SIGNIFICANT HABITATS

IN THE TOWN OF WOODSTOCK, ULSTER COUNTY, NEW YORK

Photo: Ingrid Haeckel

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

by Ingrid Haeckel, Othoniel Vázquez Domínguez, and Gretchen Stevens

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Science for Conservation

Hudsonia Ltd.
PO Box 5000
Annandale, NY 12504

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EXECUTIVE SUMMARY

Hudsonia biologists identified and mapped ecologically significant habitats in the Town of Woodstock during the period May 2011-July 2012. Through map analysis, aerial photograph interpretation, and field observations we created a large-format map showing the location and configuration of habitats throughout the town. Some of the habitats are rare or declining in the region or support rare species of plants or animals, while others are high quality examples of common habitats or are components of important habitat complexes. Among our interesting finds were extensive areas of unfragmented hardwood, mixed, and conifer forest, calcareous ledges, 25 oak-heath barrens, a circumneutral bog lake, extensive wetlands and wetland complexes, 75 intermittent woodland pools, three buttonbush pools, 27 isolated heath swamps, and numerous previously undocumented intermittent streams.

In this report we describe each of the mapped habitat types, including some of their ecological attributes, some of the species of conservation concern they may support, and their sensitivities to human disturbance. We address conservation issues associated with these habitats and provide specific conservation recommendations. We also provide instructions on how to use the habitat information, both to review site-specific proposals and for town-wide conservation planning and decision making.

The habitat map, which contains ecological information unavailable from other sources, can help the Town of Woodstock identify areas of great ecological significance, develop conservation goals, and establish conservation policies and practices that will help to protect biodiversity and water resources while serving the social, cultural, and economic needs of the human community.

INTRODUCTION

Background

Rural landscapes in the mid-Hudson Valley are undergoing rapid change as farms, forests, and other undeveloped lands are converted to residential and commercial uses. The consequences of rapid land development include widespread habitat degradation, habitat fragmentation, and the loss of native biodiversity. Although many land use decisions in the region are necessarily made on a site-by-site basis, the long-term viability of biological communities, habitats, and ecosystems requires consideration of whole landscapes. The availability of general biodiversity information for large areas such as entire towns, watersheds, or counties will allow landowners, developers, municipal planners, and others to better incorporate biodiversity protection into day-to-day decision making.

To address this need, Hudsonia Ltd., a nonprofit scientific research and education institute based in Annandale (Dutchess County), New York, initiated a series of extensive habitat mapping projects in 2001. These projects demonstrate how Hudsonia's *Biodiversity Assessment Manual for the Hudson River Estuary Corridor* (Kiviat and Stevens 2001) can be used to identify important biological resources over large geographic areas and inform local communities about biodiversity conservation.

Hudsonia has now completed town-wide habitat maps for nine Dutchess County towns (Amenia, Beekman, East Fishkill, North East, Pine Plains, Poughkeepsie, Rhinebeck, Stanford, and Washington) and sections of three others, as well as the Trout Brook watershed in Orange County, and part of the Town of Marbletown in Ulster County. This study is the first such town-wide project in Ulster County. The Woodstock mapping project has been funded by several private and public sources. The New York State Department of Environmental Conservation, the Ashokan Watershed Stream Management Program, and the Catskill Watershed Corporation provided funding to the town; Will Nixon (Woodstock resident) provided restricted funds directly to Hudsonia for the project; and the Educational Foundation of America provided programmatic support to further this and other Hudsonia projects. We received valuable in-kind assistance from the Town of Woodstock Planning Board, Town Board, and the Woodstock Land Conservancy, as well as from Mark Peritz, Spider Barbour, Michael Kudish, Dave Holden, and many local landowners.

Hudsonia staff conducted the work on this project from May 2011 through September 2012. Most of the mapping and field work was carried out by Ingrid Haeckel (Biodiversity Mapping Coordinator) and Othoniel Vázquez Domínguez (Biologist). Nava Tabak (prior Biodiversity Mapping Coordinator) and Ramana Callan (Biologist) participated in initial mapping, Kristen Bell Travis (Biologist) proofread the map, provided technical assistance, and helped with many aspects of the report, and Gretchen Stevens (Director of Hudsonia's Biodiversity Resources Center) supervised the project. Through map analysis, aerial photograph interpretation, and field observations we created a map of ecologically significant habitats in the Town of Woodstock. Some of these habitats are rare or declining in the region, some may support rare species of plants or animals, some are high quality examples of common habitats or habitat complexes, and others may provide other important services to the ecological landscape. The emphasis of this project was on identifying and mapping general habitat types; we did not conduct species-level surveys or map the locations of rare species.

To facilitate intermunicipal planning, we strive for consistency in the ways that we define and identify habitats and present the information for town use, but we also work to improve our methods and products as the mapping program evolves. Many passages in this report relating to general habitat descriptions, general conservation and planning concepts, and other information applicable to the region as a whole are taken directly from previous Hudsonia reports accompanying habitat maps in Dutchess and Ulster counties (Stevens and Broadbent 2002, Tollefson and Stevens 2004, Bell et al. 2005, Sullivan and Stevens 2005, Tabak et al. 2006, Hartwig et al. 2007, Reinmann and Stevens 2007, Knab-Vispo et al. 2008, Tabak and Stevens 2008, Bell and Stevens 2009, Deppen et al. 2009, McGlynn et al. 2009) without specific attribution. This report, however, addresses our findings and specific recommendations for the Town of Woodstock. We intend for each of these projects to build on the previous ones, and believe that the expanding body of biodiversity information will be a valuable resource for site-specific, town-wide, and region-wide planning and conservation efforts.

We hope that this map and report will help landowners understand how their properties fit into the larger ecological landscape, and will inspire them to implement habitat protection and enhancement measures voluntarily. We also hope that the Town of Woodstock will engage in proactive land use and conservation planning to ensure that future land development is carried out with a view to long-term protection of the town's very substantial biological resources.

What is Biodiversity?

The concept of biodiversity, or biological diversity, encompasses all of life and its processes. It includes ecosystems, biological communities, species, populations, and genes, as well as their interactions with each other and with the abiotic components of their environment, such as soil, water, air, and sunlight. Protecting native biodiversity is an important component of any effort to maintain healthy, functioning ecosystems that sustain the human community and the living world around us. Healthy ecosystems make the earth habitable by moderating the climate, cycling essential gases and nutrients, purifying water and air, producing and decomposing organic matter, sequestering carbon, and providing many other essential services. They also serve as the foundation of our natural resource-based economy.

The decline or disappearance of native species of plants and animals can be a symptom of environmental deterioration or collapses in other parts of the ecosystem. While we do not fully understand the roles of all organisms in an ecosystem and cannot fully predict the consequences of the extinction of any particular species, we do know that each organism, including inconspicuous organisms such as fungi and insects, plays a specific role in the maintenance of biological communities. Maintaining the full complement of native species in a region better enables ecosystems to withstand stresses and adapt to changing environmental conditions.

What are Ecologically Significant Habitats?

For purposes of this project, a "habitat" is simply the place where an organism or population lives or where a biological community occurs, and is defined according to both its biological and non-biological components. Individual species will be protected for the long term only if their habitats remain intact. The local or regional disappearance of a habitat can lead to the local or regional extinction of species that depend on that habitat. Habitats that we consider to be "ecologically significant" include:

1. Habitats that are rare or declining in the region.
2. Habitats that support rare species and other species of conservation concern.
3. High-quality examples of common habitats (e.g., those that are especially large, isolated from human activities, old, lacking harmful invasive species, or those that provide connections between other important habitat units).
4. Complexes of connected habitats that, by virtue of their size, composition, or configuration, have significant biodiversity value.

Because most wildlife species need to travel among different habitats to satisfy their basic survival needs, landscape patterns can have a profound influence on wildlife populations. The size, connectivity, and juxtaposition of both common and uncommon habitats in the landscape all have important implications for wildlife and biodiversity as a whole. In addition to their importance from a biological standpoint, habitats are also manageable units for planning and conservation at fairly large scales such as towns. By illustrating the location and configuration of significant habitats throughout Woodstock, the habitat map can serve as a valuable source of ecological information that can be incorporated into local land use planning and decision making.

Study Area

The Town of Woodstock is located in northern Ulster County in southeastern New York. It is approximately 68 mi^2 (175 km^2) in area and has a population of roughly 5,880 residents (2010 Census). The landscape is dramatic, defined by Catskill peaks and large stream valleys. Woodstock's mountains have three general high-elevation areas: a northern ridge whose highest elevations are mostly north of the town line, a central ridge that runs from the southwest to the northeast of Woodstock, and a southern ridge that follows the southern boundary of town. The northern ridge includes Carl Mountain (2880 ft [880 m]), the unnamed peak between Carl and Tremper mountains (2820 ft [860 m]), the flank of Olderbark Mountain (not the summit, but it reaches 3280 ft [1000 m], the highest elevation in Woodstock), the shoulder of Twin Mountain (2840 ft [870 m]), Overlook Mountain (3120 ft [950 m]), and Mount Guardian (2100 ft [640 m]). The Catskill Escarpment rises sharply from the Hudson Valley lowlands, forming the steep eastern slope of Overlook Mountain and continuing north of Woodstock. The central ridge includes Mount Tobias (2540 ft [770 m]), Roundtop Mountain (1980 ft [600 m]), Johns Mountain (1540 ft [470 m]), and Beetree Hill (1820 ft [550 m]). The southern ridge includes the flanks of Ticetonyk Mountain (2400 ft [730 m]), Tonshi Mountain (1980 ft [600 m]), and Ohayo Mountain (1320 ft [400 m]), although the summits of these mountains are in the towns of Olive and Hurley. Acorn Hill (1300 ft [400 m]) and Snake Rocks (1220 ft [370 m]) are south of the town center of Woodstock between the central and southern ridges. We describe the Catskill Foothills as the lowland hills and basins – mostly below 700 ft (200 m) – east of Overlook and Ohayo mountains.

Four large streams have formed the major valleys in Woodstock. In the western half of the town, Warner Creek, the Beaver Kill, and the Little Beaver Kill are all tributaries to upper Esopus Creek, the primary stream feeding the Ashokan Reservoir, which is a major component of the New York City drinking water supply. Warner Creek drains Silver Hollow in the town's northwest corner; the Beaver Kill flows south through Mink Hollow and then west between the northern and central ridges; and the Little Beaver Kill flows west, through Yankeetown Pond and between the central and southern ridges. The Saw Kill drains the eastern part of the town, flowing southwest from Echo Lake, then southeast through the Woodstock town center and on through the lower foothills of Zena in the southeast corner of the town. The town's lowest elevation is 260 ft [80 m], where the Saw Kill crosses the eastern town line. Cooper Lake, a 152-acre (62 ha) enlarged natural waterbody and the primary drinking water reservoir for the City of Kingston, drains into the Saw Kill north of the town center. All of Woodstock's streams eventually drain into Esopus Creek, a tributary of the Hudson River.

Woodstock's landscape reflects the strong influences of bedrock geology and glacier activity. The bedrock underlying the entire town is dominated by sandstone and shale, while a few of the higher peaks and ridges (Ticetonyk, Mount Tobias, Carl Mountain, Olderbark Mountain, Twin Mountain, and Overlook Mountain) have areas of more erosion-resistant conglomerate (Fisher et al. 1970). These sediments were originally deposited during the Devonian and early Mississippian period in a great delta formed by the rise and subsequent erosion of the ancient Acadian Mountains in the east (Titus 1998). The delta area was uplifted during the Permian period, and the resulting Allegheny Plateau was then slowly dissected as coarser sandstone and conglomerate formations resisted erosion and fine-grained shales were worn down by flowing water. During the ice ages, the Catskill ridges and summits were further rounded and the valleys widened by glaciers (Titus 1996). Thinly laminated sandstones originating from the coastal realm of the Catskill Delta, also known as "bluestone," have been quarried from small mines throughout the town, and these old quarries are a common feature of the local landscape.

The surficial geology of Woodstock is more varied (Figure 1). Ridges and upper flanks of mountains have exposed bedrock with no surficial deposits, and glacial till predominates on lower hillsides. The valleys of the large streams are underlain by either outwash sand and gravel or kame deposits (sand and gravel mounds deposited by a melting ice sheet), with one area of lacustrine sand (lake sediment deposits) in the lower part of the Saw Kill valley, and one alluvial fan (sediments transported downslope by water) along the Beaver Kill. Fluvial sand and/or gravel underlies the Saw Kill valley in the town center of Woodstock and an area in the southeast corner of town, north of the Saw Kill, has colluvium deposits (sediments transported downslope by gravity) (Cadwell et al. 1989).

Publicly- and privately-owned forests constitute much of the land in Woodstock, and residential development is the next largest land use. Other uses include outdoor recreation lands, and to a lesser extent agriculture and industrial production. The entire town is part of the Catskill Park, which is a mix of public and private lands. The great majority of parcels are small (five acres [2 hectares] or less) and privately owned. Of parcels over 100 ac (40 ha), 31 are privately owned and 53 are publicly owned. Public lands include approximately 7780 ac (3150 ha) of state-owned land (most is part of the Catskill Park Forest Preserve),

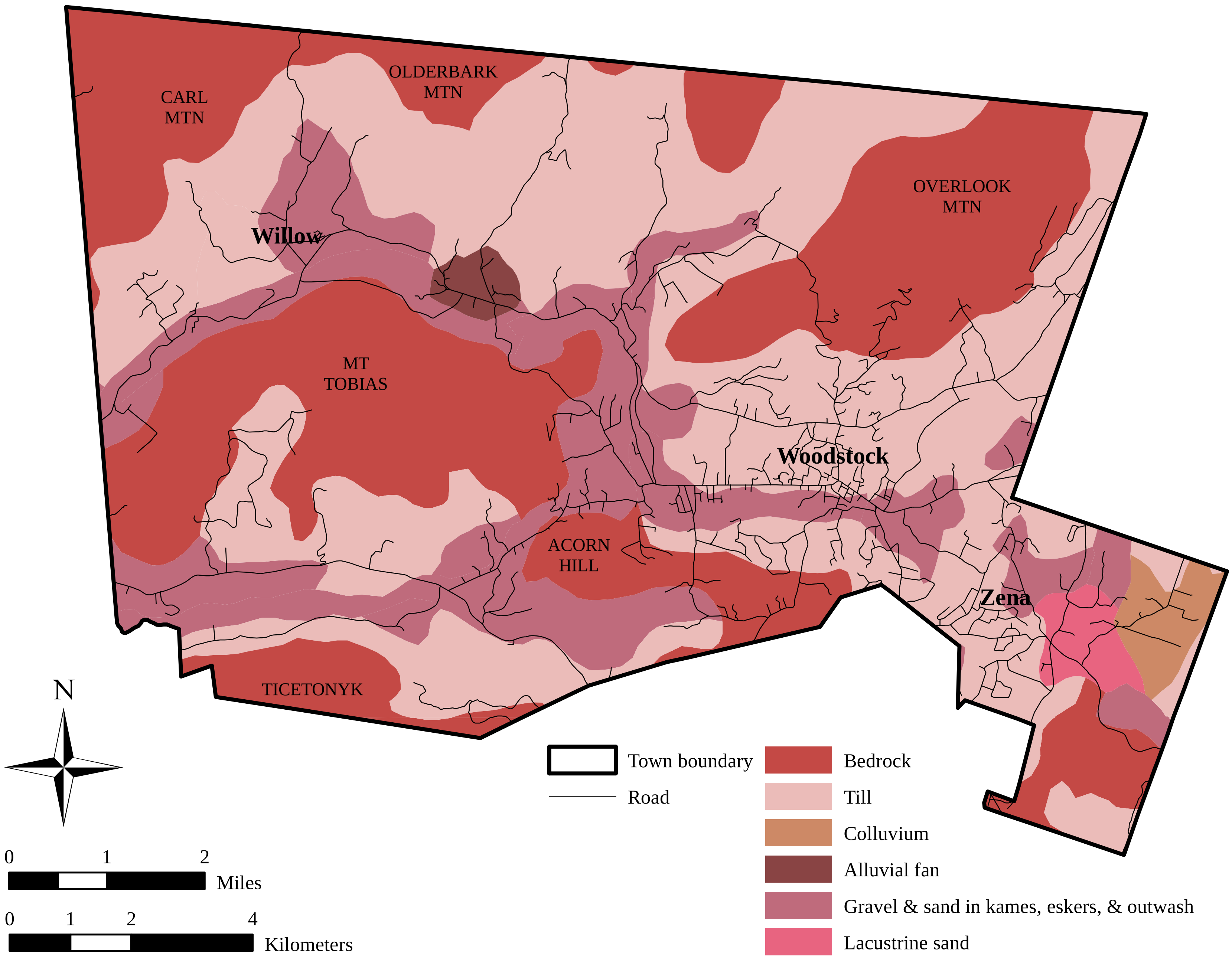
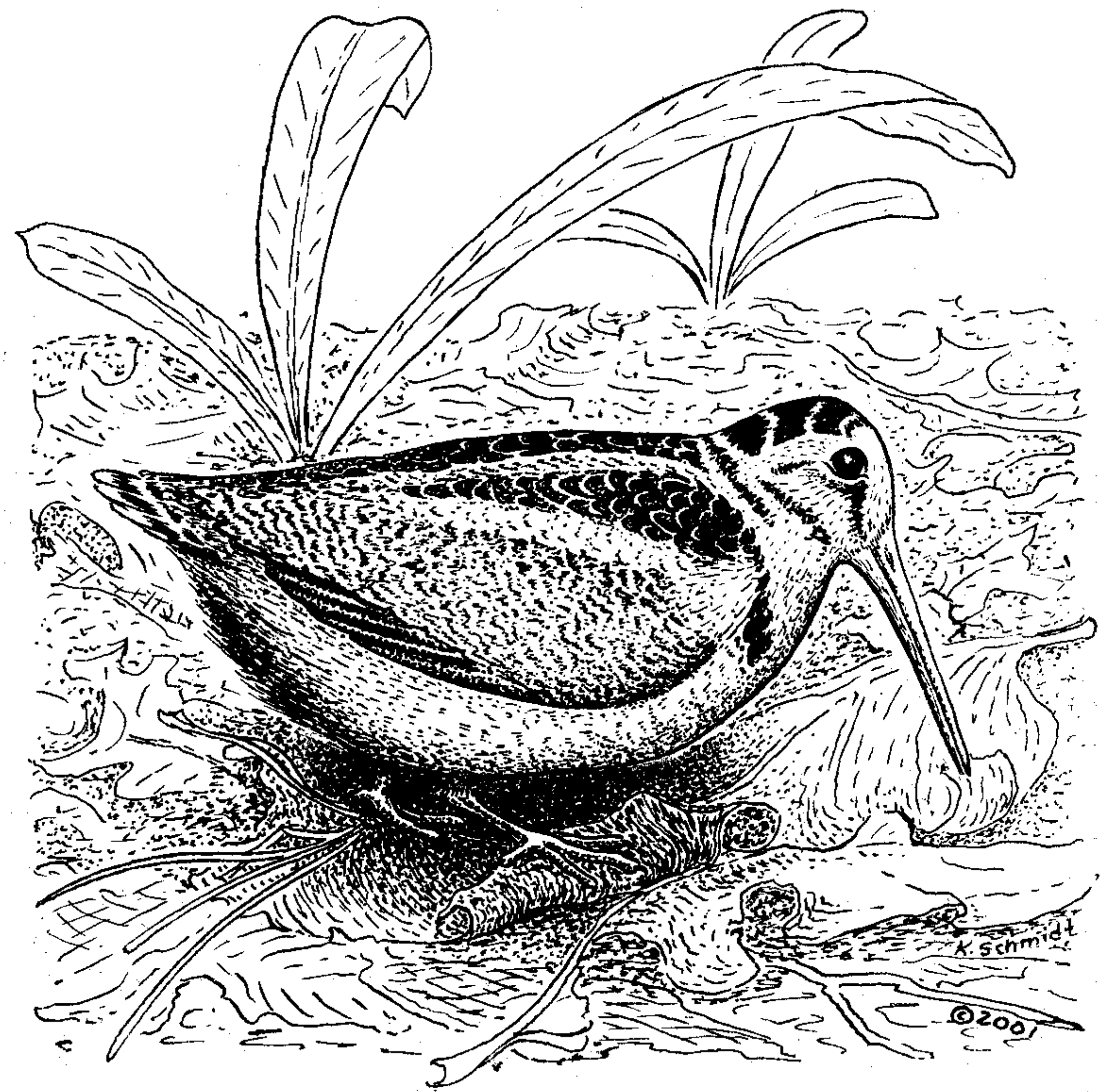


Figure 1. Generalized surficial geology in the Town of Woodstock, Ulster County, New York. Geology data from Cadwell et al. (1989). Hudsonia Ltd., 2012.

5050 ac (2040 ha) owned by New York City, 1150 ac (470 ha) owned by the City of Kingston, and 750 ac (300 ha) owned by the Town of Woodstock. In addition, approximately 260 ac (100 ha) on Overlook Mountain are owned by the Open Space Institute and will soon be transferred to state ownership, and 200 ac (80 ha) are owned by the Woodstock Land Conservancy.



American woodcock

METHODS

Hudsonia employs a combination of laboratory and field methods in the habitat identification and mapping process. Below we describe each phase in the Woodstock habitat mapping project.

Gathering Information and Predicting Habitats

During many years of habitat studies in the Hudson Valley, Hudsonia has found that, with careful analysis of map data and aerial photographs, we can accurately predict the occurrence of many habitats that are closely tied to topography, geology, and soils. We use combinations of map features (e.g., slopes, bedrock chemistry, and soil texture, depth, and drainage) and features visible on stereoscopic aerial photographs (e.g., exposed bedrock, vegetation cover types) to predict the location and extent of ecologically significant habitats. In addition to previous studies conducted by Hudsonia biologists and others in and near Woodstock (Kiviat & Barbour 1991, Stevens et al. 1991, Barbour et al. 1995, Bierhorst 1995, Kudish 2000) and biological data provided by the New York Natural Heritage Program, we used the following resources for this project:

- *1:40,000 scale color infrared stereoscopic aerial photograph prints* from the National Aerial Photography Program series taken in spring 1994, 1995, and 1997 obtained from the U.S. Geological Survey. Viewed in pairs with a stereoscope, these prints ("stereo pairs") provide a three-dimensional view of the landscape and are extremely useful for identifying vegetation cover types, wetlands, streams, and cultural landscape features.

- *High-resolution (1 pixel = 12 in [30 cm]) color infrared digital orthophotos* taken in spring 2001 and spring 2009, obtained from the New York State GIS Clearinghouse website (http://www.nysgis.state.ny.us; accessed May 2011). These digital aerial photos were used for on-screen digitizing of habitat boundaries.

- *U.S. Geological Survey topographic maps* (Woodstock, Bearsville, Kingston West, and Phoenicia 7.5 minute quadrangles). Topographic maps contain extensive information about landscape features, such as elevation contours, surface water features, and significant cultural features. Contour lines on topographic maps can be used to predict the occurrence of habitats such as cliffs, intermittent woodland pools and other wetlands, intermittent streams, and seeps.

- *Bedrock and surficial geology maps* (Lower Hudson and Hudson-Mohawk Sheets) produced by the New York Geological Survey (Fisher et al. 1970, Cadwell et al. 1989). Along with topography, surficial and bedrock geology strongly influence the development of particular soil properties and aspects of groundwater and surface water chemistry, and thus have important implications for the biological communities that become established at any site.

- *Soil Survey of Ulster County, New York* (Tornes 1979). Specific attributes of soils, such as depth, drainage, texture, and pH, convey much information about the types of habitats that are likely to occur in an area. Shallow soils, for example, may indicate the location of crest, ledge, and talus habitats. Poorly and very poorly drained soils usually indicate the location of wetland habitats such as swamps, marshes, and wet meadows. The location of alkaline soils can be used to predict the occurrence of fens and calcareous wet meadows.

- *GIS data*. A Geographic Information System enables us to overlay multiple data layers on a computer screen, greatly enhancing the efficiency and accuracy with which we can predict the diverse habitats that are closely linked to local topography, geology, hydrology, and soil conditions. GIS also enables us to create detailed, spatially accurate maps. We obtained several of our GIS data layers from the New York State GIS Clearinghouse, including municipal boundaries, roads, hydrological features, and public lands. Bedrock and surficial geology data were downloaded from the USGS and New York State Museum websites. National Wetlands Inventory data prepared by the U.S. Fish and Wildlife Service were obtained from their website. We obtained soils data from the Natural Resources Conservation Service (NRCS) website. We received 20-ft (6-m) contour, limited-extent 2-ft (0.6-m) contour, floodplain, streams, waterbody, township boundary, and tax parcel data from Ulster County Information Services. The

New York City Department of Environmental Protection Bureau of Water Supply provided an additional 10-ft (3-m) digital elevation model for part of the town.

Preliminary Habitat Mapping and Field Verification

We prepared a preliminary map of predicted habitats based on map analysis and stereo interpretation of aerial photographs. We digitized the predicted habitats onscreen over the orthophoto images using ArcView 10.0 (Environmental Systems Research Institute 2011) computer mapping software. With these draft maps in hand we conducted field visits to as many of the mapped habitat units as possible to verify their presence and extent, assess their quality, find other habitats, and identify habitats that could not be identified remotely. We utilized Garmin GPSMAP 60Cx GPS units to identify the approximate locations and boundaries of certain habitats, streams, and other features seen in the field, but did not use GPS to carry out detailed delineations of habitat boundaries.

We identified landowners using tax parcel data, and before visiting field sites we contacted landowners for permission to walk their land. We prioritized sites for field visits based both on opportunity (i.e., willing landowners) and our need to answer habitat questions that could not be answered remotely. For example, differentiating wet meadow from calcareous (calcium-rich) wet meadow and calcareous crest from acidic crest can only be done in the field. In addition to conducting field work on private land, we viewed habitats from adjacent properties, public roads, and other public access areas. Because the schedule of this project (and non-participating landowners) prevented us from visiting every parcel in the study area, this strategy increased our efficiency while maintaining a high standard of accuracy.

We field checked approximately 20810 ac (8422 ha), which represents approximately 55% of the undeveloped area in Woodstock. Areas that could not be field checked show our remotely-mapped habitats. We assume that areas of the habitat map that were field checked are generally more accurate than areas we did not visit, particularly in the cases of the numerous small wetlands in forested areas which were difficult to map remotely. Once we had conducted field work in some areas, however, we were able to extrapolate our findings to adjacent parcels and similar settings throughout the town.

Defining Habitat Types

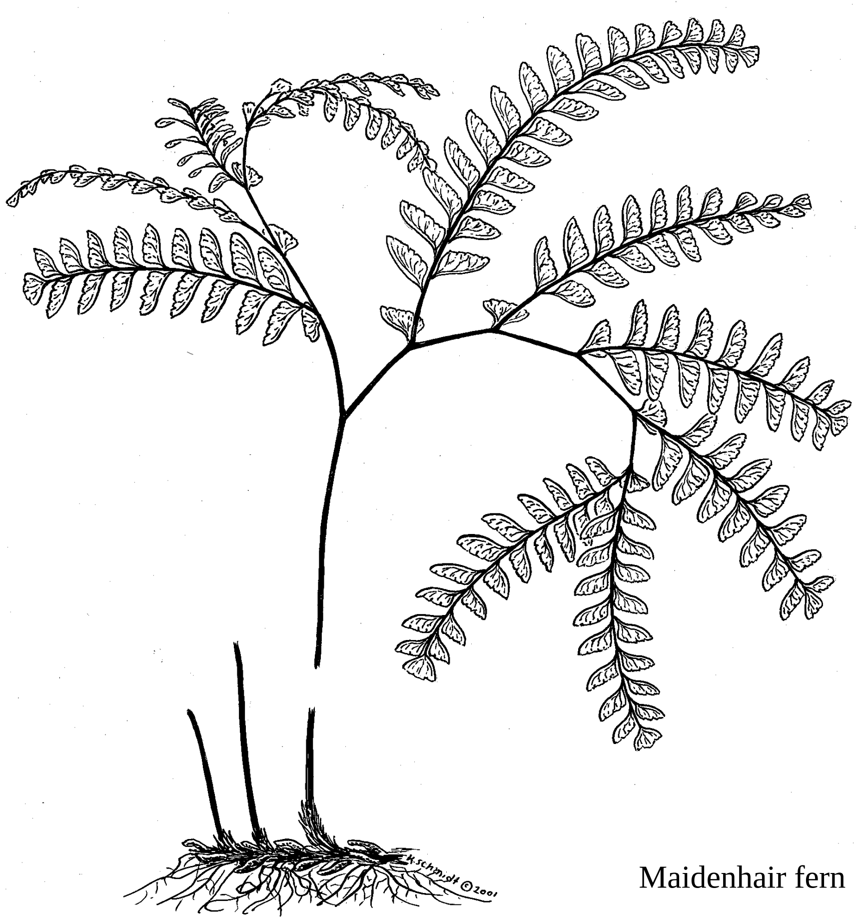
Habitats are useful for categorizing places according to apparent ecological function, and are manageable units for scientific inquiry and for land use planning. We have classified broad habitat types that are identifiable largely by their vegetation and visible physical properties. Habitats exist, however, as part of a continuum of intergrading biological communities and physical properties, and it is often difficult to draw a line to separate two habitats. Additionally, some distinct habitats are intermediates between two defined habitat types, and some habitat categories can be considered complexes of several habitats. In order to maintain consistency within and among habitat mapping projects, we have developed certain mapping conventions (or rules) that we use to delineate habitat boundaries. Some of these are described in Appendix A. Because much of the area in Woodstock was only mapped remotely, and all mapped habitat boundaries were drawn without survey or GPS equipment, all of the mapped features should be considered approximations.

Each habitat profile in the Results section describes the general ecological attributes of places that are included in that habitat type. Developed areas and other areas that we consider to be non-significant habitats (e.g., structures, paved and gravel roads and driveways, other impervious surfaces, and small lawns, meadows, and woodlots) are shown as white (no symbol or color) on the habitat map. Areas that have been developed since 2009 (the orthophoto date) were identified as such only if we observed them in the field. For this reason, it is likely that we have underestimated the extent of developed land in the town.

Final Mapping and Presentation of Data

We corrected and refined the preliminary map on the basis of our field observations to produce the final habitat map. We printed the final large-format habitat map at a scale of 1:10,000 on four sheets using a Hewlett Packard DesignJet 800PS plotter. We also printed the entire town map on a single sheet at a scale of 1:16,000. The GIS database that accompanies the map includes additional information about many of the mapped habitat units, such as some of the plant and animal species observed in the field. The habitat map, GIS database, and this report have been presented to the Town of Woodstock for use in conservation and land use planning and decision making. We request that any maps printed from this database for public viewing be printed at scales no larger than 1:10,000, and that the habitat map data be attributed to Hudsonia Ltd. Although the habitat map was carefully prepared and extensively field checked, there are inevitable inaccuracies in the final map. Because of this, we request that the following caveat be printed prominently on all maps:

> *"This map is suitable for general land-use planning, but is not suitable for detailed planning and site design, or for jurisdictional determinations (e.g., for wetlands). Boundaries of wetlands and other habitats depicted here are only approximate."*



Maidenhair fern

RESULTS

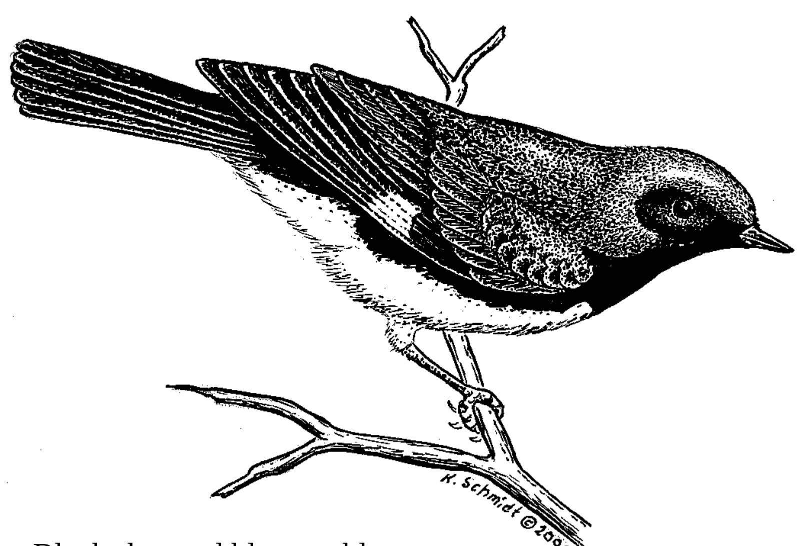
OVERVIEW

The large-format Woodstock habitat map illustrates the diversity of habitats that occur in the town and their configuration across the landscape. Figure 2 is a reduction of the completed habitat map. Of the total 67.7 mi^2 (175 km^2) encompassed in the study area, approximately 88% was mapped as significant habitat. Despite a significant network of residential development in the eastern section of the town, many large, intact patches of habitat remain. Figure 3 shows blocks of contiguous undeveloped habitat areas within the town, color-coded by size. Several types of common habitats cover extensive areas within these blocks. For example, upland forests cover approximately 79% of the land in the town, upland meadows (managed and unmanaged grassland habitats) occupy 3%, and swamps make up 2.5% of the land in the town. Much of Woodstock has shallow soils with exposed rocky crest, ledge, and talus habitat. Some of the smaller, more unusual habitats we documented include oak-heath barren, circumneutral bog lake, calcareous wet meadow, and intermittent woodland pool. In total, we identified 22 general habitat types in Woodstock that we consider to be of potential ecological importance (Table 1).

Although the mapped areas represent ecologically significant habitats, all have been altered by past and present human activities. Most or all areas of the upland forests, for example, have been logged repeatedly in the past 300 years, extensive areas have been subject to repeated burns, and many forested areas lack the structural complexity of mature forests. Many of the wetlands in the town have been extensively altered by human activities such as damming, filling, draining, and railroad and road construction. Several introduced plant species (e.g., common reed, purple loosestrife, Eurasian honeysuckles, autumn olive, multiflora rose, Japanese barberry, garlic-mustard, Japanese stiltgrass, Japanese knotweed) are widespread in upland and wetland habitats in the town, and have likely had various ecological impacts on these habitats, including the displacement of some native species. We have documented the location and extent of important habitats in Woodstock, but only in some cases have we provided information on the quality and condition of these habitats. Notes in the GIS database provide some of these assessments. Locations of a few habitat types are depicted on map figures in this report, but most habitats are shown only in Figure 2 (highly reduced) and on the large-format maps, separate from this report.

Table 1. Ecologically significant habitats documented by Hudsonia in the Town of Woodstock, Ulster County, New York, 2012.

Upland Habitats	**Wetland Habitats**
Upland hardwood forest	Hardwood & shrub swamp
Upland conifer forest	Conifer swamp
Upland mixed forest	Mixed forest swamp
Crest/ledge/talus	Intermittent woodland pool
Oak-heath barren	Circumneutral bog lake
Orchard/plantation	Marsh
Upland shrubland	Wet meadow
Upland meadow	Calcareous wet meadow
Cultural	Constructed pond
Waste ground	Open water
	Spring/seep
	Stream



Black-throated blue warbler

(A)

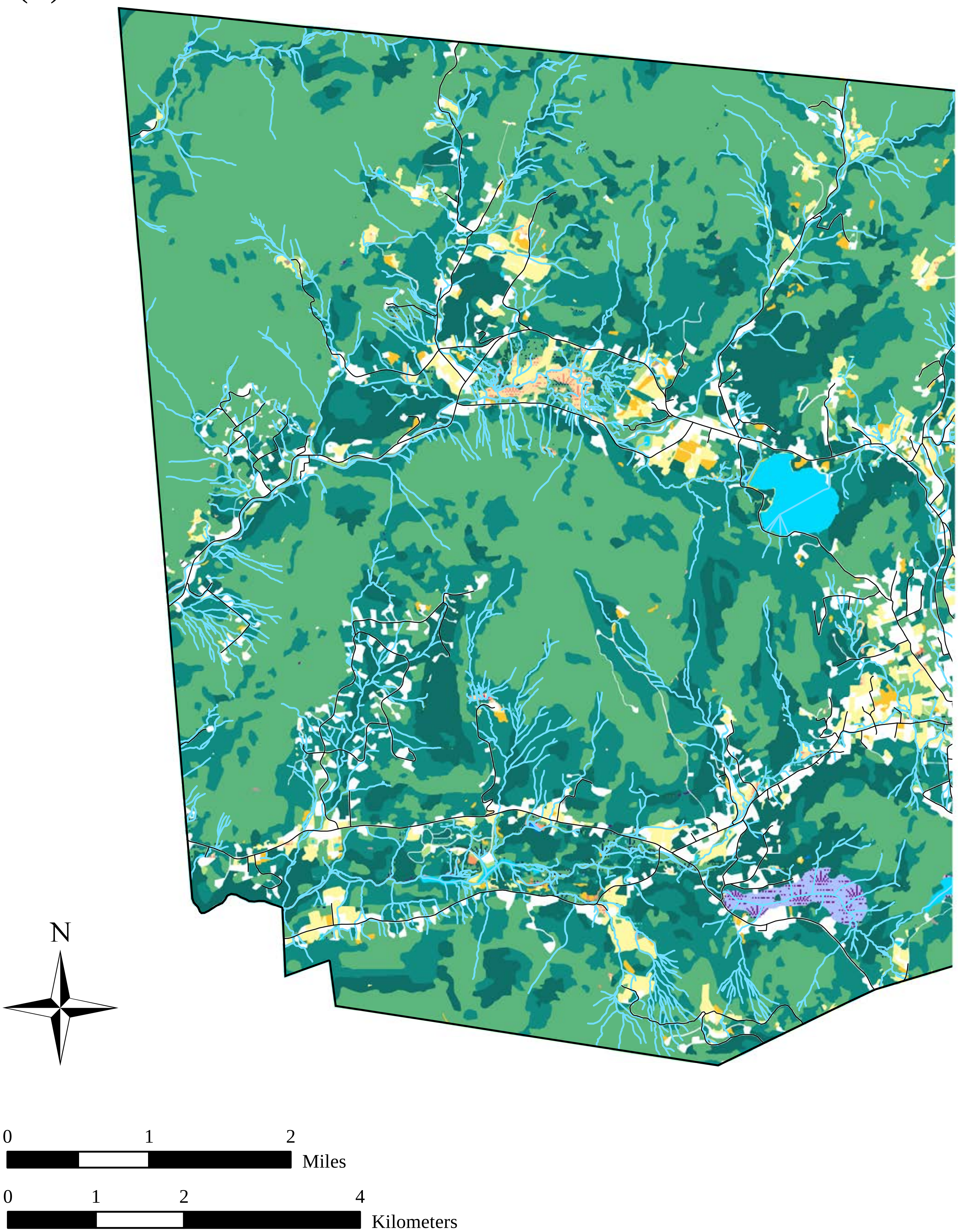


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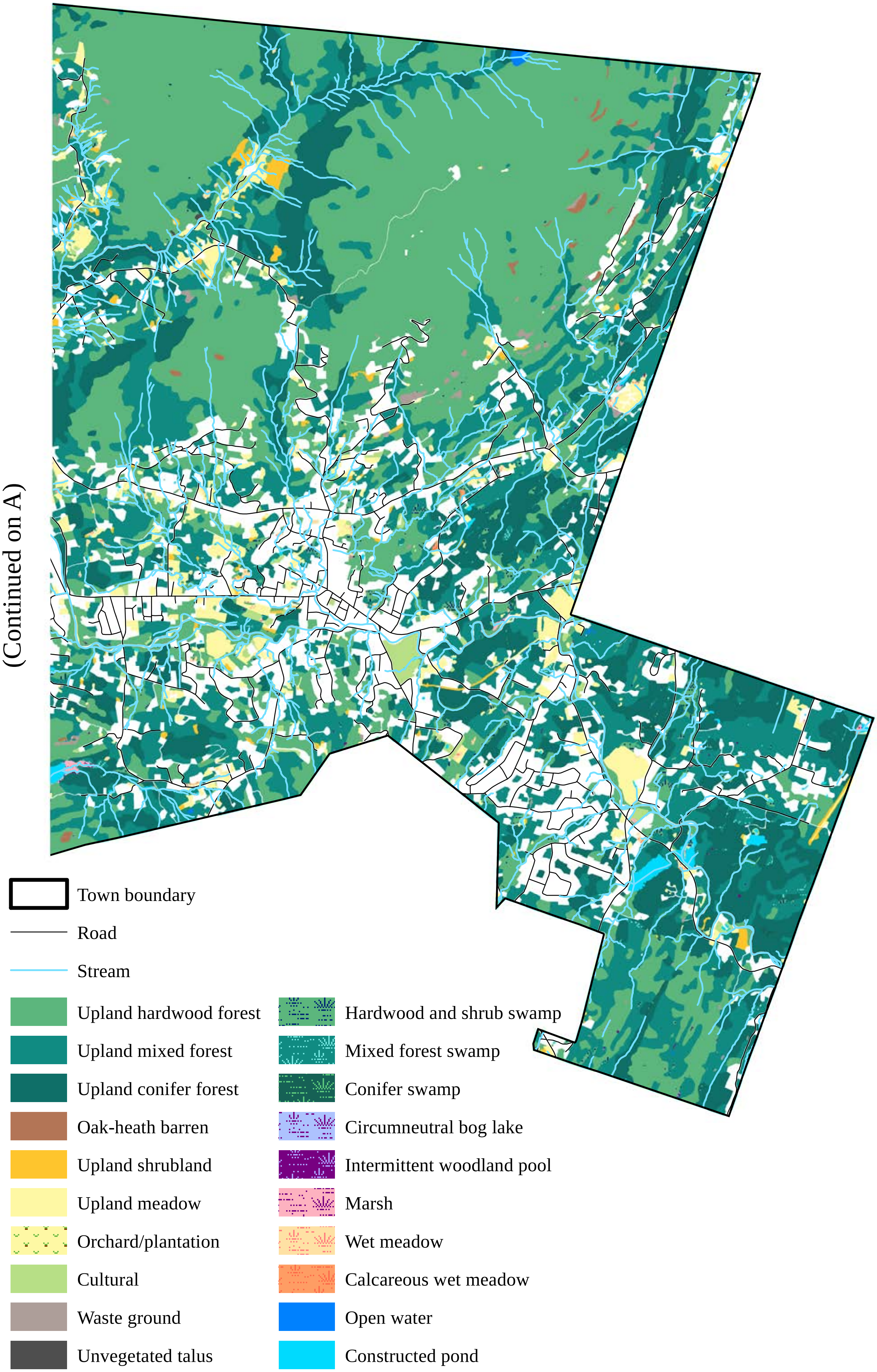
Figure 2. A reduction of the map illustrating ecologically significant habitats in the Town of Woodstock, Ulster County, New York, identified and mapped by Hudsonia Ltd. in 2011-2012. (A) Western half of town, (B) eastern half of town. Developed areas and other non-significant habitats are shown in white. The large-format map is printed in four sections at a scale of 1:10,000.

(B)



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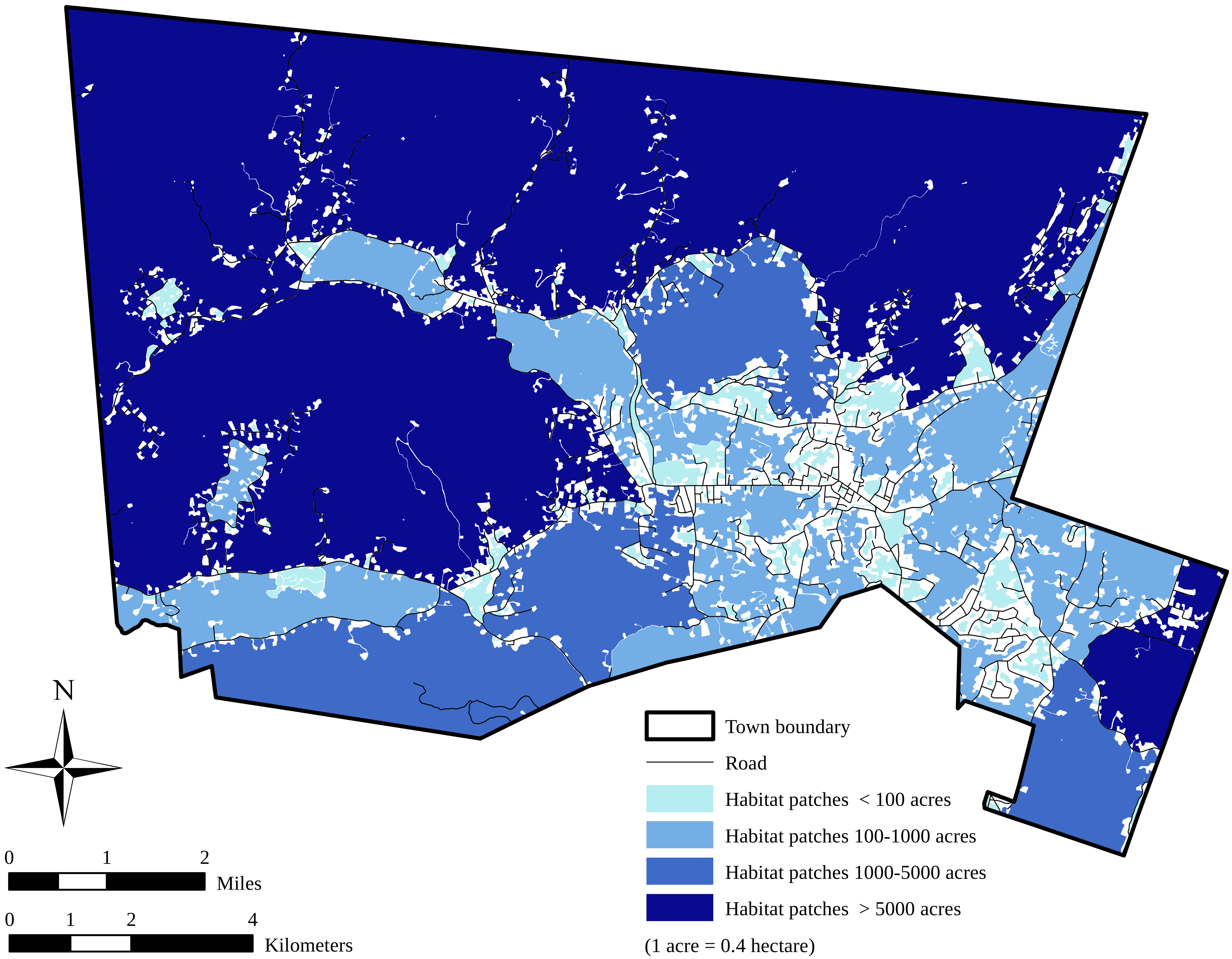


Figure 3. Contiguous habitat patches in the Town of Woodstock, Ulster County, New York. Patch area measurements take into account habitats extending beyond the town boundary. Developed areas and other non-significant habitats are shown in white. Hudsonia Ltd., 2012.

HABITAT DESCRIPTIONS

In the following pages we describe some of the ecological attributes of the habitats identified in the Town of Woodstock, and discuss some conservation measures that can help to protect these habitats and the species of conservation concern they may support. We have indicated species of conservation concern (those that are listed by state or federal agencies or considered rare or vulnerable by non-government organizations) that are associated with these habitats by placing an asterisk (*) after the species name. Appendix C provides a more detailed list of rare species that may occur in the town, organized by habitat type and including the statewide and regional conservation status of each species. Species in this appendix could occur or are likely to occur in these habitats, but are not necessarily present in them. The letter codes used in Appendix C to describe the conservation status of rare species are explained in Appendix B. Appendix D gives the common and scientific names of all plants mentioned in this report.

UPLAND HABITATS

UPLAND FORESTS

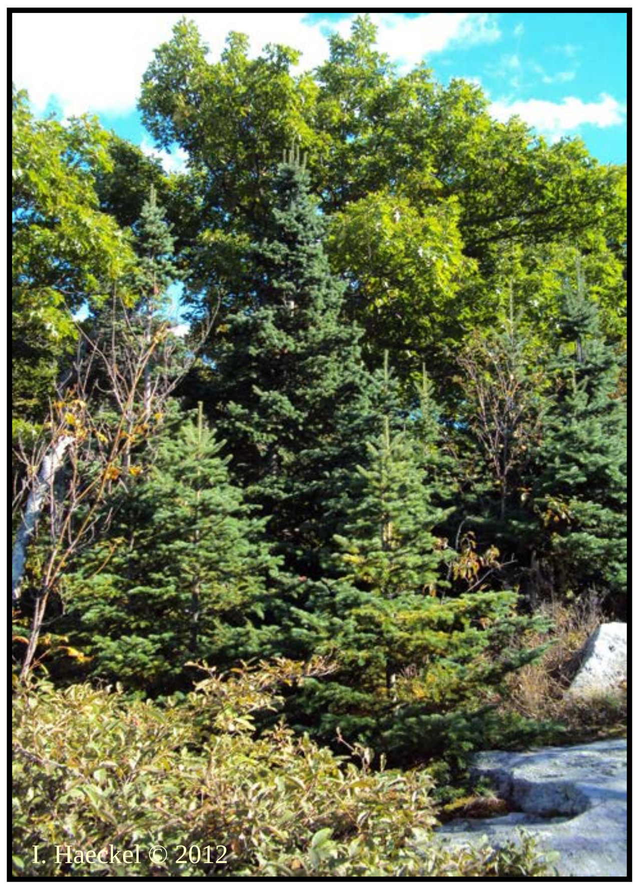
Ecological Attributes

We classified upland forests into three general types for this project: hardwood forest, conifer forest, and mixed forest. We recognize that upland forests are in fact much more variable, with each of these three types encompassing many distinct biological communities. However, our broad forest types are useful for general planning purposes, and are also the most practical for our remote mapping methods.

<u>Upland Hardwood Forest</u>

Upland hardwood forest is the most common habitat type in the region, and includes many different types of deciduous forest communities at all elevations. Upland hardwood forests are used by a wide range of common and rare species of plants and animals. The distinctive mix of species present in Woodstock's upland forests reflects the confluence of plant communities of northern and southern affinities at the boundary of the Catskills, along with boreal relicts (Kudish 2000, Bierhorst 1995). Sugar maple, American beech, and yellow birch dominate the northern hardwood forest community, which predominates at higher elevations, on north-facing slopes, and toward the interior Catskills. In Woodstock's valleys, south-facing slopes, and on the Catskill Escarpment, repeated burning by Native Americans and subsequent burns, heavy forest cutting, and other human disturbances since European settlement favored the establishment of southern hardwood species such as oaks, American chestnut, hickories, and an array of fire-tolerant shrubs such as blueberries, black huckleberry, and mountain laurel (Kudish 2000).

Dominant trees of upland hardwood forests in Woodstock included maples (sugar, red, striped), American beech, oaks (red, chestnut, white, black), hickories (shagbark, pignut, bitternut), birches (black, yellow, paper, gray), black cherry, basswood, bigtooth aspen, and



Left: Hardwood forest with dense mountain laurel thicket, Right: Spruce-fir boreal forest relict white ash. Chestnut oak was common on rocky, exposed ridgetops and slopes. Species with northern affinities such as American mountain-ash and mountain maple were limited to high elevation areas, while others including American beech, sugar maple, and yellow birch joined more typically southern trees such as sassafras, black gum, and tulip tree on the lower slopes of the Catskill Mountains. Common understory species included lowbush blueberry, hillside blueberry, black huckleberry, mountain laurel, maple-leaf viburnum, witch-hazel, serviceberry (or shadbush), striped maple, hophornbeam, white pine, and a wide variety of lichens, mosses, ferns, sedges and wildflowers. Mountain laurel forms dense, nearly impenetrable thickets (shown as an overlay) covering acres of mountainside in several areas of the town and suggests a history of repeated burning (Kudish 2000). Upland hardwood forests in the Hudson Valley and Catskills may support numerous rare plant species, such as Braun's hollyfern,* hyssop skullcap,* and twinflower* (Bierhorst 1995). The historical record of small whorled pogonia* near Woodstock is noteworthy.

Eastern box turtle* spends most of its time in upland forests and meadows, finding shelter under logs and organic litter. Many snake species forage widely in upland forests and other habitats. Upland hardwood forests provide nesting habitat for raptors, including red-shouldered hawk,* Cooper's hawk,* sharp-shinned hawk,* broad-winged hawk,* and barred owl,* and many species of songbirds including warblers, vireos, thrushes, woodpeckers, and flycatchers. American woodcock* forages and nests in young hardwood forests. Pileated woodpecker uses large trees (live or standing dead) for foraging, roosting, and nesting (Bull and Jackson 1995). Black-throated blue warbler,*, Canada warbler,* and hooded warbler* are associated with mountain laurel thickets in hardwood forests (Bull 1974, Eaton 1998). Common raven,* worm-eating warbler,* and hooded warbler* are found in mountainous forests. Acadian flycatcher,* wood thrush,* cerulean warbler,* Kentucky warbler,* and scarlet tanager* are some of the birds that may require large forest-interior areas to maintain viable populations. Large mammals such as black bear,* bobcat,* and fisher* also require large expanses of forest. Many small mammals are associated with upland hardwood forests, including eastern chipmunk, southern flying squirrel, and white-footed mouse. Hardwood trees greater than 5 inches (12.5 cm) in diameter (especially those with loose platy bark such as shagbark hickory, deeply furrowed bark such as black locust, or snags with peeling bark) can be used by Indiana bat* and other bat species for summer roosting and nursery colonies. Upland hardwood forests are extremely variable in species composition, size and age of trees, vegetation structure, soil drainage and texture, and other habitat factors. Many smaller habitats, such as intermittent woodland pools and crest, ledge, and talus, are frequently embedded within areas of upland hardwood forest.

Upland Conifer Forest

This habitat includes naturally occurring upland forests with more than 75% cover of conifer trees, as well as conifer plantations with pole-sized (approximately 5-10 in [12-25 cm] diameter at breast height) to mature trees. Eastern hemlock and white pine were both abundant throughout the town. Balsam fir and red spruce, relicts of the boreal forest, occurred on the summits of certain mountains. Pitch pine was scattered on rocky, exposed ledges, and red pine also occurred in a few areas with a history of repeated burning. Conifer forests have a very shaded and protected understory with herb and shrub layers sparse or absent. Conifer plantations contain various native and non-native tree species, and tend to be more uniform in size and age of trees, structure, and overall species composition than natural conifer stands. Both natural and planted conifer stands are used by many species of owls (e.g., barred owl,* great horned owl, long-eared owl*) and other raptors (e.g., Cooper's hawk* and sharp-shinned hawk*) for roosting and sometimes nesting. Pine siskin,* red-breasted nuthatch,* black-throated green warbler,* evening grosbeak,* purple finch,* and Blackburnian warbler* nest in conifer stands. American woodcock* sometimes uses conifer stands for nesting and foraging. Conifer stands also provide important habitat for a variety of mammals, including eastern cottontail, red squirrel, porcupine, and eastern chipmunk (Bailey and Alexander 1960). Some conifer stands provide winter shelter for white-tailed deer and can be especially important for them during periods of deep snow cover.

Upland Mixed Forest

The term "upland mixed forest" refers to non-wetland forested areas with both hardwood and conifer species, where conifer cover is 25-75% of the canopy. In the Town of Woodstock, mixed forests consisted of eastern hemlock, white pine, and occasionally pitch pine, red pine, red spruce, or balsam fir mixed with various northern hardwood species. In most cases, the distinction between conifer and mixed forest was made by aerial photograph interpretation. Mixed forests are less densely shaded at ground level and support a higher diversity and greater abundance of understory species than conifer-dominated stands.

Occurrence in the Town of Woodstock

Upland hardwood forest was the most widespread habitat type in Woodstock, and upland mixed and upland conifer forest also covered large areas. Upland forests accounted for approximately 79% of the total land area in the town. The largest areas of forest occurred on the three mountain ridges running through the town and the Bluestone Wild Forest area in the Catskill Foothills. Most forests in the mountains and foothills contained rocky crest, ledge, or talus habitats (see section below). 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.). There may be additional old forest stands that were not observed during our fieldwork. 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 in which oaks were the dominant canopy species and the floor was covered with patches of lowbush blueberry, hillside blueberry, black huckleberry, and Pennsylvania sedge. Extensive mountain laurel thickets occurred in areas of oak woodland 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 ridges, in ravines, and along perennial streams. White pine was widespread and occurred in a variety of ecological settings. White pine stands were characteristic of early successional forests growing on abandoned agricultural land. Planted conifer stands often consisted of Norway spruce or red pine. Balsam fir was restricted to summit forests on Overlook Mountain and Olderbark Mountain. Red spruce was scattered across the northern mountain ridge, but rarely abundant. Small populations of red pine occurred on Tonshi Mountain and Mount Tobias, in addition to plantations. Small numbers of pitch pine were found primarily along the Catskill Escarpment and in the foothills on rocky ledges or on shallow soils.

Sensitivities/Impacts

Forests of all kinds are important habitats for wildlife. Extensive forested areas that are unfragmented by roads, meadows, trails, utility corridors, or developed lots are especially important for certain organisms, but are increasingly rare in the region. Development located along roads may prevent wildlife from traveling between forested blocks. Houses set back from roads by long driveways further add to the fragmentation of interior forest areas. Both paved and unpaved roads act as barriers that many species either do not cross or cannot safely cross, and many animals avoid breeding near traffic noise (Forman and Deblinger 2000, Trombulak and Frissell 2000).

In addition to their wildlife habitat values, forests are perhaps the most effective type of land cover for sustaining clean and abundant groundwater and surface water. Forests with intact canopy, understory, ground vegetation, and floors (i.e., organic duff and soils) are extremely effective at promoting infiltration of precipitation (Bormann et al. 1969, Likens et al. 1970, Bormann et al. 1974, Wilder and Kiviat 2008), and may be the best insurance for maintaining groundwater quality and quantity, and for maintaining flow volumes, temperatures, water quality, and habitat quality in streams. Furthermore, forests are among the most effective kinds of land cover for long term carbon sequestration in above-ground and below-ground biomass. Maintenance and expansion of forested areas helps to offset carbon emissions to the atmosphere from other human activities (IPCC 2007).

In addition to fragmentation, forest habitats can be degraded in several other ways. Clearing the forest understory destroys habitat for birds such as wood thrush,* which nests in dense understory vegetation, and black-and white warbler,* which nests on the forest floor. Poor logging practices can also damage the understory and cause soil erosion and siltation of streams. Soil compaction and removal of dead and downed wood and debris have many negative impacts, including the elimination of habitat for mosses, lichens, fungi, cavity-using animals, amphibians, reptiles, small mammals, and insects. Where dirt roads or trails cut through forest, vehicle, horse, and pedestrian traffic can harm tree roots and cause soil erosion. The roadway itself can provide nest predators (such as raccoon and opossum) and the brown-headed cowbird (a nest parasite) access to interior forest areas. Runoff from roads can pollute nearby areas with road salt, heavy metals, and sediments (Trombulak and Frissell 2000), and mortality from vehicles can significantly reduce amphibian populations (Fahrig et al. 1995). Forests are also susceptible to invasion by shade-tolerant, non-native herbs and shrubs, and this susceptibility is increased by development-related disturbances. Gaps created by logging can provide habitat for fast-growing, shade-intolerant, non-native species such as tree-of-heaven. Once established, many of these non-native species are difficult to eliminate. Human habitation has also led to the suppression of naturally occurring wildfires which can be important for the persistence of some forest species.

Introduced forest pests are also threatening forest health in the Hudson Valley. Of note is the hemlock woolly adelgid, a non-native aphid-like insect that has infested many eastern hemlock stands from Georgia to New England, and has caused widespread loss of hemlock in the Hudson Valley. The adelgid typically kills trees within 10-15 years and has the potential to cause naturally occurring upland mixed and conifer forests to become regionally rare. In Woodstock many hemlock stands were in some stage of decline, apparently due to adelgid infestations. In addition, the emerald ash borer is a non-native beetle that infests and kills North American ash species. It was first identified in Ulster County in 2010 and we observed ash borer damage in the Zena area of Woodstock. The Conservation Priorities and Planning section gives recommendations for protecting and fostering the habitat values of large forests, and Figure 4 illustrates locations of contiguous forest blocks in Woodstock.

CREST/LEDGE/TALUS

Ecological Attributes

Rocky crest, ledge, and talus habitats often (but not always) occur together, so they are described and mapped together for this project. Crest and ledge habitats occur where soils are very shallow and bedrock is partially exposed at the ground surface, either at the summit of a hill or low-elevation knoll (crest) or elsewhere (ledge). These habitats are usually embedded within other habitat types, most commonly upland forest. They can occur at any elevation, but may be most familiar on hillsides and hilltops in the region. Talus is the term for the fields of rock fragments that often accumulate at the bases of steep ledges and cliffs. We also included large glacial erratics (glacially-deposited boulders) in the "crest/ledge/talus" habitat type. Some crest, ledge, and talus habitats supported well-developed forests, while others had only sparse, patchy, and stunted vegetation. Crest, ledge, and talus habitats often appear to be harsh and inhospitable, but they can support an extraordinary array of uncommon or rare plants and animals. Some species, such as wall-rue,* smooth cliffbrake,* purple cliffbrake,* and northern slimy salamander* are found only in and near such habitats in the region. The communities and species that occur at any particular location are determined by many factors, including bedrock type, outcrop size, aspect, exposure, slope, elevation, biotic influences, and kinds and intensity of human disturbance. Rock polypody and marginal wood fern were common plants of crest, ledge, and talus habitats in Woodstock, and smooth rock tripe, common toadskin, and other lichens were abundant in certain locations.

Because distinct communities develop in calcareous and non-calcareous environments, we differentiated calcareous bedrock exposures wherever possible. In this region, calcareous crests support trees such as eastern red cedar, hackberry, basswood, and butternut; shrubs such as bladdernut, American prickly-ash, and Japanese barberry; and herbs such as wild columbine, ebony spleenwort, and maidenhair spleenwort. They can support numerous rare plant species, such as walking fern* and yellow harlequin.* Non-calcareous crests often have trees such as red oak, chestnut oak, mountain paper birch, yellow birch, fire cherry, eastern hemlock, and occasionally American mountain ash or pitch pine; shrubs such as lowbush blueberries, chokeberries, black huckleberry, early azalea, northern bush honeysuckle, red elderberry, and scrub oak; and herbs such as rock polypody, marginal wood fern, mountain wood fern, fragile fern, Pennsylvania sedge, little bluestem, hairgrass, and bristly sarsaparilla. Rare plants of non-calcareous crests include rusty woodsia,* Appalachian shoestring fern,* Braun's holly fern,* mountain spleenwort,* clustered sedge,* slender knotweed,* and three-toothed cinquefoil.*

Northern oak hairstreak* (butterfly) occurs with oak species which are host plants for its larvae, and falcate orange-tip* can be found on dry, rocky slopes with rock-cresses or bittercresses. Rocky habitats with larger fissures, cavities, and exposed ledges may provide shelter, den, and basking habitat for eastern hognose snake,* eastern racer,* eastern ratsnake,* and northern copperhead.* Ledge areas with southeastern, southern, or southwestern exposure may provide winter den and spring "basking rocks" for timber rattlesnake.* Northern slimy salamander* occurs in non-calcareous wooded talus areas and rock piles. Breeding birds of crest habitats include prairie warbler,* golden-winged warbler,* Blackburnian warbler,* worm-eating warbler,* and cerulean warbler.* Bobcat* and fisher* use high-elevation crests and ledges for travel, hunting, and cover. Porcupine* and bobcat also use ledge and talus habitats for denning. Boreal red-backed vole* is found in some rocky areas, and eastern small-footed bat* roosts in talus habitat.

Occurrence in the Town of Woodstock

Crest, ledge, and talus habitats were widespread In the Catskill Mountains and Foothills. These habitats were found in almost all areas where field work was conducted. Extensive ledges on the Catskill Escarpment west of West Saugerties-Woodstock Road were often at least 20 ft (6 m) tall and alternated with steep forested slopes, forming a 'stair-step' pattern. Glacial erratics were common throughout the lower slopes of mountains, as were bouldery forests. These forested areas were gently sloped, but covered with boulders ranging from 0.7 ft (0.2 m) to > 9 ft (> 3 m) in diameter. We included these in the crest, ledge, and talus layer of the habitat map because we felt they have similar ecological attributes to the more typical crest, ledge, and talus habitats. Calcareous ledges were found in several areas throughout the town, but were most common in the Catskill Foothills, particularly in the Zena area.

Sensitivities/Impacts

Crest, ledge, and talus habitats often occur in locations that are valued by humans for recreational uses, scenic vistas, and house sites. Construction of trails, roads, and houses destroys crest, ledge, and talus habitats directly, and causes fragmentation of these habitats and the forested areas of which they are often a part. Rare plants of rocky habitats are vulnerable to trampling and collecting; rare snakes are susceptible to road mortality, intentional killing, and collecting; and rare breeding birds are easily disturbed by human activities nearby. The shallow soils of these habitats are susceptible to erosion from construction and logging activities, and from foot and ATV traffic. The Conservation Priorities and Planning section gives recommendations for protecting and fostering the habitat values of these rocky habitats, and Figure 5 illustrates generalized locations of crest, ledge, and talus habitat in Woodstock.

pastures,

OAK-HEATH BARREN

Top: Calcareous ledge with fragile fern and walking fern

Bottom: Oak-heath barren with scrub oak and blueberries

Ecological Attributes

A special subset of rocky crest habitat (see above), oak-heath barren occurs on ridgetops and shoulders with exposed non-calcareous bedrock, shallow, acidic soils, and vegetation dominated by some combination of pitch pine, scrub oak, other oaks, and heath (Ericaceae) shrubs. Shale, sandstone, and conglomerate are the common types of exposed bedrock. The soils are extremely thin, excessively well drained, and very nutrient-poor. Due to the open canopy, oak-heath barrens tend to have a warmer microclimate than the surrounding forested habitat in spring through fall. The exposed nature of these habitats also makes them particularly susceptible to wind, ice, and, at least historically, fire disturbance. The droughty, infertile, and exposed conditions have a strong influence on the composition and structure of the plant community; trees are often sparse and stunted. Our definition corresponds to Edinger et al.'s (2002) "pitch pine-oak forest" and "pitch pine-oak-heath rocky summit." There may be a continuous canopy of pitch pine or pitch pine-oak with a scrub oak understory, or the shrub layer (predominantly scrub oak and heath shrubs) may dominate, with only scattered pines. Dominant trees include pitch pine, white pine, chestnut oak, and red oak; the shrub layer may include scrub oak, eastern red cedar, blueberries, black huckleberry, early azalea, deerberry, and sweetfern. Common herbs include Pennsylvania sedge, poverty-grass, common hairgrass, little bluestem, and bracken. Lichens and mosses are sometimes abundant.

Oak-heath barrens can have significant habitat value for timber rattlesnake,* northern copperhead,* and other snakes. Deep rock fissures can provide crucial overwintering sites for these species and the exposed ledges provide basking and breeding habitat in the spring and early summer. Birds of this habitat include common yellowthroat, Nashville warbler, prairie warbler,* field sparrow,* eastern towhee,* and whip-poor-will.* A number of rare butterflies that use scrub oak, little bluestem, lowbush blueberry, or pitch pine as their primary food plant tend to concentrate in oak-heath barrens, including Edward's hairstreak,* cobweb skipper,* Leonard's skipper,* and brown elfin. Oak-heath barrens also appear to be refuges for several rare oak-dependent moths. Rare plants of oak-heath barrens include mountain spleenwort,* rusty woodsia,* clustered sedge,* dwarf shadbush,* bearberry,* and three-toothed cinquefoil.*

Occurrence in the Town of Woodstock

We mapped 25 oak-heath barren patches in the Catskill Mountains, although more likely exist in the rugged terrain of the Escarpment. Most were smaller than 1 ac (0.4 ha); the largest covered 6 ac (2.4 ha). The total area of oak-heath barren mapped in the town was 30 ac (12 ha).

Sensitivities/Impacts

Because most oak-heath barrens in the town are located within the state forest preserve, they have been largely protected from severe human disturbance. The most immediate threats to these fragile habitats are human foot traffic; barrens near trails are often visited for scenic views and for picnicking and camping. Trampling, soil compaction, and soil erosion can damage or eliminate rare plants, discourage use by rare animals, and encourage invasions of non-native plants. These effects are even more marked in the small areas that have seen residential development on oak-heath barrens. Barrens on hilltops can also be disturbed or destroyed by the construction and maintenance of communication towers. Construction of roads and buildings in the areas between oak-heath barrens can fragment important migration corridors for reptiles, and butterflies, thereby isolating neighboring populations and decreasing their long-term viability. Because rare snakes tend to congregate on oak-heath barrens at certain times of the year, they are highly susceptible to killing or collecting by poachers. The Conservation Priorities and Planning section gives recommendations for protecting and fostering the habitat values of oak-heath barrens, and Figure 5 illustrates locations of these habitats and their conservation zones in Woodstock.

UPLAND SHRUBLAND

Ecological Attributes

We use the term “upland shrubland” to describe non-forested uplands with significant (>20 %) shrub cover. In most cases these are lands in transition between meadow and young forest, but they also occur in recently cleared areas, and are sometimes maintained as shrubland along utility corridors by cutting or herbicides. Recently cleared or disturbed sites often contain dense thickets of shrubs and vines, including a variety of brambles and young white pine. Abandoned agricultural fields and pastures often support more diverse plant communities, including a variety of meadow grasses and forbs, shrubs such as meadowsweet, mountain laurel, sweetfern, northern blackberry, raspberries, and multiflora rose, and scattered seedling- and sapling-size eastern red cedar, white pine, and oaks. Occasional large, open-grown trees (e.g., sugar maple, red oak) left as shade for livestock or for ornament may be present.

A few species of rare plants are known from calcareous shrublands in the region, such as stiff-leaf goldenrod,* butterflyweed,* and shrubby St. Johnswort.* Rare butterflies such as Aphrodite fritillary,* dusted skipper,* Leonard’s skipper,* and cobweb skipper* may occur in shrublands where their host plants are present (violets for the fritillary and native grasses, such as little bluestem, for the skippers). Upland shrublands and other non-forested upland habitats may be used by turtles (e.g., painted turtle, wood turtle,* spotted turtle,* and eastern box turtle*) for nesting. Many bird species of conservation concern nest in upland shrublands and adjacent upland meadow habitats, including brown thrasher,* blue-winged warbler,* golden-winged warbler,* prairie warbler,* yellow-breasted chat,* clay-colored sparrow,* eastern towhee,* and northern harrier.* Extensive upland shrublands and those that form large complexes with meadow habitats may be particularly important for these breeding birds. Several species of hawks and falcons use upland shrublands and adjacent meadows for hunting small mammals such as meadow vole, white-footed mouse, and eastern cottontail.

Occurrence in the Town of Woodstock

Upland shrublands were distributed throughout the town, and ranged in size from 0.1 to 18 ac (0.04-7.3 ha), for a total of 255 ac (103 ha). Shrublands consisted of abandoned fields, logged areas, and utility corridors. Fields and logged areas were often colonized by white pine, while utility corridors had white pine, sweetfern, or huckleberry as the dominant species.

Sensitivities/Impacts

Shrublands and meadows (see below) are closely related plant communities and share many of the same ecological values. Having a diversity of ages and structures in these habitats may promote overall biological diversity, and can be achieved by rotational mowing and/or brush-hogging. To reduce the impacts of these management activities on birds, mowing should be timed to coincide with the post-fledging season for most birds (e.g., September and later) and only take place every few years, if possible. As in upland meadows, soil compaction and erosion caused by ATVs and other vehicles and equipment can reduce the habitat value for invertebrates, small mammals, nesting birds, and nesting turtles. If shrublands are left undisturbed, most will eventually become forests, which are also valuable habitats. Certain animals depend on extensive shrublands, and others depend on extensive meadows; smaller interspersed patches of shrubland and meadow will not necessarily support these more specialized species of non-forested habitats. Our upland shrubland mapping unit (characterized by >20% shrub-dominated areas) may be too general a category to distinguish habitats of certain open-land species.

UPLAND MEADOW

Ecological Attributes

This broad category includes active cropland, hayfields, pastures, equestrian fields, abandoned fields, and other upland areas dominated by herbaceous vegetation. Upland meadows are typically dominated by grasses and forbs, and have less than 20% shrub cover. The ecological values of these habitats can differ widely according to the types of vegetation present and varied disturbance histories (e.g., tilling, mowing, grazing, pesticide applications). Extensive hayfields or pastures, for example, may support grassland-breeding birds (depending on the mowing schedule or intensity of grazing), while intensively cultivated crop fields may have comparatively little habitat value for rare wildlife. We mapped these distinct types of meadow as a single habitat for practical reasons, but also because after abandonment these open areas tend to develop similar general habitat characteristics and values. Undisturbed meadows develop diverse plant communities of grasses, forbs, and shrubs and support an array of wildlife, including invertebrates, reptiles, mammals, and birds. It is for both present and potential future ecological values that we consider all types of meadow habitat to be ecologically significant.

Several species of rare butterflies, including Aphrodite fritillary,* use upland meadows that support their particular host plants. Upland meadows can be used for nesting by wood turtle,* spotted turtle,* eastern box turtle,* painted turtle, and snapping turtle.* Grassland-breeding birds such as northern harrier,* upland sandpiper,* grasshopper sparrow,* vesper sparrow,* savannah sparrow,* eastern meadowlark,* and bobolink* use extensive meadow habitats for nesting and foraging. Wild turkeys forage on invertebrates and seeds in upland and wet meadows. Upland meadows often have large populations of small mammals (e.g., meadow vole) and can be important hunting grounds for raptors, foxes, and eastern coyote.

Occurrence in the Town of Woodstock

Upland meadows accounted for about 3% of the total land area in the town. Common upland meadows were hayfields, pastures, fallow fields and forest clearings dominated by goldenrod or little bluestem, and infrequently mowed lawns. The majority of upland meadows were small (95% were smaller than 5 ac [2 ha]) and not intensively managed.

Sensitivities/Impacts

Principle causes of meadow habitat loss in the region are the regrowth of shrubland and forest after abandonment, and residential and commercial development. The dramatic decline of grassland-breeding birds in the Northeast has been attributed to the loss of large areas of suitable meadow habitat; many of these birds need large meadows that are not divided by fences or hedgerows, which can harbor predators (Wiens 1969). Another threat to upland meadow habitats is the soil compaction and erosion caused by ATVs and other vehicles and equipment, which can reduce the habitat value for invertebrates, small mammals, nesting birds, and nesting turtles. Destruction of vegetation can affect rare plant populations and reduce viable habitat for butterflies, and mowing of upland meadows during the bird nesting season can cause extensive mortality of eggs, nestlings, and fledglings. Farmlands where pesticides and artificial fertilizers are used may have a reduced capacity to support biodiversity. The Conservation Priorities section provides recommendations for maintaining large meadow habitats, and Figure 6 illustrates the location and distribution of contiguous meadow habitat in Woodstock (including both upland and wet meadows). This figure does not include areas of upland shrubland that in some cases had considerable patches of herbaceous cover.

ORCHARD/PLANTATION

This habitat type includes actively maintained or recently abandoned fruit orchards, Christmas tree farms and plant nurseries. Conifer plantations with larger, older trees were mapped as "upland conifer forest." Christmas tree farms are potential northern harrier* breeding habitat. Fruit orchards with old trees are potential breeding habitat for eastern bluebird* and may be valuable to other cavity-using birds, bats, and other animals. The habitat value of active orchards or plantations is often compromised by frequent mowing, application of pesticides, and other human activities; we considered this an ecologically significant habitat type more for its future ecological values after abandonment than its current values. These habitats have some of the vegetation structure and ecological values of upland meadows and upland shrublands, and will ordinarily develop into young forests if they remain undisturbed after abandonment. We know of only four small orchards in the Town of Woodstock, ranging from 0.4 to 2 ac (0.2-0.8 ha). Abandoned orchards that had lost their ordered structure were mapped either as upland hardwood forest or as upland shrubland depending on their structural characteristics.

CULTURAL HABITATS

We define “cultural” habitats as areas that are significantly altered and intensively managed (e.g., mowed), but are not otherwise developed with pavement or structures. We identified this as an ecologically significant habitat type more for its potential future ecological values than its current values, which are reduced by frequent mowing, application of pesticides, or other types of management and intensive human uses. Nonetheless, eastern screech-owl* and barn owl* are known to nest, forage, and roost in cultural areas. American kestrel,* spring migrating songbirds, and bats may forage in these habitats, and wood duck* may nest here. Individual ornamental trees can provide habitat for cavity-nesting birds, roosting bats (including Indiana bat*), and many other animals, as well as supporting mosses, liverworts, and lichens, potentially including rare species. Dirt roads with long-lasting rain puddles in lacustrine clay or glacial till terrains potentially support a rare species of clam shrimp (Schmidt and Kiviat 2007). Of the different types of places mapped as “cultural,” cemeteries are particularly well suited to provide habitat to a variety of species, since mature trees are often present, noise levels are minimal, and traffic is infrequent and slow. Many cultural areas have “open space” and recreational values for the human community, and some help to buffer less disturbed habitats from human activities, and link patches of undeveloped habitat together. Because cultural habitats are already significantly altered, however, their current habitat value is greatly diminished compared to relatively undisturbed habitats. Cultural areas comprised a small percentage (0.4%) of the land area in Woodstock, and included a golf course, large lawns, parks, and riding rings.

WASTE GROUND

Waste ground is a botanists' term for land that has been severely altered by previous or current human activity, but lacks pavement or structures. Most waste ground areas have been stripped of vegetation and topsoil or filled with soil or debris but remain unvegetated or sparsely vegetated. This category encompasses a variety of highly impacted areas such as active and abandoned sand and gravel mines, rock quarries, mine tailings, dumps, unvegetated or sparsely vegetation wetland fill, unvegetated or sparsely vegetated landfill cover, construction sites, and abandoned lots. Although waste ground often has low habitat value, there are notable exceptions. Several rare plant species are known to inhabit waste ground environments, including rattlebox,* slender pinweed,* field-dodder,* and slender knotweed.* Rare lichens and mosses may occur in some waste ground habitats. Several snake and turtle species of conservation concern, including eastern hognose snake and wood turtle,* may use the open, gravelly areas of waste grounds for burrowing, foraging, or nesting habitat. Bank swallow* and belted kingfisher often nest in the stable walls of inactive soil mines (or inactive portions of working mines) and occasionally in piles of soil or sawdust. Bare, gravelly, or otherwise open areas provide nesting grounds for spotted sandpiper, killdeer, and possibly common nighthawk.* Little is known of the invertebrate fauna of waste grounds but this habitat might support rare species. The biodiversity value of waste ground will often increase over time as it develops into a higher quality habitat. However, on sites where species of conservation concern are absent or unlikely, waste ground probably has a low habitat value compared to other relatively undisturbed habitats. Waste ground patches known to support a rare species (or serve as an important turtle nesting habitat) may need to be actively managed to maintain the sparse vegetation and substantially bare soil often required by these species.

Bluestone quarries are one type of waste ground in Woodstock deserving special attention. Bluestone is an even-textured sandstone derived from deposits in the Catskill Delta during the Devonian Period, approximately 345 million years ago. An attractive and durable paving stone, bluestone was first found in Ulster County, and was quarried heavily during the 1800s (Evers 1972). Most of the quarries in the Town of Woodstock are long-abandoned. Workers cut slabs of rock, leaving behind quarried ledges 5-20 ft (1.5-6 m) or higher and large piles of discarded bluestone. We mapped these large, exposed debris heaps as waste ground. Some quarries are now completely shaded by a forest canopy and mapped as upland forest with crest, ledge, and talus overlay, while others have remained treeless. These abandoned quarries now provide habitats similar to crest, ledge, and talus areas (see above) and, in some cases, intermittent woodland pools (see below). An inventory of quarries identified during field work is available in the digital dataset submitted with this report under natural history notes.

Occurrence in the Town of Woodstock

The majority of waste ground areas we mapped in Woodstock were small (0.04-6 ac [0.02-2.4 ha]). Debris heaps from abandoned bluestone quarries were the most common type of waste ground. Quarries were most frequent in the Catskill Foothills and along the Escarpment.

Abandoned bluestone quarry

WETLAND HABITATS

SWAMPS

Ecological Attributes

A swamp is a wetland dominated by woody vegetation (trees and/or shrubs). We mapped three general types of swamp habitat in Woodstock: hardwood and shrub swamp, conifer swamp, and mixed forest swamp.

Hardwood and Shrub Swamp

We combined deciduous forested and shrub swamps into a single habitat type because the two often occur together and can be difficult to separate using remote sensing techniques. Red maple, green ash, American elm, slippery elm, yellow birch, black gum, and swamp white oak were common trees of hardwood swamps in Woodstock. Typical shrubs included highbush blueberry, silky dogwood, alder, winterberry holly, spicebush, shrubby willows, swamp azalea, and nannyberry, and common herbaceous species were tussock sedge, skunk-cabbage, sensitive fern, cinnamon fern, royal fern, and marsh fern. Mosses were abundant.

Conifer and Mixed Forest Swamp

Conifer swamp is a type of forest swamp where conifer species occupy 75% or more of the upper tree canopy. Mixed forest swamp has a canopy composed of 25-75% conifers. Native conifer species at these latitudes and elevations that can tolerate wetland conditions include eastern hemlock, white pine, black spruce, eastern tamarack, eastern red cedar, and northern white cedar. Of these, we found only eastern hemlock and white pine in Woodstock swamps. The dense canopy of a conifer swamp has a strong influence on the swamp's structure and understory plant community. Shading creates a cooler microclimate, allowing snow and ice to persist longer into the early spring growing season. *Sphagnum* mosses may be abundant. Conifers growing in wetlands frequently have very shallow root systems and are therefore prone to windthrow. The resulting tip-up mounds, root pits, and coarse woody debris all contribute to the habitat's complex structure and microtopography. Mixed forest swamp has characteristics intermediate between those of hardwood and conifer swamps, and shares many of the ecological values of those habitats.

Swamps are important to a wide variety of birds, mammals, amphibians, reptiles, and invertebrates, especially when swamp habitats are contiguous with other wetland habitats or embedded within large areas of upland forest. Swamp cottonwood* is a very rare tree of deeply-flooding hardwood swamps, known from only five or six locations in the Hudson Valley. Swamps with hemlock may support great laurel,* swamp saxifrage, and early coralroot* (Bierhorst 1995). Hardwood and shrub swamps along the floodplains of clear, low-gradient streams can be an important component of wood turtle* habitat. Other turtles such as spotted turtle* and box turtle* frequently use swamps for summer foraging, drought refuge, overwintering, and travel corridors. Pools within swamps are used by several breeding amphibian species, and are the primary breeding habitat of blue-spotted salamander.* Four-toed salamander,* believed to be regionally uncommon, uses swamps with abundant moss-covered rocks, moss-covered downed wood, or woody hummocks. Red-shouldered hawk,* barred owl,* great blue heron,* wood duck,* prothonotary warbler,* Canada warbler,* Virginia rail,* and white-eyed vireo* may nest in hardwood swamps. Brown creeper and winter wren* breed in hemlock swamps (Thompson and Sorenson 2000).

Among the shrub swamps that we visited, we noted two particular types with exceptional habitat value: heath swamps and buttonbush pools. Both are more or less hydrologically isolated wetlands that may be valuable habitat for pool-breeding amphibians and other animals that depend on intermittent woodland pools. The structural differences among these swamps, however, may have implications for some species that use them (for more information on these habitats see Kiviat and Stevens 2001 and Bell et al. 2005). The few such swamps that we mapped should be considered examples of the habitats rather than a complete inventory; there may be many more shrub swamps in the town that fall into these categories that we did not visit.

- *Heath swamps* typically have deep water, moss-covered woody hummocks, a significant shrub layer dominated by highbush blueberry, winterberry holly, and/or swamp azalea, and high plant diversity. They usually seem quite acidic, supporting mountain laurel and large areas of *Sphagnum* mosses. Heath swamps are often found in depressions isolated from other wetlands, and they appear to be excellent habitat for uncommon plants, pool-breeding amphibians, four-toed salamander, and other uncommon species.

Top: Heath swamp with dense highbush blueberry stands

Bottom: Buttonbush pool with abundant threeway sedge

- *Buttonbush pools* are seasonally or permanently flooded, shrub-dominated pools, with buttonbush normally the dominant plant (although buttonbush may appear and disappear over the years in a given location). Other shrubs such as highbush blueberry, swamp azalea, and willows may also be abundant. In some cases, a shrub thicket in the middle of the pool is entirely or partly surrounded by an open water moat. The buttonbush pool may have some small trees such as red maple or green ash in the pool interior, but usually lacks a forest canopy. Standing water is present in winter and spring but often disappears by late summer, or remains only in isolated puddles. Buttonbush pools have plants and vegetation structure similar to those of kettle shrub pools described in Kiviat and Stevens (2001), but are not located in outwash soils.

Occurrence in the Town of Woodstock

Hardwood and shrub swamp was the most extensive wetland habitat type in the town, totaling 700 ac (283 ha) in Woodstock. Swamps ranged in size from <0.5 to 24 ac (<0.2-9.7 ha). Most swamps were small, with an average extent of 1 ac (0.4 ha). They were often contiguous with other wetland habitats such as marsh, wet meadow, and open water. The largest swamps in Woodstock were in Willow between Route 212 and Sickler Road and at Kenneth Wilson State Park between Wittenberg and Coldbrook roads.

Conifer and mixed forest swamps in Woodstock were typically embedded in upland conifer or mixed forests, and featured a hemlock or white pine canopy mixed with red maple, yellow birch, and occasionally black gum. The shrub layer included winterberry and highbush blueberry, and the herbaceous cover included a thick layer of mosses, as well as cinnamon fern, royal fern, goldthread, and moneywort. In the eastern section of Woodstock, long, narrow conifer and mixed forest swamps were common in shallow depressions parallel to the Catskill Foothills.

Swamps occurred in a variety of settings, such as on seepy slopes, along streams, and in depressions. Some were shrub-dominated (notably the heath swamps and buttonbush pools), while others had a full canopy of hemlock, red maple, or green ash. Water depths varied greatly, with some swamps drying completely in the summer months while others retained relatively deep pools. Swamps that were isolated from streams and other wetlands may have ecological roles similar to those of intermittent woodland pools (see below), including breeding habitat for pool-breeding amphibians, and refuge and foraging habitat for turtles.

Sensitivities/Impacts

Some swamps are protected by federal, state, or local laws, but that protection is usually incomplete or inadequate, and most swamps are still threatened by a variety of land uses. Small swamps embedded in upland forest are often overlooked in wetland protection, but can have extremely high biodiversity value, similar to intermittent woodland pools (see below). Many of the larger swamps in the region are located in low-elevation areas where human land uses are also concentrated. They can easily be damaged by alterations to the quality, quantity, or timing of surface water runoff, or by disruptions of the groundwater sources that feed some swamps. Swamps that are surrounded by agricultural land are subject to runoff contaminated with agricultural chemicals, and those near roads and other developed areas often receive runoff high in nutrients, sediment, de-icing salts, and other toxins. Polluted runoff degrades the swamp's water quality, affecting the habitat value of the swamp and its associated streams. Maintaining flow patterns, seasonal water level fluctuations, and water volumes in swamps is important to the plants and animals of these habitats. Connectivity between swamp habitats and nearby upland and wetland habitats is essential for amphibians that breed in swamps and for other resident and transient wildlife of swamps. Direct disturbance, such as logging, can damage soil structure, plant communities, and microhabitats, and provide access for invasive plants. Ponds for ornamental or other purposes are sometimes excavated or impounded in swamps, but the loss of habitat values of the pre-existing swamp usually far outweighs any habitat value gained in the new, artificial pond environment. The Conservation Priorities section provides recommendations for preserving the habitat values of swamps within larger wetland complexes, and Figure 8 illustrates the locations of swamps, other wetlands, and wetland complex conservation zones in Woodstock.

INTERMITTENT WOODLAND POOL

Ecological Attributes

An intermittent woodland pool is a small wetland partially or entirely surrounded by forest, typically with no surface water inlet or outlet (or an ephemeral one), and with standing water during winter and spring that dries up by mid- to late summer during a normal year. This habitat is a subset of the widely recognized "vernal pool" habitat, which may or may not be surrounded by forest. Despite the small size of intermittent woodland pools, those that hold water through early summer can support amphibian diversity equal to or higher than that of much larger wetlands (Semlitsch and Bodie 1998, Semlitsch 2000). Seasonal drying and lack of a stream connection ensure that these pools do not support fish, which are major predators on amphibian eggs and larvae. The surrounding forest supplies the pool with leaf litter, the base of the pool's food web; the forest is also essential habitat for amphibians during the non-breeding season.

Intermittent woodland pools provide critical breeding and nursery habitat for wood frog,* Jefferson salamander,* marbled salamander,* and spotted salamander.* Reptiles such as spotted turtle* use intermittent woodland pools for foraging, rehydrating, and resting. Wood duck,* mallard, and American black duck* use intermittent woodland pools for foraging, nesting, and brood-rearing, and a variety of other waterfowl and wading birds use these pools for foraging. The invertebrate communities of these pools can be rich, providing abundant food for songbirds such as yellow warbler, common yellowthroat, and northern waterthrush.* Springtime physa* is a regionally rare snail associated with intermittent woodland pools. Large and small mammals use these pools for foraging and as water sources. Featherfoil* occurs in intermittent woodland pools in the lower Hudson Valley.

Occurrence in the Town of Woodstock

We mapped 75 small intermittent woodland pools in Woodstock. Pools were scattered in undeveloped parts of the town within upland forests and occasionally adjacent to swamps. Most of the pools were smaller than 0.1 ac (0.04 ha), with an average size of 0.08 ac (0.03 ha). Because these pools are small and often difficult to identify on aerial photographs (particularly under a coniferous canopy), we expect there are additional intermittent woodland pools that we did not map.

Sensitivities/Impacts

We consider intermittent woodland pools to be one of the most imperiled habitats in the region. Although they are widely distributed, the pools are small (often less than 0.1 ac [0.04 ha]) and their ecological importance is often undervalued. They are frequently drained or filled by landowners and developers, used as dumping grounds, treated for mosquito control, or converted into ornamental ponds. They are often overlooked in environmental reviews of proposed developments. Even when the pools themselves are spared in a development plan, the surrounding forest so essential to the ecological function of the pools is frequently destroyed. Intermittent woodland pools are often excluded from federal and state wetland protection due to their small size and their isolation from other wetland and stream habitats. It is these very characteristics of size, isolation, and intermittency, however, which make woodland pools uniquely suited to species that do not reproduce or compete as successfully in larger wetland systems. The Town of Woodstock Wetlands and Watercourse Law offers some protection for intermittent woodland pools, including a protected buffer of 50 ft (15 m) around pools of <0.1 ac and a buffer of 100 ft (30 m) around larger pools, but the protections do not extend to the surrounding forest. The Conservation Priorities section provides recommendations for protecting the habitat values of intermittent woodland pools, and Figure 7 illustrates locations of these pools and their conservation zones in Woodstock.

CIRCUMNEUTRAL BOG LAKE

Ecological Attributes

A circumneutral bog lake is a spring-fed, calcareous water body that commonly supports vegetation of both acidic bogs and calcareous marshes. The bottom has a deep organic layer, and floating peat mats and drifting peat rafts are usually present. The peat mats are insulated from the calcareous lake water, and thus may develop herbaceous and shrubby vegetation characteristic of acidic bogs. The mats may also have dense stands of cattail or purple loosestrife. Open water often supports abundant pond-lilies and submerged aquatic vegetation, and shoreline areas may support cattails, purple loosestrife, water-willow, alder, or leatherleaf. The lakes often have swamps, calcareous wet meadows, or fens at their margins.

This is a rare habitat type in the region, and is known to support many rare and uncommon species of plants and animals. Several species of rare sedges, forbs, and submerged aquatic plants occur in circumneutral bog lakes in Dutchess and Ulster counties. Rare fauna associated with circumneutral bog lakes include eastern ribbon snake,* northern cricket frog,* spotted turtle,* blue-spotted salamander,* marsh wren,* and river otter.* These habitats have also been found to support diverse communities of mollusks, dragonflies, and damselflies. Busch (1976) described a circumneutral bog lake in the Town of Pine Plains, and Hudsonia has studied several of these habitats in Dutchess and Ulster counties (Kiviat and Zeising 1976, Kiviat 2002).

Occurrence in the Town of Woodstock

We identified one circumneutral bog lake in the Town of Woodstock, Yankeetown Pond, measuring approximately 131 ac (53 ha). Spider Barbour (pers. comm.) surveyed the pond in 2012 and created a vegetation map (not included in this report); the following description is based on his observations. White pond-lily was dominant in deeper areas of the pond, while yellow pond-lily and water-shield occurred in discreet areas. A large, floating peat mat covered the north center of the pond and hosted shrubs such as leatherleaf, large cranberry,* and water-willow; and herbs including royal fern, marsh fern, marsh St. Johnswort, and diverse sedges. Tussock sedge dominated sedge meadows at the margins of the pond and in former swamps. Buttonbush formed near monotypic stands along the south side of the pond between the shore and deeper waters and grew together with threeway sedge on mud flats in the center of the pond. The undeveloped shoreline of the pond was bordered mostly by a mosaic of swamps and upland forest. Barbour observed three or more beaver lodges, spotted turtle,* snapping turtle,* and eastern painted turtle, and a diverse bird community, including great blue heron,* osprey,* bald eagle,* American black duck,* and many other ducks, especially in spring and fall migration. River otter* were reported to us by local residents.

Sensitivities/Impacts

We believe that circumneutral bog lakes are extremely sensitive to changes in surface and groundwater chemistry and flows, and could be affected by any significant alterations to the watershed such as tree removal, soil disturbance, applications of fertilizers or pesticides, septic leachate, groundwater extraction, or altered drainage. Residential development along scenic lakeshores and agricultural uses within the watershed are common causes of these and other disturbances. Maintaining a forested buffer around the lake is critical for preserving habitat quality. Recreational uses such as boating, fishing, or hiking can be sources of garbage, pollutants, and disturbance, and should be managed carefully; use of motorized watercraft should be avoided. Mechanical disturbances in the lake or artificial changes in surface water levels or chemistry could disrupt the peat rafts and floating vegetation mats and the submerged aquatic plant communities. The Conservation Priorities section provides recommendations for preserving the habitat values of the circumneutral bog lake, and Figure 7 shows the location of Yankeetown Pond and its conservation zone in Woodstock.

MARSH

Ecological Attributes

A marsh is a wetland that has standing water for most or all of the growing season, and is dominated by herbaceous (non-woody) vegetation. Marshes often occur at the fringes of deeper water bodies (e.g., lakes and ponds), or in close association with other wetland habitats such as wet meadows or swamps. The edges of marshes, where standing water is less permanent, often grade into wet meadows. Cattail, tussock sedge, pickerelweed, arrow arum, broad-leaved arrowhead, water-plantain, common reed, and purple loosestrife are some typical emergent marsh plants in this region. Deeper water may support rooted, floating-leaved plants such as pond-lilies, or submerged aquatic plants such as pondweeds, bladderworts, and watermilfoils.

Top: Yankeetown Pond, a circumneutral bog lake

Bottom: Marsh with cattails and pond-lilies

Several rare plant species are known from marshes in the region, including spiny coontail* and buttonbush dodder.* Spatterdock darner* uses marshes at the edges of ponds or pools with abundant floating vegetation, often yellow pond-lily (Nikula 2003, Environmental Resource Mapper 2007). Marshes are important habitats for reptiles and amphibians, including eastern painted turtle, snapping turtle,* spotted turtle,* green frog, pickerel frog, spring peeper, and northern cricket frog.* Numerous bird species, including marsh wren,* common moorhen,* American bittern,* least bittern,* great blue heron,* Virginia rail,* king rail,* sora,* American black duck,* and wood duck* use marshes for nesting, nursery, or foraging habitat. Many raptor, wading bird, and mammal species use marshes for foraging.

Occurrence in the Town of Woodstock

We mapped 45 marsh areas in Woodstock, covering a total of 26 ac (10.5 ha). Marshes were frequently found along the margins of or embedded in hardwood and shrub swamps, wet meadows, or constructed ponds. Many marshes in the town, including the largest marsh (9 ac [3.6 ha]) were constructed ponds that had filled with sediment and vegetation over time. Other marshes were created or enlarged by beaver dams, which flooded forested swamps and killed the trees. These marshes had numerous standing snags, areas of open water, and emergent and floating herbaceous vegetation. Because it was sometimes difficult to distinguish marsh from shrub swamp or wet meadow on aerial photographs, all mapped marsh boundaries should be considered approximate. Cattail, common reed, purple loosestrife, sedges, and common duckweed were dominant in many of the marshes we observed in Woodstock.

Sensitivities/Impacts

In addition to direct disturbances such as filling or draining, marshes are subject to stresses from offsite (upgradient) sources. Alteration of surface water runoff patterns or groundwater flows can lead to dramatic changes in the plant and animal communities of marshes. Polluted stormwater runoff from roads, parking lots, lawns, and other surfaces in developed landscapes carries sediments, nutrients, de-icing salts, toxins, and other contaminants into the wetland. Alteration of water levels by humans or beaver can also alter the plant community and, as with elevated nutrient and sediment inputs, can facilitate invasion by non-native plants such as purple loosestrife and common reed. Noise and direct disturbance from human activities can discourage breeding activities of marsh birds. Because many animal species of marshes depend equally on surrounding upland habitats to meet various needs throughout the year, protection of the ecological functions of marshes must go hand-in-hand with protection of surrounding habitats. The Conservation Priorities section provides recommendations for preserving the habitat values of marshes within larger wetland complexes, and Figure 8 illustrates the locations of marshes and other wetlands in Woodstock.

WET MEADOW

Ecological Attributes

A wet meadow is a wetland dominated by herbaceous (non-woody) vegetation and lacking standing water for most of the year. Its period of inundation is longer than that of an upland meadow, but shorter than that of a marsh. Some wet meadows are dominated by common reed, purple loosestrife, reed canary-grass, or tussock sedge, while others have a diverse mixture of wetland grasses, sedges, forbs, and scattered shrubs. Sensitive fern, marsh fern, bluejoint, mannagrasses, woolgrass, soft rush, and blue flag are some typical plants of wet meadows.

Wet meadows with diverse plant communities may have rich invertebrate faunas. Blue flag and certain sedges and grasses of wet meadows are larval food plants for several regionally-rare butterflies. Wet meadows provide nesting and foraging habitat for songbirds such as sedge wren,* wading birds such as American bittern,* and raptors such as northern harrier.* Wet meadows that are part of extensive meadow areas (both upland and wetland) may be especially important to species of grassland-breeding birds. Large and small mammals use wet meadows and other meadow habitats for foraging. See below for the description of calcareous wet meadow, a specific type of wet meadow habitat.

Occurrence in the Town of Woodstock

Wet meadows were scattered throughout Woodstock, and were often associated with swamps and streams. We mapped 304 wet meadows, covering 194 ac (78 ha) in the town. Most wet meadows were smaller than 1 ac (0.4 ha). Some had diverse plant communities. Surprisingly few were dominated by non-native species such as purple loosestrife. We use the "wet meadow" category to describe both non-calcareous wet meadows and other wet meadows that we did not visit (since calcareous wet meadows can only be identified in the field).

Sensitivities/Impacts

Some wet meadows are able to withstand light grazing by livestock, but heavy grazing can destroy the structure of the surface soils, eliminate sensitive plant species, and invite non-native weeds. Frequent mowing has similar negative consequences. It is less damaging to the plant community to mow in late summer, when the soils are dry, than when soils are moist or wet. See the information on large meadows in the Priority Habitats section for general recommendations about mowing practices. Wet meadows that are part of larger complexes of meadow and shrubland habitats are prime sites for development or agricultural use, and are often drained or excavated. Because many wet meadows are omitted from state, federal, and site-specific wetland maps, they are frequently overlooked in environmental reviews of development proposals. The Conservation Priorities section provides recommendations for preserving the habitat values of wet meadows within larger wetland complexes, and Figure 8 illustrates the locations of wet meadows and other wetlands in Woodstock.

CALCAREOUS WET MEADOW

Ecological Attributes

A calcareous wet meadow is a type of wet meadow habitat (see above) that is strongly influenced by calcareous (calcium-rich) groundwater or soils. These conditions favor the establishment of a calcicolous plant community, including such species as lakeside sedge, sweetflag, blue vervain, New York ironweed, rough-leaf goldenrod, and small-flowered agrimony. The vegetation is often lush and tall.

High quality calcareous wet meadows with diverse native plant communities may support rare plants and species-rich invertebrate communities, including phantom cranefly* and rare butterflies such as Dion skipper,* two-spotted skipper,* and Baltimore.* Eastern ribbon snake* and spotted turtle* use calcareous wet meadows for basking and foraging, and spotted turtle may nest on sedge tussocks. Many common wetland animals, such as green frog, pickerel frog, red-winged blackbird, meadow jumping mouse, and swamp sparrow use calcareous and other wet meadows.

Occurrence in the Town of Woodstock

We documented 14 calcareous wet meadows in Woodstock, most of which were smaller than 2 ac (0.8 ha). Several diverse, calcareous wet meadows were interspersed between marsh and hardwood and shrub swamp in Kenneth Wilson State Park. Because calcareous wet meadows can only be identified by the presence of indicator plant species, they cannot be distinguished from other wet meadows by remote sensing. Therefore it is likely that some of the mapped wet meadows we did not visit were actually calcareous wet meadows.

Sensitivities/Impacts

Calcareous wet meadows have sensitivities to disturbance similar to those of other wet meadows (see above). They are particularly vulnerable to soil disturbances, nutrient enrichment, and siltation, which often facilitate the spread of invasive species. Like other small wetland habitats without permanent surface water, they are often omitted from wetland maps and consequently overlooked in the environmental review of development proposals. The recently-adopted town wetland ordinance should help to draw attention to these important habitats.

OPEN WATER

Ecological Attributes

“Open water” habitats include naturally formed ponds and lakes, large pools within marshes and swamps that lack floating or emergent vegetation, and ponds that were apparently constructed by humans but have since reverted to a more natural state (i.e., are unmanaged themselves and are surrounded by minimally managed habitats). Areas of open water within beaver wetlands are dynamic habitats that expand or contract depending on the degree of beaver activity, and these areas are often transitional to emergent marshes or wet meadows. Open water areas can be important habitat for many common species of invertebrates, fishes, frogs, and turtles, as well as for waterfowl, muskrat, beaver, and bats. These waterbodies sometimes support submerged aquatic vegetation that can provide important habitat for additional aquatic invertebrates and fish, and forage for waterfowl, wading birds, and other wildlife. Spiny coontail* is often found in calcareous ponds. Spotted turtle* uses ponds and lakes during both drought and non-drought periods, and wood turtle* may overwinter and mate in open water areas. Northern cricket frog* may occur in circumneutral ponds. American bittern,* great blue heron*, osprey,* bald eagle,* wood duck,* American black duck,* and pied-billed grebe* may use open water areas as foraging habitat. Bats and river otter* also forage in or above open water habitats.

Occurrence in the Town of Woodstock

We mapped far fewer open water habitats than constructed ponds (see below) in Woodstock (and most of these "open water" areas were likely constructed in origin). Of the 42 open water habitats we mapped, the majority were smaller than 1 ac (0.4 ha). Echo Lake was the one large water body mapped as open water. Bodies of open water where we observed abundant rooted or floating-leaved vegetation (e.g., pond-lilies, cattail, common reed) were mapped as marshes.

Sensitivities/Impacts

The habitat value of natural open water areas is enhanced when they are not intensively managed or disturbed by human activities, and when they are surrounded by other intact habitats. Open water habitats are vulnerable to human impacts from shoreline development, aquatic weed control, use of motorized watercraft, and runoff from roads, lawns, and agricultural areas. Aquatic weed control, which may include harvesting, herbicide application, or introduction of grass carp, is an especially important concern in open water habitats, and the potential negative impacts should be assessed carefully before any such activities are undertaken (Heady and Kiviat 2000). Because open water habitats are often located within larger wetland and stream complexes, any disturbance to the open water habitat may have far-reaching impacts on the surrounding landscape. To protect water quality and habitat values, broad zones of undisturbed vegetation and soils should be maintained around undeveloped ponds and lakes. If part of a pond or lake must be kept weed-free for ornamental or other reasons, it is best to avoid dredging and to allow other parts of the pond to develop abundant vegetation. This can be accomplished by harvesting aquatic vegetation only where necessary to create open lanes or pools for boating, fishing, or swimming.

CONSTRUCTED POND

Ecological Attributes

Constructed ponds include those water bodies that have been excavated or dammed by humans, either in existing wetlands or stream beds, or in upland terrain. Most ponds are deliberately created for such purposes as fishing, watering livestock, irrigation, swimming, boating, and aesthetics. Several reservoirs are also located in Woodstock, notably Cooper Lake, which serves as the principal raw water storage reservoir for the City of Kingston water supply. Some ponds are constructed near houses or other structures to serve as a source of water in the event of a fire. We also included the water bodies created during mining operations in the constructed pond category. Although most constructed ponds in developed areas have only minor habitat value, those that are not intensively managed by humans can be important habitats for many of the common and rare species that are associated with natural open water habitats. Undisturbed, shallower ponds can develop into marshes or swamps over time (see the open water and other wetland habitat descriptions).

Occurrence in the Town of Woodstock

We classified the majority of the open water bodies in Woodstock as constructed ponds. Most were maintained for ornamental or water retention purposes (and located in landscaped areas). Because of the potential value of constructed ponds as drought refuge and foraging areas for turtles and other wildlife, we mapped constructed ponds within developed areas along with those surrounded by intact habitats.

Most of the 367 constructed ponds we mapped were smaller than 1 ac (0.4 ha). However, Kingston Reservoirs One and Four, as well as Cooper Lake and the Upper and Lower ponds at Kenneth Wilson State Park were also mapped as constructed ponds. Shallow constructed ponds with substantial cover of rooted floating-leaved or emergent vegetation (e.g., pond-lilies, cattail, common reed) were mapped as marsh. Ponds entirely surrounded by forest and other minimally managed habitats were mapped as open water, even if they were constructed in origin.

Sensitivities/Impacts

The habitat value of constructed ponds varies depending on factors such as the landscape context, extent of human disturbance, and degree of invasion by non-native species. In general, the habitat value is higher when the ponds have undeveloped, un-landscaped shorelines, are relatively undisturbed by human activities, have more native vascular plant vegetation, and are embedded within an area of intact habitat. Because many constructed ponds are not buffered by sufficient natural vegetation and soil, they are vulnerable to the adverse impacts of agricultural runoff, septic leachate, pesticide or fertilizer runoff from lawns and gardens, and lights, noise, and other disturbances from nearby human activity. We expect that many of those maintained as ornamental ponds are treated with herbicides and perhaps other toxins, or contain introduced fish such as grass carp and various game and forage fishes. Since constructed ponds serve as potential habitat for a variety of common and rare species, care should be taken to minimize these impacts.

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

SPRINGS & SEEPS

Ecological Attributes

Springs and seeps are places where groundwater discharges to the ground surface, either at a single point (a spring) or diffusely (a seep). Springs often discharge into ponds, streams, or wetlands, but we mapped only springs and seeps that discharged conspicuously into upland locations. Springs and seeps originating from deep groundwater sources flow more or less continuously, while those from shallower sources flow intermittently. The habitats created at springs and seeps are determined in part by the hydroperiod and the chemistry of the soils and bedrock through which the groundwater flows before emerging. Springs and seeps are significant water sources for many of our streams, and they help maintain the cool summer temperatures of many streams—an important habitat characteristic for some rare and declining fish species and other stream organisms. They also serve as water sources for animals during droughts and cold winters, when other water sources dry up or freeze over.

Very little is known, or at least published, on the ecology of springs and seeps in the Northeast. Golden saxifrage is a plant more-or-less restricted to springs and groundwater-fed wetlands and streams. A few rare invertebrates are restricted to springs in the region, and the Piedmont groundwater amphipod* could occur in the area (Smith 1988). Gray petaltail,* arrowhead spiketail,* and tiger spiketail* are rare dragonflies found in seeps. Springs emanating from calcareous bedrock or calcium-rich surficial deposits sometimes support an abundant and diverse snail fauna. Eastern box turtle,* Northern dusky salamander,* mountain dusky salamander,* red salamander,* and spring salamander* use springs or seeps and cool streams.

Occurrence in the Town of Woodstock

Because the occurrence of springs and seeps is difficult to predict by remote sensing, we mapped only the few we saw in the field and a few larger seeps we were able to extrapolate upon based on proximity and similarity to those observed in the field. We expect there are many more springs and seeps in the town that we did not map. More detailed inventories of seeps and springs should be conducted as needed on a site-by-site basis.

Sensitivities/Impacts

Springs are easily disrupted by disturbance to upgradient land or groundwater, altered patterns of surface water infiltration, or pollution of infiltrating waters. In many areas, groundwater has been polluted or drawn-down by pumping for human or livestock water supply, affecting the quality or quantity of water issuing from seeps and springs.

STREAMS & RIPARIAN CORRIDORS

Ecological Attributes

Perennial streams flow continuously throughout years with normal precipitation, but some may dry up during droughts. They provide an essential water source for wildlife throughout the year, and are critical habitat for many plant, vertebrate, and invertebrate species. We loosely define "riparian corridor" as the zone along a perennial stream that includes the stream banks, the floodplain, and adjacent steep slopes. We did not map riparian corridors. Instead we have delineated conservation zones of a set width on either side of streams (Figure 9). These zones exceed the jurisdictional buffer zones defined in the Woodstock Wetland and Watercourse Protection Law, but represent our recommended minimum conservation area along the stream for effective protection of stream water quality and wildlife. These zones do not necessarily cover the whole riparian corridor for any stream, however, which varies in width depending on local topography, the size of the stream's catchment area, and other factors.

Riparian areas tend to have high species diversity and high biological productivity, and many species of animals depend on riparian habitats in some way for their survival (Hubbard 1977, McCormick 1978). The soils of floodplains are often sandy or silty. They can support a variety of wetland and non-wetland forests, meadows, and shrublands. Typical floodplain forests include a mixture of upland species, as well as sycamore and eastern cottonwood.

We know of many rare plants of streams and floodplains in the region, such as cattail sedge,* Davis' sedge,* and goldenseal.* The fish and aquatic invertebrate communities of perennial streams may be diverse, especially in clean-water streams with unsilted bottoms. Brook trout* and slimy sculpin* are two native fish species that require clear, cool streams for successful spawning. Wild brook trout, however, are now confined largely to small headwater streams in the region, due to degraded water quality and competition from brown trout, a non-native species stocked in many streams by the New York State Department of Environmental Conservation and by private groups. Wood turtle* uses perennial streams with deep pools and recumbent logs, undercut banks, or muskrat or beaver burrows. Perennial streams and their riparian zones, including gravel bars, provide nesting or foraging habitat for many species of birds, such as spotted sandpiper, belted kingfisher, tree swallow, bank swallow,* winter wren,* Louisiana waterthrush,* great blue heron,* American black duck,* and green heron. Red-shouldered hawk* and cerulean warbler* nest in areas with riparian forests, especially those with extensive stands of mature trees. Bats, including Indiana bat* and eastern small-footed bat,* use perennial stream corridors for foraging (U.S. Fish and Wildlife Service 2007). Muskrat, beaver, mink, and river otter* are some of the mammals that use riparian corridors regularly. Riparian forests are particularly effective at removing dissolved nutrients from stream water, and produce high quality detritus (dead plant matter) important to the aquatic food web.

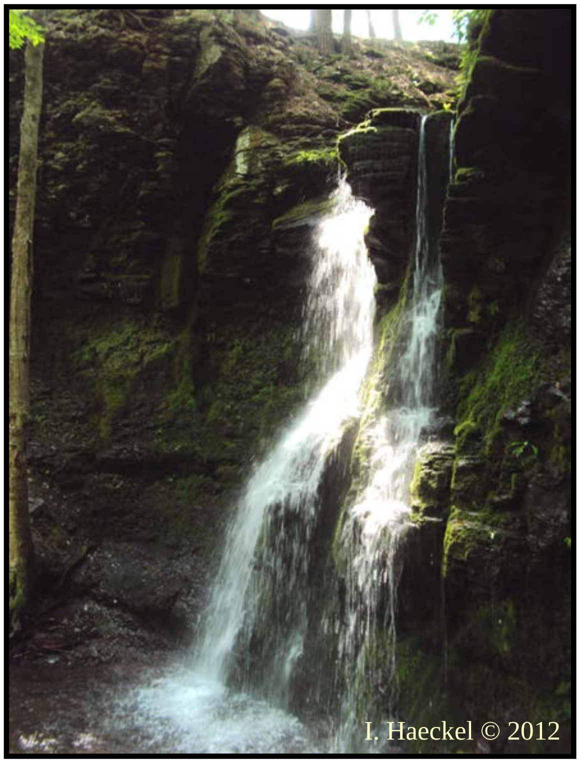
Intermittent streams flow only during certain times of the year or after rains, but some may flow throughout the growing season in wet years. They are the headwaters of most perennial streams, and are significant water sources for lakes, ponds, and many kinds of wetlands. The condition of these streams therefore directly influences the water quantity and quality of those water bodies and wetlands. Intermittent streams can be important local water sources for wildlife, and their loss or degradation in a portion of the landscape can affect the presence and behavior of wildlife populations over a large area (Lowe and Likens 2005). Plants such as winged monkey-flower,* may-apple,* and small-flowered agrimony are sometimes associated with intermittent streams. Although intermittent streams have been little studied by biologists, they have been found to support rich aquatic invertebrate communities, including regionally rare mollusks (Gremaud 1977) and dragonflies. Both perennial and intermittent streams provide breeding, larval, and adult habitat for northern dusky salamander,* mountain dusky salamander,* northern red salamander,* spring salamander,* and northern two-lined salamander. The forests and sometimes meadows adjacent to streams provide foraging habitats for adults and juveniles of these species.

Occurrence in the Town of Woodstock

The Town of Woodstock is drained by a large network of small, intermittent streams and several perennial streams. Larger streams often had significant gravel or cobble bars, which were mapped as part of the stream habitat due to their frequently changing location. Because of the town's complex topography, the courses of streams not seen in the field were sometimes difficult to discern. Even in the field, we observed some streams that apparently ended in wetlands, and several streams originating on mountain slopes that disappeared underground before re-emerging at lower elevations. It is noteworthy that many old woods roads traversing the town's extensive forests served as conduits for stormwater runoff, some having fully eroded into streambeds or having significantly altered flows of intercepting streams. In some cases, runoff down old roads created deep gullies.

The Saw Kill, the longest reach of perennial stream in Woodstock, originates in Echo Lake and flows 17.3 mi (27.8 km) through Keefe Hollow, Shady, Bearsville, the town center, and Zena, eventually draining into Esopus Creek. The Saw Kill changes from its headwaters as a steep, well-entrenched, step pool stream characterized by a high degree of bank destabilization and erosion to a meandering riffle pool stream with several large woody debris jams in the stretch from Bearsville to the Comeau property, followed by a more stable, low-gradient step pool governed by bedrock in the stretch from Comeau through Zena. The stream has probably been negatively affected by the history of logging and agricultural activities in the upper parts of the Saw Kill watershed, by the proximity of Route 212 and other roads, and by residential development along its banks.

The Beaver Kill flows 8.7 mi (14.0 km) from Mink Hollow through Willow, eventually draining into Esopus Creek in Mount Tremper. This stream changes from high- to low-gradient in Willow, spreading out into a wide rocky bed with significant cobble bars.



Seasonal waterfall on the Escarpment

Small perennial mountain stream

Warner Creek

The Beaver Kill transitions to a step pool stream west of the Willow flats and bank destabilization in this stretch has resulted in several large occurrences of mass wasting on steep slopes flanking the stream. The Beaver Kill's riparian corridor is less developed than that of the Saw Kill, although the lower part of the stream flows in close proximity to Route 212.

The Little Beaver Kill is fed by several streams originating on Ohayo Mountain and converging at Yankeetown Pond and flows 7.1 miles (11.4 km) through Woodstock. The meandering riffle and pool stream flows through a large, beaver-influenced wetland complex from Yankeetown Pond through Kenneth Wilson State Park and eventually into Esopus Creek at Route 28.

Warner Creek flows 3.4 miles (5.5 km) through Silver Hollow in the northwest part of Woodstock, draining into Stony Clove at Chichester. The portion of Warner Creek flowing through Woodstock is a low-gradient step pool stream characterized by large cobble bars.

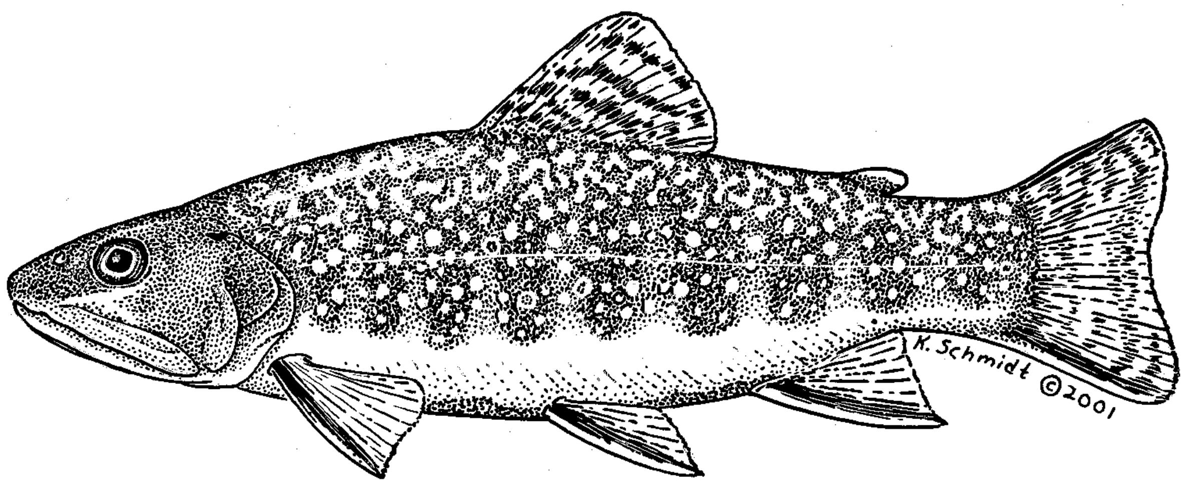
Sensitivities/Impacts

Removal of trees or other shade-providing vegetation along a stream can lead to elevated water temperatures that adversely affect aquatic invertebrate and fish communities. This effect on water temperature may be magnified when riparian conifer cover is lost (for example, when eastern hemlocks along stream corridors decline due to a hemlock woolly adelgid infestation), and such losses may also change water chemistry. Clearing of floodplain vegetation can reduce the important exchange of nutrients and organic materials between the stream and the floodplain. It can also diminish the floodplain's capacity for flood attenuation, leading to increased flooding downstream, scouring and bank erosion, and siltation of downstream reaches. Any alteration of flooding regimes, stream water volumes, timing of runoff, or water quality can profoundly affect the habitat characteristics and species of streams and riparian zones. Hardening of the stream banks with concrete, riprap, gabions, or other materials reduces the biological and physical interactions between the stream and floodplain, and tends to be harmful to both stream and floodplain habitats. Channelized streams have higher velocities which can be destructive during snowmelt and rain events. Removal of snags from the streambed degrades habitat for fishes, turtles, snakes, birds, muskrats, and their food organisms. Stream corridors are prone to invasion by a number of riparian weeds, including Japanese knotweed, an introduced plant that is spreading in the region (Talmage and Kiviat 2004) and was identified throughout the town. Didymo or “rock snot” (*Didymosphenia geminata*), an invasive species of aquatic alga, was discovered in the Esopus Creek in Ulster County in 2009 and in Stony Clove in 2010, but has not been found in the Town of Woodstock to date (S. George, pers. comm.).

The habitat quality of a stream is affected not only by direct disturbance to the stream or its floodplain, but also by land uses throughout the watershed. (A watershed is the entire land area that drains into a given water body.) Urbanization (including roads and residential, commercial, and industrial development) has been linked to deterioration in stream water quality in the region (Parsons and Lovett 1993). Activities in the watershed that cause soil erosion, changes in surface water runoff, reduced groundwater infiltration, or contamination of surface water or groundwater are likely to affect stream habitats adversely. For example, an increase in impervious surfaces (roads, driveways, parking lots, and roofs) may increase runoff, leading to erosion of stream banks and siltation of stream bottoms, and a consequent degradation of the habitat for invertebrates, fish, and other animals. Road runoff often carries contaminants such as petroleum hydrocarbons, heavy metals, de-icing salt, sand, and silt into streams. Applications of fertilizers and pesticides to agricultural fields, golf courses, lawns, and gardens in or near the riparian zone can degrade the water quality and alter the biological communities of streams. Construction, logging, soil mining, clearing for vistas, creating lawns, and other disruptive activities in and near riparian zones can hamper riparian functions and adversely affect the species that depend on streams, riparian zones, and nearby upland habitats.

Poorly designed culverts and bridges can obstruct the movement of aquatic organisms—fish, amphibians, reptiles and invertebrates—that need access to different parts of the stream at different seasons, in different climatic conditions (e.g., drought or flood), and at different life stages. The most typical problems are with culverts that are too small to handle the stream volumes or velocities, or that have inverts perched above the stream bed.

The Conservation Priorities section provides recommendations for protecting the habitat values of streams and riparian corridors, and Figure 9 illustrates the locations of streams and their conservation zones in Woodstock.



Brook trout

CONSERVATION PRIORITIES AND PLANNING

Most local land use decisions in the Hudson Valley are made on a site-by-site basis, without the benefit of good ecological information about the site or the surrounding lands. The loss of biological resources from any single development site may seem trivial, but the cumulative effects of decisions made site-by-site have been far-reaching. Regional impacts have included the disappearance of certain habitats from whole segments of the landscape, the fragmentation and degradation of many other habitats, the local and regional extinction of species, and the depletion of overall biodiversity.

Because biological communities, habitats, and ecosystems do not respect property boundaries, the best approach to biodiversity conservation is from the perspective of whole landscapes. The Woodstock habitat map facilitates this approach by illustrating the location and configuration of significant habitats throughout the town. The map, together with the information included in this report, can be applied directly to land use and conservation planning and decision making at multiple scales. In the following pages, we outline recommendations for: 1) developing general strategies for biodiversity conservation; 2) using the map to identify priorities for town-wide conservation, land use planning, and habitat enhancement; and 3) using the map as a resource for reviewing site-specific land use proposals

General Guidelines for Biodiversity Conservation

We hope that the Town of Woodstock habitat map and this report will help landowners understand how their land fits into the larger ecological landscape, and will inspire them to voluntarily adopt habitat protection measures. We also hope that the town will engage in proactive land use and conservation planning to ensure that future development is planned with a view to long-term protection of important biological resources.

A variety of regulatory and non-regulatory means can be employed by a municipality to achieve its conservation goals, including volunteer conservation efforts, master planning, zoning ordinances, tax incentives, land stewardship incentives, permit conditions, land acquisition, conservation easements, and public education. Section 4 of the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001) provides additional information about these and other conservation tools. Several publications of the Metropolitan Conservation Alliance, the Pace University Land Use Law Center, and the Environmental Law Institute describe some of the tools and techniques available to municipalities for conservation planning. For example, *Conservation Thresholds for Land-Use Planners* (Environmental Law Institute 2003) synthesizes information from the scientific literature to provide guidance to planners interested in establishing regulatory setbacks from sensitive habitats. A publication from the Metropolitan Conservation Alliance (2002) offers a model local ordinance to delineate a conservation overlay district that can be integrated into a Comprehensive Plan and adapted to the local zoning ordinance. The *Local Open Space Planning Guide* (NYS Department of Environmental Conservation and NYS Department of State 2004) describes how to take advantage of laws, programs, technical assistance, and funding resources available to pursue open space conservation, and provides contact information for relevant organizations.

In addition to regulations and incentives designed to protect specific types of habitat, the town can also apply some general practices on a town-wide basis to foster biodiversity conservation. The examples listed below are adapted from the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001).

- **Protect large, contiguous, undeveloped tracts** wherever possible.
- **Protect high quality isolated habitat patches.** Relatively small, isolated habitat areas may function as refuges for uncommon plants and for animals that have small ranges or are well adapted to edge habitats and travel through developed areas. Such “islands” of habitat may provide certain plants or animals protection from predators, diseases, and other community processes that limit their ability to survive. Isolated habitat patches are particularly valuable if they include high quality significant habitat types that meet the needs of species of conservation concern.
- **Plan landscapes with interconnected networks of undeveloped habitats** (preserve links and create new links between natural habitats on adjacent properties). When

possible, enhance the connective value of existing features such as streams, abandoned rail lines, and utility rights-of-way. When considering protection for a particular species or group of species, design the networks according to the particular needs of the species of concern.

- **Preserve natural disturbance processes** such as floods, fires, seasonal drawdowns (of standing water), and wind exposures wherever possible.
- **Design and install culverts** on roads and driveways such that stream physiography and substrates are continuous (both for intermittent and perennial streams).
- **Design and maintain roadside drainage infrastructure** to protect nearby streams and wetlands.
- **Restore and maintain broad buffer zones** of natural vegetation and undisturbed soils along streams, shores of water bodies and wetlands, and around the perimeter of other sensitive habitats.
- **Direct human uses toward the least sensitive areas**, and minimize alteration of natural features, including vegetation, soils, bedrock, and waterways.
- **Encourage development of altered land instead of unaltered land.** Promote redevelopment of brownfields and previously altered sites, "infill" development, and re-use of existing structures wherever possible (unless, of course, these areas support rare species that would be harmed by development).
- **Preserve active farmland, farmland soils, and farmland potential** wherever possible.
- **Encourage and provide incentives for developers to consider environmental concerns early in the planning process**, and to incorporate biodiversity conservation principles into their choice of development sites, their site design, and their construction practices.
- **Concentrate development along existing roads**; discourage construction of new roads or long driveways in undeveloped areas.
- **Promote clustered and pedestrian-centered development** wherever possible (in areas where no sensitive habitats are present) to maximize extent of unaltered land and minimize expanded vehicle use.
- **Minimize areas of lawn and impervious surfaces** (roads, parking lots, sidewalks, paved driveways, roof surfaces), and maximize onsite runoff retention and infiltration of rainwater and snowmelt, to help groundwater recharge, protect surface water quality, and moderate flood flows.

- **Restore degraded habitats wherever possible**, but do not use restoration projects as a license to destroy intact habitats. Base any habitat restoration on sound scientific principles and research in order to maximize the likelihood of having the intended positive effects on biodiversity and ecosystems. A restoration plan should have specific goals (species or ecological functions) and consider the need for long-term monitoring of the restored habitat to assess these effects and regular maintenance to protect restored features from degradation.
- **Modify the urban matrix to provide more habitat elements** (for example, tree-lined streets). Use public education and incentives to encourage private landowners to provide additional habitat in their yards.
- **Promote the establishment of conservation agreements** on parcels of greatest apparent ecological value.

Using the Habitat Map for Town-wide Conservation Planning

The Town of Woodstock habitat map illustrates the locations and sizes of habitat units, the degree of connectivity between habitats, and the juxtaposition of habitats in the landscape, all of which have important implications for regional biodiversity and water resources. Although intact habitats were the focus of this study, biodiversity conservation efforts in the urban and suburban landscapes in and near the Woodstock town center should also consider the potential for enhancement of developed areas for the purpose of supporting native biodiversity and protecting streams and groundwater.

Our detailed recommendations for conservation of existing habitats focus on high-priority habitats and habitat complexes, though we consider all of the mapped habitat areas to be ecologically significant and worthy of conservation attention. “Priority habitats” include those that are rare, support rare species, or are otherwise particularly important to local or regional biodiversity. For instance, there are documented occurrences of timber rattlesnake, a NYS Threatened species, in Woodstock. Oak-heath barren may be one of the core habitats most likely to support undocumented and future populations of this rare snake. Figures 4-9 illustrate the locations of some of the priority habitats and our recommended “conservation zones” associated with those habitats. These areas are especially valuable if they are located within larger areas of intact and connected habitat both within and (sometimes) extending beyond the boundaries of the town.

While most of our conservation recommendations focus on intact habitats, we also provide some general recommendations for developed areas, which aim to improve habitat characteristics for native species of conservation concern. We discuss some measures that can be taken to protect and add elements of habitats which alone are too small to map at the town-wide scale (e.g., individual trees), but can be important for some species. We also address ways to minimize disturbance to biota inhabiting and moving through natural areas in intensively developed landscapes.

The habitat map and this report provide a landscape perspective that can help the town establish conservation goals, priorities, and strategies. Taking a landscape approach to land use planning is much more likely to yield sound conservation decisions than the typical parcel-by-parcel approach. The map and report are practical tools that will facilitate selecting areas for protection and identifying sites for new development where the ecological impacts will be minimized. As habitat maps are completed in adjacent towns, the maps can also be used for conservation planning across town boundaries.

Using the Habitat Map to Review Site-Specific Land Use Proposals

In addition to town-wide land use and conservation planning, the habitat map and report can be used for reviewing site-specific development and other land use proposals, providing ecological information about both the proposed development site and the surrounding areas that might be affected. We recommend that landowners, developers, and reviewers considering a new land use proposal take the following steps to evaluate and minimize the impact of the proposed land use change on the habitats that may be present on and near the site:

1. Consult the large format habitat map and Figure 3 to see if the site in question is part of a large, contiguous block of habitat, and which ecologically significant habitats, if any, are located on and near the site.

2. Read the descriptions of those habitats in this report.
3. Check to see if any of the habitats in the area of the proposal are described in the "Priority Habitats" section of this report, either individually or as part of a habitat complex, and note the conservation issues and recommendations for each.
4. Consider whether the proposed development project can be designed or modified to ensure that the habitats of greatest ecological concern, as well as the ecological connections between them, are maintained intact. Examples of design modifications include but are not limited to:
    - Locating land disturbance and human activity areas as far as possible from the most sensitive habitats.
    - Minimizing intrusions into large, contiguous habitat mosaics.
    - Locating developed features such that broad corridors of undeveloped land are maintained between habitats.
    - Minimizing intrusions into forested areas that are within 750 ft (230 m) of an intermittent woodland pool.
    - Avoiding disturbances that would disrupt the quantity or quality of groundwater available to onsite or offsite heath swamps, buttonbush pools, circumneutral bog lake, other wetlands, and streams.
    - Directing stormwater runoff from paved areas, fertilized turf, or gardens into detention basins or rain gardens instead of directly into ditches, streams, ponds, or wetlands; installing and maintaining oil-water separators where runoff leaves paved areas.
    - Minimizing the clearing of vegetation during construction, and restoring cleared areas with native plantings instead of lawn, wherever possible.
5. Follow the general biodiversity conservation practices outlined earlier in this section of the report.

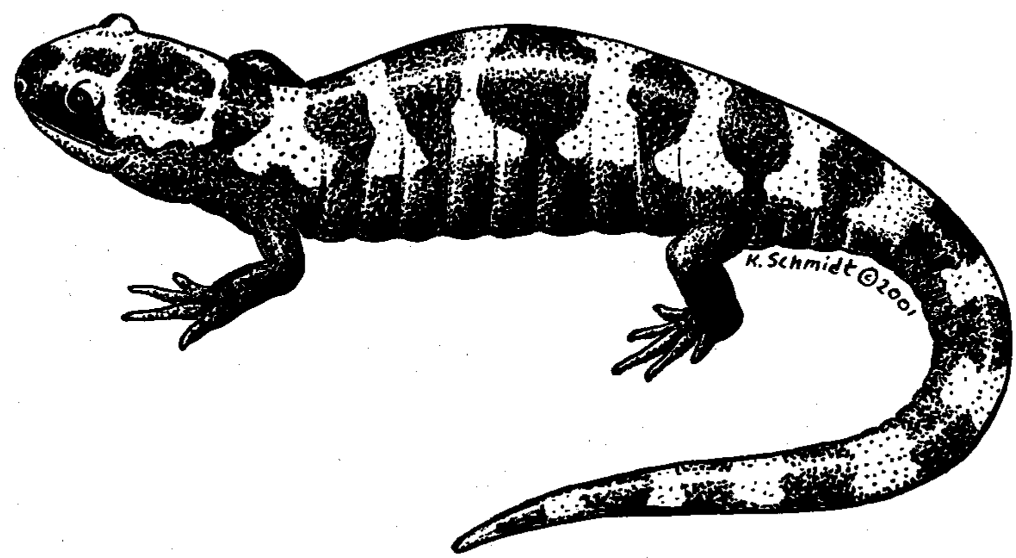
Because the habitat map has not been 100% field checked we emphasize that, at the site-specific scale, it should be used strictly as a general guide for land use planning and decision making. Onsite observations by professional biologists should be an integral part of the review process for any significant land use change.

PRIORITY HABITATS IN THE TOWN OF WOODSTOCK

Although a certain amount of land in Woodstock has been developed for residential and other uses (about 12%), large areas of high-quality habitat still remain. By employing a proactive approach to land use and conservation planning, Woodstock has the opportunity to protect the integrity of its remaining biological resources for the long term. Below we highlight some habitat types and complexes (i.e., particular combinations of habitats) that we consider to be "priority habitats" for conservation in the region. It must be understood that we believe all the habitat areas depicted on the large-format habitat map are ecologically significant and worthy of conservation attention. The list of priority habitats below, however, is a special subset with more urgent conservation needs. With limited resources to devote to conservation purposes, municipal agencies must decide how best to direct those resources to maximize conservation results. In general we recommend that high priority be placed on protecting intact habitats, a variety of habitat types in a variety of landscape settings, and the most sensitive habitat types.

For each of these habitat types, we used the requirements of a selected group of species to illustrate how the protection of habitat resources would contribute to the conservation of biological diversity in the town. We chose several species or groups of species that have large home ranges, specialized habitat needs, or acute sensitivities to disturbance (see Table 2). Many are rare or declining in the region or statewide. Each of these species or groups requires a particular habitat type for a crucial stage of their life cycle (e.g., hibernation, breeding), and those "core habitats" typically form the hub of the animal's habitat complex. The various other habitats required during other life cycle stages are typically located within a certain distance of the core habitat. This distance roughly defines the extent of the species' habitat complex and, therefore, the minimum area that needs to be protected or managed in order to maintain a local population. We call this the "conservation zone" and discuss the size of this zone in the "Recommendations" subsection for each priority habitat. We use findings in the scientific literature to estimate the priority conservation zone for the species or group of concern (Table 2). If the habitats of the sensitive species of concern are protected, many other rare and common species that occur in the same habitats will also be protected.

The conservation zones we recommend around priority habitats often overlap with already developed areas. While this will make it impossible to follow some of the recommendations for these zones (for example, protecting forest areas around a wetland when there is no remaining forest area around it), we show and discuss the full extent of these conservation zones for two reasons: 1) some conservation recommendations can still be followed in developed areas, and 2) in some cases these zones can be considered for habitat restoration.



Marbled salamander

Table 2. Priority habitats, species of concern, and associated priority conservation zones identified by Hudsonia in the Town of Woodstock, Ulster County, New York.

Priority Habitat	Focal Species or Group of Concern	Priority Conservation Zone	Rationale	References
Large forest	Forest interior-breeding birds	Unfragmented patches of at least 90-200 ac (35-80 ha).	Required for high probability of supporting breeding hermit thrush and wood thrush in a 70% forested landscape.	Rosenberg et al. 2003
Oak-heath barren	Timber rattlesnake	1.5 mi (2.4 km) from winter den.	A minimum radius of intact habitat from the den needed to protect all but the farthest ranging males	Brown 1993
Large meadow	Grassland-breeding birds	Unfragmented patches greater than 25 ac (10 ha)	Required for successful breeding and maintenance of viable populations.	Vickery et al. 1994
Intermittent woodland pool	Pool-breeding amphibians	750 ft (230 m) from pool	Partially encompasses non-breeding season foraging and refuge habitats and dispersal routes between pools.	Madison 1997, Semlitsch 1998, Calhoun and Klemens 2002
Circumneutral bog lake	Northern cricket frog	3,300 ft (1,000 m) from lake edge.	Represents the overland distance traveled between wetlands.	Gray 1983
Wetland complex	Spotted turtle	Minimum upland zone of 400 ft (120 m) beyond outermost wetlands in a complex.	Corresponds to maximum reported distance of nests from the nearest wetland.	Joyal et al. 2001
Perennial stream	Wood turtle	660 ft (200 m) from stream	Encompasses most of the critical habitat including hibernacula, nesting areas, spring basking sites, foraging habitat, and overland travel corridors.	Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997

LARGE FORESTS

Target Areas

In general, forested areas with the highest conservation value include large forest tracts, mature and relatively undisturbed forests, and those with a lower proportion of edge to interior habitat. Smaller forests that provide connections between other forests, such as linear corridors or patches that could be used as "stepping stones," are also valuable in a landscape context. The largest forest areas are illustrated in Figure 4. We approximated the size of forest patches that extend beyond the town boundary because knowing the total area of forest patches is important in understanding their habitat values. Exceptionally large forests in the northern part of Woodstock measuring over 15,400 ac (6,200 ha) were contiguous with approximately 20,000 ac (8,100 ha) of forest beyond the town boundary in the Indian Head Wilderness, Phoenicia – Mount Tobias Wild Forest, and private forests. The contiguous forested area on Mt. Tobias measured over 7,000 ac (2,800 ha) and included particularly extensive mountain laurel thickets measuring as large as 600 ac (240 ha). The forested area in Zena northeast of the Saw Kill and east of Zena Highwoods Road was contiguous with public and private forests in the Town of Ulster measuring over 5,000 ac (2,000 ha). Other large forested areas of 1,000-5,000 ac (400-2,000 ha) included Mt. Guardian, Acorn Hill/Snake Rocks, Ticetonyk/Tonshi Mountain, and the Bluestone Wild Forest in Zena. Two forest areas were 500-1,000 ac (200-400 ha), and eighteen were 100-500 ac (40-200 ha). Extensive areas of crest and ledge occurred in most of the forests in the town.

Conservation Issues

Forest loss and fragmentation are the two most serious threats facing forest-adapted organisms. The decline of extensive forests has been implicated in the declines of numerous "area-sensitive" species, which require many hundreds or thousands of acres of contiguous forest to survive and successfully reproduce in the long term. These include large mammals such as black bear* and bobcat* (Godin 1977, Merritt 1987), some raptors (Bednarz and Dinsmore 1982, Billings 1990, Crocoll 1994), and many migratory songbirds (Robbins 1980, Ambuel and Temple 1983, Wilcove 1985, Hill and Hagan 1991). The increased area of "edge" habitat created by forest fragmentation favors a set of disturbance-adapted species, including many nest predators and a nest parasite (brown-headed cowbird) of forest-breeding birds (Murcia 1995). Consequently, forest fragmentation reduces the nesting success of many species of forest birds (Lampila et al. 2005). Large forests, on the other hand, particularly those that are more circular (less linear) in outline, can support forest species that are highly sensitive to disturbance and predation along forest edges. For example, only forest patches larger than 200 ac (80 ha) are considered highly suitable for wood thrush* breeding populations in our region. In landscapes with about 70% forest cover such as Woodstock, hermit thrush requires around 90 ac (53 ha) of intact forest to have a high probability of supporting persistent breeding populations (Rosenberg et al. 2003).

Forest fragmentation can also hamper or prevent animals from moving across the landscape, and can result in losses of genetic diversity and local extinctions in populations from isolated forest patches. For example, some species of frogs and salamanders are unable to disperse effectively through non-forested habitat due to desiccation and predation (Rothermel and Semlitsch 2002). Also, road mortality of migrating amphibians and reptiles can reduce population densities (Fahrig et al. 1995) or changes in sex ratios in nearby populations (Marchand and Litvaitis 2004).

The hemlock woolly adelgid is an aphid-like insect causing widespread loss of hemlock forests in the Hudson Valley. Hemlock woolly adelgid was observed throughout Woodstock during 2011-2012 and several large hemlock stands appeared to be dying as a result of infestation. A large-scale infestation could eliminate Woodstock's hemlock forests within a few years, with devastating consequences to the biological communities of hemlock-associated habitats. It is important to protect healthy hemlock stands, in the hope that some will escape adelgid infestation and also to provide a seed source for regeneration. This protection may help buy time for the hemlock while the recently-released biological control (a species of lady beetle that feeds only on hemlock woolly adelgid) is becoming established.

In addition to their importance to biodiversity, forests are crucial for maintaining water resources and sequestering carbon. Forests with intact vegetation and forest floors are extremely effective at promoting water infiltration to the soils and recharging groundwater, and may be the best insurance for maintaining flow volumes, temperatures, water quality, bank stability, and habitat quality in streams. Also, intact forests store enough carbon in their above-ground and below-ground biomass to offset 10% or more of total U.S. carbon emissions from fossil fuels (Birdsey 2006, Pacala et al. 2007)—a service of inestimable value.

Recommendations

We recommend that the remaining blocks of large forest within the Town of Woodstock be considered priority areas for conservation, and that efforts be made to fully protect these habitats wherever possible. If new development in forested areas cannot be avoided, it should be concentrated near forest edges and near existing roads and other development so that as much unfragmented forest area as possible is preserved. New roads or driveways should not extend into the interior of the forest and should not divide the habitat into smaller isolated patches. Some general guidelines for forest conservation include the following:

1. ***Protect large, contiguous forested areas*** wherever possible, and avoid development in forest interiors.

2. ***Protect patches of forest types that are less common in the town regardless of their size***. These include mature (and old-growth, if any is present) forests, natural conifer stands, healthy hemlock stands, forests with an unusual tree species composition, or forests that have smaller, unusual habitats (such as calcareous crest, ledge, or talus) embedded in them.

3. ***Maintain or restore broad corridors of intact habitat between large forested areas.*** For example, a forested riparian corridor or a series of smaller forest patches may provide connections between larger forest areas. Forest patches on opposite sides of a road may provide a "bridge" across the road for forest-dwelling animals.

4. ***Maintain the forest canopy and understory vegetation intact***.

5. ***Maintain standing dead wood, downed wood, and organic debris, and prevent disturbance or compaction of the forest floor***. Also leave the hemlocks infested with woolly adelgid in place; cutting these trees does not slow the infestation's spread, but does interfere with natural forest processes. Dead or partly-dead standing trees should be removed only if they directly threaten roads, utility wires, trails, buildings, or other cultural features.

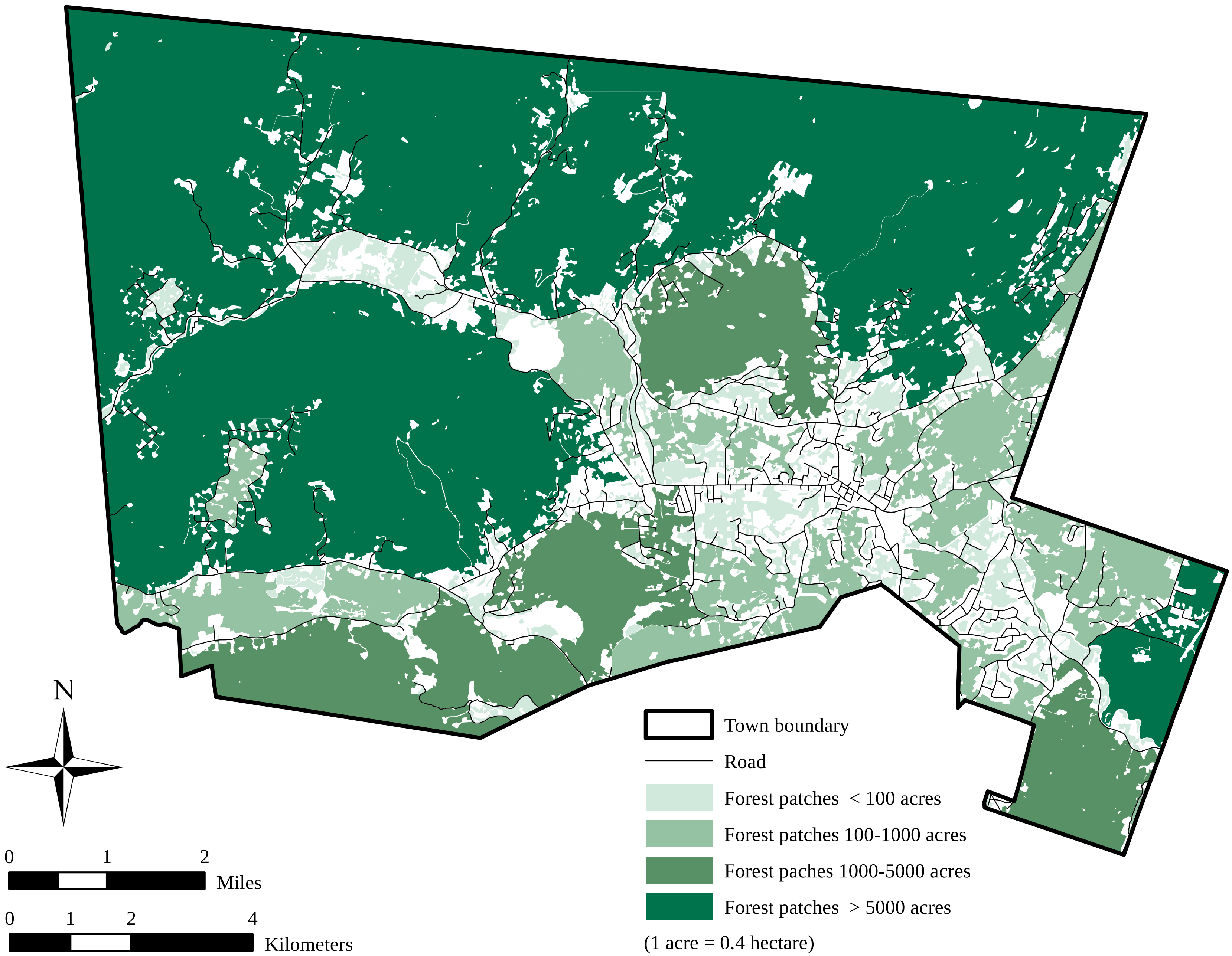


Figure 4. Contiguous forest patches (including hardwood, conifer, and mixed forests in uplands and swamps) in the Town of Woodstock, Ulster County, New York. Patch area measurements take into account forested areas extending beyond the town boundary. Hudsonia Ltd., 2012.

OAK-HEATH BARREN & other Crest/Ledge/Talus

Target Areas

We mapped 25 relatively small areas of oak-heath barren in Woodstock (most were on the Catskill Escarpment), and there are additional areas of exposed rock that may support this habitat (Figure 5). The largest patch of oak-heath barren (5.5 ac [2.2 ha]) was on a bouldery ledge below the Minister's Face cliff on Overlook Mountain and hosted abundant pitch pine and stunted red oaks. Scrub oak was dominant in other exposed oak-heath barrens with marginal tree canopy. The small barrens in Woodstock may be remnants of historically larger habitats once maintained by fire. They may now persist because shallow soils and other factors inhibit colonization by taller tree species that would otherwise shade out oak-heath barren species.

Other crest, ledge, and talus habitats occurred throughout the town in close association with mountains and ridges (Figure 5). Extensive talus slopes and ledges (many estimated at 20 ft [6 m] tall and often taller) were common on the Catskill Escarpment. The sandstone and shale bedrock of the Catskill Mountains is largely acidic, but we found calcareous ledge outcrops in several areas. In particular, ledges in the Catskill Foothills of Zena and areas east of West Saugerties-Woodstock Road were mostly calcareous.

Conservation Issues

Oak-heath barrens are uncommon in the Hudson Valley. These are disturbance-maintained ecosystems (ice, fire, wind) with shallow, droughty soils, and human suppression of wildfires has eliminated one of the disturbances that historically maintained them. The plant communities of oak-heath barrens are especially adapted to episodic fires. Without fire events, other forest species can colonize these areas, and eventually oak-heath barren specialists may be out-competed by the more typical species of rocky upland hardwood forests.

Oak-heath barrens are uncommon in the Hudson Valley and may provide core habitat for several rare reptiles that require rocky outcrops and exposed conditions at crucial stages in their life cycle, such as timber rattlesnake,* northern copperhead,* eastern rat snake,* and

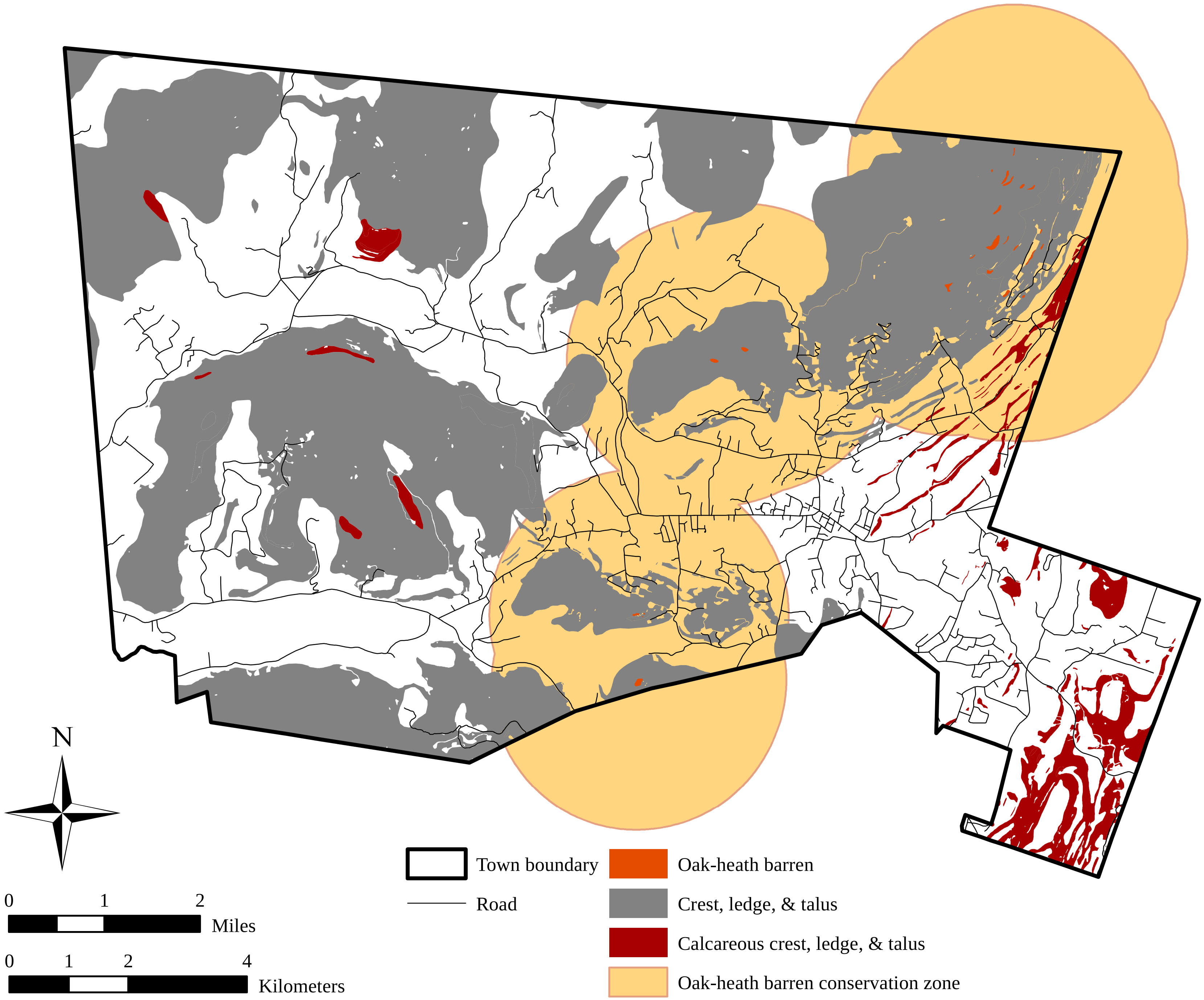


Figure 5. Generalized distribution of crest, ledge, and talus habitats and oak-heath barrens in the Town of Woodstock, Ulster County, New York. Locations identified from field observations and inferred from areas mapped (in Tornes [1979]) as having shallow or bouldery soils on steep slopes and summits. Oak-heath barren conservation zones measure 1.5 mi (2.4 km) from each barren. Hudsonia Ltd., 2012.

eastern racer.* We have chosen timber rattlesnake* (NYS Threatened) as the focal species for conservation planning in oak-heath barrens and other rocky crest, ledge, and talus habitats. Timber rattlesnake has been reported from Woodstock; however, populations of this species have been declining in the northeastern U.S. due to loss or disturbance of habitat, collection of the snakes for live trade, and malicious killing (Brown 1993, Klemens 1993); northern copperhead populations are subject to similar threats. The protection of timber rattlesnake in the Catskills is important for the species' viability in the northeastern U.S. (Klemens 1993). Timber rattlesnakes den in ledge and talus areas in somewhat open deciduous forests, such as oak-heath barrens and crest oak woodlands. Male snakes migrate widely from the den during the summer, while females travel shorter distances from the den. Males have been reported to travel distances over 4 mi (6.4 km) from the den, but the average travel distance is closer to 2 mi (3.2 km). To protect most of the snakes in a given population, protection of undisturbed habitat within a minimum radius of 1.5 mi (2.4 km) from the den is recommended (Brown 1993). Northern copperheads, eastern rat snakes, and eastern racers travel similar distances from their den sites (Blouin-Demers and Weatherhead 2002; Fitch 1960; Todd 2000).

Perhaps one of the greatest threats to the sensitive animals associated with and crest, ledge, and talus and oak-heath barrens (including far-ranging rare reptiles) is the fragmentation of large rocky forested areas and associated habitat complexes. The construction of houses, roads, and other structures in these habitats can isolate populations by preventing migration, dispersal, and genetic exchange. This, in turn, can limit the ability of these populations to adapt to changing climatic or other environmental conditions and make them more prone to local extinction.

Recommendations

To help protect crest, ledge, and talus habitats, we recommend the following measures:

1. ***Avoid disturbance of crest, ledge, and talus habitats wherever possible,*** and concentrate any unavoidable development in a manner that maximizes the amount and contiguity of undisturbed rocky habitat. Minimize the extent of new roads through undeveloped land with extensive crest, ledge, and talus. Take special measures to restrict the potential movement of snakes into developed areas, thereby minimizing the likelihood of human-snake encounters (which are often fatal for the snake) and road mortality.

2. ***Maintain broad corridors*** between crest, ledge, and talus habitats**.** Intervening areas between habitats provide travel corridors for species that migrate among different habitats for breeding, foraging, and dispersal.

3. ***Consider the impacts of habitat disturbance*** to crest, ledge, and talus when reviewing all applications for Mined Lands permits and other development proposals, keeping in mind that rare snakes typically travel long distances from their den sites.

4. ***Educate construction workers and residents*** about snake conservation and whom to contact to safely relocate venomous snakes.

Particular measures for conservation of oak-heath barrens and their associated rare species include:

1. ***Protect oak-heath barren habitats.*** All oak-heath barrens and their closely associated crest, ledge, and talus habitats should be protected from disturbances of any kind including, but not limited to, the construction of communication towers, mining, and housing and road construction. Posting cautionary signs that warn of the fragile nature of the habitat may be an important first step (Kiviat 2001).

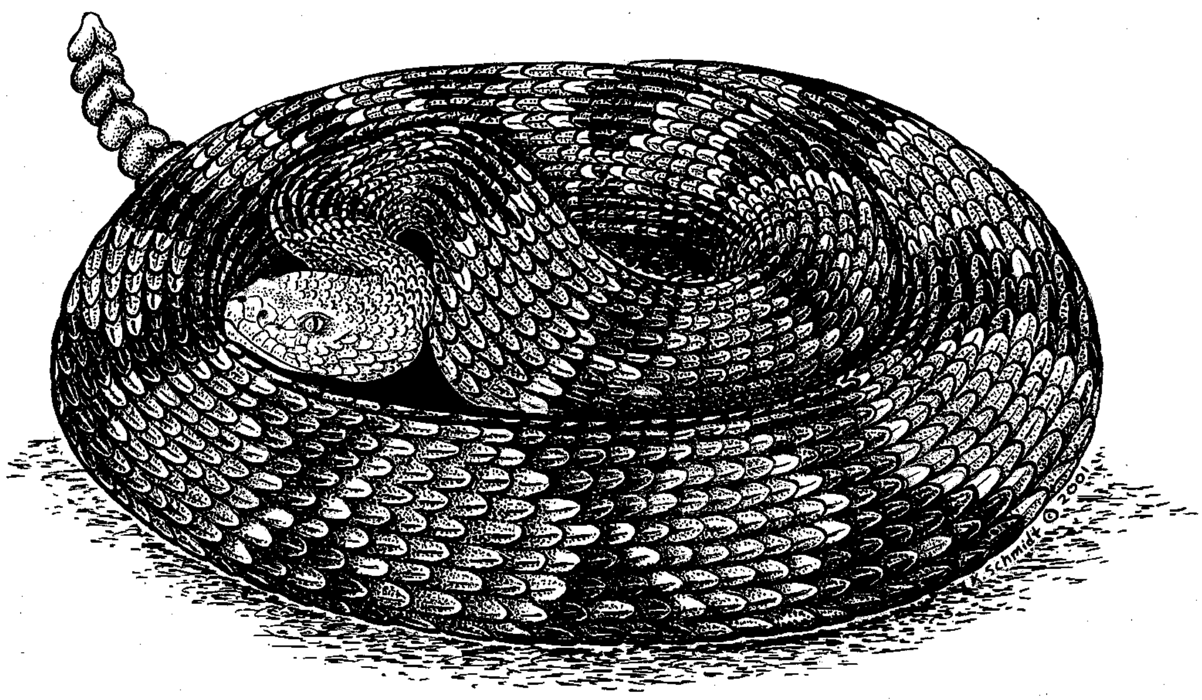
2. ***Protect oak-heath barrens from disturbances associated with high intensity human recreation.*** Locate any new trails distant from oak-heath barrens.

3. ***Protect critical adjoining habitats within 1.5 mi (2.5 km) of the barrens.*** As discussed above, to protect a population of timber rattlesnake, undisturbed habitat within a minimum radius of 1.5 miles (2.4 km) from the den must be protected (Brown 1993). Habitats within this zone should be considered critical components of the barren habitat "complex." As much as possible, avoid new development of any kind, including roads and driveways within this 1.5-mi zone. If development cannot be avoided, it should be concentrated in a manner that maximizes the amount and contiguity of undisturbed habitat, and provides as broad a buffer as possible between the barrens and the developed area. Special measures may also be needed (in consultation with the NYS DEC) to restrict the potential movement of rare snakes into the newly developed areas, thereby minimizing the likelihood of human-snake encounters (which are often fatal for the snake) and road mortality. Protecting large areas of contiguous habitat surrounding oak-heath barrens will not only protect potential foraging habitats and travel corridors for snakes of conservation concern, but may also help support the ecological and natural disturbance processes (e.g., fire) that help sustain the barrens habitats.

4. ***Maintain corridors between oak-heath barren habitat complexes.*** It is important that the intervening areas between habitat complexes remain intact to provide long-distance migration corridors for timber rattlesnake and other species for population dispersal and to accommodate snakes displaced from degraded habitats.

5. ***Avoid direct disturbance to timber rattlesnake dens***, and restrict nearby logging to the winter months when the snakes are hibernating (Brown 1993).

6. ***Consult with the Endangered Species Unit of the NYS DEC*** about any activity proposed in the vicinity of a timber rattlesnake habitat.



Timber rattlesnake

LARGE MEADOWS

Target Areas

Large and contiguous patches of meadow, particularly pastures, hayfields, and old fields, can be valuable nesting habitats for rare and uncommon grassland-breeding birds. Woodstock has few large meadows, in part because residential development has superseded agricultural land uses. The largest meadow in Woodstock, between Zena and John Joy roads, covered 47 ac (19 ha). Moderate-sized meadow complexes occurred in the vicinity of the Comeau property, between Sickler Road and Route 212, between Wittenberg and Cooper Lake roads, and along Ostrander and Swimming Hole roads (Figure 6). Smaller meadows that could potentially serve as wildlife travel corridors or "stepping stones" between nearby habitats are also important, as are small patches of wet meadow and upland shrublands with relatively sparse shrub cover.

Conservation Issues

While there can be significant habitat value in small patches of upland meadow (e.g., for invertebrates and small mammals), large patches are especially important for grassland-breeding birds. Grassland-breeding birds (our focal group for meadows) have declined dramatically in the Northeast in recent decades due to habitat loss, as meadows have been and fragmented by regrowth of forest, conversion of grasslands to row crops, and residential and commercial development (Askins 1993, Brennan and Kuvlesky 2005). These birds require large, undivided meadows (25 to 500+ ac [10-200+ ha]) to reproduce successfully (Vickery et al. 1994). Fences and hedgerows can reduce nesting success for grassland-breeding birds by providing cover and perching sites for raptors and other species that prey on the birds or their eggs (Wiens 1969). Because grassland birds have very specific habitat requirements for breeding, their survival in the northeastern U.S. may ultimately depend on active farmland and open space management (Askins 1993).

Meadows are among the habitats most vulnerable to future development. In agricultural areas, for example, development is often an attractive alternative to the economic challenges faced by farmers. Even when development does not destroy the entire meadow habitat, the remaining fragments are usually small and have much lower biodiversity value. Development around meadows can promote increased predation on grassland-breeding bird nests by human-subsidized predators such as raccoons and domestic cats. Grasslands and the rare species they support are also highly susceptible to other human activities such as mowing, conversion to row crops, application of pesticides, and ATV traffic.

Recommendations

In cases where pasture or hayfield owners have flexibility in their mowing and grazing practices, Massachusetts Audubon (http://www.massaudubon.org) has the following management suggestions for maximizing the success of grassland birds in meadows in the northeastern U.S.:

1. ***Mowing after August 1st*** helps to ensure fledging of nestling birds; if mowing must occur before then, leave some unmowed strips or patches. The unmowed patches will support nesting birds, butterflies, and many other organisms. Mowing in fall is even less disruptive (some birds continue nesting into August or September), and will help support butterflies preparing for migration.

2. ***Mowing each field only once every 1-3 years***, or doing rotational mowing so that each part of a field is mowed once every 3 years, can maintain habitat for butterflies and nesting birds.

3. ***On an active farm, leaving some hayfields out of production each year***, or mowing some fields early in the season and some fields late will improve the wildlife habitat value.

4. ***Removing fences or hedgerows between smaller fields*** enlarges the suitable habitat area for grassland breeding birds by removing hunting perches and travel corridors for nest predators.

5. ***Raising mower blades six inches or more, using flushing bars, and avoiding night mowing*** when birds are roosting all help reduce bird mortality.

6. ***Light grazing***, if livestock are rotated among fields throughout the season, can be beneficial.

7. ***If planned and executed carefully, burning grasslands (in fall) every two to six years*** can improve habitat quality.

While the ecological values of upland meadows are diverse and significant, it is important to remember that most upland meadows in this area were once areas of upland forest, another very valuable habitat type in our region—and many would return to forest if left unmanaged. Therefore, while focusing on the conservation of existing upland meadows with high

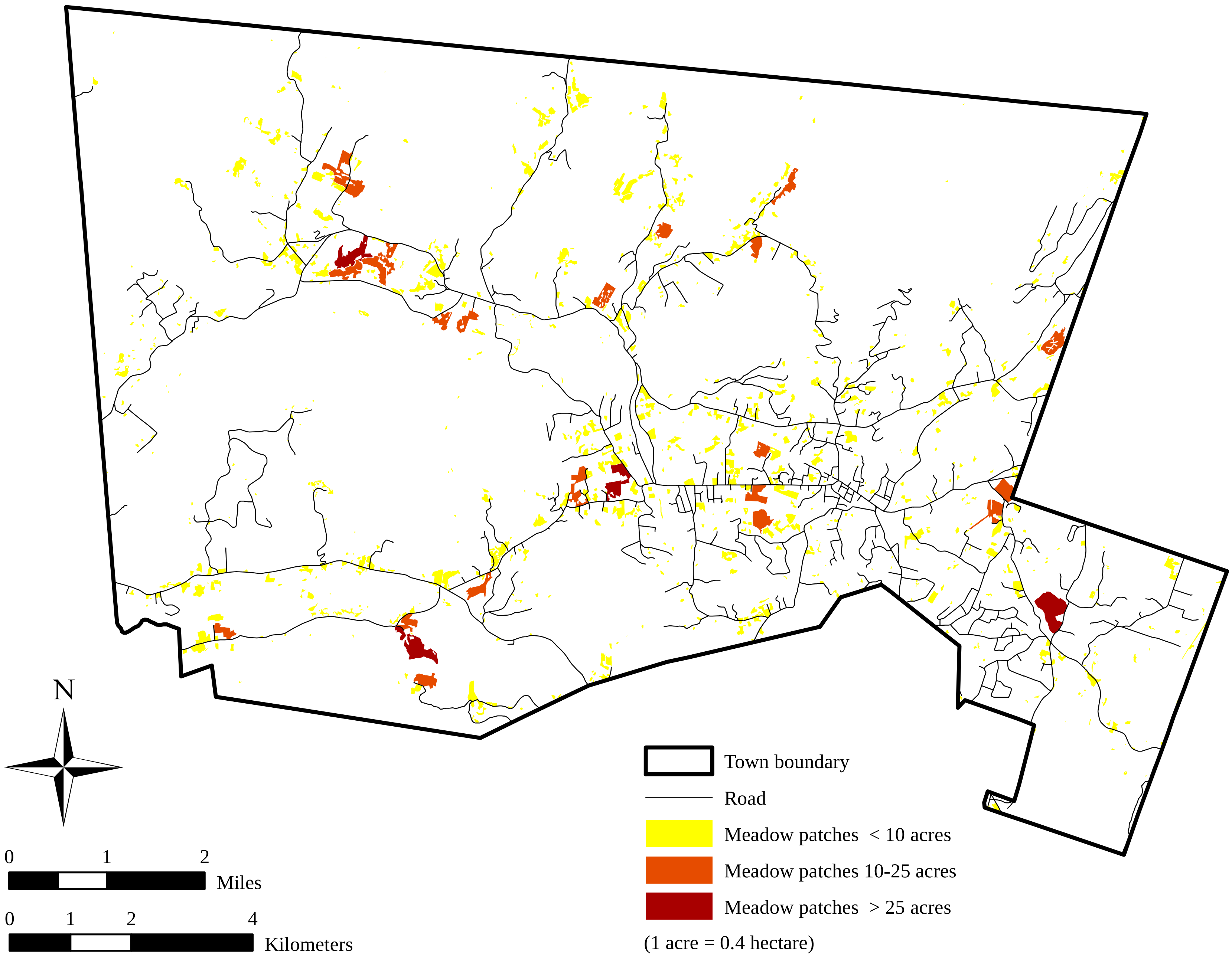


Figure 6. Contiguous meadow habitats (including upland meadow, wet meadow, and calcareous wet meadow) in the Town of Woodstock, Ulster County, New York. This map shows contiguous meadow patches without consideration of fences or hedgerows as fragmenting features. Patches include active agricultural areas and other managed and unmanaged meadow habitats. Hudsonia Ltd., 2012.

biodiversity value, the town should also consider avoiding further conversion of forest to meadow and perhaps even allowing some meadows (particularly smaller ones, or those that are contiguous with areas of upland forest) to revert to forest cover.

Beyond the ecological values, there are many other compelling reasons to conserve active farmland and land with agricultural potential. From a cultural and economic standpoint, maintaining our ability to produce food locally has obvious advantages in the face of unstable and unpredictable energy supplies, and the worldwide imperative to reduce carbon emissions. Active farms also contribute to the local economy and to the character of the town's landscape.

Pasture

INTERMITTENT WOODLAND POOLS

Target Areas

We identified and mapped 75 intermittent woodland pools in Woodstock (Figure 7), and we expect there were others that we missed. Of the swamps that we were able to see in the field, we designated 27 as heath swamps and three as buttonbush pools. Due to the seasonal flooding and relative isolation of these swamps from streams, they are likely to have similar habitat values for pool-breeding amphibians to those of intermittent woodland pools. These swamps should be considered intermittent woodland pools for the purposes of this conservation discussion. Each intermittent pool is important to preserve, but groups or networks of pools are particularly valuable from a habitat perspective. Such aggregations of pools can support "metapopulations" of pool-associated organisms–groups of small populations that are able to exchange individuals and recolonize sites where the species has recently disappeared. Most of the intermittent woodland pools in the town were part of relatively large areas of intact habitat, so protection of such networks might be both worthwhile and feasible.

Conservation Issues

Because they lack fish and certain other predators, intermittent woodland pools provide crucial breeding and nursery habitat for several amphibian species that reproduce less successfully in other wetlands. These "pool-breeding amphibians" include several of the mole salamanders (Jefferson salamander,* marbled salamander,* spotted salamander*) and wood frog.* We have chosen this special group of amphibians as the focal species assemblage for conservation planning for intermittent woodland pools. Except for the larval period and the breeding season, these amphibians are exclusively terrestrial and require the deep shade, deep leaf litter, uncompacted soil, and coarse woody debris of the surrounding upland forest for foraging and shelter. The upland forested area within a 750-ft (230-m) radius of each intermittent woodland pool is considered critical terrestrial habitat for populations of amphibians that breed in that pool (Calhoun and Klemens 2002). Disturbance of vegetation or soils within this area can have significant adverse effects on the amphibians, including the direct destruction of pool and forest habitats, alteration of the pool hydroperiod, and degradation of pool water quality or forest floor habitat quality.

Because of their annual movement patterns, pool-breeding amphibians are especially vulnerable to upland habitat fragmentation. Each year adults migrate to the intermittent woodland pools to breed, and then adults and (later) juveniles disperse from the pool to terrestrial habitats. Jefferson salamanders are known to migrate seasonally up to 2,050 ft (625 m) from their breeding pools into surrounding forests (Semlitsch 1998). A wood frog adult may travel as far as 3,835 ft (1,169 m) from a breeding pool (Calhoun and Klemens 2002). Both salamanders and frogs are susceptible to vehicle mortality where roads or driveways cross their travel routes, and roads, especially networks of roads or heavily-traveled roads, have been associated with reduced amphibian populations (Fahrig et al. 1995, Lehtinen et al. 1999, Findlay and Bourdages 2000). Open fields and clearcuts are also barriers to forest-dwelling amphibians. Juveniles have trouble crossing open fields due to a high risk of desiccation and predation in that exposed environment (Rothermel and Semlitsch 2002).

Populations of these amphibians depend not only on a single woodland pool, but on a forested landscape dotted with such wetlands among which individuals can disperse (Semlitsch 2000). A network of pools is essential to amphibians for several reasons. Each pool is different from the next in vegetation structure, plant community, and hydroperiod, so each may provide habitat for a different subset of pool-breeding species at different times. Also, there are interannual fluctuations in the habitat quality of different pools due to variations in precipitation and air temperatures. To preserve the full assemblage of pool-associated species, a variety of pools must be present for animals to choose from (Zedler 2003). Nearby pools can also serve to “rescue” a population: if the population at one pool is extirpated, individuals from another pool can recolonize the site. This rescue effect is needed to maintain the metapopulation over the long term (Semlitsch and Bodie 1998). Thus, protecting the salamander and frog species associated with intermittent woodland pools requires protecting not only their core breeding habitat (i.e., an intermittent woodland pool), but also nearby accessible pools, key foraging and wintering habitats in the surrounding upland forests, and the forested matrix that includes the migration corridors between individual pools and pool complexes.

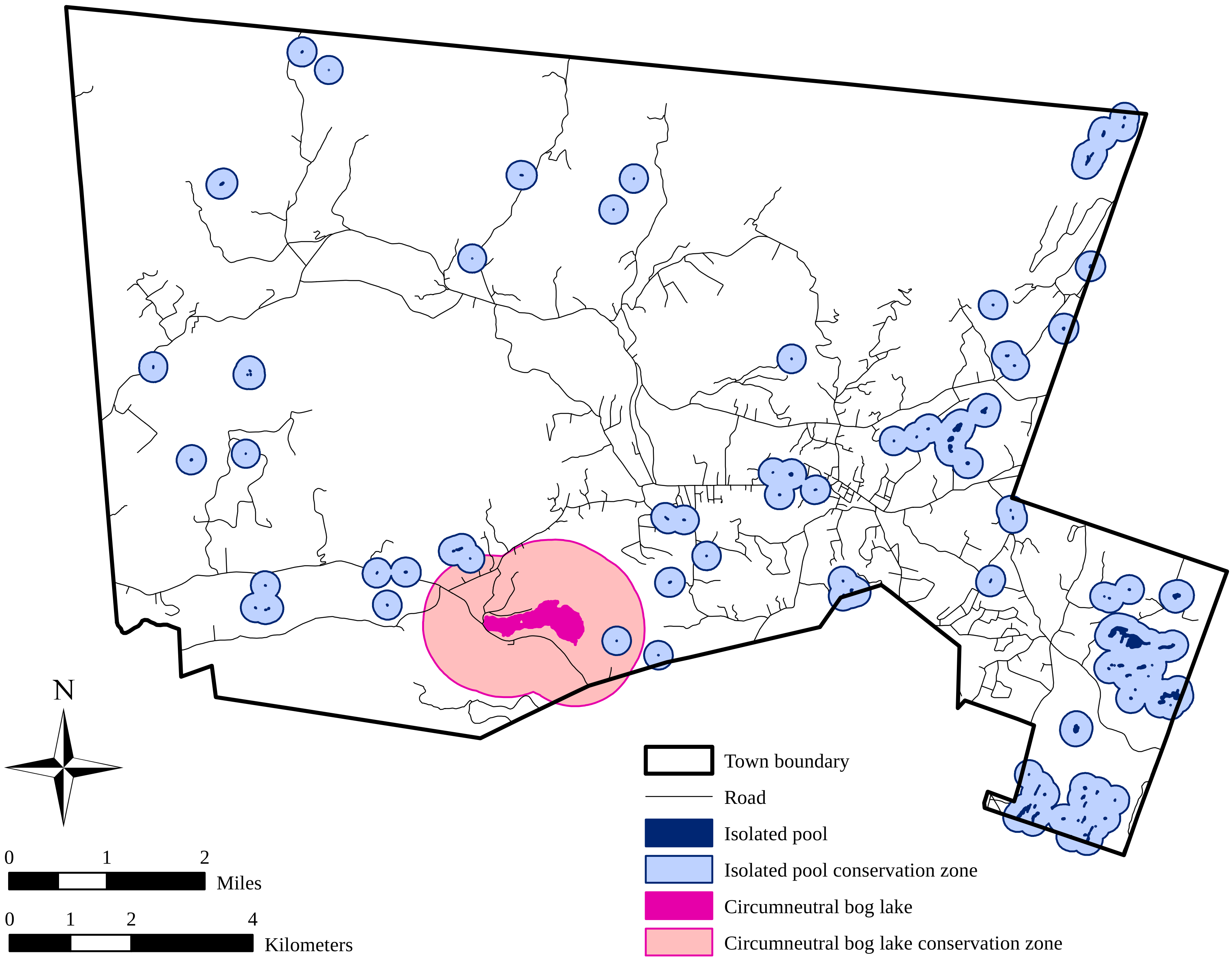


Figure 7. Isolated pools (intermittent woodland pools, heath swamps, buttonbush pools), circumneutral bog lake, and associated conservation zones in the Town of Woodstock, Ulster County, New York. Isolated pool conservation zones extend 750 ft (230 m) and circumneutral bog lake conservation zone extends 3300 ft (1000 m) from wetland boundaries. Hudsonia Ltd., 2012.

Recommendations

To help protect pool-breeding amphibians and the habitat complex they require, we recommend the following measures (adapted from Calhoun and Klemens 2002):

1. ***Protect the intermittent woodland pool depression***. Intermittent woodland pools are often overlooked during environmental reviews of proposed development projects and are frequently drained, filled, or used for dumping. We advise that intermittent woodland pools be permanently protected from development and disturbance of any kind including the construction of houses, roads, lawns, and ponds within the pool depression. This zone of protection should include the pool basin up to the spring high water mark and all associated vegetation. The soil in and surrounding the pool should not be compacted in any manner and the vegetation, woody debris, leaf litter, and stumps or root crowns within the pool should not be removed.

2. ***Protect all upland forest within 100 ft (30 m) of the intermittent woodland pool***. This zone provides important shelter for high densities of adult and recently emerged salamanders and frogs during the spring and early summer. The forest in this zone also helps shade the pool, maintains pool water quality, and provides important leaf litter and woody debris to the pool system. This organic debris constitutes the base of the pool food web and provides attachment sites for amphibian egg masses. To maintain the habitat quality of this zone, avoid any disturbance to the vegetation or soils.

3. ***Maintain critical terrestrial habitat within 750 ft (230 m) of the pool***. The upland forests within 750 ft (230 m) or more of a woodland pool are critical foraging and shelter habitats for pool-breeding amphibians during the non-breeding season. Roads, development, logging, ATV use, and other activities within this terrestrial habitat can harm amphibians and destroy the forest floor microhabitats that provide them with shelter and invertebrate food. Development within this zone can also prevent dispersal and genetic exchange between neighboring pools, thereby making local extinction more likely. To protect pool-breeding amphibians, at least 75% of this zone should remain as contiguous (unfragmented) forest with an undisturbed forest floor. Wherever possible, forested connections between individual pools should be identified and maintained to provide overland dispersal corridors. See Figure 7 for an illustration of this 750-ft zone.

4. ***Do not channel runoff from roads and developed areas (including overflow from stormwater ponds) into intermittent woodland pools.***

We also recommend the following for all development activities proposed within the critical terrestrial habitat zone (750 ft [230 m]) of an intermittent woodland pool:

1. ***Avoid or minimize the potential adverse affects of roads to the greatest extent possible*.** Pool-breeding salamanders and frogs are especially susceptible to road mortality from vehicular traffic, predation, and desiccation. Curbs and other structures associated with roads frequently intercept and funnel migrating amphibians into stormwater drains where they may be killed. To minimize these impacts:
   - Roads and driveways with projected traffic volumes in excess of 5 vehicles per hour should not be sited within 750 ft (230 m) of the pool.
   - Regardless of traffic volumes, the total length of roads within 750 ft of a woodland pool should be limited to the greatest extent possible. This can be achieved, among other ways, by clustering development to reduce the amount of needed roadway.
   - Gently sloping curbs or no-curb alternatives should be used to reduce barriers to amphibian movement.
   - Oversized square box culverts (2 ft wide by 3 ft high [0.6 m x 0.9 m]) spaced at 20-ft (6 m) intervals should be used near wetlands and known amphibian migration routes to facilitate amphibian movements under roads. Special "curbing" should also be used along the adjacent roadway to deflect amphibians into the box culverts.

2. ***Maintain woodland pool water quality and quantity at pre-disturbance levels*.** Development within a woodland pool's watershed can degrade pool water quality by increasing sediment, nutrient, and pollutant loading to the pool. Even slight increases in sediments or pollution can stress and kill amphibian eggs and larvae, and may have adverse long-term effects on the adults. The redirection of natural surface water flows can decrease the pool hydroperiod below the threshold required for successful egg and larval development. Increasing impervious surfaces or channeling stormwater runoff toward pools can increase pool hydroperiod, which can also render the habitat unsuitable for breeding amphibians. Protective measures include the following:
   - Do not use intermittent woodland pools for stormwater detention, either temporarily or permanently.
   - Aggressively treat stormwater in the pool's watershed using methods that allow for the maximum infiltration of runoff, including grassy swales, filter strips, "rain gardens," and oil-water separators in paved parking lots.
   - Avoid or minimize the use of pesticides and fertilizers within the woodland pool's watershed. If mosquito control activities are necessary, limit them to the application of bacterial or fungal larvicides, which may have lesser negative impacts on non-target pool biota than other methods. De-icing salts such as sodium chloride cannot be removed by means of treatment methods currently in use; thus it may be appropriate

to avoid use of certain de-icing compounds where they will pollute surface runoff into amphibian breeding pools.

- Maintain both surface water runoff and groundwater inputs to intermittent woodland pools at pre-construction levels. Avoid changes (either increases or decreases) in pool depth, volume, and hydroperiod.
- Minimize impervious surfaces including roads, parking lots, and buildings to reduce runoff problems and resulting stormwater management needs.

3. ***Avoid creating stormwater detention basins and other artificial depressions*** that intermittently hold water (e.g., vehicle ruts) within 750 ft (230 m) of an intermittent woodland pool or in areas that might serve as overland migration routes between pools. These "decoy wetlands" can attract large numbers of pool-breeding amphibians, but the eggs laid in them rarely survive due to the high sediment and pollutant loads or short hydroperiod.

4. ***Modify potential pitfall hazards*** such as swimming pools, excavations, window wells, or storm drain catch basins to prevent the entrapment and death of migrating amphibians and other animals. Soil test pits should be backfilled immediately after tests are completed.

5. ***Schedule construction activities to occur outside the peak amphibian movement periods of spring and early summer***. If construction activity during this time period cannot be avoided, install temporary exclusion fencing around the entire site to keep amphibians out of the active construction areas.

Wood frog

CIRCUMNEUTRAL BOG LAKE

Target Areas

Yankeetown Pond is the only circumneutral bog lake we identified in Woodstock (Figure 7). Glenford Wittenberg Road skirts its southern shore, while Charlie Spanhake Road skirts part of the northern shore, and much of the narrow strip of land between the roads and lake has residential development. Only the eastern half of the pond's shoreline borders significant habitat.

Conservation Issues

The unusual water chemistry, hydrology, and sediments of circumneutral bog lakes often combine to provide habitat for rare plants and animals. The northern cricket frog—Endangered in New York—has not been found at Yankeetown Pond, but could occur here in the future. Northern cricket frog* (NYS Endangered) is known to occur in only three counties in New York, including Ulster County, and is rapidly declining in the northern part of its range. In most of this region, circumneutral bog lakes are the critical breeding habitat for the species (Dickinson 1993). Males prefer gently-sloping banks and floating peat and aquatic vegetation to use as calling sites. The species seems to have greater reproductive success at sites with buffered (circumneutral) pH conditions (Sparling et al. 1995) and with abundant submerged vegetation which provides shelter for tadpoles (Beasley et al. 2005). This vegetation can be affected by herbicide application or herbicide-contaminated runoff into the lake, and water quality can be degraded by fertilizers and other nutrient additions, as well as sedimentation. Northern cricket frog may use a variety of overwintering sites, including deep cracks in moist soil at the perimeters of these lakes, which can be destroyed by pond dredging or clearing of surrounding vegetation (Irwin 2005). The frogs may also overwinter away from the lakes in small wetlands or forested upland sites as far away from the lake as 1,475 feet (450 m) (New York Natural Heritage Program 2012, Jason Tesauro, pers. comm.).

Individual cricket frogs have been known to disperse between ponds up to 0.8 miles (1.3 km) apart (Gray 1983) and, based on the distribution of suitable habitats in this region, they can probably disperse much farther (Dickinson 1993). The clear water, diverse plant community, and floating peat mats create unusual habitat for fish, amphibians, reptiles, and invertebrates. Maintaining the quality and quantity of groundwater and surface water feeding the lake is probably critical to the lake habitats. Aquatic vegetation can be affected by herbicide application or herbicide-contaminated runoff into the lake, and water quality is degraded by fertilizers, septic leachate, and other nutrient additions to the surrounding landscape, as well as sedimentation from silt-laden runoff.

Recommendations

1. ***Maintain water quality***. Avoid the application of herbicides for the control of invasive aquatic plants. Consider mechanical harvesting of undesired species, such as Eurasian milfoil. Reduce or eliminate use of fertilizers and pesticides on lawns and nearby agricultural fields; minimize soil disturbance within the watershed of the circumneutral bog lake; upgrade nearby septic systems to prevent nutrient enrichment of the lake; minimize runoff from roads and other impervious surfaces.

2. ***Maintain hydrology***. Avoid changing water levels or patterns of inflow and outflow. This requires attention to activities in the lake watershed such as road and building construction, stormwater management infrastructure, and groundwater extraction (e.g., wells).

3. ***Maintain or restore a vegetated buffer of 300 ft (90 m) from the lake edge***. Leaving a broad buffer of undisturbed soils and vegetation may be crucial to safeguarding wetland habitat quality, hydrology, and potential northern cricket frog overwintering sites. Discourage new development in this buffer area, and keep road treatments (such as salting or sanding) to a minimum.

4. ***Protect habitats and assess potential impacts within 3,300 ft (1,000 m) of the lake edge.*** Development within this area may sever important travel corridors between potential northern cricket frog breeding habitats, and between the lake and the cricket frog overwintering habitats. Conservation measures within this area will also protect hydrology and water quality for other rare species.

5. ***If any significant land use changes are proposed in the vicinity, conduct rare species surveys in the lake, adjacent wetlands, and surrounding forests early in the planning process***, so that development designs can accommodate the needs of sensitive species. Surveys should include rare plants, amphibians, reptiles, and breeding birds.

6. ***Discourage use of motorized watercraft***. Motorized craft pollute water, create noise disturbance, physically damage plant and animal life, and may introduce non-native species.

7. ***Avoid the introduction of non-native fish species that may disrupt the lake's food web***, including grass carp (used for biological weed control) or game fish.

WETLAND COMPLEXES

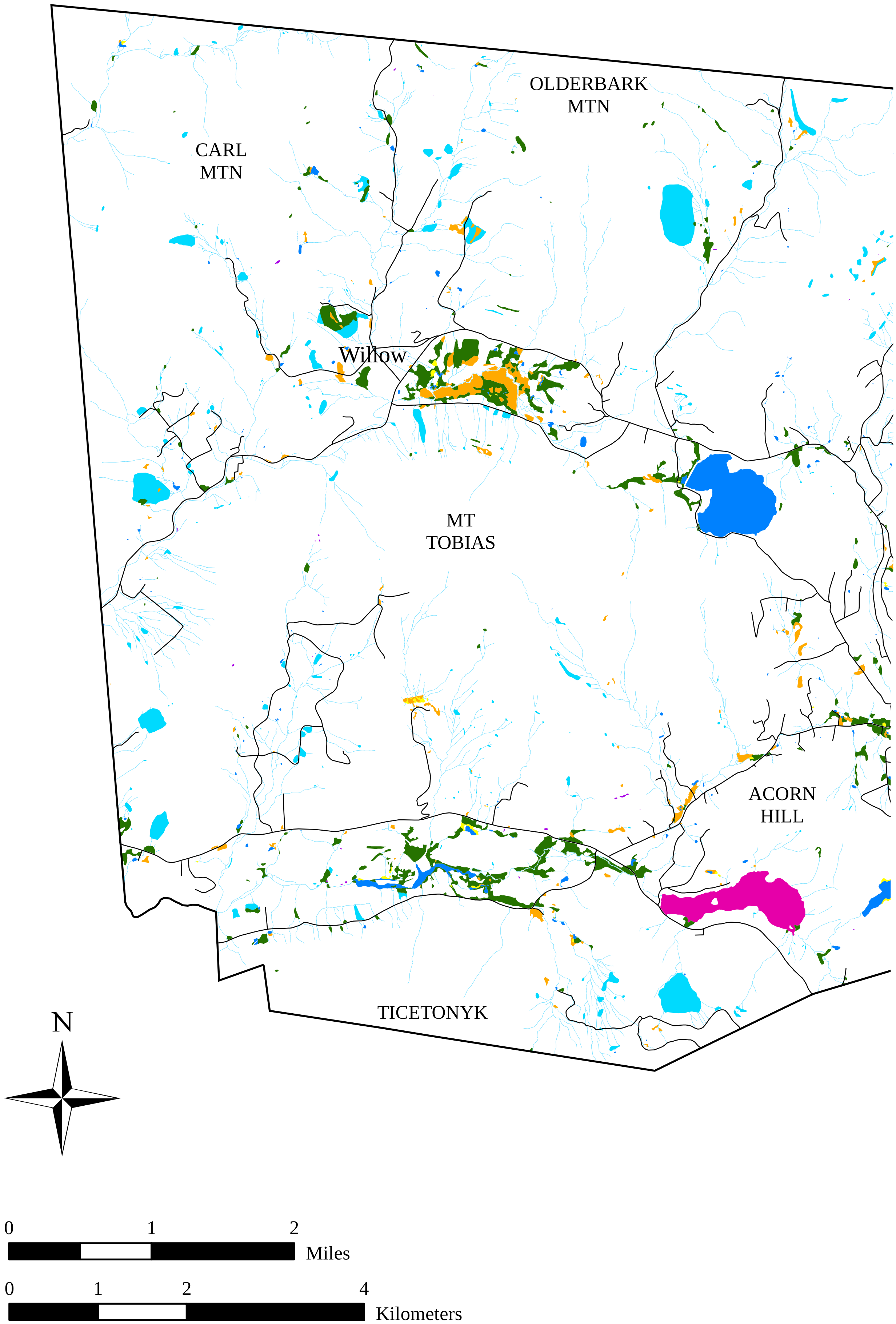
Target Areas

A wetland complex is any group of adjacent and nearby swamps, marshes, wet meadows, other wetland types, or streams. Wetland complexes with especially high habitat value include extensive complexes, those with a wide variety of wetland types, and those that have intact upland habitat between the wetlands. The exceptional abundance of small wetlands found in eastern Woodstock means that most of the area east of the town center can be considered one large wetland complex (Figure 8). The largest contiguous wetlands area in the town extends from Yankeetown Pond west along the Little Beaver Kill. This complex includes circumneutral bog lake, marsh, swamp, open water, and wet meadow habitats, and has been extensively altered by beaver activity. An additional large wetland complex altered by beaver activity is located between Route 212 and Sickler Road. Most of the town, however, is characterized by scattered, small or medium-sized wetlands in a matrix of upland forest. The habitat value of wetland complexes in these areas depends on the upland forests and other intervening habitats remaining intact.

Conservation Issues

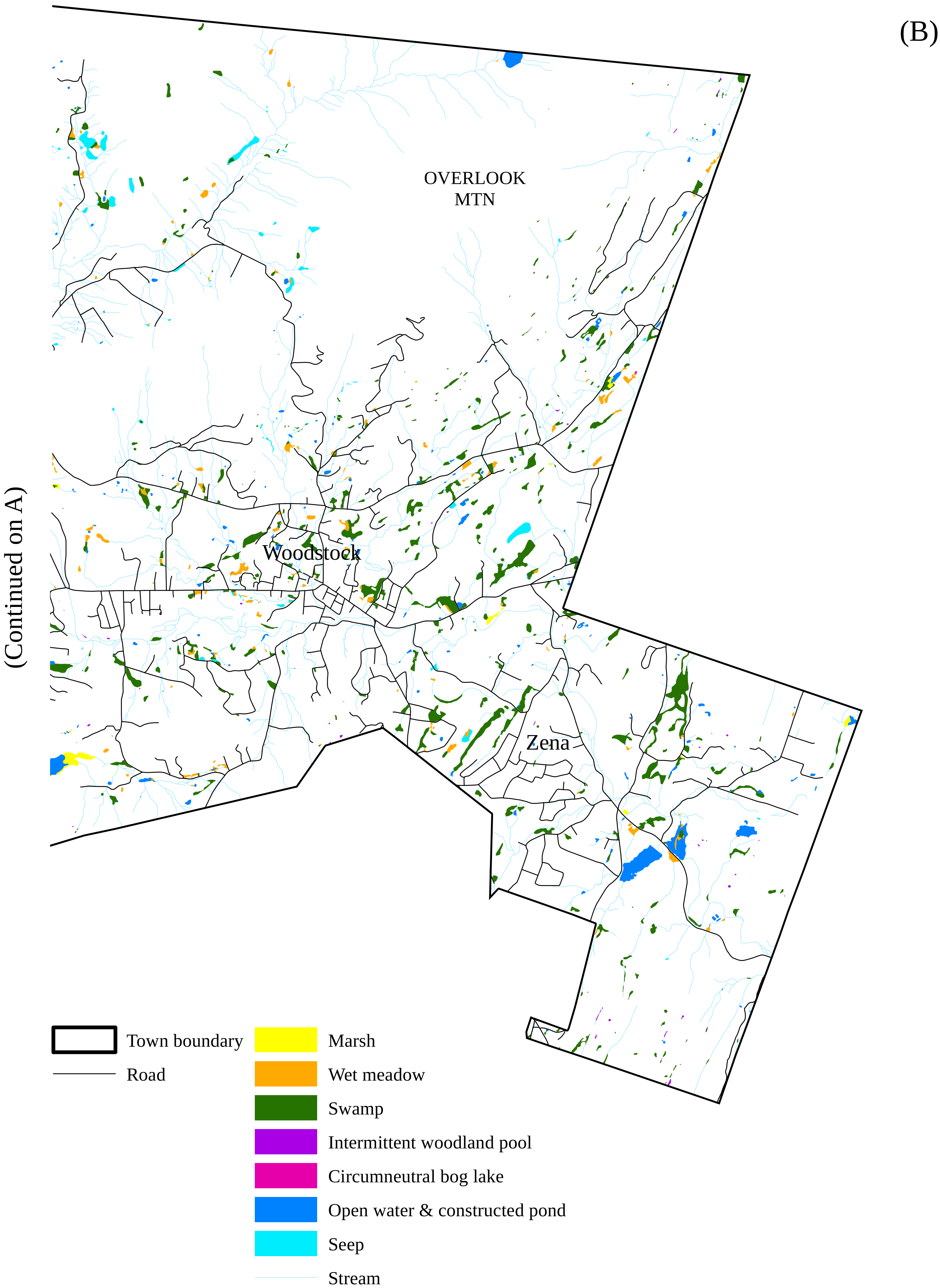
Many animals move among several types of wetland and upland habitats throughout the year, taking advantage of wetlands in close proximity to each other, the intervening upland habitats, and safe travelways between. We have chosen the spotted turtle* as the focal species for wetland complexes because of its mobile habits and its need for a variety of habitats to meet its life history requirements. The spotted turtle is known to use marsh, fen, wet meadow, hardwood and shrub swamp, shrub pool, intermittent woodland pool, and open water habitats within a single year (Fowle 2001). Furthermore, although it depends on a large number of wetlands, spotted turtle may spend up to three-quarters of its time during the active season in

(A)



(Continued on B)

Figure 8. Wetland habitats (simplified) in the Town of Woodstock, Ulster County, New York. Hudsonia Ltd., 2012.



(B)
(Continued on A)
OVERLOOK MTN
Woodstock
Zena
Town boundary
Road
Marsh
Wet meadow
Swamp
Intermittent woodland pool
Circumneutral bog lake
Open water & constructed pond
Seep
Stream

uplands. This species follows an annual pattern of activity (which likely varies by individual, population, and region): it usually overwinters in bottomland hardwood swamps or wet meadows, spends spring and early summer in one to several seasonal and permanent pools, travels up to 1,870 ft (570 m) to nest in open upland habitat, and spends late summer aestivating (quiescent) in upland forest. It can travel 3,300 ft (1,000 m) or more between wetlands. Because of this intricate annual pattern of habitat use, whole complexes of wetland and upland habitats are required to support spotted turtle populations, including seasonal wetlands such as intermittent woodland pools (Joyal et al. 2001, Milam and Melvin 2001). It should be noted that spotted turtle is thought to occur primarily below 700 ft (210 m) elevation in New York State (Gibbs et al. 2007); however, Barbour observed the species at Yankeetown Pond (940 ft [290 m] elevation) in 2012 and we believe that several high quality wetland complexes in Woodstock's valleys (including other areas above 700 ft) provide suitable spotted turtle habitat. The conservation recommendations provided below are also applicable to wetland complexes in the Catskill Mountains used by other mobile wetland fauna, such as blue-spotted salamander.*

Recommendations

1. ***Protect intermittent woodland pools, heath swamps, buttonbush pools, circumneutral bog lakes, and their conservation zones*** as described in previous sections of this report. These are habitats used by spotted turtle (and many other species) especially in the summer.

2. ***When the above habitats are located within 3,300 ft (1,000 m) of a swamp, marsh, or wet meadow (wintering habitat), protect those wetlands and the intervening upland habitats***. These upland areas encompass spotted turtle travel corridors, and nesting, aestivation, and basking sites.

3. ***Protect from disturbance any potential spotted turtle nesting habitat within 390 ft (120 m) of all the wetlands***. Spotted turtle usually nests in open sites such as fields or lawns, but sometimes also in sedge tussocks in wetlands.

A GIS file with wetland complexes delineated according to these recommendations is included in the digital dataset provided to the town. Although not within 3,300 ft of an isolated pool, a large area of contiguous wet meadow and swamp north of Sickler Road is included with other wetland complexes and could provide high-quality spotted turtle habitat.

STREAMS AND RIPARIAN CORRIDORS

Target Areas

The Saw Kill, Beaver Kill, Little Beaver Kill, and Warner Creek are the major perennial streams in Woodstock (Figure 9). The town's widespread network of smaller perennial and intermittent streams are important habitats in their own right, and are critical contributors to the stream flows, water quality, and habitat quality of the larger streams.

Conservation Issues

We have chosen the wood turtle* as the focal species for perennial streams. Low gradient, perennial streams are essential core habitat for the wood turtle, a NYS Species of Special Concern. Wood turtles use streams with overhanging banks, muskrat burrows, or other underwater shelter for overwintering. In early spring, they use logs and stream banks for basking. In late spring and summer, wood turtles move away from the stream to bask and forage in a variety of wetland and upland habitats, and females may travel long distances from their core stream habitat to find open, sparsely-vegetated upland nesting sites.

Conserving wood turtles requires protecting not only their core perennial steam habitat, but also their riparian wetland and upland foraging habitats, upland nesting areas, and the upland migration corridors between these habitats. The wood turtle habitat complex can encompass the wetland and upland habitats within 660 ft (200 m) or more of a core stream habitat (Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997). Development activity within this zone can adversely affect wood turtles. Effects include habitat degradation from stream alteration; removal of woody debris from stream beds; habitat fragmentation from culverts, bridges, roads, and other structures; the direct loss of wetland habitat; water quality degradation from siltation, pesticides, fertilizers, sewage, and toxic compounds; increased nest predation by human-subsidized predators; disturbance from human recreational activities; and road mortality of nesting females and other individuals migrating between habitats.

Water quality in large streams depends in large part on the water quality and quantity of the small, intermittent streams that feed them (Lowe and Likens 2005). In order to protect water quality and habitat in intermittent streams, the adjoining lands should be protected to at least 160 ft (50 m) on each side of the stream (and further on steep slopes). This conservation zone provides a buffer for the stream and can help to filter sediment, nutrients, and contaminants from runoff, stabilize stream banks, contribute organic material, prevent channel erosion, regulate microclimate, and preserve other ecosystem processes (Saunders et al. 2002).

Recommendations

To help protect wood turtles and their habitat complexes, as well as many other stream-associated wildlife species, we recommend the following measures.

Within 160 ft (50 m) of all streams:

1. ***Protect the integrity of stream habitats***.
    - Prohibit engineering practices that alter the physical structure of the stream channel such as stream channelization, artificial stream bank stabilization (e.g., rock rip-rap, concrete), construction of dams or artificial weirs, vehicle crossing (e.g., construction or logging equipment, ATVs), and the clearing of natural stream bank vegetation and woody debris. These activities can destroy key wood turtle hibernation and basking habitat.
    - Avoid direct discharge of stormwater runoff, chlorine-treated wastewater, agricultural by-products, and other potential pollutants into streams.
    - Establish a stream conservation zone extending at least 160 ft (50 m) on either side of all streams in the watershed, including perennial and intermittent tributary streams, whether or not they are used by wood turtles. These conservation zones should remain naturally vegetated and undisturbed by construction, conversion to impervious surfaces, agriculture and livestock use, pesticide and fertilizer application, and installation of septic leachfields or other waste disposal facilities.

2. ***Minimize impacts from new and existing stream crossings***. Engineered elements of stream crossings, particularly undersized bridges and narrow culverts, may be significant barriers to wood turtle movement along their core stream habitats. Wood turtles may shy away from entering such structures and choose an overland route to reach their destination, putting them in the way of vehicles and other hazards. If a stream crossing completely blocks the passage of turtles, individuals can be cut off from important foraging or basking habitats, or be unable to

interbreed with turtles of neighboring populations. Such barriers could significantly diminish the long-term viability of these populations. If new stream crossings must be constructed, we recommend that they be specifically designed to accommodate the passage of turtles and other wildlife. The following prescriptions, although not specifically designed for wood turtles, may be an important first step to improving the connectivity of stream corridors (adapted from Singler and Graber 2005):

- Use bridges and open-bottomed arches instead of culverts.
- Use structures that span at least 1.2 times the full width of the stream so that one or both banks remain in a semi-natural state beneath the structure. This may facilitate the overland passage of turtles and other wildlife.
- Design the structure to be at least 4 ft (1.2 m) high and have an openness ratio of at least 0.5 (openness ratio = the cross-sectional area of the structure divided by its length). Higher openness ratio values mean that more light is able to penetrate into the interior of the crossing. Brighter conditions beneath a crossing may be more favorable for the passage of wood turtles and other animals.
- Install the crossing in a manner that does not disturb the natural substrate of the stream. If the substrate must be disturbed, re-construct the substrate of natural materials and match the texture and composition of upstream and downstream substrates.
- If the stream bed must be disturbed during construction, design the final elevation and gradient of the structure bottom so as to maintain water depth and velocities at low flow that are comparable to those found in natural stream segments just upstream and downstream of the structure. Sharp drops in elevation at the inlet or outlet of the structure can be a physical barrier to the passage of wood turtles and other animals.

In addition, within 660 ft (200 m) of perennial streams:

1. ***Protect riparian wetland and upland habitats.*** All riparian areas should be protected from filling, dumping, drainage, impoundment, incursion by construction equipment, siltation, polluted runoff, and hydrological alterations. Additional activities that create pitfall hazards for turtles and other small animals should be avoided (see above recommendations for buttonbush pools/kettle shrub pools). Establish a 660 ft (200 m) stream conservation zone in which large, contiguous blocks of upland habitats (e.g., forests, meadows, shrublands) are preserved to the greatest extent possible to provide basking, foraging, and nesting habitat for the wood turtle. Special efforts may need to be taken to protect particular components of the habitat complex such as wet meadows and alder stands; wood turtle has been found to favor stands of alder, and wet meadows are often sought by wood turtles, especially females, for spring basking and foraging (Kaufmann 1992). These wetlands are often omitted from state, federal, and site-specific wetland maps and are frequently overlooked in the environmental reviews of development proposals.

2. ***Minimize impacts from new and existing roads***. Road mortality of nesting females and individuals dispersing to new habitats is one of the greatest threats to wood turtle populations. To help minimize the adverse effects of roads on this species, we recommend the following actions be undertaken within the 660-ft (200-m) wide stream conservation zone:
   - Prohibit the building of new roads crossing or adjoining wood turtle habitat complexes. This applies to public and private roads of all kinds, including driveways.
   - Keep vehicle speeds low on existing roads by installing speed bumps (where possible), low speed limit signs, and wildlife crossing signs.

3. ***Maintain broad corridors between habitats and habitat complexes***. Broad, naturally vegetated travel corridors should be maintained between individual habitats within a complex (e.g., between core stream habitats, foraging wetlands, and upland nesting areas) and between neighboring habitat complexes.

4. ***Protect nesting areas***. Wood turtles often nest in upland meadow or open shrublands, habitats that also tend to be prime areas for development. Construction of roads, houses, and other structures on potential nesting habitats could severely limit the reproductive success of the turtles over the long term. We recommend that large areas of potential nesting habitat within the 660 ft (200 m) stream conservation zone (e.g., upland meadows, upland shrublands, waste ground with exposed sandy or gravelly soils) be protected from development and other disturbance, and that broad travelways between those areas and the nearby wetlands and stream be maintained intact.

Wood turtle along the Beaver Kill

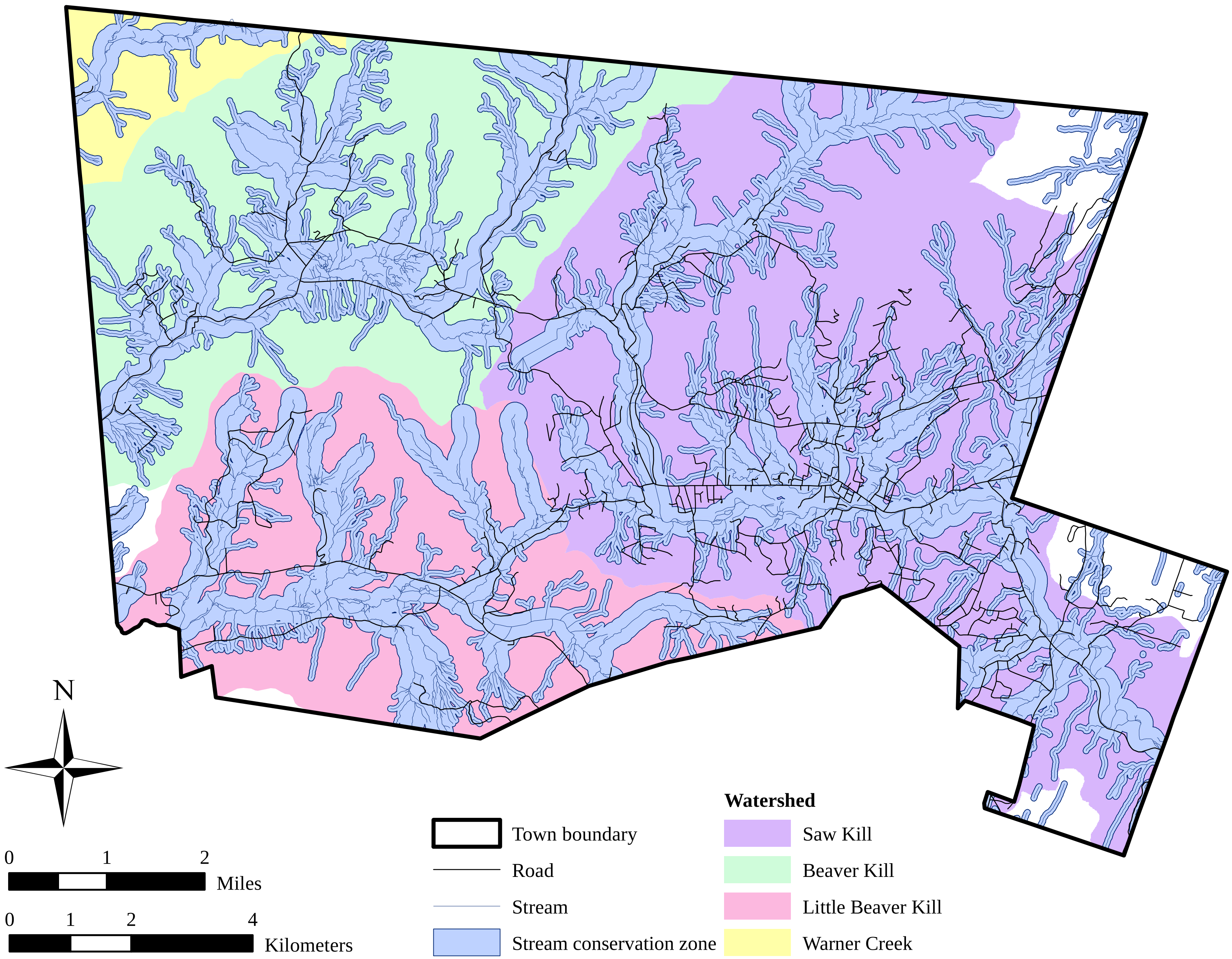


Figure 9. Streams and their associated conservation zones in the Town of Woodstock, Ulster County, New York. Conservation zones extend at least 160 ft (50 m) from stream edges, and 650 ft (200 m) from edges of large, perennial streams.These zones were identified by Hudsonia, and exceed the jurisdictional buffer zones defined in the Wodstock Wetland and Watercourses Protection law. Watersheds of primary perennial streams shown in background. Hudsonia Ltd., 2012.

ENHANCEMENT OF DEVELOPED AREAS

A well-rounded biodiversity conservation approach in village, suburban, and rural landscapes must also consider areas that are already developed. Although developed areas are most frequently used by common wildlife species (e.g., pigeons, starlings, gray squirrels, raccoons, white-footed mice) that are adapted to human activities and infrastructure, uncommon species can also inhabit or travel through developed areas if nearby habitats are suitable. Bats (including Indiana bat*) and certain species of birds (including eastern screech owl,* barn owl,* and Cooper's hawk*) will take advantage of individual trees, small groves, and structures in developed areas. Songbirds feed on berries, seeds, and other fruit of ornamental plants, as well as insects associated with those plants. Turtles sometimes nest in gardens, lawns, and other unshaded areas of developed landscapes.

There are many modifications and practices that can be applied to the developed parts of Woodstock that would assist in the protection of species of conservation concern. Within the developed matrix, some small areas may serve as buffers to intact habitats by moderating the effects of development, some may provide travel corridors for wildlife, and some may themselves provide habitat for certain species. Hudsonia did not map these small areas or isolated habitat features (such as individual trees) as habitats in their own right due to the impracticality of such mapping at a town-wide scale (see description of mapping conventions in Appendix A). Nevertheless, the habitat map can help to focus both habitat enhancements and disturbance minimization efforts on locations where they will achieve the greatest returns for biodiversity conservation.

Following are some examples of conservation measures for developed areas (adapted in part from Adams and Dove 1989, and Adams 1994). There are many other ways in which urban and suburban areas can be modified to reduce their negative environmental impacts and even contribute positively to the natural environment, with many examples of their implementation to be found in European cities (Beatley 2000). The costs of implementing these measures and their effectiveness in given locations will vary, and while some must be implemented by the town or other government entities, others can be practiced voluntarily by private landowners.

The town can take a leading role in educating the general public about such actions and encouraging landowner participation.

ENHANCING HABITAT CHARACTERISTICS

1. ***Preserve trees of a variety of species and age classes.*** Trees are an important component of the habitat of many wildlife species, and some species of plants and animals can use hedgerows as habitat corridors. Trees also provide services such as helping to moderate climate extremes, reducing wind velocities, controlling erosion, and abating noise.
   - Preserve large trees wherever possible, and especially those with exfoliating bark that might serve as summer roost sites for bats.
   - Plant a variety of native tree species along streets, and reduce the use of salt on roads to minimize damage to the trees.
   - Allow natural regeneration of trees where possible, to provide replacements for older trees and those that must be removed for safety reasons.
   - Allow dead trees (snags) to remain standing and fallen trees to decay in place where safety concerns allow. Snags provide good habitat for animals such as insects, woodpeckers, and bats, and decomposing trees provide both habitat for wildlife and a source of nutrients for plants, fungi, lichens, mosses, liverworts, and invertebrates.

2. ***Replace lawn areas with multi-layered landscapes.*** Manicured lawns have little biodiversity value and their maintenance requires higher inputs of water and chemicals than other types of horticultural landscaping, such as wildflower meadows, perennial gardens, or ornamental woodlands. Lawns are usually maintained with motorized lawn mowers, which consume fossil fuels and contribute to air and noise pollution. While the choice to maintain lawns in residential areas is often one of personal taste or safety, public education and landowner incentives can promote landscaping that provides higher quality resources for wildlife while reducing water, air, and noise pollution in developed areas.

3. ***Manage constructed ponds (such as stormwater control ponds and ornamental ponds) for wildlife.***

- Discourage construction of ponds in existing wetlands.
- Avoid or minimize the use of pesticides and fertilizers in and near ponds, and do not introduce non-native fish species
- Plant or maintain shoreline vegetation.
- Add small, gently sloping, vegetated islands to large ponds (>5 ac [2 ha]).
- Encourage a combination of emergent vegetation and open water (i.e., interspersed shallow and deep areas).
- Include irregular shorelines, gently sloped shores, and the capability for controlling water levels in the design of new ponds.

4. ***Restore natural stream buffers wherever possible.*** Vegetated stream shorelines and floodplains serve to control erosion, moderate flooding, and protect water quality. They contribute organic detritus, reduce stream water temperatures, and enhance the overall habitat quality of the stream and in some cases its recreational value. They also allow for natural movements of the stream channel over time, which improves the stream's capacity to dissipate the energy of water flow. (See the Streams and Riparian Corridors priority habitat section above).

5. ***Maximize onsite infiltration of rainwater and snowmelt.*** Impervious surfaces such as pavement and roofs alter hydrological patterns by preventing precipitation from infiltrating through the soil to groundwater, instead promoting overland flow to ditches, streams, and ponds. This effect prevents the recharge of groundwater and the filtration of pollutants by soil and vegetation, while increasing the likelihood of flooding, stream bank erosion, and surface water pollution (including sedimentation).
   - Encourage the use of pervious driveway materials in residential and commercial construction and renovation and PAH-free driveway sealers.
   - Construct stormwater retention ponds, wetlands, and rain gardens that allow infiltration of surface water to groundwater.
   - Follow stormwater Best Management Practices (BMPs) in areas of new construction. Examples of BMPs include preserving natural vegetation and installing and maintaining soil retention structures, check dams, soil traps, and silt fences. A national menu of stormwater BMPs can be found on the U.S. Environmental Protection Agency website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

- Encourage the collection of rainwater in barrels and cisterns for use in gardens and lawn areas (as long as these containers are carefully screened to prevent mosquito breeding).

MINIMIZING DISTURBANCE TO RESIDENT AND MIGRATORY BIOTA

1. ***Minimize the impacts of roads on wildlife.*** One of the greatest immediate threats to wildlife in suburban areas is road mortality. A study to identify roadways with the highest incidence of wildlife mortality could be used to direct the following measures to the places where they will be most effective. The maps of conservation zones in this report could also inform such efforts (e.g., roads within conservation zones for intermittent woodland pools could be priorities for facilitating amphibian crossings).
    - Reduce speed limits and post wildlife crossing signs along roads in areas of concentrated wildlife use.
    - Install structures for safe wildlife crossing, such as culverts, overpasses, underpasses, and modified roadside curbs. Design such passageways to accommodate the largest possible number of species (or particular rare or vulnerable species, such as woodland pool-breeding amphibians, that may occur near roads). The USDA wildlife crossing toolkit is an online source of information on such structures (http://www.fs.fed.us/wildlifecrossings/index.php).
    - Modify the immediate roadside areas to promote safer wildlife crossings. Factors to be considered include the location of barriers such as guardrails, type of roadside vegetation, and distance of vegetation to the road's edge (Barnum 2003, Clevenger et al 2003).

2. ***Minimize noise and light pollution.*** High levels of noise and light in cities and residential areas can be a deterrent to many wildlife species. While some noise and light are inevitable in suburban environments, certain sources can be minimized. Below are examples of actions that can be implemented and/or enforced as local or town-wide light and noise ordinances.
    - Require that outdoor lights be directed downward (rather than outward or upward) to minimize the light pollution to offsite and overhead areas.

- Prohibit the use of fireworks in order to minimize disturbance to birds and other wildlife.
- Encourage the use of light technologies (such as low-pressure sodium lights) that minimize the attraction of flying insects, and prohibit the use of "bug-zappers."

3. ***Discourage human-sponsored predators, including domestic cats and dogs.*** Human-sponsored predators are species such as raccoon, opossum, and striped skunk, whose populations often burgeon in response to conditions created by humans. Human interference with the habits and diets of wild animals not only impacts population dynamics, but can lead to nuisance behavior.
    - Properly secure trash receptacles and compost piles.
    - Feed pets indoors, and do not intentionally feed wildlife.
    - Keep cats and dogs indoors or supervise them when they are outdoors.

4. ***Include biodiversity considerations in development planning.***
    - Plan for low-disturbance human activities/developments adjacent to intact habitats, and design undisturbed buffer zones around sensitive habitat areas.
    - Consider wildlife travel routes (including bird flight paths) in the placement of developments and buildings.
    - Encourage building designs that minimize harm to wildlife. For example, consult New York City Audubon's publication "Bird-Safe Building Guidelines" (Brown and Caputo 2007) when planning building construction and renovation.

CONSERVATION AREAS IN WOODSTOCK

The Town of Woodstock has an exceptional diversity and quality of habitats distributed throughout the town. To synthesize the information presented in preceding chapters, and facilitate discussion of conservation priorities, we have divided the town into four "conservation areas," each with its unique combination of priority habitats (Figure 10). We hope that this presentation of geographic groupings of priority habitats will help to put each specific location in Woodstock within a larger context, to assist with townwide planning, and to focus local conservation efforts on those measures most appropriate to each conservation area. For discussion of conservation issues and recommendations for each habitat type, refer to the preceding sections.

Catskill Mountains

Woodstock lies at the eastern edge of the Catskills. This entire mountain range is recognized by the NYS DEC as a Significant Biodiversity Area, because it encompasses large areas of contiguous, high quality forest, including first growth forest, as well as alpine communities, gorges, headwater streams, and reservoirs (Penhollow et al. 2006). The area supports regionally significant populations of forest interior nesting birds (including the southernmost breeding population of the rare Bicknell's thrush), bald eagle, large mammals, coldwater fish, reptiles, and rare communities and plants. Within the Town of Woodstock the Catskill Mountains are biologically distinct. The bedrock is primarily sandstone and shale and includes small areas of conglomerate on mountain summits, with many exposed ledges, rocky crests, and waterfalls. The exposed bedrock and shallow soils on the crests lead to droughty conditions and stunted oak crest forests and oak-heath barrens─rare habitats in southeastern New York. The isolated wetlands on the ridges tend to be acidic because they are fed primarily by rainwater and not buffered by calcareous bedrock. Many of the steep slopes and summit areas may never have been completely cleared (by humans), and support forest communities with very few non-nativeplants. Approximately half of the more than 27,000-ac (11,000-ha) forested mountain area within the town is in private ownership. We recommend that the town strongly discourage further development within this area because of its exceptional importance for regional biological diversity. Where any new development is planned, we recommend that landowners, developers, and town agencies pay close attention to maintaining a high degree of landscape connectivity, and avoiding disturbance of interior habitat patches.

Priority habitats in the Catskill Mountains include:

- Extensive upland hardwood, mixed, and conifer forest, including the largest area of contiguous forest (approx. 15,400 ac [6,200 ha]) in the Town of Woodstock. A variety of forest types are represented, each depending on the altitude and aspect, the depth and chemical characteristics of the soil, and the disturbance history. In general, the forests along the lower slopes of the mountains are less biologically and structurally diverse and have a higher density of non-native invasive plants, probably due to the history of past disturbance (e.g., forest clearing, logging, quarrying, grazing). The forests along the steep upper slopes and ridges, on the other hand, are remarkably free of invasive plants and represent high quality examples of the different forest types. Extensive mountain laurel thickets, the largest measuring approximately 600 ac (240 ha) occur on several mountain ridges and slopes. We observed large mammals such as black bear* and fisher* in these forests and saw signs of bobcat.* We also observed uncommon or vulnerable birds such as barred owl,* red-shouldered hawk,* northern goshawk,* wood thrush,* scarlet tanager,* eastern wood pewee,* and black-and-white warbler,* and rare or vulnerable reptiles such as timber rattlesnake,* eastern racer,* eastern box turtle,* and slimy salamander* in these forests.
- Two patches of possible old growth spruce-fir forest and other areas with uncommon or rare northern plant species, such as oak fern,* Braun's holly fern,* northern wild raisin, mountain holly, American mountain-ash, three-toothed cinquefoil,* and Schreber's aster.*
- A natural population of red pine on the north slopes of Tonshi Mountain, a rarity in the Catskills (Kudish 2000).
- Over 30 acres (12 ha) of oak-heath barren. The Catskills are the only area in the town where this habitat occurs. The oak-heath barrens are of particular importance as core

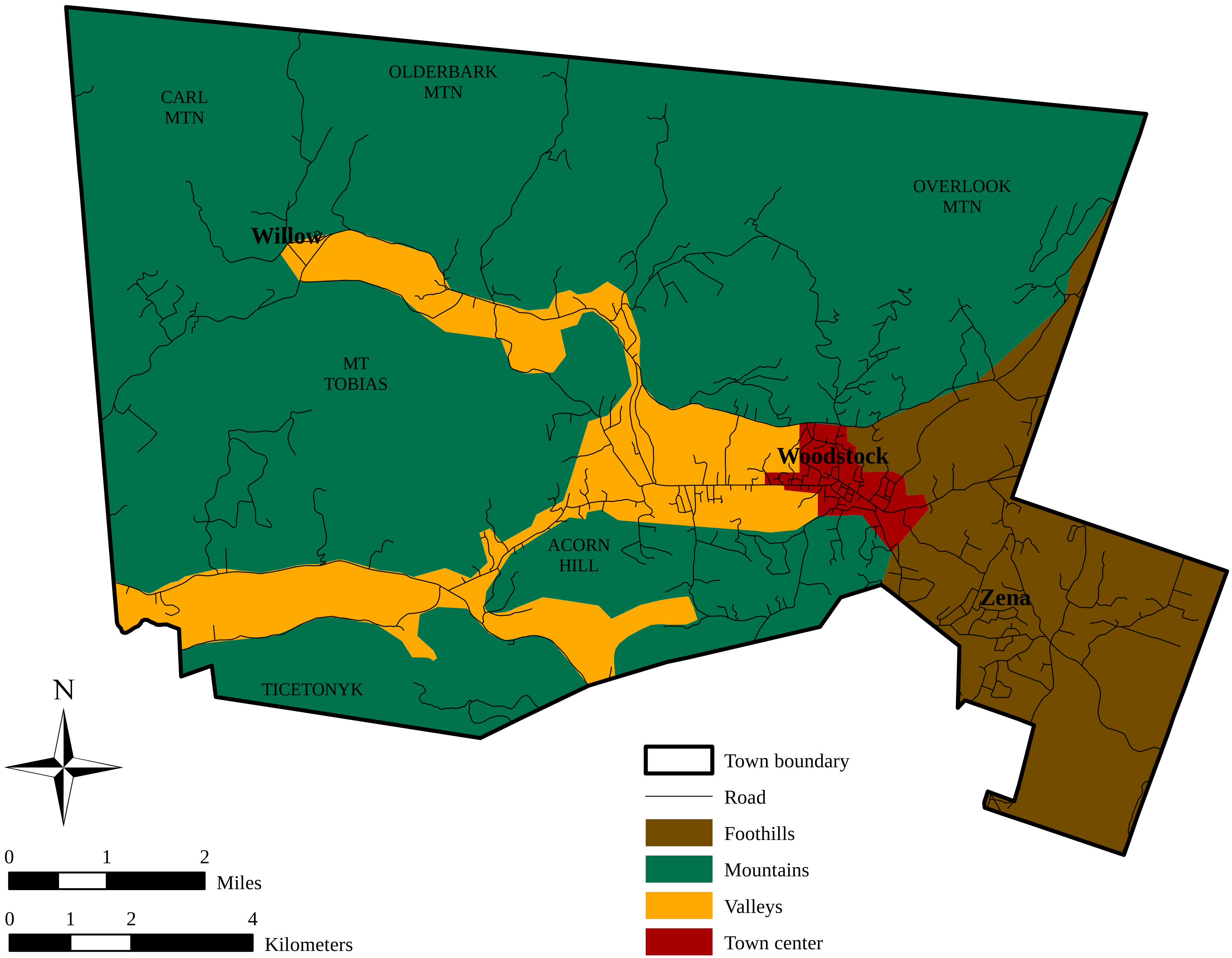


Figure 10. Conservation areas in the Town of Woodstock, Ulster County, New York. These areas were identified by Hudsonia based on geophysical and biological attributes of the town, and are intended to aid in townwide conservation planning. See page 107 for descriptions of special features of each area. Hudsonia Ltd., 2012.

habitat for the timber rattlesnake,* and are likely to be used by other snakes of conservation concern for basking and breeding, and perhaps overwintering.

- Other barrens on mountain summits with similar physical characteristics to oak-heath barren, but with stunted mountain paper birch, yellow birch, and red oak dominant (included in the crest, ledge, and talus layer). These barrens offer similar habitat values for snakes.
- Extensive rocky ledge, talus, and crest habitats, including calcareous outcrops, where we observed a variety of rare plants, including walking fern* and mountain spleenwort.*
- Numerous hardwood, mixed, and conifer forest swamps on mountain ledges and depressions. We observed rare plant species such as Buxbaum's sedge* in such isolated swamps.
- Many springs, seeps, and small streams, including extensive seepage areas. We observed spring salamander* in a mountain seep area and rare plants such as glade fern* and silvery spleenwort* growing along intermittent streams.
- Fine examples of rocky, woodland perennial streams, such as Warner Creek.
- Thirty-four isolated woodland pools, including two heath swamps on the Escarpment.
- Unusual glacial kettle formations on the slopes of Olderbark Mountain and in the saddle between Mount Tobias and its western knob (Kudish 2000 and pers. comm.).

Catskill Foothills

This area includes the lowland hills and basins east of the town center, from West Saugerties-Woodstock Road to Zena. The Catskill Foothills were a center of activity for bluestone quarrying in the 19th century and remnant quarries are abundant. The topography runs strongly parallel to the Catskill Escarpment and is characterized by calcareous ledges and frequent small wetlands. Conservation priorities in the Catskill Foothills include:

- Extensive upland hardwood, mixed, and conifer forest, including a large undeveloped forest area contiguous with public and private forested areas outside the town boundary measuring greater than 5000 acres (Figure 4).

- Numerous calcareous rocky ledge, talus, and crest habitats, including frequent shallow ravines, where we observed a variety of rare and uncommon plants, including walking fern,* rusty woodsia,* and bluntlobe cliff fern.*
- Numerous hardwood and mixed forest swamps, including many isolated swamps potentially suitable for rare pool-breeding amphibians. We observed rare plant species such as cattail sedge* in hardwood swamps.
- Wet meadows in wetland complexes, where we found spotted turtle.*
- Seventy-five isolated woodland pools, including 24 heath swamps and three buttonbush pools, where we observed rare plant species such as Virginia chain fern.* Many of these isolated pools are surrounded by extensive upland forest habitats and provide high quality breeding, foraging, or refuge habitat for Jefferson,* blue-spotted,* and marbled salamanders,* and wood frog.* Along with intervening upland habitats, these typically small wetlands form complexes with each other and other types of wetlands, providing habitat for species such as spotted turtle.*

Catskill Valleys

This area includes the wide portions of valleys of the Beaver Kill, Little Beaver Kill, and Saw Kill extending west from the town center of Woodstock. These valleys encompass wetlands, meadows, and forests, and have exceptional scenic value. Priority habitats within this area include:

- Extensive upland forests along stream corridors, where we observed red-shouldered hawk* and wood thrush.* The large upland forest along the Little Beaver Kill west of the ponds in Wilson State Park is a rare example of an intact stream corridor forest in the Catskills (Barbour et al. 1995).
- Large, connected riparian wetland complexes with active beavers. We observed uncommon plant species in these complexes such as large cranberry,* woodland bulrush,* and great laurel.*
- Yankeetown Pond, a circumneutral bog lake with reported river otter* and where Barbour observed osprey,* bald eagle,* and spotted turtle, and large cranberry.*

- Ten calcareous wet meadows, in addition to extensive non-calcareous wet meadows. We found the rare northern bog clubmoss* and wood turtle* in wet meadows.
- Moderate complexes of upland meadows, where we observed eastern bluebirds.*
- Eleven intermittent woodland pools.
- The Beaver Kill, Little Beaver Kill, and Saw Kill; medium-sized, perennial streams, tributaries of Esopus Creek. Lowland stretches of these streams in Woodstock’s valleys provide valuable habitat for wood turtle,* which we documented along the Beaver Kill.
- Unusual glacial kettle formations in Kenneth Wilson State Park just north of campsites 46, 48, 49, 52, and 54 (Kudish 2000).

Woodstock Town Center

The commercial and residential areas within and surrounding the Woodstock town center are entwined with several ecologically valuable wetland areas and streams. We strongly recommend concentrating future development in the Town of Woodstock within the town center and surrounding developed area as much as possible, practicing “infill” development and the re-use of existing structures wherever feasible, and applying strict conservation measures to safeguard the integrity of the following priority habitats:

- The Saw Kill and its tributaries flowing through the town center and forming a corridor between the Catskill Valleys and Catskill Foothills conservation areas.
- The wetland complex on Playhouse Lane.
- The heath swamp near Pike Lane.

CONCLUSION

The Town of Woodstock has a considerable diversity of ecologically significant habitats, including some known to support species considered rare or vulnerable in the town or in the region. For example, we mapped extensive upland forests, including over 15,400 acres contiguous with large state forest preserves in Greene County, and parts of which included possible old growth stands. We found 25 oak-heath barrens, the core habitat for timber rattlesnake, a NYS Threatened species known to occur in Woodstock. Seventy-five intermittent woodland pools, which are critical breeding and nursery habitat for amphibians of conservation concern, were scattered throughout the town, in addition to 27 heath swamps and three buttonbush pools sharing similar characteristics. We also documented a circumneutral bog lake, calcareous ledges, and calcareous wet meadows, any of which can support rare plant species. We mapped numerous intermittent streams, springs, and seeps that contribute to maintaining flow volumes, temperatures, water quality, and habitat quality of larger perennial streams in the watersheds. Over 14,400 acres of valuable habitat is currently owned and protected by the state, New York City, the City of Kingston, the Town of Woodstock, the Open Space Institute, and the Woodstock Land Conservancy; however, the remaining 28,900 ac of the town is in private ownership and largely unprotected with the exception of the few private properties under conservation easements. With development pressure expected to increase in the near future, strategic land use and conservation measures are needed to ensure that species, communities, and ecosystems are protected for the long term. We hope that the habitat map and this report will help landowners, developers, and town agencies consider the biological landscape as a whole, and design effective measures to protect the resources of greatest importance.

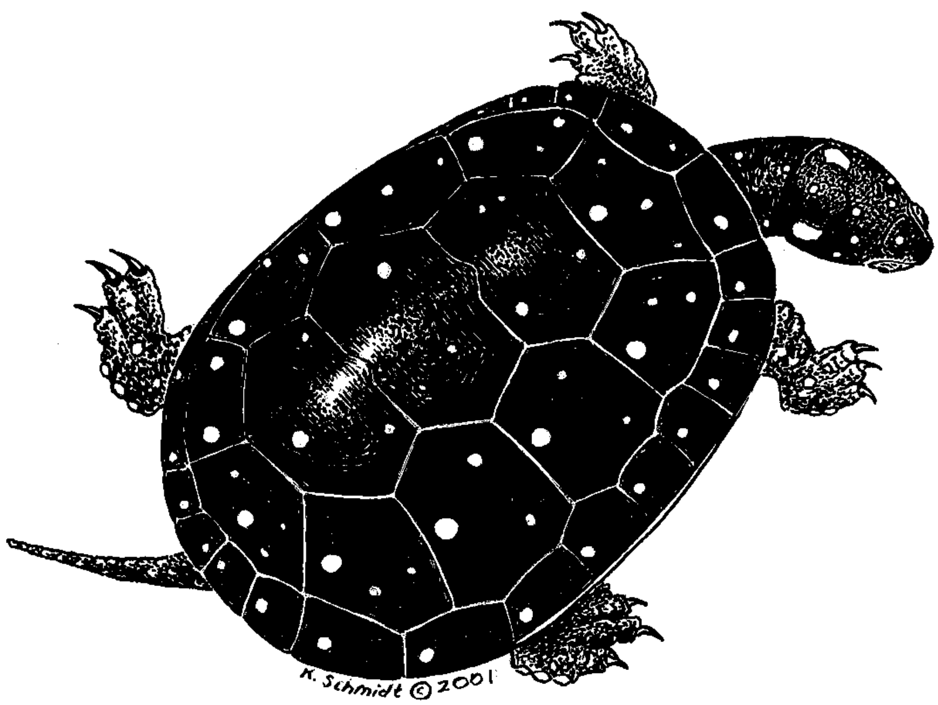
The map provides a bird’s-eye view of the landscape, illustrating the location and configuration of ecologically significant habitats. At the printed scale of 1:10,000, many interesting ecological and land use patterns emerge, such as the location and extent of unfragmented forest blocks, areas where special habitats are concentrated, and the patterns of habitat fragmentation caused by roads and other development. This kind of general information can help the town consider where future development should be concentrated and where future conservation efforts should be targeted, as well as how development can be designed to reduce its impacts. An understanding of the significant biological resources in the town will enable local decision makers to focus limited conservation resources where they will have the greatest impact.

At the site-specific scale, we hope the map will be used as a resource for routine deliberations over development proposals and other proposed land use changes. The map and report provide an independent body of information for environmental reviews, and will help raise questions about important biological resources that might otherwise be overlooked. We strongly emphasize, however, that the map has not been exhaustively field checked and should therefore be used only as a source of general information. In an area proposed for development, for example, the habitat map can provide basic ecological information about the site and the surrounding lands, but the map should not be considered a substitute for site visits by qualified professionals. During site visits, the presence and boundaries of important habitats should be verified, changes that have occurred since our mapping should be ascertained, and the site should be assessed for additional ecological values. Detailed, up-to-date ecological information is essential for making informed decisions about specific development proposals. Because the natural landscape and patterns of human land use are dynamic, the town should consider refining and/or updating the habitat map over time.

The habitat approach to conservation is quite different from the traditional parcel-by-parcel approach to land use decision making. It requires examining the landscape beyond the boundaries of any particular land parcel, and considering the size and juxtaposition of habitats in the landscape, the kinds of biological communities and species they support, and the ecological processes that help to maintain those species. Hudsonia hopes to assist Woodstock's town agencies and others in interpreting the map, understanding the ecological resources of the town, and devising ways to integrate this new information into land use planning and decision making.

Conservation of habitats is one of the best ways to protect biological resources. We hope that the information contained in the habitat map and in this report will help the Town of

Woodstock plan wisely for future development while taking steps to protect biological resources. Incorporating this approach into planning and decision making will help to minimize the adverse effects of human activities on the landscape, integrate the needs of the human community with those of the natural communities, and protect the ecological patterns and processes that support us and the rest of the living world.



Spotted turtle

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APPENDICES

Appendix A. Mapping conventions used to draw boundaries between habitat types, and additional information on defining habitat types.

Crest, ledge, and talus. Because crest, ledge, and talus habitats are usually embedded within other habitat types (most commonly upland forest), they were depicted as an overlay over other habitats. Places where this overlay appears with an underlying habitat of "unvegetated talus" signify bare rock exposures that were large enough to map as their own habitat, for example, landslides that occurred from mass wasting events along large perennial streams. Except for the most exposed ledges, these habitats do not have distinct signatures on aerial photographs and were therefore mapped mostly based on a combination of field observations and locations of potential bedrock exposures inferred from the mapped locations of very or extremely bouldery soils, shallow soils (<20 inches [50 cm]), and shallow soils on steep slopes (>15%) in Tornes (1979). The final overlay of crest, ledge, and talus habitats is therefore an approximation; we expect that there are additional bedrock exposures outside the mapped areas. The precise locations and boundaries of these habitats should be determined in the field as needed. The distinction between calcareous and non-calcareous crest, ledge, and talus habitats can only be made in the field. The areas that appear on the map as calcareous crest, ledge and talus were extrapolated from the locations of calcareous outcrops observed in the field. Nevertheless, the bedrock of the entire town (mostly sandstone and shale) is potentially calcareous.

Cultural. We define "cultural" habitats as areas that are significantly altered and intensively managed (e.g., mowed), but are not otherwise developed with wide pavement or structures. These include golf courses, playing fields, cemeteries, and large lawns. On aerial photos it was sometimes difficult to distinguish extensive lawns from less intensively managed upland meadows, so in the absence of field verification some lawns may have erroneously been mapped as "upland meadow," and vice versa.

Developed areas. Paved and gravel roads, driveways, and parking lots; buildings; and adjacent lawns were considered "developed" and not mapped as significant habitats. Habitat areas surrounded by or intruding into developed land were identified as ecologically significant and mapped only if their dimensions exceeded 50 m (165 ft) in all directions, or when their total area was roughly two acres (0.8 ha) or larger. This area threshold was adjusted slightly to exclude the mapping of some areas slightly larger than two acres in heavily developed areas, and to include smaller areas when they were immediately adjacent to larger mapped habitats. Exceptions to this protocol were wetlands and waterbodies within developed areas, which we mapped (along with their immediately adjacent, non-cultural habitats) if they were identifiable on the aerial photographs or if we observed them in the field. Even though such wetlands may lack many of the habitat values of wetlands in more natural settings, they still may serve as important drought refuges for rare species and other species of conservation concern. Lawns near buildings and roads were mapped as developed; large lawns not adjacent to buildings or roads and adjacent to significant habitats were mapped as "cultural" habitats.

Intermittent woodland pools. Intermittent woodland pools are best identified in the spring when the pools are full of water and occupied by invertebrates and breeding amphibians. The presence of fairy shrimp is often a good indicator that the standing water is intermittent. For those intermittent woodland pools we visited in late summer and fall, we relied on general physical features of the site to distinguish them from isolated swamps. We classified those wetlands with an open basin as intermittent woodland pools and those dominated by trees or shrubs as swamps, but both often serve similar ecological functions. Many intermittent woodland pools can also be mapped remotely since they have a distinct signature on aerial photographs, and are readily visible within areas of deciduous forest on photographs taken in a leaf-off season. Those within conifer forests, however, are not easily identified on aerial photographs, and we may have missed some of these in areas we were unable to visit.

Open water and constructed ponds. Most bodies of open water in Woodstock were created by damming or excavation. Those that we mapped as "open water" habitats included natural ponds; large, substantially unvegetated pools within marshes and swamps; pools formed by flooding on perennial stream floodplains; and ponds that were constructed but are now surrounded by unmanaged vegetation (thus presumed to be unmanaged ponds). All other ponds were classified as "constructed pond."

Springs and seeps. Springs and seeps are difficult to identify by remote sensing. We mapped only the very few we happened to see in the field. We expect there were many more springs and seeps in the town that we did not map. The precise locations and boundaries of seeps and springs should be determined in the field on a site-by-site basis.

Streams. We created a streams map in our GIS that was based on field observations and interpretation of topographic maps and aerial photographs. We depicted streams as continuous where they flowed through ponds, impoundments, or large wetlands. We mapped the likely location of streams that are diverted underground only when they re-surfaced at a distance of less than 200 meters (650 ft). The courses of many small headwater streams we observed in the field were difficult to map based on aerial photographs and other remote sources, especially under conifers; when not visible remotely, we mapped them to the best of our ability based on locations and bearings taken in the field and GIS contour data. We expect there were additional intermittent streams that we did not map, and we recommend these be added to the database as information becomes available. Because it was often difficult to distinguish between perennial and intermittent streams based on aerial photograph and map interpretation, these distinctions were made using our best judgment. Streams that were channelized or diverted by humans (i.e., ditches) were mapped when observed in the field or on aerial photos; we included ditches as stream habitat because they function as such from a hydrological perspective.

Upland forests. We mapped just three general types of upland forests: hardwood, mixed, and conifer forest. Although these forests are extremely variable in their species composition, size and age of trees, vegetation structure, soil drainage and texture, and other factors, we used these broad categories for practical reasons. Hardwood and coniferous trees are generally distinguishable in aerial photos taken in the spring, although dead or deciduous conifers can be mistaken for hardwoods. Different forest communities and ages are not easily distinguished on aerial photographs, however, and we could not consistently and accurately separate forests according to dominant tree species or size of canopy trees. Our “upland forest” types therefore include non-wetland forests of all ages, at all elevations, and of all species mixtures, including floodplain forests. Grass and dirt roads (where identifiable) were mapped as boundaries between adjacent forested habitat areas, since they can be significant fragmenting features. Old woods roads were abundant in Woodstock’s extensive upland forests and many continued to be accessible by truck or ATV, but often they were obscured by forest canopy cover and could not be mapped.

Upland meadows and upland shrubland. We mapped upland meadows divided by fences and hedgerows as separate polygons, to the extent that these features were visible on the aerial photographs or field verified. Because upland meadows often have a substantial shrub component, the distinction between upland meadows and upland shrubland habitats is somewhat arbitrary. We defined upland shrubland habitats as those with widely distributed shrubs that accounted for more than 20% of the cover.

Wetlands. We mapped wetlands remotely using topographic maps, soils data, and aerial photographs. In the field, we identified wetlands primarily by the predominance of hydrophytes and easily visible indicators of surface hydrology (Environmental Laboratory 1987). We did not examine soil profiles. Along stream corridors and in other low-lying areas with somewhat poorly drained soils, it was often difficult to distinguish between upland forest and hardwood swamp without the benefit of onsite soil data. On the ground, these areas were characterized by moist, fine-textured soils with common upland trees in the canopy, often dense thickets of vines and shrubs (e.g., Japanese barberry, non-native honeysuckles) in the understory, and facultative wetland and upland species of shrubs, forbs, and graminoids. In most cases, we mapped these areas as upland forest. Because we did not examine soil profiles in the field, and we only sketched the wetland boundaries (i.e., we did not use GPS or other land survey equipment), all wetland boundaries on the habitat map should be treated as approximations, and should not be used for jurisdictional determinations. Wherever the actual locations of wetland boundaries are needed to determine jurisdictional limits, the boundaries must be identified in the field by a wetland scientist and mapped by a land surveyor. We attempted to map all wetlands in the town, including those that were isolated from other habitats by development.

Appendix B. Explanation of ranks of species of conservation concern listed in Appendix C. Explanations of New York State Ranks and New York Natural Heritage Program Ranks are from the New York Natural Heritage Program website, accessed in 2012 (http://www.dec.ny.gov/animals/29338.html).

NEW YORK STATE RANKS

For animals, categories of Endangered and Threatened species are defined in New York State Environmental Conservation Law section 11-0535. Endangered, Threatened, and Special Concern species are listed in regulation 6NYCRR 182.5. For plants, the following categories are defined in regulation 6NYCRR 193.3 and apply to New York State Environmental Conservation Law section 9-1503.

ANIMALS

E **Endangered Species**. Any species which meet one of the following criteria: 1) Any native species in imminent danger of extirpation; 2) Any species listed as endangered by the US Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

T **Threatened Species**. Any species which meet one of the following criteria: 1) Any native species likely to become an endangered species within the foreseeable future in New York; 2) Any species listed as threatened by the US Department of the Interior, as enumerated in the Code of the Federal Regulations 50 CFR 17.11.

SC **Special Concern Species**. Those species which are not yet recognized as endangered or threatened, but for which documented concern exists for their continued welfare in New York. Unlike the first two categories, species of special concern receive no additional legal protection under Environmental Conservation Law section 11-0535 (Endangered and Threatened Species).

PLANTS

E **Endangered Species**. Listed species are those 1) with five or fewer extant sites, or 2) with fewer than 1,000 individuals, or 3) restricted to fewer than 4 USGS 7.5 minute map quadrangles, or 4) listed as endangered by the US Department of the Interior, as enumerated in the Code of the Federal Regulations 50 CFR 17.11.

T **Threatened Species**. Listed species are those 1) with 6 to fewer than 20 extant sites, or 2) with 1,000 or fewer than 3000 individuals, or 3) restricted to not less than 4 or more than 7 USGS 7.5 minute map quadrangles, or 4) listed as threatened by the US Department of the Interior, as enumerated in the Code of the Federal Regulations 50 CFR 17.11.

R **Rare Specie**s. Listed species are those with 1) 20-35 extant sites, or 2) 3,000 to 5,000 individuals statewide.

NEW YORK NATURAL HERITAGE PROGRAM RANKS – ANIMALS AND PLANTS

S1 Critically imperiled in New York State. Typically 5 or fewer occurrences, very few remaining individuals, acres, or miles of stream, or some factor of its biology making it especially vulnerable in New York State.

S2 Imperiled in New York State. Typically 6-20 occurrences, few remaining individuals, acres, or miles of stream, or factors demonstrably making it very vulnerable in New York State.

S3 Rare in New York State. Typically 21-100 occurrences, limited acreage, or miles of stream in New York State.

S4 Apparently secure in New York State.

SH Historically known from New York State, but not seen in the past 20 years.

B,N These modifiers indicate when the breeding status of a migratory species is considered separately from individuals passing through or not breeding within New York State. B indicates the breeding status; N indicates the non-breeding status.

SPECIES OF GREATEST CONSERVATION NEED (SGCN) IN NEW YORK – ANIMALS

Species that meet one or more of the following criteria (NYSDEC 2005):

- Species on the current federal list of endangered or threatened species that occur in New York.
- Species that are currently State-listed as endangered, threatened or special concern.
- Species with 20 or fewer elemental occurrences in the New York Natural Heritage Program database.
- Estuarine and marine species of greatest conservation need as determined by New York Department of Environmental Conservation, Bureau of Marine Resources staff.
- Other species determined to be in great conservation need due to status, distribution, vulnerability, or disease.

REGIONAL STATUS (HUDSON VALLEY) – ANIMALS AND PLANTS

RG Hudsonia has compiled lists of native plants and animals that are rare in the Hudson Valley but do not appear on statewide or federal lists of rarities (Kiviat and Stevens 2001). We use ranking criteria similar to those used by the NYNHP, but we apply those criteria to the Hudson Valley below the Troy Dam. Our regional lists are based on the extensive field experience of biologists associated with Hudsonia and communications with other biologists working in the Hudson Valley. These lists are subject to change as we gather more information about species occurrences in the region. In this report, we denote all regional ranks (rare, scarce, declining, vulnerable) with a single code (RG). Species with New York State or New York Natural Heritage Program ranks are presumed to also be regionally rare, but are not assigned an 'RG' rank. For birds, the RG code sometimes refers specifically to their breeding status in the region.

PARTNERS IN FLIGHT PRIORITY SPECIES LISTS – BIRDS

The Partners in Flight (PIF) WatchList is a list of landbirds considered to be of highest conservation concern, excluding those already designated as endangered under the federal Endangered Species Act. The WatchList is compiled jointly by several federal and private associations, including the Colorado Bird Observatory, the American Bird Conservancy, Partners in Flight, and the U.S. Fish and Wildlife Service. The current PIF WatchList is based on a series of scores assigned to each species for seven different aspects of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and "area importance" (relative abundance of the species within a physiographic area compared to other areas in the species' range). Scores for each of these factors range from 1 (low priority) to 5 (high priority), and reflect the degree of the species' vulnerability associated with that factor. Species are assigned "**High Regional Priority**" if their scores indicate high vulnerability in a physiographic area (delineated similarly to the physiographic areas used by the Breeding Bird Survey), and "**High Continental Priority**" if they have small and declining populations, limited distributions, and deteriorating habitats throughout their entire range. The most recent WatchList was updated in July 2008.

PIF1* High continental priority (Tier IA and IB species)
PIF2 High regional priority (Tier IIA, IIB, and IIC species)

***** Prothonotary warbler was not included on the WatchLists for our region, but we have included it with the PIF1 species because it is listed as "High Continental Priority" in PIF's national North American Landbird Conservation Plan (Rich et al. 2004).

Appendix C. Species of conservation concern potentially associated with habitats in the Town of Woodstock. These are not comprehensive lists, but merely a sample of the species of conservation concern known to use these habitats in the region. The codes given with each species name denote its conservation status. Codes include **New York State ranks** (E, T, R, SC), **NY Natural Heritage Program ranks** (S1, S2, S3, S4, SH), **NYS Species of Greatest Conservation Need** (SGCN), and **Hudsonia's regional ranks** (RG) for those organisms not on other lists. For birds, we also indicate those species listed by **Partners in Flight** as high conservation priorities at the continental (PIF1) and regional (PIF2) level. These ranking systems are explained in Appendix B.

UPLAND HARDWOOD FOREST		
Plants	***Vertebrates***	***Vertebrates (cont.)***
silvery spleenwort (RG)	wood frog (RG)	Acadian flycatcher (S3)
silvery glade fern (RG)	spotted salamander (RG)	wood thrush (RG, PIF1, SGCN)
oak fern (RG)	Jefferson salamander (SC, S3, SGCN)	scarlet tanager (PIF2, SGCN)
broad beech fern (RG)	blue-spotted salamander (SC, S3, SGCN)	cerulean warbler (SC, PIF1, SGCN)
American yew (RG)	marbled salamander (SC, S3, SGCN)	Kentucky warbler (S2, RG, PIF1, SGCN)
red baneberry (RG)	red salamander (RG, SGCN)	Blackburnian warbler (RG, PIF2)
blue cohosh (RG)	mountain dusky salamander (RG)	black-and-white warbler (PIF2)
northern monk's-hood (T, S2)	spring salamander (RG)	black-throated blue warbler (RG, SGCN)
hackberry (RG)	eastern box turtle (SC)	black-throated green warbler (RG)
spring avens (E, S2S3)	eastern racer (RG, SGCN)	hooded warbler (RG)
rough avens (E, S2)	eastern rat snake (RG)	ovenbird (RG)
leatherwood (RG)	northern goshawk (SC, S3N, SGCN)	Louisiana waterthrush (PIF2, SGCN)
bunchberry (RG)	red-shouldered hawk (SC, SGCN)	blue-headed vireo (RG)
mountain maple (RG)	Cooper's hawk (SC, SGCN)	winter wren (RG)
American ginseng (RG)	sharp-shinned hawk (SC, SGCN)	dark-eyed junco (RG)
hyssop skullcap (E, S1)	broad-winged hawk (RG)	Indiana bat (E, S1, SGCN)
twinflower (RG)	ruffed grouse (SGCN)	eastern small-footed bat (SC, S2, SGCN)
fly honeysuckle (RG)	American woodcock (RG, PIF1, SGCN)	eastern pipistrelle (RG)
Schreber's aster (RG)	barn owl (S3, SGCN)	black bear (RG)
small whorled pogonia (E, SH)	barred owl (RG)	bobcat (RG)
Invertebrates	red-headed woodpecker (SC, PIF1, SGCN)	southern bog lemming (RG)
tawny emperor (butterfly) (S3)	eastern wood-pewee (RG, PIF2)	woodland jumping mouse (RG)
		rock vole (RG)

UPLAND CONIFER FOREST		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
American yew (RG)	American woodcock (RG, PIF1, SGCN)	Blackburnian warbler (RG, PIF2)
twinflower (RG)	pinesap (RG)	pine siskin (RG)
Vertebrates	long-eared owl (RG, SGCN)	red-breasted nuthatch (RG)
blue-spotted salamander (SC, S3, SGCN)	ruffed grouse (SGCN)	evening grosbeak (RG)
red salamander (RG, SGCN)	barred owl (RG)	purple finch (PIF2)
Cooper's hawk (SC, SGCN)	black-throated green warbler (RG)	
sharp-shinned hawk (SC, SGCN)	Bicknell's thrush (SC, S2S3B, SGCN)	

NON-CALCAREOUS CREST/LEDGE/TALUS

Plants
Appalachian shoestring fern (E, S1)
woolly lip fern (E, SH)
mountain spleenwort (T, S2S3)
Bradley's spleenwort (E, SH)
alpine cliff fern (E, S1)
bluntlobe cliff fern (RG)
rusty woodsia (RG)
Braun's holly fern (RG)
small-flowered crowfoot (T, S3)
northern monk's-hood (T, S2)
Allegheny-vine (RG)
eastern prickly-pear (RG)
rock sandwort (RG)
Appalachian sandwort (T, S3)
smooth rock-cress (RG)
slender knotweed (R, S3)
bearberry (RG)
three-toothed cinquefoil (RG)
goat's-rue (RG)
whorled milkwort (S3)
whorled milkweed (S3)
blunt-leaf milkweed (RG)
dittany (RG)
Torrey's mountain-mint (E, S1)
harebell (RG)

Plants (cont.)
downy arrowwood (RG)
stiff-leaf aster (RG)
highland rush (T, S2)
Bicknell's sedge (T, S3)
bronze sedge (RG)
clustered sedge (T, S2S3)
reflexed sedge (E, S2S3)
black-edge sedge (E, S2)
Resnicek's sedge (S1S2)

Invertebrates
Edward's hairstreak (butterfly) (S3S4)
striped hairstreak (butterfly) (RG)
brown elfin (butterfly) (RG)
falcate orange-tip (butterfly) (S3S4[W])
northern hairstreak (butterfly) (S1S3, SGCN)
gray hairstreak (butterfly) (RG)
Horace's duskywing (butterfly) (RG)
swarthy skipper (butterfly) (RG)
Leonard's skipper (butterfly) (RG)
cobweb skipper (butterfly) (RG)
dusted skipper (butterfly) (S3)

Vertebrates
slimy salamander (RG)
marbled salamander (SC, SGCN)
Fowler's toad (RG, SGCN)

Vertebrates (cont.)
eastern box turtle (SC)
eastern racer (RG, SGCN)
eastern rat snake (RG, SGCN)
northern copperhead (RG, SGCN)
eastern hognose snake (SC, S3S4, SGCN)
timber rattlesnake (T, S3, SGCN)
turkey vulture (RG)
black vulture (RG)
whip-poor-will (SC, PIF2, SGCN)
common nighthawk (SC, SGCN)
common raven (RG)
winter wren (RG)
eastern bluebird (RG)
hermit thrush (RG)
Blackburnian warbler (RG, PIF2)
cerulean warbler (SC, PIF1, SGCN)
worm-eating warbler (RG, PIF1)
prairie warbler (PIF1, SGCN)
blue-headed vireo
eastern small-footed bat (SC, S2, SGCN)
boreal redback vole (RG)
rock vole (RG)
porcupine (RG)
fisher (RG)
bobcat (RG)

CALCAREOUS CREST/LEDGE/TALUS

Plants
purple cliffbrake (RG)
smooth cliffbrake (T, S2)
walking fern (RG)
bulblet fern (RG)
alpine cliff fern (E, S1)
small-flowered crowfoot (T, S3)
northern monk's-hood (T, S2)
yellow harlequin (S3)

Plants (cont.)
Dutchman's breeches (RG)
pellitory (RG)
Small-flowered crowfood (T, S3)
hairy rock-cress (RG)
roundleaf dogwood (RG)
spikenard (RG)
butterflyweed (RG)
Emmons' sedge (S3)
plantain sedge (RG)

Invertebrates
anise millipedes (RG)

Vertebrates
eastern hognose snake (SC, S3S4, SGCN)
eastern racer (RG, SGCN)
eastern ratsnake (RG, SGCN)
northern copperhead (RG, SGCN)
eastern small-footed bat (SC, S2, SGCN)
whip-poor-will (SC, PIF2, SGCN)

OAK-HEATH BARREN

Plants
rusty woodsia (RG)
bearberry (RG)
dwarf shadbush (RG)
three-toothed cinquefoil (RG)
bronze sedge (RG)
clustered sedge (T, S2S3)

Invertebrates
brown elfin (butterfly) (RG)

Invertebrates (cont.)
cobweb skipper (butterfly) (RG)
Leonard's skipper (butterfly) (RG)
Edward's hairstreak (butterfly) (S3S4)

Vertebrates
northern copperhead (RG, SGCN)
timber rattlesnake (T, S3, SGCN)
turkey vulture (RG)
black vulture (RG)
golden eagle (E, SHB, S1N, SGCN)

Vertebrates (cont.)
whip-poor-will (SC, PIF2, SGCN)
common raven (RG)
hermit thrush (RG)
Nashville warbler (RG)
prairie warbler (PIF1, SGCN)
eastern towhee (PIF2)
field sparrow (PIF2)
vesper sparrow (SC, SGCN)

UPLAND SHRUBLAND		
Plants	***Vertebrates***	***Vertebrates (cont.)***
shrubby St. Johnswort (T, S2)	wood frog (RG)	white-eyed vireo (RG)
butterflyweed (RG)	spotted turtle (SC, SGCN)	blue-winged warbler (PIF1, SGCN)
hyssop skullcap (E, S1)	eastern box turtle (SC, S3, SGCN)	golden-winged warbler (SC, PIF1, SGCN)
stiff-leaf goldenrod (RG)	wood turtle (SC, SGCN)	prairie warbler (PIF1, SGCN)
Invertebrates	eastern racer (RG, SGCN)	yellow-breasted chat (SC, SGCN)
Aphrodite fritillary (butterfly) (RG)	northern harrier (T, S3B, S3N, SGCN)	clay-colored sparrow (S2)
dusted skipper (butterfly) (S3)	northern saw-whet owl (RG)	vesper sparrow (SC, SGCN)
Leonard's skipper (butterfly) (RG)	brown thrasher (PIF2, SGCN)	grasshopper sparrow (SC, PIF2, SGCN)
cobweb skipper (butterfly) (RG)	loggerhead shrike (E, S1B)	eastern towhee (PIF2)
		field sparrow (PIF2)

UPLAND MEADOW		
Plants	***Vertebrates***	***Vertebrates (cont.)***
rattlebox (E, S1)	spotted turtle (SC, SGCN)	common nighthawk (SC, SGCN)
yellow wild flax (T, S2)	snapping turtle (SGCN)	sedge wren (T, S3B, PIF2, SGCN)
hyssop skullcap (E, S1)	eastern box turtle (SC, S3, SGCN)	eastern bluebird (RG)
Invertebrates	wood turtle (SC, SGCN)	bobolink (RG, SGCN)
Aphrodite fritillary (butterfly) (RG)	eastern racer (RG, SGCN)	eastern meadowlark (RG, SGCN)
dusted skipper (butterfly) (S3)	northern harrier (T, S3B, S3N, SGCN)	savannah sparrow (RG)
Leonard's skipper (butterfly) (RG)	upland sandpiper (T, S3B, PIF1)	vesper sparrow (SC, SGCN)
swarthy skipper (butterfly) (RG)	barn owl (SC3, SGCN)	grasshopper sparrow (SC, PIF2, SGCN)
cobweb skipper (butterfly) (RG)		

WASTE GROUND		
Plants	***Invertebrates***	***Vertebrates (cont.)***
slender knotweed (R, S3)	"feminine" clam shrimp (RG)	northern copperhead (RG, SGCN)
orangeweed (RG)	***Vertebrates***	American black duck (RG, PIF1, SGCN)
slender pinweed (T, S2)	Fowler's toad (RG, SGCN)	common nighthawk (SC, SGCN)
rattlebox (E, S1)	wood turtle (SC, SGCN)	bank swallow (RG)
field dodder (S1)	spotted turtle (SC, SGCN)	common raven (RG)
blunt mountain-mint (T, S2S3)	snapping turtle (SGCN)	grasshopper sparrow (SC, PIF2, SGCN)
hair-rush (RG)	eastern hognose snake (SC, S3S4, SGCN)	
toad rush (RG)		

SWAMP		
Plants	***Plants (cont.)***	***Vertebrates (cont.)***
moss (*Entodon brevisetus*) (S1)	early coralroot (RG)	great blue heron (RG)
wood horsetail (RG)	***Invertebrates***	wood duck (RG, PIF2)
Virginia chain fern (RG)	phantom cranefly (RG)	red-shouldered hawk (SC, SGCN)
swamp cottonwood (T, S2)	***Vertebrates***	Virginia rail (RG)
rhodora (T, S2)	blue-spotted salamander (SC, SGCN)	American woodcock (RG, PIF1, SGCN)
great laurel (RG)	four-toed salamander (RG, SGCN)	barred owl (RG)
Jacob's-ladder (R, S3)	spotted turtle (SC, SGCN)	white-eyed vireo (RG)
winged monkey-flower (R, S3)	snapping turtle (SGCN)	eastern bluebird (RG)
wild calla (RG)	wood turtle (SC, SGCN)	prothonotary warbler (S2, PIF1, SGCN)
woodland bulrush (RG)	eastern box turtle (SC, S3, SGCN)	Canada warbler (RG, PIF1)
Buxbaum's sedge (T, S2)		

INTERMITTENT WOODLAND POOL		
Plants	***Vertebrates***	***Vertebrates (cont.)***
featherfoil (T, S2)	four-toed salamander (RG, SGCN)	spotted turtle (SC, SGCN)
false hop sedge (R, S2)	Jefferson salamander (SC, SGCN)	wood turtle (SC, SGCN)
Invertebrates	marbled salamander (SC, SGCN)	wood duck (RG, PIF2)
black dash (butterfly) (RG)	spotted salamander (RG)	American black duck (RG, PIF1, SGCN)
mulberry wing (butterfly) (RG)	wood frog (RG)	northern waterthrush (RG)
springtime physa (snail) (RG)		

CIRCUMNEUTRAL BOG LAKE		
Plants	***Plants (cont.)***	***Vertebrates (cont.)***
spiny coontail (T, S3)	pipewort (RG)	spotted turtle (SC, S3, SGCN)
pitcher-plant (RG)	twig-rush (RG)	eastern ribbon snake (RG, SGCN)
roundleaf sundew (RG)	ovate spikerush (E, S1S2)	pied-billed grebe (T, S3B, S1N, SGCN)
globe-fruited ludwigia (T, S2)	knotted spikerush (T, S2)	American bittern (SC, SGCN)
spikenard (RG)	olivaceous spikerush (RG)	least bittern (T, S3B, S1N, SGCN)
southern dodder (E, S1)	prairie sedge (RG)	great blue heron (RG)
floating bladderwort (T, S2)	rose pogonia (RG)	wood duck (RG, PIF2)
hidden-fruit bladderwort (S3)	***Vertebrates***	American black duck (RG, PIF1, SGCN)
swollen bladderwort (E, S2)	wood frog (RG)	red-shouldered hawk (SC, SGCN)
horned bladderwort (RG)	blue-spotted salamander (SC, SGCN)	sharp-shinned hawk (SC, SGCN)
Beck's water-marigold (T, S3)	four-toed salamander (RG, SGCN)	king rail (T, S1B, PIF1, SGCN)
spotted pondweed (T, S2)	red salamander (RG, SGCN)	marsh wren (RG)
water-thread pondweed (E, S1)	northern cricket frog (E, S1, SGCN)	river otter (RG, SGCN)
Hill's pondweed (T, S2)	bog turtle (E, S2, SGCN)	
wild calla (RG)		

MARSH		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
spiny coontail (T, S3)	eastern racer (RG, SGCN)	northern harrier (T, S3B, S3N, SGCN)
buttonbush dodder (E, S1)	pied-billed grebe (T, S3B, S1N, SGCN)	king rail (T, S1B, PIF1, SGCN)
winged monkey-flower (R, S3)	American bittern (SC, SGCN)	Virginia rail (RG)
Vertebrates	least bittern (T, S3B, S1N, SGCN)	sora (RG)
northern leopard frog (RG)	great blue heron (RG)	common moorhen (RG)
snapping turtle (SGCN)	wood duck (RG, PIF2)	marsh wren (RG)
spotted turtle (SC, SGCN)	American black duck (RG, PIF1, SGCN)	

WET MEADOW		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
northern bog clubmoss (RG)	two-spotted skipper (butterfly) (RG)	wood turtle (SC, SGCN)
glade fern (RG)	meadow fritillary (butterfly) (RG)	eastern ribbon snake (RG, SGCN)
greater fringed gentian (RG)	Baltimore (butterfly) (RG)	smooth green snake (RG)
closed gentian (RG)	bronze copper (butterfly) (RG)	American bittern (SC, SGCN)
cattail sedge (T, S1)	eyed brown (butterfly) (RG)	northern harrier (T, S3B, S3N, SGCN)
ragged fringed orchid (RG)	Milbert's tortoiseshell (butterfly) (RG)	Virginia rail (RG)
Invertebrates	phantom cranefly (RG)	American woodcock (RG, PIF1, SGCN)
mulberry wing (butterfly) (RG)	***Vertebrates***	sedge wren (T, S3B, PIF2, SGCN)
black dash (butterfly) (RG)	spotted turtle (SC, SGCN)	southern bog lemming (RG)

CALCAREOUS WET MEADOW		
Plants	***Plants (cont.)***	***Invertebrates (cont.)***
wood horsetail (RG)	showy ladyslipper (RG)	Baltimore (butterfly) (RG)
Kalm's lobelia (RG)	***Invertebrates***	mulberry wing (butterfly) (RG)
ovate spikerush (E, S1S2)	phantom cranefly (RG)	***Vertebrates***
Schweinitz's sedge (T, S2S3)	eyed brown (butterfly) (RG)	spotted turtle (SC, S3, SGCN)
Bush's sedge (S3)	black dash (butterfly) (RG)	eastern ribbon snake (SGCN)
devil's-bit (T, S1S2)	two-spotted skipper (butterfly) (RG)	northern harrier (T, S3B, S3N, SGCN)
slender lady's-tresses (RG)	Dion skipper (butterfly) (S3)	sedge wren (T, S3B, SGCN, PIF2)

OPEN WATER/CONSTRUCTED POND		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
spiny coontail (T, S3)	spotted turtle (SC, SGCN)	great blue heron (RG)
Invertebrates	wood turtle (SC, SGCN)	American bittern (SC, SGCN)
spatterdock darner (dragonfly) (S2, SGCN)	snapping turtle (SGCN)	bald eagle (T, S2S3B, SGCN)
Vertebrates	pied-billed grebe (T, S3B, S1N, SGCN)	osprey (SC, SGCN)
red salamander (RG, SGCN)		

SPRING/SEEP		
Plants	***Invertebrates***	***Vertebrates***
northern monk's-hood (T, S2)	Piedmont groundwater amphipod (RG, SGCN)	northern dusky salamander (RG)
Jacob's-ladder (R, S3)	gray petaltail (dragonfly) (SC, S2, SGCN)	mountain dusky salamander (RG)
spiked wood-rush (E, S1)	tiger spiketail (dragonfly) (S1, SGCN)	spring salamander (RG)
Bush's sedge (S3)	arrowhead spiketail (dragonfly) (S2S3, SGCN)	red salamander (RG, SGCN)
		longtail salamander (SC, S2S3, SGCN)

STREAM & RIPARIAN CORRIDOR		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
spiny coontail (T, S3)	mocha emerald (dragonfly) (S2S3, SGCN)	spring salamander (RG)
northern monk's-hood (T, S2)	sable clubtail (dragonfly) (S1, SGCN)	wood turtle (SC, SGCN)
may-apple (RG)	*Marstonia decepta* (snail) (RG)	great blue heron (RG)
goldenseal (T, S2)	brook floater (mussel) (T, S1, SGCN)	American black duck (RG, PIF1, SGCN)
river birch (S3)	*Pisidium adamsi* (fingernail clam) (RG)	wood duck (RG, PIF2)
swamp rose-mallow (RG)	*Sphaerium fabale* (fingernail clam) (RG)	red-shouldered hawk (SC, SGCN)
riverweed (T, S2)	***Vertebrates***	American woodcock (RG, PIF1, SGCN)
Jacob's-ladder (R, S3)	creek chubsucker (fish) (RG)	bank swallow (RG)
false-mermaid (RG)	bridle shiner (fish) (RG, SGCN)	Louisiana waterthrush (SGCN)
winged monkey-flower (R, S3)	brook trout (fish) (RG, SGCN)	cerulean warbler (SC, PIF1, SGCN)
wingstem (RG)	slimy sculpin (fish) (RG)	river otter (RG, SGCN)
cattail sedge (T, S1)	American eel (fish) (SGCN)	Indiana bat (E, S1, SGCN)
Davis' sedge (T, S2)	mountain dusky salamander (RG)	eastern small-footed bat (SC, S2, SGCN)
Invertebrates	northern dusky salamander (RG)	eastern pipistrelle (RG)
arrowhead spiketail (dragonfly) (S2S3, SGCN)	red salamander (RG, SGCN)	

Appendix D. Common and scientific names of plants mentioned in this report. Most scientific names follow the nomenclature of Weldy and Werier (2012).

Common Name	Scientific Name	Common Name	Scientific Name
agrimony, small-flowered	*Agrimonia parviflora*	bunchberry	*Cornus canadensis*
alder	*Alnus incana* ssp. *rugosa*	bush-honeysuckle, northern	*Diervilla lonicera*
Allegheny-vine	*Adlumia fungosa*	butterflyweed	*Asclepias tuberosa* ssp. *interior*
arrowhead, broad-leaved	*Sagittaria latifolia*	butternut	*Juglans cinerea*
arrowwood, downy	*Viburnum rafinesquianum*	buttonbush	*Cephalanthus occidentalis*
arum, arrow	*Peltandra virginica*	calla, wild	*Calla palustris*
ash, green	*Fraxinus pennsylvanica*	canary-grass, reed	*Phalaris arundinacea*
ash, white	*Fraxinus americana*	cattail	*Typha*
aspen, bigtooth	*Populus grandidentata*	cedar, eastern red	*Juniperus virginiana*
aster, Schreber's	*Aster schreberi*	cedar, northern white	*Thuja occidentalis*
avens, rough	*Geum laciniatum*	cherry, black	*Prunus serotina*
avens, spring	*Geum vernum*	cherry, fire	*Prunus pensylvanica*
azalea, early	*Rhododendron prinophyllum*	chestnut, American	*Castanea dentata*
azalea, swamp	*Rhododendron viscosum*	chokeberry	*Aronia*
baneberry, red	*Actaea spicata* ssp. *rubra*	cinquefoil, three-toothed	*Sibbaldiopsis tridentata*
barberry, Japanese	*Berberis thunbergii*	cliffbrake, purple	*Pellaea atropurpurea*
basswood	*Tilia americana*	cliffbrake, smooth	*Pellaea glabella* ssp. *glabella*
bearberry	*Arctostaphylos uva-ursi*	clubmoss, northern bog	*Lycopodiella inundata*
beech, American	*Fagus grandifolia*	cohosh, blue	*Caulophyllum thalictroides*
birch, black	*Betula lenta*	columbine, wild	*Aquilegia canadensis*
birch, gray	*Betula populifolia*	coontail, spiny	*Ceratophyllum echinatum*
birch, mountain paper	*Betula cordifolia*	coralroot, early	*Corallorhiza trifida*
birch, paper	*Betula papyrifera*	cottonwood, swamp	*Populus heterophylla*
birch, river	*Betula nigra*	cranberry, large	*Vaccinium macrocarpon*
birch, yellow	*Betula alleghaniensis*	crowfoot, small-flowered	*Ranunculus micranthus*
black gum	*Nyssa sylvatica*	deerberry	*Vaccinium stamineum*
blackberry, northern	*Rubus allegheniensis*	devil’s-bit	*Chamaelirium luteum*
bladdernut	*Staphylea trifolia*	didymo	*Didymosphenia geminata*
bladderwort	*Utricularia*	dittany	*Cunila origanoides*
bladderwort, floating	*Utricularia radiata*	dodder, buttonbush	*Cuscuta cephalanthi*
bladderwort, hidden-fruit	*Utricularia geminiscapa*	dodder, field	*Cuscuta campestris*
bladderwort, horned	*Utricularia cornuta*	dodder, southern	*Cuscuta australis*
bladderwort, swollen	*Utricularia inflata*	dogwood, roundleaf	*Cornus rugosa*
blueberry, highbush	*Vaccinium corymbosum*	dogwood, silky	*Cornus amomum* ssp. *amomum*
blueberry, hillside	*Vaccinium pallidum*	duckweed, common	*Lemna minor*
blueberry, lowbush	*Vaccinium angustifolium*	Dutchman's breehes	*Dicentra cucullaria*
blue-joint	*Calamagrostis canadensis*	elderberry, red	*Sambucus racemosa* v. *racemosa*
bluestem, little	*Schizachyrium scoparium* v. *scoparium*	elm, American	*Ulmus americana*
blue-joint	*Calamagrostis canadensis*	elm, slippery	*Ulmus rubra*
breeches, Dutchman’s	*Dicentra cucullaria*	false-mermaid	*Floerkea proserpinacoides*
bulrush, woodland	*Scirpus expansus*	featherfoil	*Hottonia inflata*

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Common Name	Scientific Name	Common Name	Scientific Name
fern, alpine cliff	*Woodsia alpina*	hobblebush	*Viburnum lantanoides*
fern, Appalachian shoestring	*Vittaria appalachiana*	holly, largeleaf	*Ilex montana*
fern, bluntlobe cliff	*Woodsia obtusa*	holly, mountain	*Nemopanthus mucronatus*
fern, bracken	*Pteridium aquilinum*	holly, winterberry	*Ilex verticillata*
fern, Braun's holly	*Polystichum braunii*	honeysuckle, Eurasian	*Lonicera* x *bella*
fern, broad beech	*Phegopteris hexagonoptera*	honeysuckle, fly	*Lonicera canadensis*
fern, bulblet	*Cystopteris bulbifera*	hophornbeam, American	*Ostrya virginiana*
fern, cinnamon	*Osmunda cinnamomea*	horsetail, wood	*Equisetum sylvaticum*
fern, fragile	*Cystopteris fragilis*	huckleberry, black	*Gaylussacia baccata*
fern, glade	*Diplazium pycnocarpon*	ironweed, New York	*Vernonia noveboracensis*
fern, maidenhair	*Adiantum pedatum*	Jacob's-ladder	*Polemonium vanbruntiae*
fern, marginal wood	*Dryopteris marginalis*	knotweed, Japanese	*Fallopia japonica* v. *japonica*
fern, marsh	*Thelypteris palustris* v. *pubescens*	knotweed, slender	*Polygonum tenue*
fern, mountain wood	*Dryopteris campyloptera*	lady's-tresses, slender	*Spiranthes lacera*
fern, oak	*Gymnocarpium dryopteris*	ladyslipper, showy	*Cypripedium reginae*
harebell	*Campanula rotundifolia*	laurel, great	*Rhododendron maximum*
harlequin, yellow	*Corydalis flavula*	laurel, mountain	*Kalmia latifolia*
fern, royal	*Osmunda regalis* v. *spectabilis*	leatherleaf	*Chamaedaphne calyculata*
fern, sensitive	*Onoclea sensibilis*	leatherwood	*Dirca palustris*
fern, silvery glade	*Deparia acrostichoides*	lobelia, Kalm's	*Lobelia kalmii*
fern, Virginia chain	*Woodwardia virginica*	locust, black	*Robinia pseudoacacia*
fern, walking	*Asplenium rhizophyllum*	loosestrife, purple	*Lythrum salicaria*
fern, woolly lip	*Cheilanthes lanosa*	ludwigia, globe-fruited	*Ludwigia sphaerocarpa*
fir, balsam	*Abies balsamea*	mannagrass	*Glyceria*
flag, blue	*Iris versicolor*	maple, mountain	*Acer spicatum*
flax, yellow wild	*Linum sulcatum*	maple, red	*Acer rubrum*
foxtail, short-awn	*Alopecurus aequalis* v. *aequalis*	maple, striped	*Acer pensylvanicum*
garlic-mustard	*Alliaria petiolata*	maple, sugar	*Acer saccharum*
gentian, closed	*Gentiana andrewsii*	may-apple	*Podophyllum peltatum*
gentian, greater fringed	*Gentianopsis crinita*	meadowsweet	*Spiraea alba* v. *latifolia*
ginseng, American	*Panax quinquefolius*	milkweed, blunt-leaf	*Asclepias amplexicaulis*
globeflower, spreading	*Trollius laxus*	milkwort, whorled	*Polygala verticillata*
goat's-rue	*Tephrosia virginiana*	moneywort	*Lysimachia nummularia*
goldenrod, rough-leaf	*Solidago patula* ssp. *patula*	monkey-flower, winged	*Mimulus alatus*
goldenrod, stiff-leaf	*Oligoneuron rigidum* v. *rigidum*	monk's hood, northern	*Aconitum noveboracense*
goldenseal	*Hydrastis canadensis*	(a moss)	*Entodon brevisetus*
goldthread	*Coptis trifolia*	moss, peat	*Sphagnum*
grass, reed canary	*Phalaris arundinacea*	moss, peat	*Sphagnum*
grass-of-Parnassus	*Parnassia glauca*	mountain-ash, American	*Sorbus americana*
hackberry	*Celtis occidentalis*	mountain-mint, blunt	*Pycnanthemum muticum*
hairgrass	*Avenella flexuosa*	mountain-mint, Torrey's	*Pycnanthemum torrei*
hemlock, eastern	*Tsuga canadensis*	nannyberry	*Viburnum lentago*
hickory, bitternut	*Carya cordiformis*	oak, black	*Quercus velutina*
hickory, pignut	*Carya glabra*	oak, chestnut	*Quercus montana*
hickory, shagbark	*Carya ovata*	oak, red	*Quercus rubra*

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Common Name	Scientific Name	Common Name	Scientific Name
oak, scarlet	*Quercus coccinea*	rush, toad	*Juncus bufonius*
oak, scrub	*Quercus ilicifolia*	sandwort, Appalachian	*Minuartia glabra*
oak, swamp white	*Quercus bicolor*	sandwort, rock	*Minuartia michauxii*
oak, white	*Quercus alba*	sarsaparilla, bristly	*Aralia hispida*
olive, autumn	*Elaeagnus umbellata*	sassafras	*Sassafras albidum*
orangeweed	*Hypericum gentianoides*	saxifrage, golden	*Chrysosplenium americanum*
paintbrush, scarlet Indian	*Castilleja coccinea*	saxifrage, swamp	*Saxifraga pensylvanica*
pellitory	*Parietaria pensylvanica*	sedge	*Carex nigromarginata*
pickerelweed	*Pontederia cordata*	sedge	*Carex reznicekii*
pine, pitch	*Pinus rigida*	sedge, Bicknell's	*Carex bicknellii*
pine, red	*Pinus resinosa*	sedge, bronze	*Carex aenea*
pine, white	*Pinus strobus*	sedge, Bush's	*Carex bushii*
pinesap	*Monotropa hypopithys*	sedge, Buxbaum's	*Carex buxbaumii*
pinweed, slender	*Lechea tenuifolia*	sedge, cattail	*Carex typhina*
pitcher-plant	*Sarracenia purpurea*	sedge, clustered	*Carex cumulata*
pogonia, rose	*Pogonia ophioglossoides*	sedge, Davis'	*Carex davisii*
pogonia, small whorled	*Isotria medeoloides*	sedge, false hop	*Carex lupuliformis*
polypody, rock	*Polypodium virginianum*	sedge, lakeside	*Carex lacustris*
pond-lily, white	*Nymphaea odorata*	sedge, Pennsylvania	*Carex pensylvanica*
pond-lily, yellow	*Nuphar advena*	sedge, plantain	*Carex plantaginea*
pondweed	*Potamogeton*	twinflower	*Linnaea borealis* ssp. *americana*
pondweed, Hill's	*Potamogeton hillii*	vervain, blue	*Verbena hastata* v. *hastata*
pondweed, spotted	*Potamogeton pulcher*	viburnum, maple-leaf	*Viburnum acerifolium*
pondweed, water-thread	*Potamogeton diversifolius*	violet	*Viola*
poverty-grass	*Danthonia spicata*	wall-rue	*Asplenium ruta-muraria*
prickly-ash, American	*Zanthoxylum americanum*	water-marigold, Beck's	*Bidens beckii*
prickly-pear, eastern	*Opuntia humifusa* v. *humifusa*	watermilfoil	*Myriophyllum*
raspberry	*Rubus*	water-plantain	*Alisma triviale*
rattlebox	*Crotalaria sagittalis*	water-shield	*Brasenia schreberi*
reed, common	*Phragmites australis*	sedge, prairie	*Carex pensylvanica*
rhodora	*Rhododendron canadense*	sedge, reflexed	*Carex retroflexa*
riverweed	*Podostemum ceratophyllum*	sedge, Schweinitz's	*Carex schweinitzii*
rock tripe, smooth	*Umbilicaria mammulata*	sedge, threeway	*Dulichium arundinaceum* v. *arundinaceum*
rock-cress, hairy	*Arabis hirsuta* v. *pycnocarpa*	sedge, tussock	*Carex stricta*
rock-cress, smooth	*Boechera laevigata*	serviceberry	*Amelanchier*
rose, multiflora	*Rosa multiflora*	shadbush, dwarf	*Amelanchier stolonifera*
rose-mallow, swamp	*Hibiscus moscheutos*	skullcap, hyssop	*Scutellaria integrifolia*
rush, highland	*Juncus trifidus*	skunk-cabbage	*Symplocarpus foetidus*
rush, soft	*Juncus effusus*	spicebush	*Lindera benzoin*

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Common Name	Scientific Name	Common Name	Scientific Name
spikenard	*Aralia racemosa* ssp. *racemosa*	sweetflag	*Acorus americanus*
spikerush, knotted	*Eleocharis equisetoides*	sycamore	*Platanus occidentalis*
spikerush, olivaceous	*Eleocharis olivacea*	tamarack, eastern	*Larix laricina*
spikerush, ovate	*Eleocharis obtusa*	toadskin, common	*Lasallia papulosa*
spleenwort, Bradley's	*Asplenium bradleyi*	tree of heaven	*Ailanthus altissima*
spleenwort, ebony	*Asplenium platyneuron* v. *platyneuron*	tulip tree	*Liriodendron tulipifera*
spleenwort, maidenhair	*Asplenium trichomanes*	water-willow	*Decodon verticillata*
spleenwort, mountain	*Asplenium montanum*	wild-raisin, northern	*Viburnum nudum* v. *cassinoides*
spleenwort, silvery	*Deparia acrostichoides*	willow	*Salix*
spruce, Norway	*Picea abies*	willow, sage-leaved	*Salix candida*
spruce, red	*Picea rubens*	wingstem	*Verbesina alternifolia*
St. Johnswort, marsh	*Triadenum virginicum*	witch-hazel	*Hamamelis virginiana*
St. Johnswort, shrubby	*Hypericum prolificum*	wood-rush, spiked	*Luzula spicata*
stiltgrass, Japanese	*Microstegium vimenium*	woodsia, rusty	*Woodsia ilvensis*
sundew, roundleaf	*Drosera rotundifolia* v. *rotundifolia*	woolgrass	*Scirpus cyperinus*
sweetfern	*Comptonia peregrina*	yew, American	*Taxus canadensis*