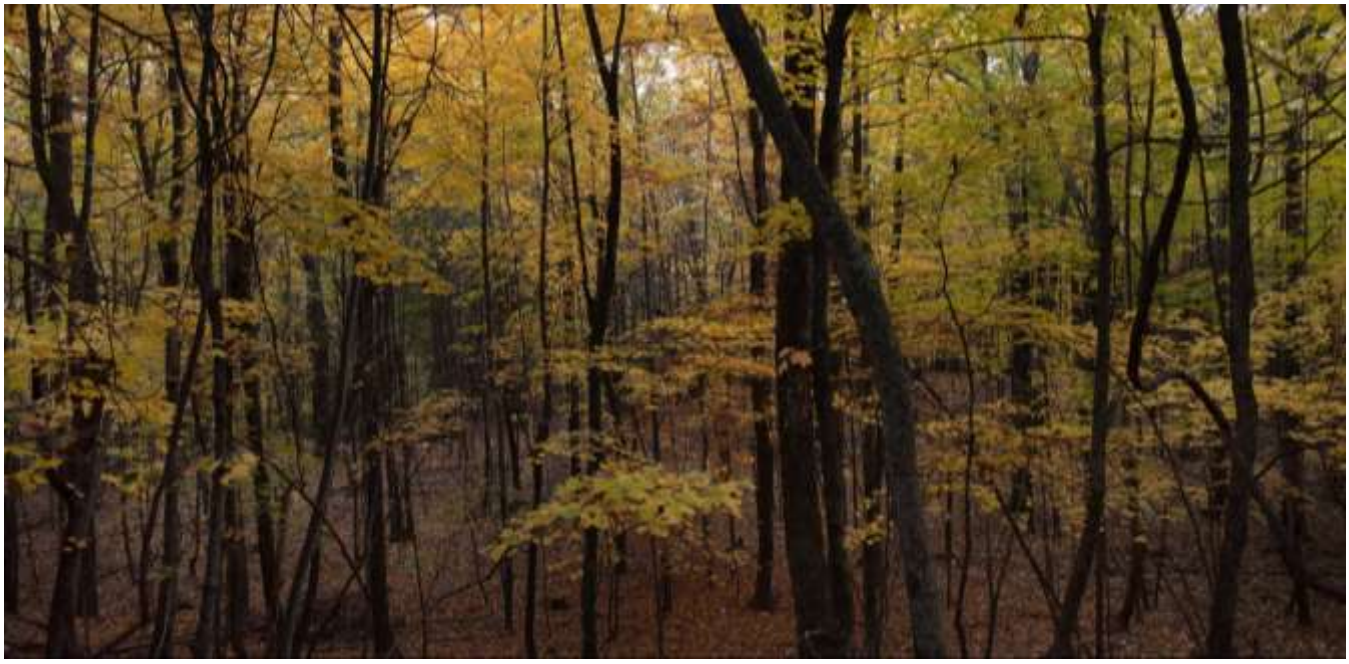
			NYS Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Hudson River Valley Priority Bird	Species of Greatest Conservation Need xx = high priority	Special Concern	Threatened	Endangered	**Data Source**
downy woodpecker	*Picoides pubescens*	forest	x					NYBBA
eastern kingbird	*Tyrannus tyrannus*	young forest, shrubland	x					NYBBA
eastern towhee	*Pipilo erythrophthalmus*	young forest, shrubland	x					NYBBA
eastern wood-pewee	*Contopus virens*	forest	x					NYBBA
field sparrow	*Spizella pusilla*	young forest, shrubland	x					NYBBA
least flycatcher	*Empidonax minimus*	forest	x					NYBBA
Louisiana waterthrush	*Seiurus motacilla*	forest	x	x				NYBBA
northern flicker	*Colaptes auratus*	forest	x					NYBBA
osprey	*Pandion haliaetus*	open water, wetland	x		x			NYBBA
peregrine falcon	*Falco peregrinus*	cliff	x	x			NY	NYBBA
purple finch	*Carpodacus purpureus*	forest	x					NYBBA
red-shouldered hawk	*Buteo lineatus*	forest	x	x	x			NYBBA
rose-breasted grosbeak	*Pheucticus ludovicianus*	forest	x					NYBBA
ruffed grouse	*Bonasa umbellus*	young forest, shrubland	x	x				NYBBA
scarlet tanager	*Piranga olivacea*	forest	x	x				NYBBA
sharp-shinned hawk	*Accipter striatus*	forest	x		x			NYBBA
veery	*Catharus fuscescens*	forest	x					NYBBA

			NYS Conservation Status					
Common Name	**Scientific Name**	**General Habitat**	Hudson River Valley Priority Bird	Species of Greatest Conservation Need xx = high priority	Special Concern	Threatened	Endangered	**Data Source**
whip-poor-will	*Caprimulgus vociferus*	young forest, shrubland	x	xx	x			NYBBA
willow flycatcher	*Empidonax trailli*	young forest, shrubland	x					NYBBA
wood thrush	*Hylocichla mustelina*	forest	x	x				NYBBA
yellow-throated vireo	*Vireo flavifrons*	forest	x					NYBBA
Reptiles								
eastern box turtle	*Terrapene c. carolina*	forest, young forest		xx	x			Hudsonia
eastern hogsnake snake	*Heterodon platirhinos*	forest		xx	x			NYARA
snapping turtle	*Chelydra serpentina*	wetland, stream, forest, lake		x				NYARA
spotted turtle	*Clemmys guttata*	wetland		xx	x			Hudsonia
timber rattlesnake	*Crotalus horridus*	forest, rocky summit		xx		NY		NYARA
wood turtle	*Clemmys insculpta*	stream		xx	x			NYARA
Fish								
brook trout	*Salvelinus fontinalis*	stream		x				DEC
Insects								
lyre-tipped spreadwing	*Lestes unguiculatus*	wetland, vernal pool		x				NYNHP

Large Forests (Map 19)

Forests provide numerous benefits including wildlife habitat, clean water, climate moderation, and forest products. Woodstock lies in one of the most intact forested regions of New York State and the eastern United States. Large forested areas are protected by New York State as part of the Catskill Forest Preserve and by New York City and the City of Kingston to manage drinking water supplies. The Town and the Woodstock Land Conservancy have also protected some forests. In addition, significant forest acreage remains in private ownership. There are opportunities to support and promote forest stewardship throughout the Town, and to guide future land use in ways that maintain large forest tracts and minimize impacts to interior forest habitat.

Woodstock's forests have been profoundly influenced by human land uses dating as far back as early Native American settlement in the region about 4,000 years ago.[93] Munsee Lenape settlements were concentrated along productive soils of the river valleys, but native people also used middle elevation forests for hunting, fishing, and collecting plants. Perhaps most significantly, though, they practiced repeated burning of the forests, which promoted the establishment of southern hardwood forests along the Catskill escarpment and southern edges of the Catskills, including Overlook Mountain, Ticetonyk, and Mount Tobias. Native Americans burned forests to clear them for a variety of reasons, including for better hunting, better blueberry crops, and for ease of travel. In contrast, the interior Catskills were spared from this burning regime, and maintained northern hardwood forest that is not tolerant to fire. The distribution of forest types in Woodstock today is thus a legacy of Native American burning practices over millennia.



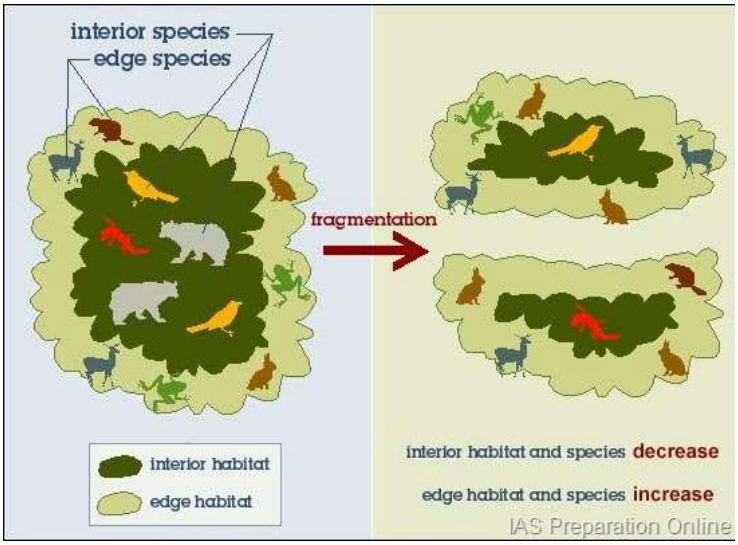
Fall Forest. Fionn Reilly

[93] Kudish, M. *The Catskill Forest: A History*. Purple Mountain Press and ColorPage, Fleischmanns and Kingston, NY, 2000, pgs. 47-48.

European settlement in the late 18th and early 19th centuries brought about an expansion of intensive land uses, including agriculture, timber harvesting, tanning, and mining. It is estimated that in the Catskills, the maximum acreage of agriculture and minimum of forest cover was achieved by the 1850s and persisted well into the 20th century. Hemlock bark-peeling for the tanning industry nearly wiped out all specimens of this species above 14 inches diameter. All in all, forest clearing was nearly complete except for the most inaccessible locations. Forests made a remarkable recovery in the 20th century and now cover approximately 79% of Woodstock. Today, introduced forest pests and diseases, overabundant deer populations, and climate change are among the greatest threats to Catskill forests, along with encroachment by new roads and development.

Forest Condition Index

Forest fragmentation occurs as large forests are divided into smaller patches by human development, and is a process linked to decreased habitat quality and health, disruptions in wildlife movement, and the spread of invasive species. These impacts are greatest at forest edges but can extend for hundreds of feet into forest patches, often displacing sensitive species that depend on interior forest. After fragmentation occurs, interior habitat, sometimes referred to as core forest, is unable to support the same diversity of species, and other ecological benefits of forests are also impacted.



Forest fragmentation is the process of breaking large patches of forest into smaller areas, often by clearing it for new roads or development. Fragmentation decreases forest habitat quality and health, disrupts wildlife movement, and facilitates the spread of invasive species.

The New York Natural Heritage Program, Cornell University, and DEC developed a Hudson Valley Forest Condition Index to map and prioritize forest patches based on a variety of metrics relating to ecosystem health or integrity. Large forest patches were first identified using forested and other woody land cover classes from the 2016 National Land Cover Database. The resulting areas represent continuous patches of forest unfragmented by major roads, railroads, and non-forest habitat, with a minimum patch size of 100 acres. The forest patches were then scored for 22 metrics related to forest condition, connectivity, stress, habitat, and other ecosystem values. These component metrics were summed to create the index and ranked according to percentile of all forest patches in the Hudson River estuary watershed.[94]

Woodstock supports some of the highest condition forests in the Hudson Valley in terms of size,

[94] Conley, A. K., E. Cheadle, and T. G. Howard. *Updating Forest Patches and a Patch Assessment for the Hudson Valley.* New York Natural Heritage Program, State University of New York College of Environmental Science and Forestry, 2019, Albany, NY. www.nynhp.org/forest-patches

connectivity, biodiversity, and carbon sequestration value. Forests of the escarpment, Overlook Mountain, and Indian Head range west to Mount Tremper, as well as forest on Mount Tobias rank among the top 1% region-wide according to the index. The Indian Head range is also recognized as a globally significant matrix forest block, shown in the Ecological Context map. In addition, forests on Ticetonyk, Mt. Guardian, and the Bluestone Wild Forest area of Zena all rank among the region's top 5% according to the index.

Core Forests

The Large Forest map also displays core forest areas, which are interior forest areas surrounded by at least a 100-meter-wide buffer of edge forest habitat. These interior forest areas support a unique array of plants and animals that are easily disturbed by human activity generally associated with more open habitats (e.g. agricultural fields, meadow, roads and developed areas). Core forest is especially important for sensitive wildlife including many forest songbirds, which avoid nesting near areas with human disturbance. Although the value of individual forest patches for wildlife depends on landscape context and other factors, core forests that are at least 500 acres in size are more likely to provide enough suitable habitat to support a diversity of interior forest species.

Core forests were mapped using the large forest patches identified for the Forest Condition Index, described above. Both data layers may be viewed and queried for attributes using the Hudson Valley Natural Resource Mapper tool.[95] Avoiding further fragmentation of core forests will help conserve the integrity and habitat value of ecologically significant forest patches.

Woodstock Forest Habitats

The Hudsonia Habitat Map provides a more detailed depiction of forest types in the Town, including the distribution of upland hardwood, mixed, and conifer forests, and forested swamps. Extensive forests of the escarpment and Catskill Mountains in the Town have also been mapped as high-quality examples of "significant ecological communities" by the New York Natural Heritage Program (see the Important Biodiversity Areas map). The following description of local forests is from the Habitat Map report:[96]

> Upland hardwood forest was the most widespread habitat type in Woodstock, and upland mixed and upland conifer forest also covered large areas. Most forests in the mountains and foothills contained rocky crest, ledge, or talus habitats…. We presume that virtually all forests in the town have been cleared or logged in the past. Only two possible 'virgin' stands remain within the town boundary, a small spruce-fir forest patch to the north of the Overlook Mountain fire tower, and the ridge-top forest of Olderbark Mountain (M. Kudish, pers. comm.)…. Most of the forests we observed were relatively mature with few invasive non-native plants. On certain crests, hardwood forests provided an open "oak woodland" habitat.... Extensive mountain laurel thickets occurred in [such] areas…on Mount Tobias, Mount Guardian, and Overlook Mountain. Most of the natural conifer forests were dominated by white pine and eastern hemlock, and most were embedded within more extensive areas of mixed forest. Eastern hemlock stands were found most commonly on acidic slopes and

[95] "Hudson Valley Natural Resource Mapper." http://www.dec.ny.gov/lands/112137.html
[96] Haeckel et al., pg. 25, 2012.

ridges, in ravines, and along perennial streams. White pine was widespread and occurred in a variety of ecological settings.

Some forest community descriptions are embedded in the GIS data for the Habitat Map, and more information about forest wildlife is provided in the report.

Wildlife records reflect the abundance of high-quality forest interior habitat in Woodstock. Summer foraging habitat for NY-Endangered Indiana bat and NY-Threatened northern long-eared bat is documented in the Town's eastern forests. The *2000-2005 NYS Breeding Bird Atlas* documented 22 forest bird species of conservation concern in the town, including NY-Special Concern cerulean warbler and many NY-Species of Greatest Conservation Need, such as scarlet tanager and wood thrush (Table 7). Three NY-Special Concern raptors were also documented in Hunter: Cooper's hawk, red-shouldered hawk, and sharp-shinned hawk. The National Audubon Society has delineated the highest priority forest bird habitat in the Catskill Peaks Important Bird Area, shown in the Ecological Context Map. In addition to birds, forests in Woodstock support rare snakes such as NY-Special Concern eastern hognose snake and NY-Threatened timber rattlesnake, which travels long distances surrounding den sites to forage during the summer. NY-Special Concern eastern box turtles also known to occur in Woodstock's forests and typically overwinter in the soil and leaf litter of the forest floor.

Forest Health

The greatest threat to forests in Woodstock today is arguably the introduction of tree diseases, forest pests, and other invasive species inadvertently brought in by people through landscaping and international commerce. Eastern Catskill forests have been significantly impacted in the recent decades by the spread of hemlock woolly adelgid and emerald ash borer, which are expected to eventually kill most large trees of these common species in the region. The Catskill Regional Invasive Species Partnership (CRISP) works to promote education, prevention, early detection and control of invasive species in the Catskills and is helping communities to prepare for and respond to this threat. Landowner education is also available through the Cornell Cooperative Extension's Agroforestry Resource Center. Guiding future development to minimize forest fragmentation will help avoid the spread of invasive species into interior forests and conserve important habitats in the Town.

Intact Habitat Cores (Map 20)

In 2013, Ulster County was selected as a case study for a collaboration with the Green Infrastructure Center (GIC) and NYS DEC to develop a methodology for mapping natural green infrastructure and create a model for replication by other counties in New York State. [97] The project was developed around a vision to "draw more focused attention to critical resource protection areas…in a meaningful, visual and accessible manner. Borne of this focused attention are initial steps to address pressing concerns and potential threats to Ulster County's critical resources as well as new recognition of great opportunities inherent in better protecting and understanding our natural assets."[98]

The GIC formed a mapping team with county staff coordinated by the Ulster County Department of the Environment and determined the key focal areas to overlay on the base map. The county staff reviewed and consulted key documents, such as the Open Space Plan; technical reports, such as those covering the Catskills and Shawangunk Ridges; and current on-going efforts such as the Greenways Plan. The GIC also consulted with key stakeholder groups, such as the Nature Conservancy, Hudsonia and the Federated Sportsmen's Club of Ulster County; local towns within Ulster County's borders; other county departments and agencies, such as Economic Development and Tourism; state and regional offices of the DEC; and the U.S. Environmental Protection Agency.

To create a map of intact habitats, a digital data layer consisting of large areas of intact habitat was created using natural land cover. Next, a layer consisting of developed lands and transportation features was overlaid to determine which areas were fragmented. Edge areas were removed to determine the amount of land that makes up the interior habitat. Following that step, the habitat cores were analyzed for additional attributes relating to size, biological and habitat diversity and water quality. Finally, based on these attributes, the cores were ranked to aid in prioritization for protection or conservation actions. Resulting intact habitat cores were ranked based on habitat size and shape, species diversity, and water quality and quantity values.

In Woodstock, Overlook Mountain and the Indian Head range are mapped as part of an "outstanding" habitat core. The Carl Mountain-Mt Tremper forest and a forest extending east of Yankeetown Pond to Acorn Hill are ranked "very high." Mt Tobias, Ticetonyk, and Mt Guardian are ranked "high" compared with other cores across the county. Several additional examples of medium and general-ranked cores are located throughout the Town. These areas represent significant natural "green infrastructure" on the landscape providing clean air and water and valuable ecological functions that are otherwise costly to replicate through engineering. Habitat cores provide pathways for wildlife, protect water and air quality, and support natural resources industries such as farming, forestry and recreation. They can be used to inform local planning and prioritization for conservation.

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[97] Firehock, K. *Evaluating and Conserving Green Infrastructure Across the Landscape: A Practitioner's Guide for New York.* Green Infrastructure Center, Charlottesville, VA, 2013. Ulster County case study available at http://www.gicinc.org/PDFs/GIC%20NY-Practitioners%20Guide-Chapter%205-reduced.pdf

[98] Ibid., pg. 87

Climate Resilience (Map 21)

Areas with diverse physical environments, complex topography, and connected habitats are most likely to support a diversity of plants and animals *today*, and into the future.

Climate change is bringing profound changes to natural communities in Woodstock. Warming temperatures and changing precipitation patterns will make conditions less hospitable for some of local flora and fauna—and more hospitable to other species, including newcomers. This process is shifting species ranges and rearranging habitats in ways that are difficult to predict. The locations of rare species or important natural communities may change. Common habitats providing important ecosystem benefits to Woodstock will also be affected. These include large, intact forests, wetlands, and stream corridors that support stormwater management, flood control, aquifer recharge, climate moderation, and carbon sequestration.

In a dynamic, changing environment, it is important to identify natural areas most likely to support biodiversity and ecological services into the future. Conserving these "strongholds" for nature will ensure that plants and animals have places to move and adapt as local climate conditions change. Conserving resilient sites for nature will also contribute to Woodstock's adaptation and resilience to flooding, extreme heat, and other climate-related hazards.

The Climate Resilience Map shows climate resilience values for biodiversity and natural areas from the Nature Conservancy's *Resilient Sites for Terrestrial Conservation*[99] and *Resilient and Connected Landscapes*[100] projects. Modeling for climate resilience was based on three primary attributes: geodiversity (diversity of physical environments), topographic complexity, and landscape connectedness. Sites that have diverse physical environments, complex topography, and connected habitats are places most likely to support a diversity of plants, animals, and habitats today and in the future.

- **Geodiversity** reflects unique combinations of geology, elevation, and landforms. Ecosystem and species diversity relate strongly to their associated geophysical settings. Conserving a range of physical environments will in turn protect a diversity of plants and animals under both current and future climates.
- **Complex topography** is important because it creates a range of temperature and moisture options for the species, providing a variety of local microclimates. Factors that create microclimates include slope, aspect (i.e., north vs south-facing), shade, and proximity to waterbodies.

[99] Anderson, M.G., M. Clark, and A. Olivero Sheldon. 2012. *Resilient Sites for Terrestrial Conservation in the Northeast and Mid-Atlantic Region*. The Nature Conservancy, Eastern Conservation Science.

[100] Anderson, M.G., Barnett, A., Clark, M., Prince, J., Olivero Sheldon, A. and Vickery B. 2016. *Resilient and Connected Landscapes for Terrestrial Conservation*. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA.

- **Connected landscapes** are places that allow species to move and disperse, and processes like water movement can occur unimpeded. Maintaining a connected area in which species can move ensures that the area can adapt to climate change.

The map also includes modeling from TNC for species movement zones and corridors connecting resilient sites. Flow refers to the gradual movement of plant and animal populations in response to changes in the climate. Population range shifts were common and widespread in past episodes of climate change and have already been detected for hundreds of plant and animal populations in response to current climate change. "Climate Flow Zones" occur in intact natural areas where high amounts of flow can spread-out and expand in many directions. These areas correspond to the least fragmented landscapes. "Climate Corridors" occur where high amounts of flow become concentrated in relatively small channels or pinch points. Climate corridors often correspond to natural ridgelines (terrestrial corridors) or relatively intact riparian and floodplain areas (riparian climate corridors) embedded in a matrix of development and agriculture. Climate corridors may connect climate flow zones or areas of confirmed biodiversity.

Escarpment Forest. Ingrid Haeckel

On the Climate Resilience Map, dark green indicates high estimated resilience. Brown indicates areas vulnerable to climate change. Woodstock is predicted to be one of the most resilient sites for biodiversity into the future owing to the presence of large, intact, high quality habitats, complex topography, and connected landscapes. With the exception of the Woodstock, Bearsville, and Zena hamlet areas, most of the Town is predicted to provide above-average resilience. The highest resilience scores are found in the Catskill Mountains and Bluestone Forest. Much of the Indian Head range and Mount Tobias are also mapped as a climate flow zone owing to the exceptionally large, intact landscape. The Bluestone Forest is mapped as a climate corridor, indicating that species mobility is more concentrated or restricted within the resilient area. These data add weight to the significance of these forested landscapes to biodiversity looking toward the future. Continued forest conservation efforts in these areas should be included within a broader climate adaptation strategy.

Section 6: Land Use

Zoning
(Refer to official Zoning map)

Cities, towns and villages in New York State are authorized by state statutes to regulate the use of land by enacting what is commonly referred to as "zoning." Zoning governs the way land in a municipality is used and developed. Its goal is to carry out the municipality's long-range land use objectives. Zoning regulates the uses to which property may be devoted, the siting of development on land, and the density of development on property. Typically, zoning laws divide the community into land use districts and establish building restrictions regarding building height, lot area coverage, the dimension of structures, and other aspects of building and land use.

To access Woodstock's Zoning Code one can visit https://ecode360.com/8008828, which includes the definitions for the Town's varied zoning districts. Additionally, pages 40 to 42 of Woodstock's 2018 Comprehensive Plan contain comments related to both the zoning code and its enforcement.

Most significant to natural resource protection in Woodstock, the Town has adopted "Scenic Overlay" and "Wetlands and Watercourses Protection Standards" laws. These unique laws represent the value Woodstockers place on their mountain views and the importance of water quality and water quantity protection, and the value of wetlands, buffers and floodplains for climate resiliency. The complete laws can be accessed in the Zoning Code and are briefly described here.

The Town's **Scenic Overlay District** provides for special permit review of all development at an elevation greater than 1,200 feet above sea level. It serves to mitigate the visual impact of such development, and includes specific requirements related to outdoor lighting, reflective glass, color and materials used in exterior structure, and disallows tree removal except for driveway and septic. For complete details applicants should consult the Town's Scenic Overlay handbook. See the Topography map for a depiction of areas located above 1,200 feet elevation in the Town.

Adopted in 2011, the Town's **Wetlands and Watercourses Protection Standards** aim to protect the Town's water resources and assure clean and abundant water in its lakes, ponds, wetlands and streams. A process was created where the applicant completes and submits a "Wetland Watercourse Determination Form" obtained from the Buildings Department for their project, which is then reviewed by the Town Planning Board and regulated by the Building Department.

Examining the zoning map in relation to other maps of the Natural Resources Inventory can provide insight into potential development scenarios that could affect the existing natural resource base, ecology, and other significant features. This map is also useful when placed in relation to the other NRI maps when making decisions about how to update the comprehensive plan and zoning districts.

Environmental Permits (not mapped)

State and federal agencies regulate many types of facilities to maintain environmental quality and public health. The New York State Department of Environmental Conservation (DEC) has created an online web map, the DECinfo Locator, which provides digital access to regularly updated DEC documents and public data about the environmental quality of specific sites. There are a few permits issued throughout Woodstock for wastewater treatment, dams, bulk petroleum or other storage, air pollution, and more. Visit the DECinfo Locator for details.

SPDES Permit Sites
New York's State Pollutant Discharge Elimination System (SPDES) program is intended to control surface wastewater and stormwater discharges in accordance with the Clean Water Act. Permits are required for constructing or using an outlet or discharge pipe (i.e., a "point source") discharging wastewater to surface waters or ground waters of the state and disposal systems such as a sewage treatment plant.[101]

Petroleum Bulk Storage Facility
These locations are regulated under the NYS Petroleum Bulk Storage (PBS) program, which applies to facilities that store more than 1,100 gallons of petroleum in aboveground and underground storage tanks.[102]

Active or Reclaimed Mine
These are regulated sites in the mining and oil and gas industries. At the time of writing, there are no active mines in Woodstock. Several reclaimed mines are present, and numerous unmapped 19th-century bluestone mines are located throughout the Town.[103]

Understanding these sites in relation to other maps in the Natural Resource Inventory can provide insight into possible threats (i.e., pollution) to natural resources and other significant features in Woodstock.

[101] "State Pollutant Discharge Elimination System (SPDES) Permit Program." NYS Department of Environmental Conservation. https://www.dec.ny.gov/permits/6054.html.
[102] "Bulk Storage of Chemicals, Petroleum, and Liquefied Natural Gas." NYS Department of Environmental Conservation. https://www.dec.ny.gov/chemical/287.html.
[103] "Mining and Reclamation." NYS Department of Environmental Conservation. https://www.dec.ny.gov/lands/5020.html.

Agricultural and Forestry Resources (Map 22)


Longyear Farm. Maxanne Resnick

The Agricultural Resources Map shows the distribution of high-quality farmland soils, designated agricultural districts, and properties receiving a property tax exemption for forest management in Woodstock.

Soils

Successful agriculture requires quality soils. High quality soils require small fertilizer and nutrients inputs, leading to lower costs and higher production rates. Prime Farmland Soils are defined by the USDA and New York State and considered the most productive soils for farming. Farmland Soils of Statewide Importance are soils that do not meet all criteria for Prime Farmland. Though not as productive as Prime Farmland, if managed properly, these soils can produce fair to good yields.

Prime Farmland soils in Woodstock are limited in extent, concentrated along river valleys. They consist primarily of Barbour loam, Castile gravelly silt loam, Haven loam, Lackawanna flaggy silt loam, Tunkhannock gravelly loam, and Unadilla silt loam.

Tax Exemptions and Agricultural Districts

County agricultural district designation entitles landowners to a mix of incentives aimed at preventing the conversion of farmland to non-agricultural uses. Agricultural tax exemptions limit local property tax liability to a prescribed agricultural assessment value.

Though Woodstock was largely an agricultural community 100 years ago, few farms remain today. Table 8 lists current operating farms in Woodstock and their products.

The **NYS Agricultural Districts Law** allows for state review of local laws affecting farms located within an agricultural district. In cases where a local law is determined to be unreasonable, the NYS Department of Agriculture and Markets will work with the local government to develop mutually acceptable alternatives.

Table 8. Farms in the Town of Woodstock

Name	Address	Acres	Agricultural Products
Lenny Bee's	403 Wittenberg Rd	10	smoked Fish, honey, sulfite free wine, jelly, propolis
Longyear Farm	42 Schoonmaker Ln	36	eggs, honey, maple syrup; turkeys, garlic
Reynolds Farm	85 Wittenberg Rd	13	eggs, maple syrup, maple products, honey, blueberries
Zena Farmstead	403 Zena Rd	11	organic vegetables, eggs, chicken, and lamb

Understanding the distribution of these agricultural resources should be an important consideration in local planning and development management processes. Growing food locally can benefit the local economy, the environment, and the health and welfare of the community if sustainable agricultural practices are used. In addition to providing the community with a local source of crops, livestock, and economic benefits, farmlands can also serve as an important source of food and cover for wildlife, and provided certain practices are used, can help control flooding and protect wetlands and watersheds. Farmland also contributes to scenic beauty and open space.

Forestry Lands

Approximately 79% of Woodstock is forested, much of it in private ownership. The ability of private forest landowners to periodically harvest timber or other forest products provides an important source of income that can help landowners avoid subdivision of land or conversion to non-forest uses. Working forests also contribute to the local economy and demand very little in the way of community services in return for the property taxes their owners pay. DEC's Municipal Guide to Forestry in New York State offers guidance to encourage local governments to actively support and promote multiple forest uses and stewardship of the land.[104]

To encourage the long-term management of woodlands to produce forest products, the State of New York in 1974 enacted the 480-a forest tax law to qualifying owners. Any tract of forest land is eligible if it consists of at least 50 contiguous acres, exclusive of any portion not devoted to the production of forestry. Participants must commit land to the production of forest crops and to follow a management plan, prepared by a forester and approved DEC, for the next succeeding ten years beginning each year that they receive a tax exemption. The Agricultural and Forestry Resources Map shows tax parcels enrolled in the 480-a program at the time of writing in 2020. A total of 23 parcels were enrolled, with 1,385 acres committed to the program. More information about the 480-a program is available at https://www.dec.ny.gov/lands/5236.html.

Additional properties may be managed for forestry without enrollment in 480-a. All private, non-industrial, forest landowners who are looking for introductory management and technical advice are eligible for a free visit with a DEC forester. More information about DEC's Forest Stewardship Program is available at https://www.dec.ny.gov/lands/4972.html.

[104] Daniels, K.H. 2005. *A Municipal Official's Guide to Forestry*. A joint publication of the New York Planning Federation, Department of Environmental Conservation, and Empire State Forest Products Association. Albany, NY. Available at: http://www.dec.ny.gov/docs/lands_forests_pdf/guidetoforestry.pdf

Conservation and Public Lands (Map 23)

Woodstock's 2018 Comprehensive Plan captured survey results from more than 700 residents, with 94% responding that natural surroundings are the top reason for their attraction to the Town. The protection of water and natural resources, water quality, and open space were the survey respondents' top priorities. Woodstockers thrive on the Town's natural surroundings; access to parks and open space within this community brings substantial social, environmental, economic, and health benefits.[105] Providing opportunities to enjoy the region's natural beauty has also long inspired our many local artists, and has offered for others cherished relaxation and locales for exercising. Additionally, conservation of lands leads to improved habitat, helps manage water and air quality, supports climate resiliency, and can help lessen flooding impacts.

A variety of parks, preserves, and other protected lands in the Town were mapped utilizing data provided from Ulster County, The New York City Department of Environmental Protection (DEP), and the Woodstock Land Conservancy, a local nonprofit land trust. The NY Protected Areas Database (NYPAD) was also used as a reference in identifying public and conservation lands. NYPAD is a spatial database of lands protected, designated, or functioning as open space, natural areas, conservation lands, or recreational areas created by the NY Natural Heritage Program, and can be accessed through NYPAD.org or through the Hudson River Valley Natural Resource Mapper.[106] Land conservation and ownership status was classified, identifying lands owned by New York State, New York City DEP, City of Kingston Water Works, Woodstock Land Conservancy, or the Town (limited to properties containing natural resource or recreation values), and privately-owned land under conservation easement.

Over 36% of the Town of Woodstock, or 16,314 of its 44,735 acres, is publicly owned or formally conserved, primarily in fee by public agencies. A fee sale entails 100% ownership. For DEP and the New York State, fee acquisition provides high-value water and land protection in Woodstock, while often allowing for public recreational use on those same properties. In addition to fee-protected lands, some properties in the Town are protected by conservation easements held by DEP, the State, the Town, or the Woodstock Land Conservancy. A conservation easement is a voluntary legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values. Landowners retain many of their rights, including the right to recreate on the land, farm, forest harvest, and sell or pass it on to their heirs.[107] New York City DEP and the Woodstock Land Conservancy offer conservation easement programs that may pay residents to preserve their land for future generations.

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[105] Sherer, P. M. *The Benefits of Parks: Why America Needs More City Parks and Open Space*. 2006

[106] "Hudson Valley Natural Resource Mapper." http://www.dec.ny.gov/lands/112137.html

[107] "What can you do?" Land Trust Alliance. https://www.landtrustalliance.org/what-you-can-do/conserve-your-land/questions

The strong conservation ethos in Woodstock is driven by a number of factors. Half of the Town lies within the New York City Watershed where streams feed into the Ashokan Reservoir to provide water to the City. DEP-owned lands in Woodstock were purchased specifically to protect NYC drinking water quality and total 5,134 acres. Additionally, the New York State Department of Environmental Conservation has protected 8,221 acres of wilderness areas and forestland in Woodstock for the Catskill Forest Preserve. The City of Kingston Water Works owns 1,162 acres for protection of its drinking water supply and the Cooper Lake reservoir. The Woodstock Land Conservancy owns 254 acres of land in the Town and holds conservation easements on additional privately-owned parcels. The Town of Woodstock itself owns 751 acres of open lands (in addition to several developed parcels). Many of these lands offer recreational opportunities for hiking, walking, biking, hunting, and fishing. A summary of conservation and public lands with recreation use is provided in Table 9.

Hiking. Ellie Reese

One of the most significant area properties is the 76-acre town-owned Comeau Property. It has a variety of functions, including the Town offices, a popular wooded, meadow and streamside trail, several soccer fields, the Historical Society, and the outdoor stage for Summer's Bird On A Cliff productions. The property has a conservation easement held by Woodstock Land Conservancy created after a unanimous Town Board resolution, which in turn required and successfully was authorized by a voter referendum. While there was a 6-year delay due to litigation, the conservation easement and its first amendment were executed on November 16, 2009 and recorded the following day. A Comeau Stewardship Plan was created and a volunteer Comeau Stewardship Advisory Committee oversees its implementation on behalf of the Town.

Residents and visitors looking for more information about recreation opportunities in Woodstock are encouraged to visit Ulster County REConnect. REConnect is an interactive mapping tool designed to help plan your next outdoor adventure. For additional information on any of the recreational features on the map, just click on the icon and additional information will be displayed. Visit: https://ulstercountyny.gov/maps/recreation/

In addition, for more specific information about recreation on New York City DEP lands, visit https://www1.nyc.gov/site/dep/recreation/recreation.page and view the interactive watershed recreation areas map.[108]

[108] DEP Watershed Recreation Lands Mapper. https://nycdep.maps.arcgis.com/apps/webappviewer/index.html?id=9622fdc0897a4067a80fe25bc2f25f53

Table 9. Recreation Areas in the Town of Woodstock

Property Name	Hiking	Fishing	Hunting	Features	Owner
Comeau Property	x			76 acres—trails, soccer fields, dog park	Town of Woodstock
Andy Lee Field				Ball fields	Town of Woodstock
Rick Volz Field				Ball fields, dog park	Town of Woodstock
Overlook Mountain Trail	x		x	Trails, old hotel ruins, fire tower	NYS DEC
Kenneth Wilson Campground and Day Use Area	x	x		Trails, canoes, camping, picnic area	NYS DEC
Sloan Gorge Preserve	x			88 acres with trails	Woodstock Land Conservancy
Snake Rocks Preserve	x			36 acres with trails	Woodstock Land Conservancy
Zena Cornfield	x			23-acre hayfield w trail	Woodstock Land Conservancy
Thorn Preserve	x			60 acres with trails	Catskill Center for Conservation and Development
Mink Hollow	x	x	x	644 acres	NYC DEP
Olderbark	x			186 acres	NYC DEP
Warner Creek South	x		x	156 acres	NYC DEP
Beaver Kill	x	x	x	422 acres	NYC DEP
Beetree Hill	x			624 acres	NYC DEP
Yankeetown Pond Unit*	x	x	x	821 acres	NYCDEP
South Yankeetown Pond*	x	x		13 acres	NYC DEP
Wittenberg	x	x	x	286 acres	NYC DEP
Mink Hollow Trail	x			5.3-mile trail	NYS DEC
Byrdcliffe Trail/ Mt. Guardian	x			Trail, several miles	Woodstock Guild and Town of Woodstock

**The South end, off Pond Rd, of Yankeetown Pond is privately owned and not open for recreation.*