Significant Habitats
in the Town of Pound Ridge, Westchester County, New York

Report to the Town of Pound Ridge, the Hudson River Estuary Program,
and the Westchester Community Foundation

By Christopher Graham, Elise Heffernan,
and Gretchen Stevens

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Hudsonia Ltd.
P.O. Box 5000
Annandale, NY 12504

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The Conservation Board contracted with Hudsonia Ltd. for this report:
Significant Habitats in the Town of Pound Ridge (2021).
Hudsonia Ltd., in an advisory role, included recommendations in this report.
The recommendations are non-binding to town boards and agencies.

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EXECUTIVE SUMMARY

Hudsonia biologists identified and mapped ecologically significant habitats throughout the Town of Pound Ridge during the period of June 2017 through December 2020. Through map analysis, aerial photograph interpretation, and field observations we created a large-format map showing the locations and configurations of habitat. Some of the habitats are rare or declining in the region or support rare species of plants or animals, others are high quality examples of common habitats or habitat complexes, and others represent important landscape connections between other habitat areas. Among our more interesting finds were: 36 rocky barrens; extensive crest, ledge, talus communities; 94 intermittent woodland pools; 12 fens; two buttonbush pools; many extensive wetland complexes; and extensive areas of contiguous forest, including three larger than 400 acres (ac) (160 hectares [ha]).


C. Graham © 2018

In this report we describe each of the mapped habitat types, including 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 ideas on how to use this report and the habitat map for conservation planning and policy-making, and for site-specific environmental reviews.

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

INTRODUCTION

Background

Rural landscapes in Westchester County have undergone much change over the last century as farms, forests, and other undeveloped lands have been converted to residential and other uses. Most of this development has occurred without knowledge of the biological resources that may be lost or harmed by physical development or increased exposure to human activities. The consequences are beautiful residential settings, but also widespread habitat loss and fragmentation, loss of native biodiversity, and loss of ecosystem services to the human community. The Town of Pound Ridge still retains large areas of undeveloped land, however, with intact habitats that support water resources, plants, animals, and biological communities of conservation concern, and the people of Pound Ridge in uncountable seen and unseen ways.

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. Very little biodiversity information is available for large areas such as entire towns, counties, or watersheds, making it difficult for landowners, developers, municipal planners, and others to incorporate biodiversity protection into day-to-day decision making.

To address this need, Hudsonia Ltd., a nonprofit institute for scientific research and education, initiated a habitat mapping program in 2001. Using the approach set forth in the *Biodiversity Assessment Manual for the Hudson River Estuary Corridor* (Kiviat and Stevens 2001) we identify important biological resources over large geographic areas and inform local communities about effective measures for biodiversity conservation.

The Pound Ridge habitat mapping project described in this report was initiated by the Pound Ridge Conservation Board, and funded by a variety of sources, including grants to the Town of Pound Ridge from the Westchester Community Foundation and the New York State Environmental Protection Fund through the Hudson River Estuary Program of the NYS Department of Environmental Conservation; see the Acknowledgments for a complete list of donors. We also received endorsement and assistance from the Town of Pound Ridge Conservation Board, the Town Board, and landowners. This project has been incorporated into the Pound Ridge Natural Resource Inventory, and it contributes to the town's achievement of Pledge Element 7—Conserve Natural Areas—for Bronze-level certification in the New York State Climate Smart Communities program.

Hudsonia has now completed townwide habitat maps of thirteen Hudson Valley towns in addition to other large areas in the region. In Westchester County we have also assisted in habitat mapping projects for the towns of Somers and Bedford. These projects have been funded by a variety of public and private sources.

Biologists Christopher Graham and Elise Heffernan conducted most of the work on this project from June 2017 through December 2020; Gretchen Stevens, director of Hudsonia's Biodiversity Resources Center, participated in most aspects and supervised the project. Through map analysis, aerial photograph interpretation, and field observations, we created a map of ecologically significant habitats throughout the Town of Pound Ridge. Some of these habitats are rare or declining in the region, some are high quality examples of common habitats or habitat complexes, some may support rare species of plants or animals, and some may provide landscape connections between important habitat areas. The goal of this project was to identify and map general habitat types; we did not conduct species-level surveys or map the locations of rare species.

To facilitate intermunicipal and regional planning, we strive for consistency in the ways that we define and identify habitats and present the information for town use, but we also strive to improve our methods and products as the program evolves. Many passages in this report on general habitat descriptions, general conservation and planning concepts, and information applicable to the region as a whole are taken directly from previous Hudsonia reports accompanying habitat maps in Dutchess County (e.g., Stevens and Broadbent 2002, Bell et al. 2005, Knab-Vispo et al. 2008, Graham et al. 2012, Haeckel et al. 2012) without specific attribution. This report, however, addresses our findings and specific recommendations for the Town of Pound Ridge. 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, townwide, and region-wide planning and conservation efforts.

We hope that this map and report will help landowners understand how their properties contribute to the larger ecological landscape, and will inspire them to implement habitat protection and enhancement measures voluntarily. We also hope that the Town of Pound Ridge municipal agencies will engage in proactive land-use and conservation planning to ensure that future land development is planned with a view to long-term protection of the town's considerable biological and water resources.

What is Biodiversity?

The concept of biodiversity, or biological diversity, encompasses all of life and its processes, including ecosystems, biological communities, populations, species, and genes, as well as their interactions with each other and with the non-biological 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 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 can be a symptom of environmental deterioration or collapse. 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 ones such as fungi and insects, plays a unique role in the maintenance of biological communities. Maintaining the full complement of native species in a region allows an ecosystem to withstand stresses and adapt to changing environmental conditions.

What are Ecologically Significant Habitats?

For the 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, or lacking harmful invasive species).
4. Complexes of connected habitats that, by virtue of their size, composition, or configuration, have significant biodiversity value.
5. Habitat units that provide landscape connections between other important habitat patches.

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 biodiversity. In addition to their importance from a biological standpoint, habitats are also manageable units for planning and conservation over large areas such as whole towns. By illustrating the locations and configurations of ecologically significant habitats throughout the Town of Pound Ridge, the habitat map that accompanies this report provides valuable ecological information that can be incorporated into local land-use planning and decision making.

Study Area

The Town of Pound Ridge is located in eastern Westchester County in southeastern New York. It encompasses approximately 23.1 mi^2 (59.5 km^2) and has a population of roughly 5,100 residents (2010 US Census). The town's landscape largely comprises rolling hills, low, rocky ridges, myriad wetlands, and stream valleys. The town straddles two major watersheds. The northern part of the town (9.4 mi^2 [24.3 km^2]) is in the Croton River watershed, ultimately draining to the Lower Hudson River. The Stone Hill River flows east to west across the northern half of the town, but most of the streams in the northern part of Pound Ridge drain to the Cross River, which flows through the northeastern corner of town. The southern part of town (13.7 mi^2 [35.5 km^2]) drains into the Mianus River and the Mill River, which both ultimately drain to Long Island Sound (Figure 1). The Mianus River forms the southwestern town boundary.

Elevations in Pound Ridge range from 260 feet (ft) (79 meters [m]) above mean sea level along the Mianus River to 860 ft (262 m) at the site of a former fire tower on a rocky crest in Ward Pound Ridge Reservation (WPRR). Most of the highest elevations (over 650 ft [200 m]) are in the northern part of town in the WPRR.

Pound Ridge is predominantly underlain by gneiss and amphibolite in the Fordham and Bedford Formations, and amphibolite and pelitic schist in the Hartland Formation. Ward Pound Ridge Reservation has a band of Pound Ridge gneiss that bends from the northeast to southwest corners of the reservation. Additionally there are two bands of Inwood marble (and schist) in the town—one at the foot of the Pound Ridge gneiss, and the other in the Lake Kitchawan/Trinity Lake/Halle Ravine corridor. The southeastern corner of the town is predominantly amphibolite and pelitic schist in the Hartland Formation (Fisher et al. 1970; Figure 2). The surficial material is primarily glacial till, but there are large areas where bedrock is exposed or very near the surface, especially in the WPRR. Glacial outwash deposits (sand and gravel) and peat and muck occur in low-lying areas along the Stone Hill River (Cadwell et al. 1989). West Lane cuts through a small kame—a glacially-deposited mound of sand, gravel, and till.

Primary land uses in Pound Ridge are residential, park and preserve land, and water utility land surrounding drinking water reservoirs. Residential development is fairly evenly distributed south of WPRR, with moderate concentrations around the hamlet of Scotts Corners and around the intersection of Pound Ridge Road and Westchester Avenue. The town has 3671 ac (1486 ha) of open space park and preserve land, which amounts to 28.6 percent of the town: Westchester Parks Commission (the owner of WPRR) holds 2826 ac (1144 ha); the Pound Ridge Land Conservancy owns 366 acres (148 ha); the Westchester Land Trust owns 129 ac (52 ha); and the privately-managed Henry Morgenthau Preserve holds 85.5 ac (34.5 ha). Water utility land occupies about 10% of the town (1463 ac [592 ha]), and the Town of Pound Ridge owns about 310 ac (125 ha).

Figure 1. Overview of the Town of Pound Ridge, Westchester County, New York. Watershed boundary and streams from the US Geological Survey National Hydrography Dataset. Waterbodies from the NYS Hydrography Dataset. Hudsonia Ltd, 2021.

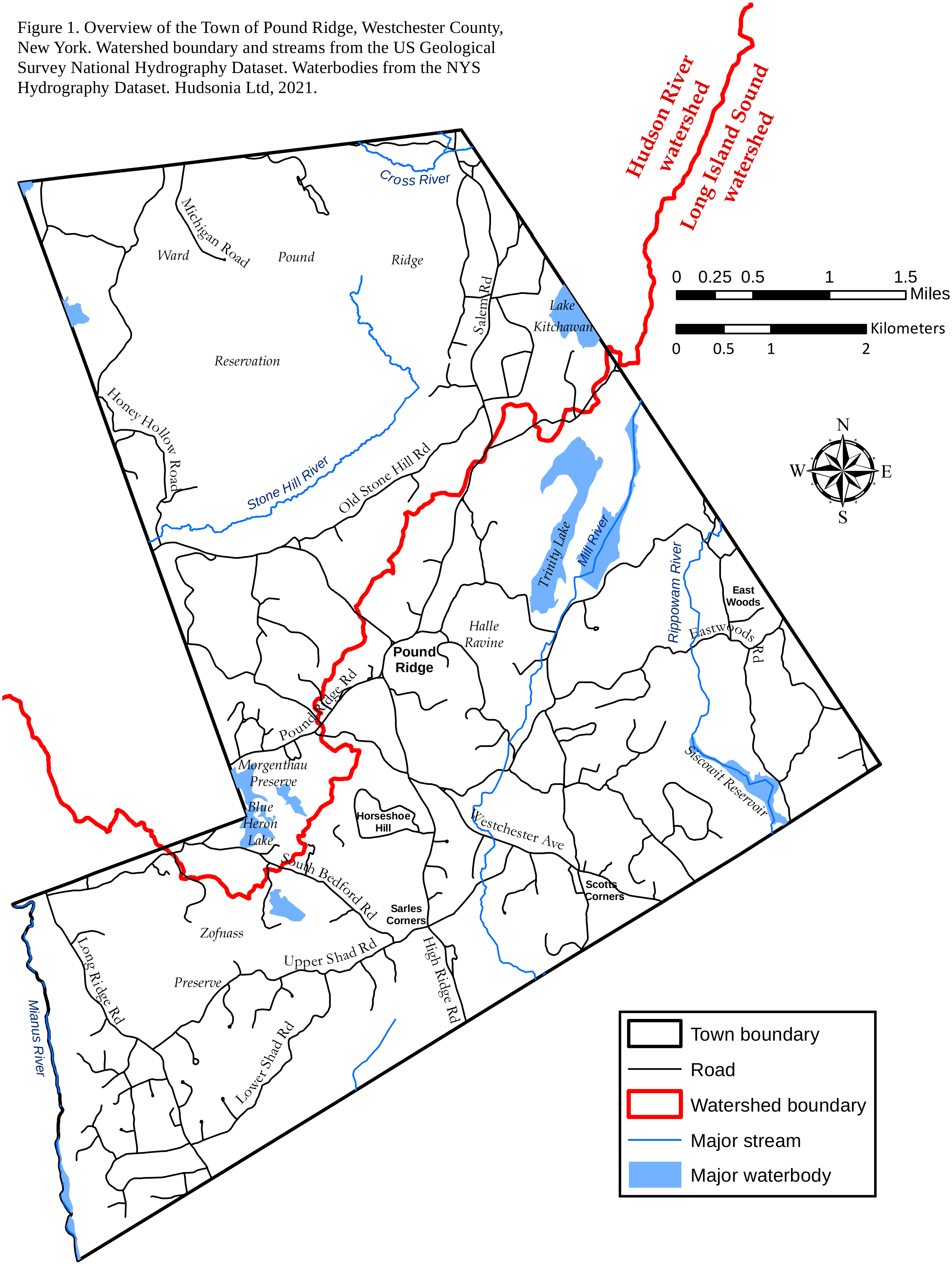
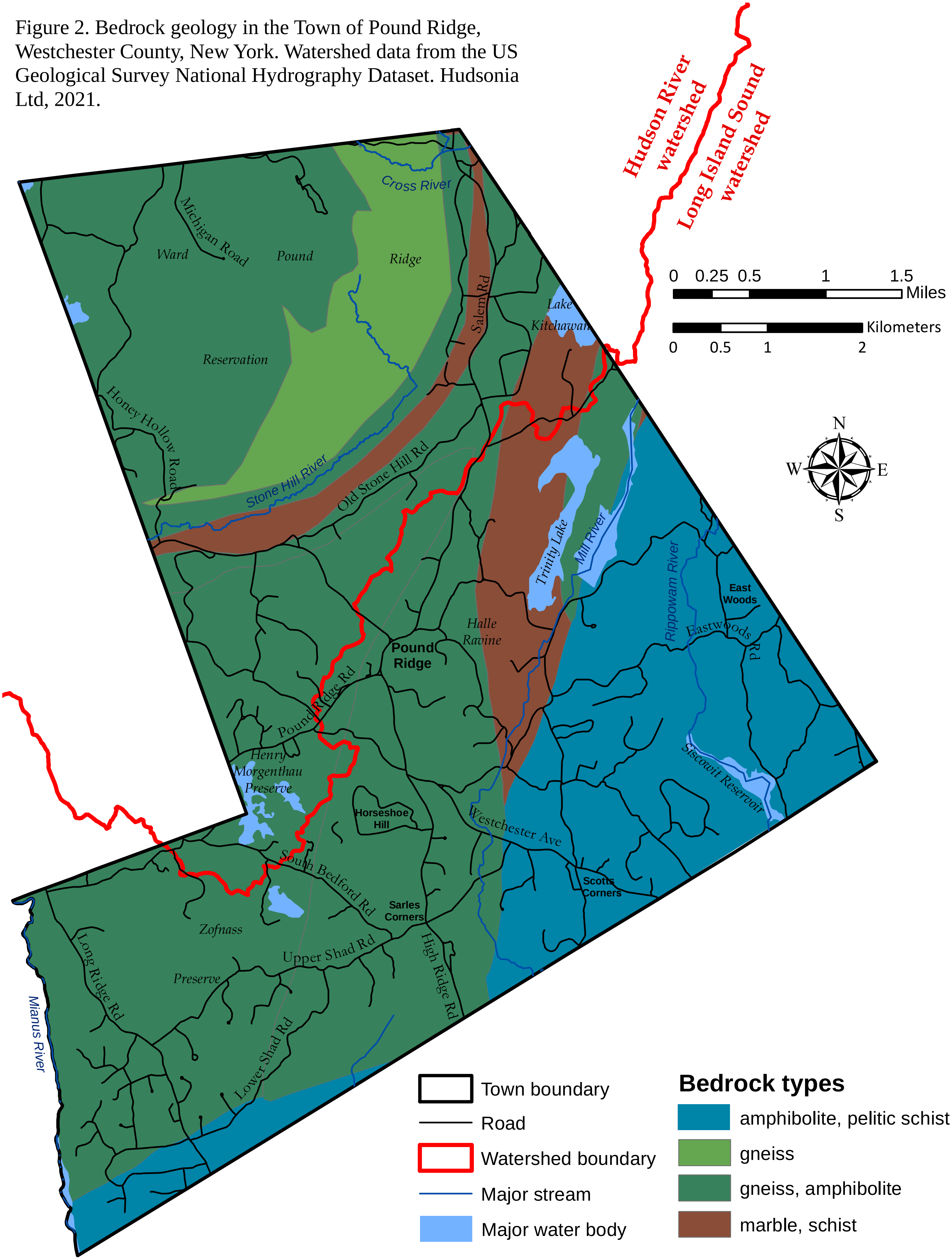


Figure 2. Bedrock geology in the Town of Pound Ridge, Westchester County, New York. Watershed data from the US Geological Survey National Hydrography Dataset. Hudsonia Ltd, 2021.



METHODS

Hudsonia employs a combination of laboratory and field methods in the habitat identification and mapping process, as described below.

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 aerial orthophotos (e.g., exposed bedrock, vegetation cover types) to predict the location and extent of ecologically significant habitats. In addition to biological data provided by the New York Natural Heritage Program, we used the following resources for this project:

- *High-resolution (1 pixel = 6 in [15.2 cm]) 4-band digital orthophotos* taken in spring 2009 and 2016 and *true color and color infrared digital orthophotos (1 pixel = 12 in [30 cm])* taken in spring 2016, 2018, and 2020, obtained from the Discover GIS Data NY website. We use these digital aerial photos for remote analysis and on-screen digitizing of habitat boundaries.

- *U.S. Geological Survey topographic maps* (Pound Ridge, NY, and Peach Lake, NY, 7.5 minute quadrangles). Topographic maps illustrate elevation contours, surface water features, and significant cultural features (e.g., roads, railroads, buildings). We use contour lines to predict the occurrence of such habitats as cliffs, wetlands, intermittent streams, and seeps.

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

- *Soil Survey of Putnam and Westchester County, New York* (Seifried 1994). Specific attributes of soils, such as depth, drainage, texture, and pH, convey a great deal of information about the types of habitats that are likely to occur in an area. Shallow soils, for example, may indicate the locations of crest, ledge, and talus habitats. Poorly and very poorly drained soils usually indicate 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.

- *Geographic Information Systems (GIS) data*. We obtained several of our GIS data layers from the New York State GIS Clearinghouse, including municipal boundaries, roads, hydrological features, and 2-ft contour data. National Wetlands Inventory data prepared by the US Fish and Wildlife Service were obtained from the USFWS website. We obtained soils data from the Natural Resources Conservation Service (NRCS) website. Tax parcel data came from the Town of Pound Ridge. We used ArcMap 10.5, 10.6, and 10.8 software (ESRI 2017, 2018, and 2020) to examine these data layers and the orthophoto images, and to digitize the habitat boundaries.

Red eft on moss carpet

Preliminary Habitat Mapping and Field Verification

The project was carried out in two stages due to funding limitations. First, in 2017-2018, we chose 24 large tracts of undeveloped land for the initial study area, covering 52 percent of the land area of the town (7660 ac [3100 ha]). We mapped that area and prepared a report, published in 2018. Then, with additional funding obtained in 2020, we completed the mapping for the rest of the town. This report combines the findings of both stages.

For both stages we prepared a preliminary map of predicted habitats based on map and aerial orthophoto analysis. We digitized the predicted habitats onscreen over the orthophoto images using ArcMap 10.5, 10.6, and 10.8 mapping software. With these draft maps in hand we conducted field visits to as many of the mapped habitat units as possible to verify or correct their presence and extent, to assess their quality, and to identify any habitats that could not be identified remotely.

We identified landowners using tax parcel data, and before going to field sites we contacted landowners for permission to visit their land. We prioritized sites for field visits based both on opportunity (i.e., willing landowners and public-access properties) and our need to answer questions about habitat identification or boundaries that could not be answered remotely. For example, distinctions between wet meadow and calcareous (calcium-rich) wet meadow, and calcareous crest and acidic crest, can only be made in the field. In addition to conducting field work on private and public 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 conducting intensive field verification on every parcel in the town, this prioritization strategy contributed to our efficiency and accuracy in carrying out the work.

We field-checked approximately 47% of the undeveloped land of the town. We used remote sensing to map habitats in areas that we did not see in the field, but were able to extrapolate our findings from field observations to adjacent parcels and similar settings throughout the town. We assume that areas of the habitat map that were field-checked are generally more accurate than areas we did not visit.

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. For these townwide habitat mapping projects we classify broad habitat types that are identifiable largely by their vegetation and other visible physical properties. However, habitats exist as part of a continuum of intergrading characteristics, and drawing a line to separate two "habitats" sometimes seems quite arbitrary. Furthermore, some habitat types are intermediates between two other defined habitat types, and some habitat categories can be considered complexes of several habitat types. In order to maintain consistency within and among habitat mapping projects, we have developed certain mapping conventions that we use to classify habitats and delimit their boundaries. Some of these conventions are described in Appendix A. In any case, all of our mapped habitat boundaries should be considered approximations. Much of the town was only mapped remotely, and even the field-checked habitat boundaries were sketched without the use of GPS or other land survey equipment.

Each habitat profile in the Results section, below, describes the general ecological attributes of places that are included in that habitat type. Developed areas and other places that we consider non-significant habitats (e.g., structures, paved and gravel roads and driveways, other impervious surfaces, and small lawns, small meadows, and small woodlots) are shown as white (no symbol or color) on the habitat map. Areas that have been developed or otherwise altered significantly since spring 2020 (the orthophoto date) were identified as such only if we observed them in the field, so 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 1:14,000 using a Hewlett Packard DesignJet 800PS plotter. The GIS database that accompanies the map includes additional information about many of the mapped habitat units, such as notable plant and animal species observed in the field. The habitat map, GIS database, and this report have been conveyed to the Town of Pound Ridge Conservation Board 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 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 unsuitable for detailed planning and site design or for jurisdictional determinations. Boundaries of wetlands and other habitats depicted here are approximate."*

Rock sandwort, a plant of rocky crests and open rocky woodlands

RESULTS

Overview

The large-format Pound Ridge habitat map illustrates the diversity of habitats that occur in the town and the complexity of their configuration in the landscape. A reduction of the habitat map is shown in Figure 3. Of the total 14,782 ac (5982 ha) in the town, approximately 79% is undeveloped land (i.e., without structures, paved roads, manicured lawns, etc.). Existing development is dispersed along roads and at the ends of sometimes lengthy driveways throughout the town, so that the undeveloped land has been fragmented into discontinuous and irregularly shaped patches. Several types of common habitats cover extensive areas of the town. For example, approximately 68% of the town is forested (including both upland forest and swamp habitats) and 15% is wetland. Some of the more unusual habitats we documented are a buttonbush pool, mixed forest swamps, fens, and rocky barrens. In total, we identified 24 different habitat types that we consider to be of ecological importance (Table 1).

All the mapped areas represent ecologically significant habitats that have been altered to various degrees by past and present human activities. Most areas of upland forest, for example, have been logged repeatedly or used for agricultural land in the past 250+ years, so they lack the structural complexity of old-growth forests. The hydrology of many wetlands in the town has been extensively altered by filling, draining, and construction of dams, reservoirs, and roads. Purple loosestrife and common reed (introduced invasive species) are common and sometimes dominant plants in marshes and wet meadows, and Japanese stiltgrass (another non-native invasive) is common on moist forest soils. Although we have documented the location and extent of important habitats in the town, in only a few cases have we provided information on the quality and condition of particular habitat units.

Table 1. Ecologically significant habitats identified by Hudsonia in the Town of Pound Ridge, Westchester County, New York, 2017-20.

Upland Habitats	**Wetland Habitats**
Upland hardwood forest	Hardwood swamp
Upland conifer forest	Mixed forest swamp
Upland mixed forest	Shrub swamp
Red cedar woodland	Intermittent woodland pool
Crest/ledge/talus	Buttonbush pool
Calcareous crest/ledge/talus	Marsh
Rocky barren	Wet meadow
Upland shrubland	Fen
Upland meadow	Constructed pond
Orchard/plantation	Open water
Waste ground	Spring/seep
Cultural	Stream

Figure 3. A reduction of the map illustrating ecologically significant habitats in the Town of Pound Ridge, Westchester County, New York, as identified and mapped by Hudsonia Ltd in 2017-2020. Hudsonia Ltd, 2021.

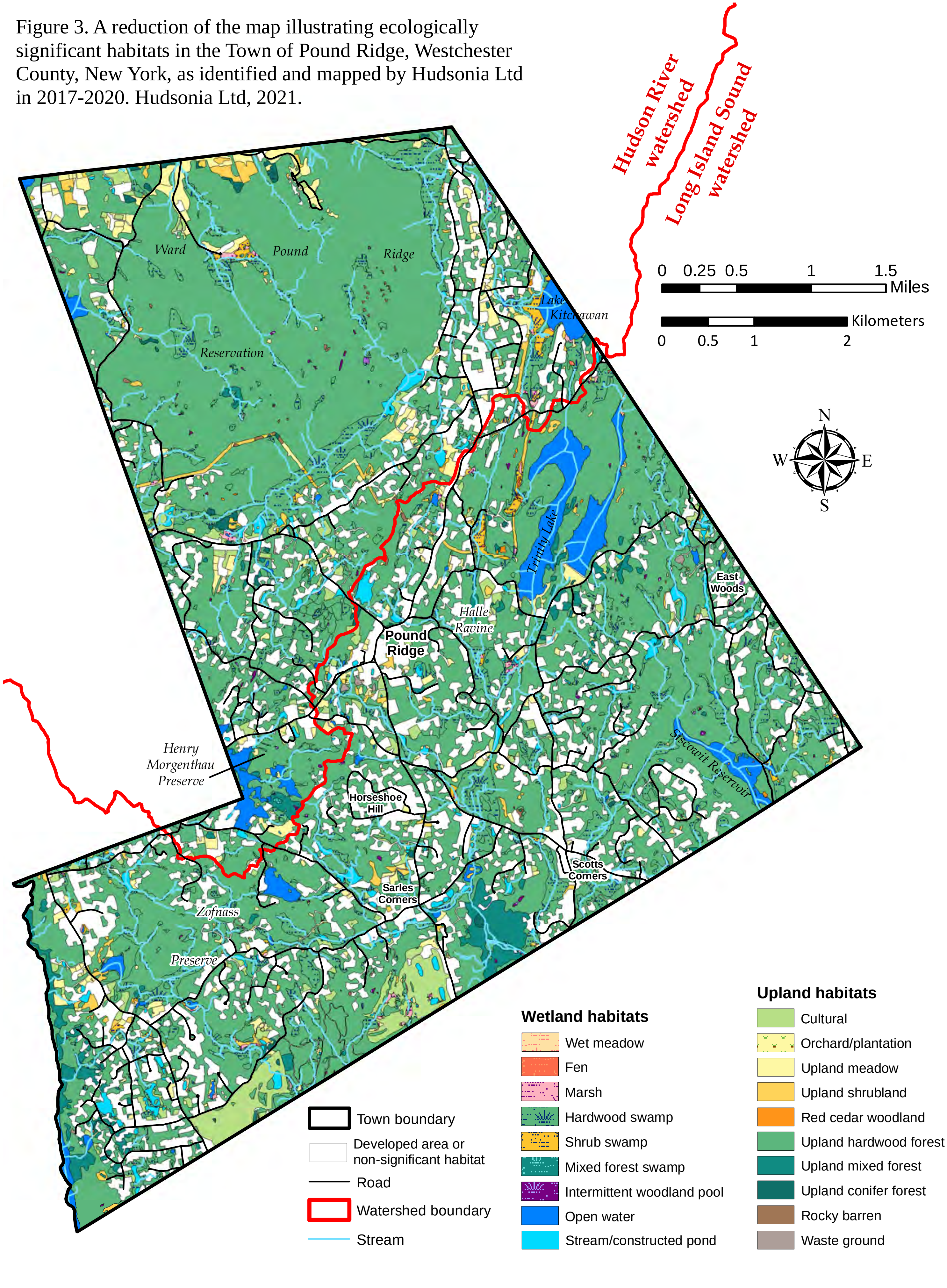
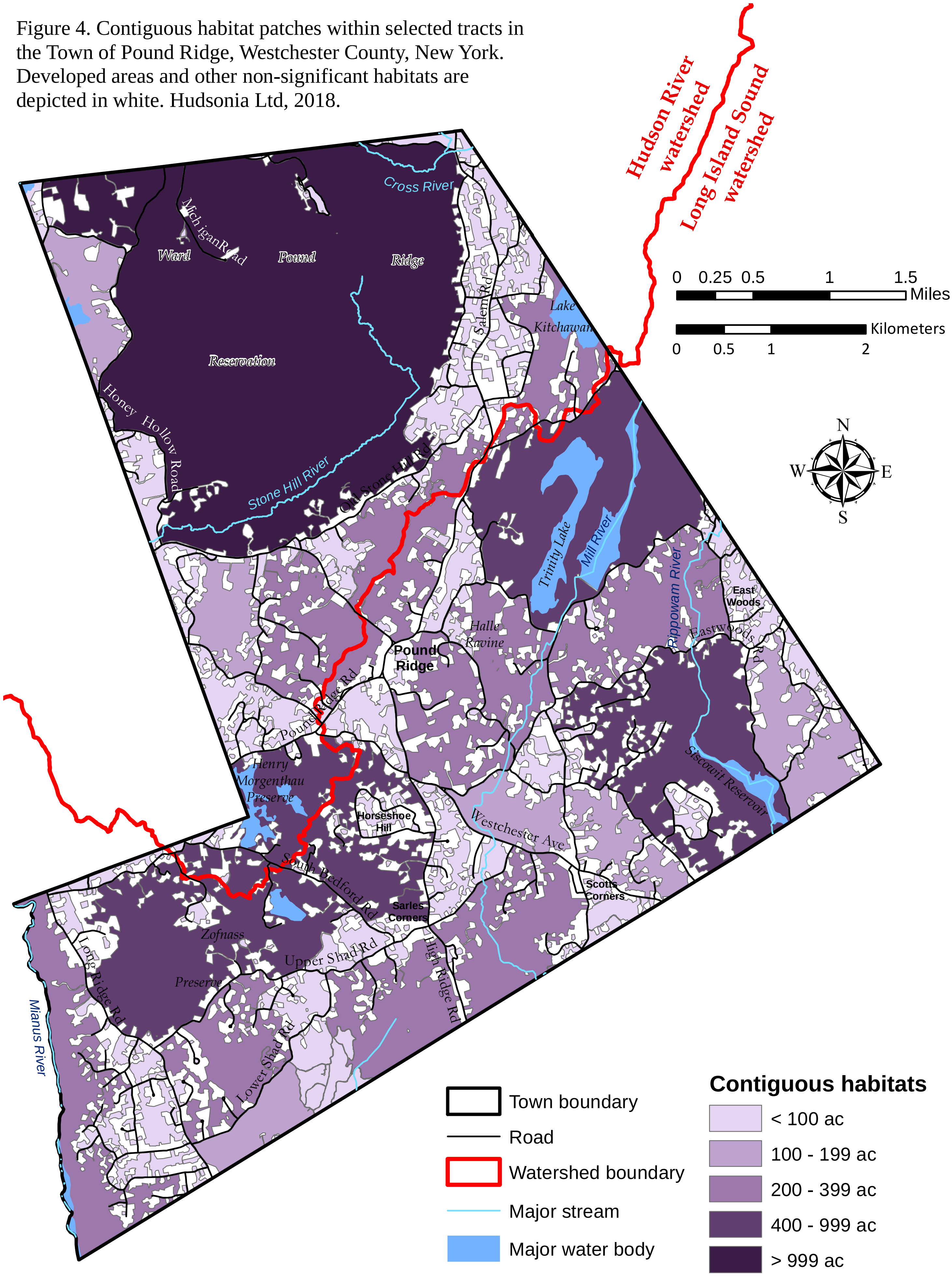


Figure 4. Contiguous habitat patches within selected tracts in the Town of Pound Ridge, Westchester County, New York. Developed areas and other non-significant habitats are depicted in white. Hudsonia Ltd, 2018.



HABITAT DESCRIPTIONS

In the following pages we describe some of the ecological attributes of the habitats identified in the town, and discuss some conservation measures that can help to protect these habitats and the species of conservation concern they may support. A large-format map (scale of 1:14,000) accompanying this report depicts the locations of habitats. Figure 3 is a reduced version of the whole-town map. In the narrative below we indicate plant and animal species of conservation concern (those that are listed as such by state agencies or by non-government organizations) by placing an asterisk (*) after the species name. Appendix C provides a longer list of rare species associated with each habitat type, including their statewide or regional conservation status. Species in that appendix could occur in their assigned habitat types but are not necessarily present in any particular habitat unit. The letter codes used in Appendix C to describe the conservation status of species are explained in Appendix B. Appendix D gives the common and scientific names of all plant taxa mentioned in this report.

UPLAND HABITATS

UPLAND FORESTS

Ecological Attributes

We classified upland (i.e., non-wetland) forests into three general types for this project: upland hardwood forest, upland conifer forest, and upland mixed forest. All three types ranged in age from young stands in which most overstory trees were just 3-6 inches (in) (7-15 centimeters [cm]) in diameter at breast height (dbh), to the most mature stands found in Pound Ridge, in which the dominant canopy trees were 12-18 in (30-46 cm) dbh. Older, more mature forest stands were the most common type found in the town. We recognize that upland forests are very variable, with each of these three types encompassing many distinct biological communities, but our broad forest types are useful for general planning purposes, and are also the most practical for our remote mapping methods.

Upland Hardwood Forest

Upland hardwood forest is the most common habitat type in the region and is extremely variable in species composition, size and age of trees, vegetation structure, soil drainage and texture, and other habitat factors. The habitat includes many different types of deciduous forest communities, and is used by a large array of common and rare species of plants and animals. Many smaller habitats, such as intermittent woodland pools and crest, ledge, and talus, are frequently embedded within areas of upland hardwood forest.

In mature upland hardwood forests (dominant trees with dbh ≥ 12 in [30 cm]), red oak and sugar maple were by far the most common dominant trees, though black birch, black and chestnut oaks, American beech, pignut hickory, and tulip poplar were also frequent dominants. Younger hardwood forests were frequently dominated by some combination of red oak, sugar maple, red maple, black cherry, black locust, and white ash. Those on shallow, rocky soils of ridges and slopes were frequently dominated by chestnut oak and some combination of black oak, scarlet oak, red oak, pignut hickory, and mockernut hickory. Common understory species included mountain laurel, maple-leaf viburnum, witch-hazel, Japanese barberry, Bell's honeysuckle, lowbush blueberries, and a wide variety of wildflowers, sedges, ferns, and mosses. In addition, while many of the forest edges of Pound Ridge had abundant invasive plant species, the interiors of larger stands, i.e., areas farther from forest edges, were often relatively free of invasive herbs and shrubs.

Red oak forest

Upland forests of all kinds provide habitat for a large array of wildlife, including many species of conservation concern. Eastern box turtle* spends most of its time in upland forests and meadows, finding shelter under logs and organic litter, while spotted turtle* uses upland forests for aestivation (summer dormancy) and travel. Many snake species, such as eastern ratsnake,* northern black racer,* and red-bellied snake, forage widely in upland forests and other habitats. Upland hardwood forests provide important nesting habitat for raptors, including red-shouldered hawk,* Cooper's hawk,* sharp-shinned hawk,* broad-winged hawk, and barred owl, and many species of songbirds, including warblers, vireos, thrushes, and flycatchers. American woodcock* forages and nests in young hardwood forests and shrublands. Acadian flycatcher,* wood thrush,* cerulean warbler,* Kentucky warbler,* and scarlet tanager* are some of the birds that may require large forest-interior areas to nest successfully and maintain populations in the long term. Large mammals such as black bear,* bobcat,* and fisher* also require large expanses of forest, although they also range into forest fragments and unforested areas. Many small mammals are associated with upland hardwood forests, including eastern chipmunk, southern flying squirrel, and white-footed mouse. Higher densities of small mammals occur in forest areas with abundant logs and other woody debris, and these are favored by snakes such as copperhead, eastern ratsnake, and northern black racer. Hardwood trees larger than 5 in (12.5 cm) dbh—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 big brown, little brown, northern long-eared,* and other bats for summer roosting and nursery colonies.

Animals of conservation concern that use upland forests in Pound Ridge include four-toed salamander,* spotted salamander,* marbled salamander,* eastern box turtle,* eastern worm snake,* eastern hognose snake,* northern black racer,* northern copperhead,* northern goshawk,* Acadian flycatcher,* wood thrush,* scarlet tanager,* black-throated green warbler,* Canada warbler,* cerulean warbler,* Kentucky warbler,* bobcat,* and many others (Miller and Klemens 2002; NYNHP 2020; Anonymous, pers. comm.; Graham, pers. obs.). We observed ambiguous sedge* in a rich, bottomland forest, and black cohosh* in two locations of rich upland soils.

Upland Conifer Forest

This habitat type comprises both naturally occurring upland forests in which conifers represent more than 75% of canopy cover, and conifer plantations with pole-sized (5-10 in [12-25 cm] dbh) and larger trees. Eastern hemlock, eastern white pine, and eastern red cedar are typical species of naturally occurring conifer stands in the area, and Norway spruce, Scotch pine, and red pine are frequently planted. Eastern red cedar is relatively short-lived and is typically replaced by hardwoods over time, while eastern hemlock forests are long-lived and capable of perpetuating themselves in the absence of significant disturbance or disease. Conifer stands are used by many species of owls (e.g., barred owl, great horned owl) and other raptors (e.g., Cooper's hawk* and sharp-shinned hawk*) for roosting and sometimes nesting. Red-breasted nuthatch,* purple finch,* and black-throated green 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, and eastern chipmunk (Bailey and Alexander 1960). Conifer stands provide winter shelter for white-tailed deer and can be especially important for them during periods of deep snow cover. Common rattlebox,* a NYS-Endangered plant, is known from an open, sandy conifer forest in Pound Ridge (NYNHP 2020).

Red pinesap, a regionally-rare species of upland forests

Upland Mixed Forest

We use the term "upland mixed forest" for non-wetland forested areas with both hardwood and conifer species in the overstory, where conifer cover is 25-75% of the canopy. 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 tend to support a higher diversity and greater abundance of understory species than pure conifer stands.

Occurrence in the Town of Pound Ridge

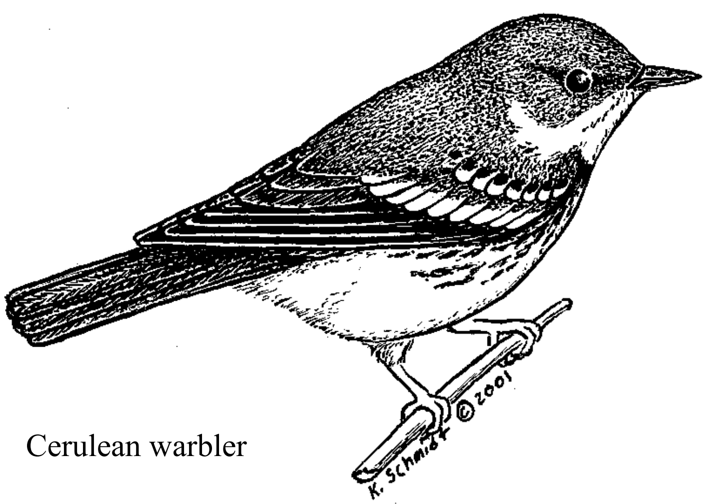
Upland hardwood forests covered a total of 8100 ac (3278 ha, 55%) in the town, by far the most common habitat type (Figure 3), while upland conifer and upland mixed forests together covered only 327 ac (132 ha). We presume that virtually all forests in the town have been cleared or logged in the past and that no "virgin" stands remain, except perhaps in the Mianus River Gorge. Forested areas on very steep slopes may have been logged selectively, but not completely cleared. There may be small stands of old-growth forest in the town that we did not observe during field work.

Though most were much smaller, four patches of upland hardwood forest exceeded 400 ac (120 ha), and the largest, at WPRR, was 2165 ac (876 ha). Upland conifer forest and upland mixed forest were scattered around the WPRR. Much of the upland conifer forest along the border with the Town of Lewisboro was recovering from storm damage. Eastern white pine and eastern hemlock occurred in and dominated small stands throughout the town, but eastern red cedar occurred in only a few patches. While conifer forest accounted for a small fraction of Pound Ridge's land area, and the largest patch was only 7 ac (2.8 ha), mixed forest was much more extensive, totaling 2% of the town. The largest patches of upland mixed forest were 89 ac (36 ha) at and around the Bye Preserve, and 25 ac (10 ha) along the Mianus Gorge. Both were hemlock-hardwood forests, although in the latter the hemlock was predominant in the understory rather than in the canopy.

Sensitivities/Impacts

Forests of all kinds are important habitats for wildlife. Extensive forested areas that are unfragmented by roads, driveways, trails, utility corridors, residential lots, or meadows are especially important for certain organisms, but are increasingly rare in the region. Fragmenting features pose many threats to wildlife and the forest itself. Paved and unpaved roads act as barriers that many species will not cross or cannot safely cross (Forman and Deblinger 2000). Mortality from vehicles can significantly reduce the population densities of amphibians (Fahrig et al. 1995), and many animals will not breed near traffic noise (Trombulak and Frissell 2000). Long driveways intruding deep into forests cause significant fragmentation of core forest areas. Development along existing roads is far less disruptive, though it may still block important wildlife travel corridors between forested patches. Roadways, including driveways, can provide access to interior forest areas for nest predators (such as raccoon and opossum) and the brown-headed cowbird (a brood parasite), which reduce the reproductive success of many forest interior birds. Runoff from roads and driveways can pollute nearby areas with road salt, heavy metals, and sediments (Trombulak and Frissell 2000). Where dirt roads or trails cut through forest, vehicle, horse, and pedestrian traffic can harm tree roots and cause soil erosion. Forests are also susceptible to invasion by shade-tolerant non-native herbs and shrubs, which easily disperse along roads and trails and by logging machinery, ATVs, and other vehicles.

Forest habitats can be degraded in many other ways besides fragmentation. Clearing the forest understory destroys habitat for birds such as wood thrush,* which nests in dense understory vegetation, and black-and-white warbler* and ovenbird,* which nest on the forest floor. Removal of mature and especially large trees eliminates habitat for lichens, fungi, and bryophytes, as well as the many kinds of animals that use cavities and that forage in and around large and decaying trees. Selective logging can also damage the understory and cause soil erosion, compaction, and rutting, and sedimentation of streams. Soil compaction and removal of dead and downed wood and debris eliminates habitat for mosses, lichens, fungi, birds, amphibians, reptiles, small mammals, and insects. Human habitation near fire-prone forests has led to the suppression of naturally occurring wildfires, which can be important for some forest species and the forest ecosystem as a whole.



Cerulean warbler

Introduced forest pests are also threatening forest health in the Hudson Valley. Of note is the hemlock woolly adelgid (HWA), 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 years and has the potential to cause the near extirpation of hemlock forests in the region. Also of note is the emerald ash borer (EAB), a non-native tree borer that infests ash species that is now widespread in Westchester County. While the adults do little damage to the tree, the larvae feed on the phloem and cambium; a heavy infestation will effectively girdle a tree, killing it within 2-4 years. Early detection of the emerald ash borer is difficult, and outbreaks are almost impossible to contain once identified. White and green ash (*Fraxinus americana* and *F. pensylvanica*) are common trees in Pound Ridge, and black ash (*Fraxinus nigra*) also occurs here. White ash is frequently found in upland forests and as a street tree, green ash is common in floodplains and hardwood swamps, and black ash occurs in swamps. Emerald ash borer has killed many of the ash trees in Pound Ridge, and may destroy most or all of the remaining ashes in the near future.

In addition to their tremendous value for wildlife and plants, forests are the most effective type of land cover for maintaining clean and abundant surface water and groundwater. Forests with intact canopy, understory, ground vegetation and floors promote infiltration of precipitation to the organic duff and soils (Bormann et al. 1969, Likens et al. 1970, Bormann et al. 1974, Wilder and Kiviat 2008), and may be the best insurance for maintaining groundwater quality and quantity in Pound Ridge, for reducing rapid runoff and soil erosion, and for maintaining flow volumes, cool temperatures, water quality, bank stability, and habitat quality in streams.

Forests also provide long-term storage of large amounts of carbon in above-ground and below-ground biomass, so maintaining and restoring forests can help to offset some of the carbon emissions of human activities. Forests help to moderate local and regional air temperatures and the water temperatures of streams and wetlands. Forests and other intact habitats in floodplains and adjacent areas also help to accommodate the large flood events that may be increasing in frequency and magnitude.

The Conservation Priorities and Planning section of this report gives recommendations for protecting and fostering the habitat and water resource values of forests, and Figure 7 illustrates locations of large, contiguous forest blocks in Pound Ridge.

RED CEDAR WOODLAND

Ecological Attributes

"Red cedar woodlands" have an overstory of widely-spaced eastern red cedar trees and grassy meadow remnants among them. Red cedar is one of the first woody plants to colonize oldfields on mildly acidic to alkaline soils in this region, and red cedar woodlands are often transitional between upland meadow and young forest habitats. The seeds of red cedar are bird-dispersed, and the seedlings are successful at becoming established in the hot, dry conditions of old pastures (Holthuijzen and Sharik 1984). The cedars tend to develop particularly dense stands in areas with calcareous (calcium rich) soils. Other, less common trees of this habitat include gray birch, red maple, quaking aspen, and red oak. The understory vegetation is similar to that of upland meadows. Kentucky bluegrass and other hayfield and pasture grasses are often dominant in the understory, particularly in more open stands; little bluestem is often dominant on poorer soils. Red cedars can persist in these stands for many years even after a hardwood forest grows up around them. When the red cedar trees reach a certain density and few open grassy spaces remain, we classify the stands as upland conifer or upland mixed forest.

Red cedar woodland

Rare plants of red cedar woodlands on calcareous soils in the region include Carolina whitlow-grass,* yellow wild flax,* and Bicknell's sedge.* We found whorled milkweed* and butterflyweed* (a milkweed) in one red cedar woodland. The olive hairstreak* (butterfly) uses red cedar as a larval host. Open red cedar woodlands with exposed gravelly or sandy soils may be important nesting habitat for several reptile species of conservation concern, including wood turtle,* spotted turtle,* eastern box turtle,* and eastern hognose snake.* These animals may travel considerable distances overland from their primary wetland, stream, or forest habitats to reach the nesting grounds. Eastern hognose snake may also use these habitats for basking, foraging, and over-wintering. The berry-like cones of red cedar are a food source for eastern bluebird,* cedar waxwing, and other birds. Many songbirds, including field sparrow,* eastern towhee,* and brown thrasher,* also use red cedar for nesting and roosting. Insectivorous birds such as black-capped chickadee and golden-crowned kinglet forage in red cedar.

Occurrence in the Town of Pound Ridge

We found nine red cedar woodlands in the town; most were on shallow soils and rocky slopes. The largest was a 0.9 ac- (0.4-ha)-woodland atop Joe's Hill in WPRR, surrounding a rocky barren. Another was on marble bedrock in the Isaacson Preserve.

Sensitivities/Impacts

Red cedar woodlands on abandoned agricultural lands are often considered prime development sites, and thus are particularly vulnerable to direct habitat loss or degradation. Woodlands on steep slopes with fine sandy soils may be especially susceptible to erosion from ATV traffic, driveway construction, and other human uses. Use of heavy equipment may harm or destroy the nests of turtles, snakes, and ground-nesting birds. Human disturbances may also facilitate the invasion of non-native forbs and shrubs that tend to diminish habitat quality by forming dense stands that discourage or displace native plant species. Wherever possible, measures should be taken to prevent the direct loss or degradation of these habitats and to maintain unfragmented connections with nearby wetlands, forests, and other important habitats. Red cedar woodlands are typically a transitional habitat that, if left unmanaged, will ordinarily develop into young forest with the cedars gradually overtopped by deciduous trees.

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 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 large rock fragments that often accumulate below steep ledges and cliffs. We also include large glacial erratics (glacially-deposited boulders) in this habitat type. Some crest, ledge, and talus habitats support well-developed forests, while others have only sparse, patchy, and stunted vegetation. Crest, ledge, and talus habitats often appear to be harsh and inhospitable, but they can support an extraordinary diversity of uncommon and rare plants and animals. Some species, such as wall-rue,* smooth cliffbrake,* purple cliffbrake,* and northern slimy salamander* are found only in and near rocky places in the region. The communities and species that occur at any particular location are determined by many factors, including bedrock type, outcrop size, aspect, exposure, slope, elevation, biotic influences, and kinds and intensity of human disturbance.

A typical rocky forest in Pound Ridge.

Because distinct communities develop in calcareous and non-calcareous environments, we distinguished calcareous bedrock exposures wherever possible. Calcareous crests often have trees such as eastern red cedar, northern hackberry,* American basswood, and butternut; shrubs such as bladdernut, American prickly-ash, and Japanese barberry; and herbs such as wild columbine, ebony spleenwort, maidenhair spleenwort, maidenhair fern, and fragile fern. They can support numerous rare plant species, such as walking fern,* yellow harlequin,* and Carolina whitlow-grass.* Non-calcareous crests often have trees such as red oak, chestnut oak, eastern hemlock, and occasionally pitch pine; shrubs such as lowbush blueberries, chokeberries, and scrub oak; and herbs such as Pennsylvania sedge, little bluestem, common hairgrass, bristly sarsaparilla, and rock polypody. Rare plants of non-calcareous crests include mountain spleenwort,* clustered sedge,* and slender knotweed.*

Rocky areas in Pound Ridge were frequently associated with chestnut oak, red oak, black birch, and mountain laurel. Other common plants of such places included lowbush blueberries, black huckleberry, rock polypody, marginal wood fern, Pennsylvania sedge, Swan's sedge, and poverty grass. Calcicoles (calcium-associated plants) of calcareous crest, ledge, and talus included wild columbine, bloodroot, black cohosh,* wild ginger, maidenhair fern, and ebony and maidenhair spleenworts.

Northern hairstreak* (butterfly) occurs with oak species that are host plants for its larvae, and olive hairstreak* occurs on crests with its host eastern red cedar. Rocky habitats with larger fissures, cavities, and exposed ledges may provide shelter, den, and basking habitat for eastern hognose snake,* northern copperhead,* and other snakes of conservation concern. Northern slimy salamander* occurs in non-calcareous wooded ledge and talus areas. Breeding birds of crest habitats include worm-eating warbler* and cerulean warbler.* Bobcat* and fisher* use crests and ledges for travel, hunting, and cover. Bobcats use ledge and talus habitats for denning. Southern red-backed vole* is found in some rocky areas, and eastern small-footed bat* roosts in talus habitat. Eastern ratsnake,* eastern hognose snake,* northern black racer,* northern copperhead,* worm-eating warbler,* cerulean warbler,* and bobcat* are all known to occur in Pound Ridge (Miller and Klemens 2002).

We mapped as “calcareous crest, ledge, and talus” those areas that we identified as such in the field and nearby areas with similar physiography. We mapped as simply “crest, ledge, and talus” those areas that we confirmed as non-calcareous in the field, as well as all other ledgy areas that we did not visit or visited too late in the season for indicator species. Thus, the “crest, ledge, and talus” designation serves as a catch-all for non-calcareous outcrops and talus plus other such rocky habitats of unknown chemistry. For areas that we could not visit in the field, we mapped predicted coverage of crest, ledge, and talus based on the coincidence of shallow soils (as mapped in Seifried 1994) and steep slopes.

Occurrence in the Town of Pound Ridge

Crest, ledge, and talus habitats occurred throughout the town, mostly on hills, ridges, and steep slopes (Figure 8). Extensive non-calcareous crest, ledge, and talus occurred in WPRR (especially the southern and eastern slopes), in and around the Zofnass Preserve, and around the northern ends of Trinity Lake and Mill River Reservoir. Altogether, we mapped 2281 ac (923 ha) of known or predicted crest, ledge, and talus habitat. A few, small calcareous (marble) outcrops were located south of Lake Kitchawan, in the Isaacson Preserve, and off the south end of the Halle Ravine. We mapped a total of 19 ac (7.7 ha) of calcareous ledges, and expect that there are more on lands that we did not visit.

Sensitivities/Impacts

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

ROCKY BARREN

Ecological Attributes

A subset of rocky crest habitat (see above), rocky barrens occur on knoll tops, hilltops, and steep slopes with exposed bedrock and shallow, often acidic soils. The vegetation may be predominantly grassy or woody or a combination thereof, but extensive exposed bedrock is the unifying feature. The exposed bedrock can be of various types, but many of the barrens habitats in Pound Ridge are on gneiss. The soils are extremely shallow, excessively well-drained, very nutrient poor, and susceptible to drought. Some of these ecosystems may be maintained by episodic fire events, which limit colonization by species that are not fire-adapted, help certain plant species such as pitch pine regenerate, return nutrients to the soil, and prevent the overgrowth of trees that can shade out the typical barren species that require full sunlight. Because these barrens are usually located in exposed areas with shallow soils, woody plants are susceptible to breakage and windthrow from wind and winter storms to which crests are fully exposed (Thompson and Sarro 2008); this exposure contributes to the sparse tree growth and shrubby, stunted character of barrens vegetation. Due to the open canopy, exposed rock, and dry soils, rocky barrens tend to have a much warmer microclimate in summer than the surrounding forested habitat, especially in the spring and fall, and a colder microclimate in winter.

A grass-dominated rocky barren.

Although these habitats seem inhospitable (in part because of exposure to extreme temperatures and short growing seasons [Thompson and Sarro 2008]), their plants and animals are adapted to harsh conditions. Dominant trees include pitch pine, chestnut oak, red oak, and scarlet oak; the shrub layer may include scrub oak, eastern red cedar, blueberries, black huckleberry, deerberry, and sweetfern. Common herbs include Pennsylvania sedge, poverty grass, common hairgrass, little bluestem, and bracken. Lichens and mosses are often abundant. Our definition of these habitats corresponds to Edinger et al.'s (2014) "pitch pine-oak forest," "pitch pine-oak-heath rocky summit," "red cedar rocky summit," and "rocky summit grassland." There may be a continuous canopy of pitch pine or pitch pine and oak with a scrub oak understory; the shrub layer (largely scrub oak and/or heath shrubs) may dominate, with only scattered pines or eastern red cedars; or the vegetation may be predominantly grassy with scattered shrubs and trees.). Common species in the rocky barrens of Pound Ridge were chestnut oak, scarlet oak, and pitch pine, with lowbush blueberries, black huckleberry, poverty grass, and panic grasses common in the understory. Mosses and lichens also were often abundant.

Rare plants of rocky barrens include clustered sedge,* mountain spleenwort,* and dwarf shadbush.* Rare butterflies that use scrub oak, little bluestem, lowbush blueberry, or pitch pine as their primary food plant tend to concentrate in rocky barrens, including Edward's hairstreak,* cobweb skipper,* and Leonard's skipper.* Woody barrens also provide habitat for several rare oak-dependent moths. Deep rock fissures can provide crucial shelter for northern copperhead* and other snakes of conservation concern, and the exposed ledges provide basking and breeding habitat in the spring and early summer. Birds of these habitats include common yellowthroat, prairie warbler,* field sparrow,* eastern towhee,* and whip-poor-will.* Northern copperhead,* eastern ratsnake,* and northern black racer* are all found in Pound Ridge (Miller and Klemens 2002) and are likely to use these rocky barrens.

Occurrence in the Town of Pound Ridge

A total of 36 rocky barrens were found in Pound Ridge (Figure 8). Most of these in WPRR, scattered throughout the reservation, but many were concentrated in the southern and southeastern parts thereof. The three largest rocky barrens were ca. 0.8-0.9 ac (0.3-0.4 ha); most of the others were between 0.1 and 0.3 ac (0.04 – 0.12 ha). These barrens may be a remnant of historically larger habitats once maintained by fire and now persisting because shallow soils inhibit establishment of taller tree species that would shade out the barren species. Because these communities are difficult to find remotely, we expect there are additional small, rocky barrens in the areas of exposed bedrock that we did not field-check.

Sensitivities/Impacts

The most immediate threat to these fragile habitats is 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. 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 rocky barrens and other exposed crests can fragment important migration corridors for snakes and butterflies, thereby isolating neighboring populations and reducing their long-term viability. Because snakes tend to congregate on rocky barrens and other exposed crests at certain times of the year, the snakes are highly vulnerable to being killed or harassed, or collected by poachers. Barrens tend to be disturbance-maintained ecosystems, but wildfire suppression eliminates this important disturbance regime. The scarcity of fires enables other, less-specialized forest species to colonize these areas. The Conservation Priorities and Planning section of this report gives recommendations for protecting and fostering the habitat values of barrens habitats.

UPLAND SHRUBLAND

Ecological Attributes

We use the term "upland shrubland" for shrub-dominated upland (non-wetland) habitats in which shrub cover is 20% or more. In most cases these are lands in transition between meadow and young forest, but they also occur along utility corridors maintained by cutting or herbicides, and in areas of recent forest clearing. Land use (both historical and current) and soil characteristics are important factors influencing the species composition of shrub communities. Shrublands often host native shrubs such as meadowsweet, gray dogwood, northern blackberry, and raspberries, as well as scattered seedlings and saplings of eastern red cedar, hawthorns, eastern white pine, gray birch, red maple, quaking aspen, and oaks. Among the shrubs are native and non-native grasses and forbs. Other shrublands, however, are dominated by non-native, invasive species such as Japanese barberry, Bell's honeysuckles, oriental bittersweet, mile-a-minute vine and multiflora rose. Occasionally, large, open-grown trees (e.g., sugar maple, red oak, white oak, sycamore) left as shade for livestock or ornament may be present. Many non-native, invasive plants tend to thrive in places with a history of recent agricultural use (up to 40-80 years ago) and fine soil texture (Lundgren et al. 2004, Johnson et al. 2006). Recently-logged areas, if left unmanaged, usually have a shrubland phase with abundant tree saplings and northern blackberry before transitioning to young forest.

Rare butterflies such as Aphrodite fritillary,* dusted skipper,* Leonard's skipper,* and cobweb skipper* may occur in shrublands where their larval host plants are present (the fritillary uses violets and the skippers use native grasses such as little bluestem). Upland shrublands and other non-forested upland habitats may be used by turtles for nesting, aestivating (e.g., painted turtle, wood turtle,* spotted turtle,* and eastern box turtle*) or foraging (eastern box turtle and wood turtle). Many bird species of conservation concern nest in upland shrublands and adjacent upland meadow habitats, including brown thrasher,* blue-winged warbler,* golden-winged warbler,* prairie warbler,* yellow-breasted chat,* field sparrow,* and eastern towhee. Many shrubland birds (including blue-winged warbler) do not seem to be area-sensitive in shrubland patches larger than about 1 ha, and they will nest in small to medium-sized shrublands within forest openings, particularly those with low vegetation, few trees, and dense shrub cover (Askins et al. 2007). Nevertheless, most of these birds avoid forest edges (Schlossberg and King 2008) so extensive upland shrublands (>12.5 ac [5 ha]) and those that form large complexes with meadow habitats may be particularly important (Shake et al. 2012). Several species of hawks and falcons use upland shrublands and adjacent meadows for hunting small mammals such as meadow vole, white-footed mouse, eastern cottontail, and New England cottontail.* The last species, once common in the Northeast but now of conservation concern, seems to do best in large shrublands with dense shrub thickets. The Hudson Valley east of the Hudson River and western Connecticut are believed to be important parts of the remaining range of this species; we do not know if it is extant in Pound Ridge.

Occurrence in the Town of Pound Ridge

Upland shrublands were sparsely distributed throughout the town (Figure 3), and ranged from less than 0.1 ac to 9 ac (< 0.04 – 3.6 ha). The largest patches were in former oldfields and in utility corridors, with smaller shrublands occurring in forest blow-downs and canopy gaps. Common plants included Bell's honeysuckle, multiflora rose, gray dogwood, Japanese barberry, eastern red cedar, goldenrods, and grasses.

Sensitivities/Impacts

Shrublands and meadows are closely related habitats. 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., October and later), and only take place every few years, if possible. Prescribed or spontaneous fires can also maintain shrublands and grasslands. Soil compaction and erosion caused by ATVs, 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.

UPLAND MEADOW

Ecological Attributes

This broad category includes abandoned fields and other upland areas dominated by herbaceous (non-woody) 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 the disturbance histories (e.g., tilling, mowing, grazing, pesticide applications). Undisturbed meadows often develop diverse plant communities of grasses, forbs, and shrubs and can support a large array of wildlife, including invertebrates, some frog species, reptiles, mammals, and birds. Meadows with shallow, nutrient-poor soils often support a higher abundance and diversity of native, warm-season grasses and other native plants. It is for both present and potential ecological values that we consider all types of meadow habitat to be ecologically significant.

Common rattlebox* and stiff-leaved goldenrod* are known from upland meadows in Pound Ridge (NYNHP 2020), and Hudsonia biologists observed Bush's sedge* in an oldfield within the town. Several species of rare butterflies, such as Aphrodite fritillary,* meadow fritillary, * dusted skipper,* Leonard's skipper,* swarthy skipper,* and striped hairstreak use upland meadows that support their particular host plants. Northern oak hairstreak* has been found in upland meadows of Pound Ridge (NYNHP 2020). Upland meadows can also be used for nesting by wood turtle,* spotted turtle,* box turtle,* painted turtle, and snapping turtle. Grassland-breeding birds such as grasshopper sparrow,* savannah sparrow,* eastern meadowlark,* and bobolink* use large meadow habitats for nesting and/or 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 Pound Ridge

There were 396 ac (160 ha, 2.7%) of upland meadow in the town. The largest patches were 21 and 11 ac (8.5 and 4.5 ha) along the northern town boundary in WPRR, but the meadow complex extended into the Lewisboro section of the reservation, so was much larger overall. Many other small meadows occurred around developed areas, where they were an alternative to mowed lawns.

Sensitivities/Impacts

Upland meadow patch

Principal causes of the loss of high-quality meadow habitat in the Northeast are the intensification of agriculture, regrowth of shrubland and forest after abandonment of agriculture, and residential development. The dramatic decline of grassland-breeding birds in the Northeast has been attributed to the loss of large patches 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). Mowing of upland meadows during the nesting season can cause extensive mortality of eggs, nestlings, and fledglings. 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 plants and reduce viable habitat for butterflies. Horse pastures potentially have open-space, scenic, and biodiversity values, but those that are grazed intensively have little <u>current</u> value for native biodiversity.

Good management of small meadows can be critical for invertebrates and small mammals. Different groups of butterflies depend on different kinds of meadow habitats (oldfields, hayfields, stream or pond margins, wet meadows, dry, shallow-soiled fields [Vispo and Knab-Vispo 2012]), and different species have variously-timed life cycles. Perhaps the best management strategy for butterfly conservation is to mow fields only in halves or portions which cut across topography. For example, if the field has wet and dry parts, cut half the wet and half the dry in any one year, rather than all the wet this year, and all the dry next year (Conrad Vispo, personal communication). Mow strategically to ensure that early-, mid-, and late-flowering forbs are available to serve insects with different active periods. Nectar from October flowers, for example, will support late-flying native bees and butterflies when many other food sources have gone to seed.

ORCHARD/PLANTATION

This habitat type includes actively maintained or recently abandoned fruit orchards, tree farms, and plant nurseries. Conifer plantations with larger, older trees were mapped as "upland conifer forest," and those that had been partially harvested and colonized by shrubs were mapped as "upland shrubland." Fruit orchards with old trees may provide breeding habitat for eastern bluebird* and can be valuable to other cavity-using birds, bats, and other animals. 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. The habitat values 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. We found only a few small orchard/plantations (abandoned); the largest was a spruce plantation of 1.8 ac (0.7 ha) in WPRR.

CULTURAL

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. Large lawns, golf courses, and athletic fields are typical examples. We consider them to be ecologically significant when they are large and adjacent to other ecologically significant habitats (i.e., when they are not entirely

Anise millipedes in turkey tail mushrooms surrounded by developed areas). We identified this as a significant habitat type more for its potential ecological values than its current values, which are reduced by frequent mowing, application of fertilizers and 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* and American kestrel* may nest here, as may several species of turtles. Large individual ornamental or fruit trees can provide habitat for cavity-nesting birds such as eastern bluebird,* roosting bats, and many other animals, and for mosses, liverworts, and lichens, potentially including rare species. 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 vehicular traffic is infrequent and slow. Many cultural areas have "open space" values for the human community (e.g., recreational or scenic), and some provide important services such as buffering less-disturbed habitats from human activities and linking patches of undeveloped habitat. However, because cultural areas are already significantly altered, their habitat values are greatly diminished compared to those of relatively undisturbed habitats. Cultural habitats in the town included playing fields, riding rings, large lawns, and manicured borders of ponds. They ranged from smaller than 0.1 ac to 94 ac (< 0.04 - 38 ha); the largest were golf courses.

WETLAND HABITATS

SWAMPS

Ecological Attributes

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

Hardwood Swamp

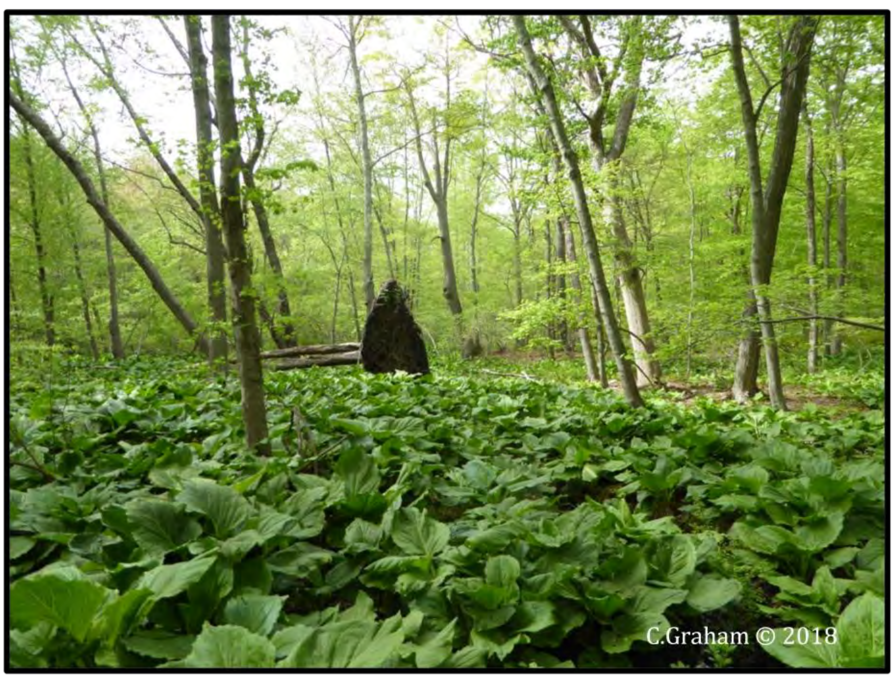
Hardwood swamps in Pound Ridge were typically dominated by red maple, and had other tree species such as green ash, American elm, slippery elm, and yellow birch. One large hardwood swamp south of Lake Kitchawan was dominated by black ash, indicating calcareous soils. Many hardwood swamps contained abundant shrubs, including highbush blueberry, coast pepperbush, winterberry holly, glossy buckthorn, multiflora rose, and spicebush. Common herbaceous species included tussock sedge, skunk-cabbage, orange jewelweed, yellow iris, false nettle, and sensitive, cinnamon, royal fern, and marsh ferns. Hardwood swamps are sometimes difficult to distinguish from shrub swamps on aerial photos, and might therefore be over-estimated in areas that were not field checked.

Mixed Forest Swamp

Mixed forest swamps have a canopy composed of 25-75% conifers. Eastern hemlock was the typical conifer species of these wetlands. This habitat has characteristics intermediate between those of hardwood and conifer swamps, and shares many of the ecological values of those habitats.

Shrub Swamp

A shrub swamp is a subset of hardwood swamp where shrubs instead of trees are dominant. If trees are present, they are widely spaced. Typical shrubs included glossy buckthorn (which dominated several large shrub swamps in areas of marble bedrock), winterberry holly, highbush blueberry, coast pepperbush, silky dogwood, alders, northern arrowwood, and spicebush.



A hardwood swamp carpeted with skunk cabbage

Swamps are important to a wide variety of birds, mammals, amphibians, reptiles, and invertebrates, especially when the swamp is contiguous with other wetland types or embedded within large areas of upland forest. Swamp cottonwood* is a very rare tree of deeply-flooding hardwood swamps and is known from only a handful of sites in the Hudson Valley. Purple milkweed* is known from one shrub swamp in Pound Ridge (NYNHP 2020). Hardwood and shrub swamps along the floodplains of clear, low-gradient streams can be an important component of wood turtle* habitat. Spotted turtle* frequently uses swamps for summer foraging, drought refuge, overwintering, and travel corridors. Pools within swamps are used by several pool-breeding amphibian species, and are the primary breeding habitat of blue-spotted salamander.* Four-toed salamander,* believed to be regionally rare or scarce, uses swamps with rocks or abundant, moss-covered, downed wood or woody hummocks. Eastern ribbon snake* forages for frogs in swamps. Red-shouldered hawk,* barred owl, great blue heron,* wood duck,* American black duck,* red-headed woodpecker,* Canada warbler,* and white-eyed vireo* nest in hardwood swamps.

Among hardwood and shrub swamps that we mapped, we noted a particular type worth distinguishing (denoted with a star on the habitat map): pool-like swamp. *Pool-like swamps* have hydrological properties similar to intermittent woodland pools—pool areas that dry up during the summer and are isolated from other wetlands and streams—but also have the trees and shrubs characteristic of swamps. Because of their impermanent water and their isolation from streams and other wetlands, these swamps may have ecological roles similar to those of intermittent woodland pools. See the section on intermittent woodland pools (below) for additional ecological attributes and occurrence information.

Occurrence in the Town of Pound Ridge

Swamps occurred in a variety of settings: on seepy slopes, along streams, in depressions, and as part of large wetland complexes. Swamps ranged from smaller than 0.1 to over 117 ac (< 0.04 - 47 ha), and were often contiguous with other wetland habitats such as marsh, wet meadow, and open water (Figure 12). We mapped a total of 1516 ac (614 ha) of swamps, accounting for 10% of the town. Hardwood swamps covered 1442 ac (584 ha), while mixed forest swamps (8 ac [3.2 ha]) and shrub swamps (64 ac [26 ha]) accounted for far less land area. The two largest swamps were along the Stone Hill River (116 ac [47 ha]) and along the Cross River (77 ac [31 ha]). We classified 68 of these swamps as pool-like swamps, many of them scattered throughout WPRR.

Sensitivities/Impacts

Song sparrow in its shrub swamp habitat

While some swamps may be protected by federal or state laws, 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 sometimes overlooked in environmental reviews, but can have extremely high biodiversity values, and play similar ecological roles to those of intermittent woodland pools (see below). Many of the larger swamps are located in low-elevation areas where human land uses are also concentrated. They can easily be damaged by alterations to the quality or quantity of surface water runoff, or by disruptions of groundwater sources that feed them. 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 sediment- and toxin-laden runoff. Polluted runoff and groundwater can degrade a swamp's water quality, affecting the ecological condition (and thus habitat value) of the swamp and its associated streams. Maintaining flow patterns 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 lost habitat values of the pre-existing swamp usually far outweigh any habitat values gained in the new, artificial pond environment. The Conservation Priorities and Planning section of this report provides recommendations for preserving the habitat values of swamps within larger wetland complexes. Recommendations for preserving the habitat values of pool-like swamps are given in the Conservation Priorities and Planning section on intermittent woodland pools, and Figure 9 shows their conservation zones.

INTERMITTENT WOODLAND POOL (& POOL-LIKE SWAMP)

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 fall, 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 occur in forested or open settings). 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 organic detritus, which is the base of the pool's food web. The forest is also essential habitat for adult pool-breeding amphibians during the non-breeding season.

Common plant species of intermittent woodland pools in Pound Ridge included black gum, red maple, highbush blueberry, winterberry holly, marsh fern, and tussock sedge, mostly around pool edges.

Pool-like swamps have hydrological properties similar to intermittent woodland pools, in addition to woody vegetation characteristic of swamps. Because of their isolation from streams and other wetlands, these swamps may have ecological roles similar to those of intermittent woodland pools—that is, they may provide seasonal water with fewer aquatic predators, rich and diverse invertebrate communities, breeding habitat for pool-breeding amphibians, and refuge for turtles.

Intermittent woodland pools (and pool-like swamps) provide critical breeding and nursery habitat for wood frog,* Jefferson salamander (and hybrids),* marbled salamander,* and spotted salamander* and are also used by other amphibians such as spring peeper, blue-spotted salamander* and four-toed salamander.* Reptiles such as spotted turtle* and eastern ribbon snake* 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. During the breeding season, birds may be more abundant and diverse around intermittent woodland pools than in upland forest (McKinney & Paton 2009). 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.

An intermittent woodland pool, nearly dry in summertime

Featherfoil* and false hop sedge* seem to specialize in this habitat; indeed, we found false hop sedge* in two intermittent woodland pools in Pound Ridge, and featherfoil was previously known from a woodland pool in the town (NYNHP 2020). We found a small population of swamp cottonwood* in a large intermittent woodland pool, the only occurrence in town that we know of. There were roughly 30 trees from 1-12 in (2.5-30 cm) dbh, as well as 100+ seedlings that appeared to be sprouting from stumps.

Occurrence in the Town of Pound Ridge

Figure 9 illustrates locations of intermittent woodland pools and their conservation zones in Pound Ridge. We found 94 intermittent woodland pools scattered across the town; the largest was 0.7 ac (0.3 ha). Many were connected by undeveloped forest habitat, which increases the habitat value of the network of pools. Some intermittent woodland pools were part of larger hardwood swamps, but we mapped these only when the entire swamp was isolated from streams or larger waterbodies. We also found 67 pool-like swamps and two buttonbush pools, both of which may serve as suitable habitat for pool-breeding amphibians and other organisms of isolated pools with intermittent hydroperiods. Because pools were small and often difficult to identify on aerial photographs, we expect there are additional such habitats 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 has long been undervalued. They have been frequently drained or filled by landowners and developers, used as dumping grounds, treated for mosquito control, and sometimes converted into ornamental ponds. They are often overlooked in environmental reviews of proposed developments, and even when the pools themselves are spared in a development plan, the surrounding forest, so essential to the ecological functions of the pools, is frequently destroyed. Intermittent woodland pools are often excluded from federal and state wetland protection due to their small size, intermittent surface water, and isolation from streams or larger waterbodies. However, it is these very characteristics of size, intermittency, and isolation that make woodland pools uniquely suited to species that do not reproduce or compete as successfully in larger wetland systems. The Conservation Priorities section of this report provides recommendations for protecting the habitat values of intermittent woodland pools and pool-like swamps.

BUTTONBUSH POOL

Ecological Attributes

Buttonbush pools are seasonally or permanently flooded shrubby pools normally dominated by buttonbush, though 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, an open water moat entirely or partly surrounds a shrub thicket in the middle of the pool, which may include small trees such as red maple or green ash. Conversely, the shrub stands may occupy the outer portions of the area with open water in the middle. These pools are typically isolated from streams, though some may have a small intermittent inlet and/or outlet. Standing water is normally present in winter and spring but often disappears by late summer or remains only in isolated puddles. Buttonbush pools are a kind of shrub swamp, and can also be considered a kind of intermittent woodland pool, providing many of the same habitat values for aquatic and terrestrial wildlife.

Occurrence in the Town of Pound Ridge

We documented only one buttonbush pool in the town, covering 1.1 ac (0.4 ha). The pool was west of the northernmost end of the Stone Hill River (Figure 9). Because these pools are often difficult to identify on aerial photographs, there may be others in the town that we did not map.

Sensitivities/Impacts

Buttonbush pools may be particularly sensitive to changes in hydrology. Groundwater extraction or changes in infiltration in the vicinity could alter the pool's hydroperiod and water depth, and alteration of surface water entering or leaving the pool could drastically change its character. These pools are also sensitive to changes in water chemistry; runoff from roads, agricultural fields, lawns, and construction sites all negatively affect water quality. Development and habitat fragmentation in the surrounding landscape threaten the habitat connections between these pools and other wetland and upland habitats that are essential to pool-breeding amphibians, and other wildlife. Like intermittent woodland pools, buttonbush pools are occasionally excavated for ornamental ponds and they are often partly drained by means of ditches. The intermittent woodland pools section of Conservation Priorities and Planning, below, provides recommendations for protecting the habitat values of buttonbush pools.

Female common yellowthroat, a warbler of marshes, swamps, and thickets

MARSH

Ecological Attributes

A marsh is a wetland that has standing water for much or all of the growing season and is dominated by herbaceous (non-woody) vegetation. Marshes often occur at the fringes of deeper waterbodies (e.g., lakes and ponds), or in close association with other wetland habitats such as wet meadows or swamps. The edges of marshes, where standing water is less permanent, often grade into wet meadows. Cattails, tussock sedge, common reed, arrow arum, broad-leaved arrowhead, water-plantain, and purple loosestrife are some typical emergent marsh plants in this region. Some marshes are dominated by floating-leaved plants such as pond-lilies, watershield, and duckweeds. Many of the marshes we observed in Pound Ridge were dominated by common reed or cattails.

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

Occurrence in the Town of Pound Ridge

We mapped 35 ac (14 ha) of marsh in the town (Figure 12), much of it occurring as part of larger wetland complexes. Marshes ranged in size from 0.1 to 3 ac (0.04 to 1.2 ha); the largest was in the center of Ward Pound Ridge Reservation, just south of Michigan Road. The southern end of Thalheim Preserve also has an extensive wetland complex with many patches of marsh.

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 compounds, and other contaminants into the wetland. Nutrient and sediment inputs and human or beaver alteration of water levels can also alter the plant community and facilitate invasion by non-native plants such as purple loosestrife and common reed. Purple loosestrife and common reed have displaced many native wetland graminoids in the marsh habitats of our region in recent decades and are dominant in numerous marshes in the town. 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 for their life history needs, protection of the ecological functions of marshes must go hand-in-hand with protection of the surrounding habitats. The Conservation Priorities and Planning section of this report provides recommendations for preserving the habitat values of marshes within larger wetland complexes.

WET MEADOW

Ecological Attributes

A wet meadow is a wetland dominated by herbaceous (non-woody) vegetation, and which retains little or no standing water during most of the growing season. The period of inundation or soil saturation is longer than that of an upland meadow, but shorter than that of a marsh. Some wet meadows are dominated by purple loosestrife, common reed, or reed canary grass, while others have a diverse mixture of wetland grasses, sedges, forbs, and scattered shrubs. Mannagrasses, woolgrass, reed canary grass, soft rush, spotted Joe-Pye-weed, common jewelweed, sensitive fern, and marsh fern are some typical native plants of wet meadows.

Wet meadows with diverse plant communities may have rich invertebrate faunas. Blue flag and certain sedges and grasses of wet meadows are larval food plants for regionally-rare butterflies. Eastern ribbon snake,* which is known from Pound Ridge (Miller and Klemens 2002), may use calcium-rich wet meadows. Wet meadows provide foraging habitat for songbirds, wading birds, raptors, reptiles, and mammals. Wet meadows that are part of extensive meadow areas (both upland and wetland) may be especially important to species of grassland-breeding birds.

Occurrence in the Town of Pound Ridge

We mapped 14 ac (5.7 ha) of wet meadow in the town (Figure 12), the largest being nearly 2 ac (0.8 ha).

Sensitivities/Impacts

Some wet meadows are able to withstand light mowing or light grazing by livestock, but heavy grazing or frequent mowing can destroy the soil structure, eliminate sensitive plant species, and invite non-native weeds. Mowing and grazing when soils are dry, e.g., in late summer, is less damaging to the soils and the plant community, and postponing mowing until late August or September will help to protect late-nesting birds. Wet meadows that are part of larger complexes of meadow and shrubland habitats are prime sites for development or agricultural uses, and are often drained, filled, 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. See the Conservation Priorities and Planning section of this report for recommendations on preserving the habitat values of wet meadows within larger wetland complexes.

FEN

Ecological Attributes

A fen is a low-stature shrub- and herb-dominated wetland that is fed by calcareous groundwater seepage. Fens typically occur in areas influenced by carbonate bedrock (e.g., limestone or marble), and are identified by their low, often sparse vegetation and their distinctive plant community. Tussocky vegetation and small seepage rivulets are often present, and some fens have substantial areas of bare mineral soil or organic muck. Fens in Pound Ridge were dominated by a mix of shrubby cinquefoil, woolly-fruited sedge, and hard-stemmed bulrush. Most of the fens had been invaded by glossy buckthorn and common reed—both non-native—which were often abundant. Other common species were marsh fern, lakeside sedge, inland sedge, bottle-shaped sedge, and skunk-cabbage. The fens had numerous regionally rare plants, including leatherleaf,* large cranberry, round-leaved sundew,* pitcher plant,* grass pink,* buckbean,* grass-of-parnassus,* and alder-leaved buckthorn.* One fen also had brown bog sedge,* and a few had hidden spikemoss.*

Fens are a rare habitat type because of the limited distribution of carbonate bedrock, calcareous soils, and calcareous groundwater seepage, and the historic alteration of wetlands. Fens support many species of conservation concern, including rare plants, invertebrates, reptiles, and breeding birds. More than 12 state-listed rare plants are found almost exclusively in fen habitats, including handsome sedge,* Schweinitz's sedge,* bog valerian,* scarlet Indian paintbrush,* spreading globeflower,* and swamp birch.* Rare butterflies such as Dion skipper* and black dash,* as well as rare dragonflies, such as forcipate emerald* and Kennedy's emerald,* are largely restricted to fen habitats. Other uncommon invertebrates, including phantom cranefly,* can also be found in fens. Fens comprise the core habitat for the endangered bog turtle* in southeastern New York, though this species may have been extirpated from Westchester County. Fens are also used by other reptiles of conservation concern such as the spotted turtle* and eastern ribbon snake,* both known from Pound Ridge (Miller and Klemens 2002).

Occurrence in the Town of Pound Ridge

We mapped twelve fens in Pound Ridge (Figure 11), all over or near a band of Inwood marble (see Figure 2). The fens were all relatively small. The two largest fens that we found, at 0.6 ac and 0.5 ac (0.2 ha), were in a much larger wetland complex west of Trinity Lake. We also mapped three fens within a larger, calcareous swamp complex south of Lake Kitchawan, and several in the Isaacson Preserve.

Fen dominated by hard-stem bulrush, shrubby cinquefoil, and marsh fern

Because fens are difficult to identify by remote sensing, there may be other unmapped fens in areas we did not visit. Unmapped fens are most likely to occur in low-elevation areas over Inwood marble, including edges or interiors of wet meadows, swamps, marshes, or calcareous wet meadows, upper edges of stream floodplains, or at the bases of ridges.

Sensitivities/Impacts

Fens are highly vulnerable to degradation from direct disturbance and from activities in nearby upland areas. Nutrient and salt pollution from septic systems, fertilizers, or road runoff, disruption of groundwater flow by new wells or excavation nearby, sedimentation from agricultural or construction activity, or direct physical disturbance can lead to changes in the character of the habitat, including a decline in overall plant diversity and invasion by non-native species and tall shrubs (Aerts and Berendse 1988, Panno et al. 1999, Richburg et al. 2001, Drexler and Bedford 2002). Such changes can render the habitat unsuitable for bog turtle* and other fen animals and plants that require the particular structural, chemical, or hydrological environment of an intact fen. The Conservation Priorities and Planning section of this report provides recommendations for preserving the habitat values of fens.

SPRING and SEEP

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). Although springs often discharge into ponds, streams, or wetlands such as fens and swamps, we generally mapped only springs and seeps that discharged conspicuously into upland locations. Springs and seeps originating from deep groundwater sources flow more or less continuously, and emerge at a fairly constant temperature, creating an environment that is cooler in summer and warmer in winter than the surroundings. For this reason, seeps and springs sometimes support aquatic or wetland species that are ordinarily found at more northern or southern latitudes. The habitats created at springs and seeps are determined in part by the hydroperiod and the chemistry of the soils and bedrock through which the groundwater flows before discharging. Springs and seeps are water sources for many streams, and they help maintain the cool water temperature of streams, which is an important habitat characteristic for certain rare and declining fishes, amphibians, and other aquatic organisms. Springs and seeps also serve as water sources for animals during droughts and in winters when other water sources are frozen.

Very little is known about the ecology of seeps in the Northeast. Golden saxifrage is a plant more-or-less restricted to springs and groundwater-fed wetlands and streams. Herbaceous plant diversity may be higher in seeps than in surrounding upland forest (Morley and Calhoun 2009). 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* and tiger spiketail* are two rare dragonflies found in seeps. Springs emanating from calcareous bedrock or calcium-rich surficial deposits sometimes support an abundant and diverse snail fauna. Northern dusky salamander* uses springs and cool streams.

Seep in upland hardwood forest

Occurrence in the Town of Pound Ridge

We mapped 34 springs and 30 ac (12 ha) of seepage. Many of the mapped springs and seeps occurred in clusters or loose groupings associated with the same physiographic feature; e.g., a particular hillside or stream valley. They were also usually associated with streams or wetlands. Seeps contained typical wetland vegetation or a mixture of wetland and upland plants. Because the occurrence of springs and seeps is difficult to predict by remote sensing, we mapped only those we saw in the field and those that had a distinct signature on one of our map sources. We expect there are many more springs and seeps in the town that we did not map. More detailed surveys for these habitats should be conducted as needed on a site-by-site basis.

Sensitivities/Impacts

Springs are easily disrupted by disturbance to up-gradient land or groundwater, altered patterns of surface water infiltration, or pollution of infiltrating waters. Some springs have been modified for water supply, with constructed or excavated basins and sometimes spring houses. Pumping of groundwater for human or livestock water supply can deplete water available to nearby springs and seeps.

OPEN WATER

Ecological Attributes

"Open water" habitats include naturally formed ponds and lakes, large pools lacking floating or emergent vegetation within marshes and swamps, and unvegetated ponds that may have originally been constructed by humans but have since reverted to a more natural state (e.g., surrounded by unmanaged vegetation). Open water areas can be important habitat for many common species, including invertebrates, fishes, frogs, turtles, waterfowl, muskrat, beaver, and bats. Open water areas sometimes support submerged aquatic vegetation that can provide important habitat for aquatic invertebrates and fish. Dusky dancer* (a damselfly) is known from a large open waterbody in Pound Ridge (NYNHP 2020). Spotted turtle* uses ponds and lakes during both drought and non-drought periods, and wood turtle* may overwinter and mate in open water areas. Wood duck,* American black duck,* pied-billed grebe,*osprey,* and bald eagle may use open water areas as foraging habitat, and these can be important stopover sites for migrating waterfowl. Bats, American mink, and river otter* also forage at open water habitats.

Occurrence in the Town of Pound Ridge

We mapped 434 ac (176 ha) of open water, or 3% of the town. Most of the large water-supply reservoirs in town were mapped as open water because their shorelines had little or no development. Waterbodies ranged in size from well under one acre to the 117-ac (47-ha) Trinity Lake. Other large open water areas included the Mill River Reservoir (71 ac [29 ha]), the Siscowit Reservoir (42 ac [17 ha]), and Lake Kitchawan (42 ac [17 ha]), which extends into neighboring Lewisboro.

Sensitivities/Impacts

Female spangled skimmer, a dragonfly of ponds and lakes.

The habitat values of natural open water areas are often greater than those of constructed ponds, since the areas are less intensively managed, less disturbed by human activities, and surrounded by undeveloped land. Open water habitats are vulnerable to human impacts such as 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, Kiviat 2009). Because open water areas are often within larger wetland and stream complexes, any disturbance to the habitat may have far-reaching effects on the surrounding landscape. To protect water quality and habitat values, broad zones of undisturbed vegetation and soils should be maintained around ponds and lakes. If part of a pond or lake must be kept open (unvegetated) for ornamental, recreational, 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 are waterbodies that have been excavated or dammed by humans, either in existing wetlands or streambeds, or in upland terrain. Many of these ponds are created for fire protection, fishing, watering livestock, irrigation, swimming, boating, or aesthetics. Some were excavated incidental to mining operations. If constructed ponds are not intensively managed by humans, they can be important habitats for many of the common and rare species that are associated with naturally formed open water habitats (see below). We have mapped constructed ponds and reservoirs that have long been unmanaged and are now surrounded by intact habitats as "open water" or "marsh," depending on the vegetation structure.

Occurrence in the Town of Pound Ridge

More than half of the waterbodies in the town were constructed ponds, but these occupied a much smaller area, 218 ac (88 ha), than the areas mapped as open water. The largest constructed pond was 10.2 ac (4 ha). Most constructed ponds were ornamental ponds or former agricultural ponds. Ornamental ponds were usually located within landscaped areas in close proximity to residences. Because of the potential value of constructed ponds as drought refuges and foraging areas for turtles, waterfowl, wading birds, and other wildlife, we mapped constructed ponds within developed areas as well as those surrounded by intact habitats. Constructed ponds with substantial cover of emergent vegetation (e.g., cattail, purple loosestrife, common reed) were mapped as marsh.

Sensitivities/Impacts

The habitat values of constructed ponds vary depending on the landscape context and the extent of human disturbance. In general, the habitat value is higher when the ponds have undeveloped, unmanaged shorelines, are relatively undisturbed by human activities, have more vascular plant vegetation, and are embedded within an area of intact habitat. Because many constructed ponds are not buffered by sufficient natural vegetation and undisturbed soils, they are vulnerable to the adverse impacts of agricultural runoff, septic leachate, and pesticide or fertilizer runoff from lawns and gardens. Ponds that are treated with herbicides or other pesticides, or have introduced fish such as grass carp and non-native game and forage fishes are likely to have limited value for native plants and animals.

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

STREAM and RIPARIAN CORRIDOR

Ecological Attributes

Perennial streams flow continuously throughout years with normal precipitation, but some may dry up during droughts. They provide essential water sources 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 areas. These corridors often have a variety of wetland and non-wetland forests, meadows, and shrublands, and are integral to the stream ecosystem.

We did not map actual riparian corridors but instead mapped "conservation zones" of a set width on either side of streams (Figure 13). These zones represent a minimum area along the stream that is needed for effective protection of stream water quality, habitat quality, and wildlife (see Streams & Riparian Corridors in the Priority Habitats section). Our mapped zones do not necessarily cover the whole riparian corridor for any stream, however, which varies in width depending on factors such as local topography, soil characteristics, and land uses in the watershed, and in some cases the size of the stream.

Forested perennial stream

Rare plants of riparian areas in the region include cattail sedge,* Davis' sedge,* winged monkeyflower,* and goldenseal,* among others. The fish and aquatic invertebrate communities of perennial streams may be diverse, especially in clean-water streams with unsilted bottoms. Tiger spiketail* and arrowhead spiketail* (dragonflies) are both known from streams in Pound Ridge (NYNHP 2020). Brook trout* is a native species that requires clear, cool streams for successful spawning and other life needs. Wild brook trout, while confined largely to small headwater streams in the region due to degraded water quality and competition from brown trout (a non-native species), is present in a few streams in the WPRR. Wood turtle* uses perennial streams with deep pools and recumbent logs, undercut banks, or muskrat or beaver burrows, and is known to occur in Pound Ridge (Miller and Klemens 2002). Perennial streams and their riparian zones 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,* and green heron. Red-shouldered hawk* and cerulean warbler* nest in areas with extensive riparian forests, especially those with mature trees. Bats use perennial stream corridors for foraging. Muskrat, beaver, American mink, and river otter* are some of the mammals that regularly use riparian corridors.

Intermittent streams may flow for a few days or for many months during the year, but ordinarily dry up at some time during years of normal precipitation. They are the headwaters of most perennial streams, and are significant water sources for lakes, ponds, and wetlands of all kinds. The condition of these streams therefore influences the water quantity and quality of those larger waterbodies and wetlands. Intermittent streams provide microhabitats not present in perennial streams, supply aquatic organisms and organic drift to downstream reaches, and can be important local water sources for wildlife (Meyer et al. 2007). Their loss or degradation in a portion of the landscape can affect the presence and behavior of wildlife populations over a large area (Lowe and Likens 2005). Plants such as winged monkeyflower* and may-apple* 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* and northern two-lined salamander. The forests and, sometimes, meadows adjacent to streams provide foraging habitats for adults and juveniles of these species.

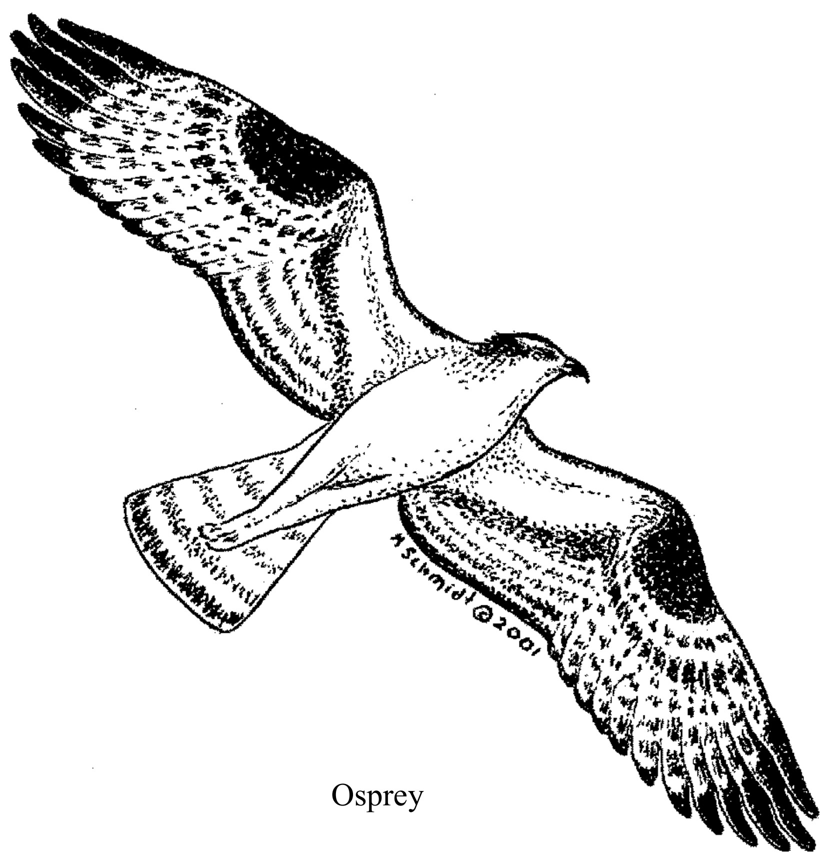
Occurrence in the Town of Pound Ridge

Figure 13 shows the streams throughout Pound Ridge. The largest streams are the Cross River, Mill River, Stone Hill River, and Mianus River. While only a short length of the Cross River flows through the northeastern part of town, the Mill River (3.9 mi [6.3 km]) and Stone Hill River (3.2 mi [5.2 km]) both have significant lengths in the town. The Mianus River flows south along the southwestern boundary of the town, through the Mianus Gorge, for about 2.5 mi (4 km). Other named streams include the Rippowam River, the Waccabuc River, and the East Branch Mianus River. Numerous perennial and intermittent tributaries flow into these larger streams. The combined length of perennial streams mapped in the town was 20 mi (32 km). Intermittent streams were myriad, with a combined length of 50 mi (81 km).

Sensitivities/Impacts

Removal of trees or other shade-producing vegetation along a stream can lead to elevated water temperatures that adversely affect aquatic invertebrate, salamander, and fish communities. Clearing of vegetation in and near floodplains can reduce the important exchange of nutrients and organic materials between the stream and the floodplain, and reduce the amount and quality of organic detritus available to support the aquatic food web. It can also diminish the floodplain's capacity for floodwater attenuation, leading to increased flooding downstream, scouring and bank erosion, and sedimentation of downstream reaches. Any alteration of flooding regimes, stream water volumes, timing of runoff, and water quality can profoundly affect these habitats and the species that use them. 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. Removal of snags (fallen trees or logs) from the streambed degrades habitat for fishes, turtles, snakes, birds, muskrats, and their food organisms.

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, or catchment, is the entire land area that drains into a given waterbody). Watershed urbanization—including roads and residential, industrial, and commercial development—has been linked to deterioration in stream water quality (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, parking lots, roofs) may elevate runoff volumes, leading to erosion of stream banks and siltation of stream bottoms or incision (deep erosion of streambeds), degrading the habitat for invertebrates, fish, and other animals. Road runoff often carries contaminants such as petroleum hydrocarbons, heavy metals, road salt, sand, and silt into streams. Fertilizers and pesticides applied 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. The Conservation Priorities and Planning section of this report provides recommendations for protecting the habitat values of streams and riparian corridors.



Osprey

CLIMATE CHANGE AND BIODIVERSITY

In 2011, the New York State Energy Research and Development Agency (NYSERDA) issued a report titled *Responding to Climate Change in New York State* (Rosenzweig et al. 2011), nicknamed the ClimAID report, and then published a brief update with new information in 2014 (Horton et al. 2014). The ClimAID projections for air temperature, precipitation, heat waves, sea-level rise, and flooding for the state through 2100 were developed with regional data in a global model used for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report. Westchester County is in the part of the state called ClimAID Region 5 that encompasses the Mohawk Valley region and Hudson Valley counties east of the Hudson River. Much of the information in the discussion of climate change below is from the ClimAID documents.

Global air temperatures have been increasing for the last century (Horton et al. 2014). Here in Westchester County, springs arrive sooner, summers are hotter, fall frosts begin later, spring frosts end earlier, winters are warmer, and depth and duration of snow cover are reduced from those of past decades. The effects of climate change are likely to be felt more acutely in the coming years—higher temperatures, larger and more frequent floods, more severe droughts, wildfires, and more frequent and more severe storms, as well as some less dramatic symptoms such as increases in invasive pests, and pathogens affecting humans and wildlife, and depletion of native biological diversity (Rosenzweig et al. 2011).

Climate change is driven by emissions of greenhouse gases (GHGs) to the atmosphere—especially carbon dioxide, methane, and nitrous oxide—that trap heat near the earth's surface. The increased emissions are largely due to human activities such as production, transport, and burning of fossil fuels in power plants and automobiles, and by the accumulated effects of many other activities, such as burning of wood and other organic materials, and emissions from agriculture and industry. If worldwide GHG emissions are lowered in the coming years, then the changes we experience will still be significant but reduced. If emissions continue to increase at the current rate, however, these changes are likely to increase dramatically over the coming decades.

Large rainstorms and snowstorms, ice storms, heat waves, and droughts have long been characteristic of New York State and the Northeast in general, but overall climate patterns remained fairly consistent since European settlement until the latter part of the 20th century (Union of Concerned Scientists 2006). The climate is now changing rapidly, and some aspects are changing more rapidly in the Northeast than in the rest of the US or the world. A warming climate is expected to affect both the quantity and quality of Westchester County's groundwater and surface water resources, as well as the habitat quality of streams and ponds. Both total annual rainfall and rainstorm intensity are predicted to increase in New York in the coming years, with multiple consequences to the land and water resources.

In New York, average annual temperatures have increased 2°F since 1970 and average winter temperatures have increased 5°F. Higher temperatures are creating new problems for human health, agriculture, energy demand, and recreation, as well as for plants, animals, and habitats of natural areas. The average annual temperature in Westchester County is projected to increase approximately 4-6°F by mid-century and as much as 11 degrees by the end of the century. Summer heat waves are expected to be more frequent, more intense, and lengthier. Even at the lowest projected rate of carbon emissions, Westchester County summers by 2100 could be similar to those of northern North Carolina today (Union of Concerned Scientists 2006).

In the northeastern US, the total precipitation amount has increased only slightly in recent decades, but has become much more variable and more extreme. The amount of rain falling in heavy storm events increased 74% from 1958 to 2011. The current models predict that total annual precipitation could increase as much as 12% by 2050 and 21% by 2100 (Horton et al. 2014). The models project more droughts, heavier rains in the intervening periods, and reduced snow cover in winter (Rosenzweig et al. 2011).

In addition to more extreme precipitation events, periods of drought are predicted to become more frequent and more severe in New York. Droughts can severely stress aquatic communities of streams and ponds, and plants and wildlife in natural upland and wetland habitats. Droughts can extend the low-flow period of streams, and further stress the fish and other organisms that are already suffering from pollution, warmer stream temperatures, and stream barriers. Drought can threaten drinking water supplies, including both surface water reservoirs and groundwater wells. In the higher-emissions scenario, long-term droughts (longer than three months) that now occur every 20-30 years could occur every 6-10 years (Union of Concerned Scientists 2006).

More frequent and intense heat waves pose threats to human health, agriculture, wildlife, and native plants, and are likely to alter many aspects of the natural landscape. Warmer, shorter winters are predicted to increase the occurrence of rainfall while the ground is frozen, hastening snowmelt, reducing groundwater recharge, and increasing the likelihood of flooding.

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

Heat stress and the effects of warmer winters with less snow cover may eliminate some of the cold-adapted species— such as sugar maple, brook trout, and fisher—from our landscapes. Together with non-climate stressors such as habitat fragmentation, water pollution, invasive species, and overharvesting, climate change may have synergistic effects that magnify the stresses and hazards to wildlife. Warmer winters with less snow will alter the habitat suitability for native plants and animals. Warmer, shorter winters and prolonged winter thaws may make some perennial plants more vulnerable to mid-winter freeze damage by disrupting their accustomed dormancy period, and may subject the early leaves and flower buds to frost damage (Wolfe et al. 2011). Reduced snow cover will harm small mammals and other animals that depend on snow for insulation and protection from predators, but may favor white-tailed deer—already over-abundant—whose intense grazing pressure has been transforming our forests for several decades. Many of our native plants and animals have adapted over thousands of years to the seasonal temperature ranges of the Northeast, and are ill-equipped to adapt quickly to the present-day pace of warming—several orders of magnitude faster than the temperature changes experienced during the most recent Ice Age (Wolfe et al. 2011). The widespread fragmentation of today's landscape by roads and land development poses additional obstacles to adaptation and migration.

Alterations to air temperatures, snow cover, and freeze/thaw patterns are likely to disrupt the seasonal synchrony between pollinators and plants, and predators and prey. Already, many plant species now bloom 4-8 days earlier on average than in the early 1970s (Union of Concerned Scientists 2006)—an effect that may have far-reaching ecological consequences. Insect pollinators whose activity periods are closely tied to the particular flowering periods of their food plants may find that their pollen and nectar food is unavailable at critical times in the pollinators' life cycles. This would add to the existing stresses from more frequent and more severe weather events, and could severely harm regional populations of these insects.

Longer growing seasons may increase overall forest productivity (Kareiva and Ruckelshaus 2013), but increases in pests and pathogens may cancel out the potential benefits to the timber industry. Shorter, warmer winters and longer, hotter summers have been aiding the spread of pathogens and invasive non-native species. Pathogens that benefit from less-severe winters will also take advantage of the weakened condition of trees and other plants stressed by rising temperatures and droughts. Invasive plants such as mile-a-minute weed are expected to thrive under elevated atmospheric levels of carbon dioxide (Wolfe et al. 2011). Forest pests such as the hemlock woolly adelgid and the emerald ash borer are likely to transform our forest communities with wide-ranging ecosystem consequences.

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

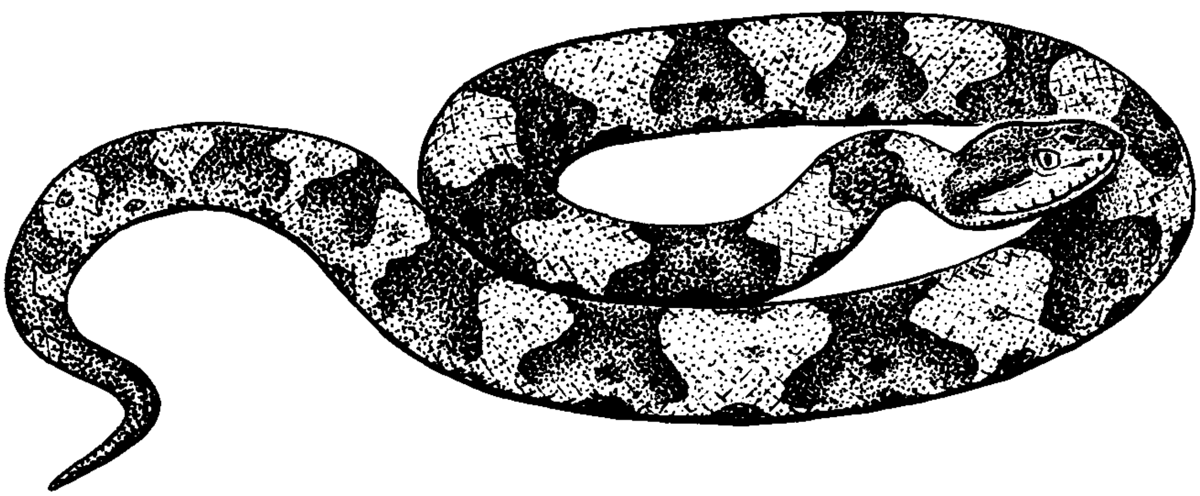
Wetlands that have perennially saturated soils develop deep layers of peat—decaying organic matter—that continues to accumulate over hundreds and thousands of years if the wetland hydrology and vegetation remains intact. Due to this capability for peat accumulation, wetlands have the greatest capacity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

Flooding hazards may increase due to the increased intensity of large rainstorms. The areas within 100-year and 500-year flood zones will be particularly at risk, but additional areas may also be affected. The magnitude of flooding at any location will depend on the timing and intensity of large storms and the condition of the land—the ability to absorb large water volumes at the time of the storm—as well as the structures or other obstacles in the flood zone that may act to divert, concentrate, and accelerate floodflows. While floods and droughts are normal and expected events in this region, extreme floods and droughts can add to the multiple stresses on ecosystems from human activities. Floods and droughts, as well as increases in water temperatures, are likely to adversely impact sensitive stream organisms that rely on cool, clear streams and unsilted stream substrates.

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

Ticks do not survive prolonged periods of very cold temperatures. Warming temperatures are a significant factor in the northward spread of Lyme disease (Leighton et al. 2012) and the increased numbers of Lyme-infected ticks in the Northeast (Levi et al. 2015). The flourishing populations of wood ticks and Lyme-infected black-legged ticks in Westchester County have been aided by the warmer winter temperatures. Perhaps an even greater threat than increased populations of pest organisms is the likelihood of greater use of pesticides, which can have wide-ranging detrimental effects on non-target species.

The best ways to preserve ecosystem functions and native biodiversity in the changing environment are to maintain intact, broadly-connected areas with complex physical geography and diverse habitats. This will preserve the habitats of area-sensitive wildlife species that require large habitat patches to fulfill their life history needs, will afford plants and animals the greatest array of options as they adjust to new conditions, and will help to ensure the continuity of ecosystems, even when the composition of biological communities changes.



Northern copperhead is a NYS Species of Greatest Conservation Need
(Illustration: Kathleen A. Schmidt © 2001)

CONSERVATION PRIORITIES AND PLANNING

Planning and Biodiversity

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 losses from thousands of site-by-site decisions are substantial. Regional impacts include the disappearance of certain habitats from whole segments of the landscape, the fragmentation and degradation of many other habitats, the local extirpation of species, the depletion of overall biodiversity, and the impairment of ecosystem function and services.

Because biological communities, habitats, and ecosystems cross property and municipal boundaries, the best approach to biodiversity conservation is from the perspective of whole landscapes. The Pound Ridge habitat map facilitates this approach by illustrating the location and configuration of significant habitats throughout the town. The map, together with the information provided 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 townwide 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 Pound Ridge 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 the valuable biological and water resources.

A variety of regulatory and non-regulatory means can be employed by a municipality to achieve its conservation goals, including volunteer conservation efforts by individual land-owners, master planning, zoning ordinances, tax incentives, land stewardship incentives, permit conditions, land acquisition, conservation easements, and public education. 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 land-use 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 local zoning ordinance. The *Local Open Space Planning Guide* (NYSDEC and NYSDOS 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. A publication from Cornell and the New York State Department of Environmental Conservation (NYSDEC), *Conserving Natural Areas and Wildlife in Your Community* (Strong 2008), describes the tools and resources available to municipalities to help protect their important natural assets.

In addition to regulations and incentives designed to protect specific types of habitat, the town can also apply some general practices on a townwide basis to foster biodiversity conservation. The examples listed below are adapted from the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001). We encourage the Town of Pound Ridge to apply these measures to townwide planning and to every new land-use proposal that comes before the town, and to distribute this list to applicants who are considering new land-use projects.

- **Protect large, contiguous, undeveloped tracts** wherever possible.
- **Plan landscapes with interconnected networks of undeveloped habitats** (preserve and restore links between natural habitats on adjacent properties). 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 fires, floods, seasonal water level changes, landslides, and wind exposures wherever possible.
- **Restore and maintain broad buffer zones** of natural vegetation along streams, shores of waterbodies and wetlands, and around the perimeters 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 (with exceptions for such areas that support rare species that would be harmed by development).
- **Preserve farmland soils and farmland potential** wherever possible by avoiding development on Prime Farmland Soils or Farmland Soils of Statewide Importance, and avoiding fragmentation of active or potential farmland.
- **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, site design, and construction practices.
- **Concentrate development near existing population centers and along existing roads**; discourage construction of new roads in undeveloped areas. **Promote clustered and pedestrian-centered development** wherever possible to maximize extent of unaltered land and minimize expanded vehicle use.
- **Minimize areas of lawn and impervious surfaces** (roads, parking lots, sidewalks, driveways, roof surfaces) and design stormwater management to maintain pre-construction volumes and seasonal patterns of onsite runoff retention and infiltration. These measures will foster groundwater recharge, protect offsite surface water quality, and moderate downstream flood flows. Retrofit existing infrastructure to achieve these goals wherever possible.
- **Restore degraded habitats wherever possible**, but do not use restoration projects as a license to destroy existing habitats. Base any habitat restoration on sound scientific principles and research in order to maximize the likelihood of having the intended positive impacts on biodiversity and ecosystems. Any restoration plan should include monitoring of the restored habitat for at least several years to assess the outcomes and regular maintenance to protect restored features from degradation.
- **Modify urban areas to provide more habitat elements** (for example, rain gardens and tree-lined streets). Use public education and incentives to encourage private landowners to improve the habitat quality of their yards.

- **Promote the establishment of conservation agreements** on parcels of greatest apparent ecological value.

Using the Habitat Map for Townwide Conservation Planning

The Pound Ridge 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. Habitat fragmentation is among the primary threats to biodiversity worldwide (Davies et al. 2001) and in the Hudson Valley. While some species and habitats may be adequately protected in small patches, many wide-ranging species, such as black bear,* barred owl, and red-shouldered hawk,* require large, unbroken blocks of habitat. Many species, such as wood turtle,* spotted turtle,* and Jefferson salamander,* need to travel among different habitats to satisfy their basic needs for food, water, cover, nesting and nursery areas, and population dispersal. Landscapes that are fragmented by roads, utility corridors, and development limit animal movements and interactions, disrupting patterns of dispersal, reproduction, competition, and predation. Habitat patches surrounded by human development function as islands, and species unable to move between habitats are vulnerable to genetic isolation and possible extinction over the long term.

Landscapes with interconnected networks of unfragmented habitat, on the other hand, are more likely to support a broad diversity of native species and the ecological processes and disturbance regimes that maintain those species. Corridors and habitat connectivity allow for the safe movement of organisms as they adapt to changing conditions, so will become even more important in the face of global climate change. Careful siting and design of new development can help to protect the remaining large habitat patches (Figure 4) and maintain broad corridors between them.

The habitat map can also be used to identify high priority habitats for conservation, including those that are rare or support rare species, or that seem particularly important to regional biodiversity. For instance, the buttonbush pool and nearby wetland and upland habitats may support the spotted turtle, which needs a complex of habitats to fulfill its seasonal needs for foraging, nesting, basking, aestivating, rehydrating, and overwintering. Figures 7-12 illustrate the areas we have identified as "priority habitats" and their "conservation zones." These places are especially valuable if they are located within larger areas of intact and connected habitat (Figure 4).

The habitat map and this report are practical tools that can help the town select areas for protection and identify sites for new development where the ecological impacts will be minimized. The map can also be used with the biotic corridor map (Miller and Klemens 2002) and the habitat map of Bedford for conservation planning across town boundaries.

Reviewing Site-Specific Land Use Proposals

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

1. Consult the large-format habitat map to see what kinds of ecologically significant habitats have been identified on and near the project site.
2. Read the descriptions of those habitats in this report, and note the discussion of habitat sensitivities.
3. Consult Figures 7-12 to see if any of the "Priority Habitats" or their conservation zones occur on or near the site. 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 and their conservation zones, as well as the ecological connections between them, are maintained intact. Examples of design modifications include but are not limited to:
    - Locating human activity areas as far as possible from the most sensitive habitats.
    - Minimizing intrusions into large forested or meadow 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 streams or wetlands fed by groundwater.

- Channeling stormwater runoff from paved areas or fertilized turf through oil-water separators and into detention basins or “rain gardens” instead of directly into ditches, streams, ponds, or wetlands.
- Locating developed features such that broad corridors of undeveloped land are maintained between important habitats on and off the site.

6. Consider how the new project could be designed to maximize the habitat connectivity between onsite and offsite habitat areas.

Because the habitat map has not been 100% field-verified we emphasize that, at the site-specific scale, it should be used strictly as a general guide for land-use planning and decision making. Site visits by qualified professionals to identify the details of habitats and ecological communities should be an integral part of the review process for any proposed land-use change.

Oyster mushrooms on a sugar maple log

Landscape-scale Conservation

Habitat loss and fragmentation are significant threats to wildlife populations, especially for those that have large area requirements or those that need to move between habitats to fulfill their life history needs. In this age of a rapidly changing climate, migration and dispersal needs are even greater (Debinski and Holt 2000, Walther et al. 2002, Howard and Schlesinger 2013). Many models have predicted that species will need to move to higher latitudes or higher elevations, or seek out *in situ* microclimate refugia (Walther et al. 2002, Howard and Schlesinger 2013, Morelli et al. 2016) as former habitats become unsuitable. These movements are increasingly hazardous in the urbanizing and fragmented landscapes of southeastern New York.

One approach to landscape conservation in these fragmented landscapes is a network of conservation areas in a hub-and-spoke configuration, in which a large area—a "hub"—that provides continuous habitat for plants and animals is connected by spokes, or corridors (Brown and Harris 2005). If the hub area is large and unfragmented and has diverse habitats, the target species should be able to succeed in these areas over multiple generations (Brown and Harris 2005). The connecting areas between hubs may be highly constrained by developed land. While the term "corridor" conjures an image of a linear, narrow landscape feature, the broader the corridor is, the more likely it will be used successfully by a wide array of wildlife species (Ricketts 2001, Brown and Harris 2005). Narrow corridors have a large edge-to-interior ratio, which influences the interior conditions (moisture, light, noise) and wildlife use.

The hub-and-spoke models are frequently subsidized by "stepping stone" areas, which are smaller and can be used as temporary refugia between hubs (Saura et al. 2014). While the hub-and-spoke models have some limitations, the goal is to maintain a network of large habitat areas within a fragmented landscape that is still somewhat permeable to wildlife (Ricketts 2001, Brown and Harris 2005, Howard and Schlesinger 2013, Saura et al. 2014).

The hub-and-spoke model can be implemented at multiple scales to achieve connected landscapes. Within the Hudson Valley, five large habitat areas have been identified for wildlife conservation and migration (Hudson Highlands, Shawangunk Range, Catskill Mountains, Taconic Mountains, Rensselaer Plateau) (Howard and Schlesinger 2013). The closest large area, the Hudson Highlands, can be connected to Pound Ridge via the Eastern Westchester Biotic Corridor (EWBC), a regionally important area of 22,000 acres (8900 hectares) running through the towns of Pound Ridge, Lewisboro and North Salem, delineated by the Metropolitan Conservation Alliance (Miller and Klemens 2002) (Figure 5). The original EWBC was extended to include habitat areas in the Town of Bedford, based on field surveys by MCA (LaBruna and Klemens 2007). Additionally, ecologically significant habitats throughout Bedford have been mapped by the Bedford Conservation Board (Figure 6). Much of Pound Ridge is within the EWBC, and the central hub is the Ward Pound Ridge Reservation. The WPRR, straddling the boundary between Pound Ridge and Lewisboro, is designated by NYS DEC as a Significant Biodiversity Area (Penhollow et al. 2006) and, at 4,700 acres (1900 ha), is the largest continuous habitat area within the EWBC.

The goal of the EWBC project was to establish a regional, multi-town approach to the conservation of wildlife and habitats. The four towns were selected because they contain an impressive diversity of wildlife and habitats; they are under development pressures that threaten those natural resources; and there is a growing awareness within the towns of a need to address these issues (Miller and Klemens 2002).

The EWBC was identified by surveying "focal species" throughout the original, tri-town area. Focal species are those that respond very noticeably to land development, habitat loss, and habitat fragmentation. The analysis considered two broad categories of focal species:

> Category I (Specialists): Species that experience population declines as a result of urbanization. These tend to be wildlife with very specific habitat requirements, such as neotropical migratory songbirds or pool-breeding amphibians. These species often disappear from human-settled landscapes.
>
> Category II (Generalists): Species that experience population increases in response to urbanization. These tend to be habitat generalists, such as bullfrog, blue jay, and gray squirrel.

The MCA used existing data from the New York Natural Heritage Program and from the Ward Pound Ridge Reservation and conducted additional field surveys to discover the relative proportion of Category I and Category II species in different parts of the three towns, and assess the relative importance of individual sites for conservation. Those sites with solid populations of Category I species are likely to have higher quality, less-degraded habitats than those with higher proportions of Category II species, and may therefore be more worthy of conservation efforts. Directing new development to the more-degraded areas will help preserve the ecological integrity of the more intact sites, and will help to maintain the rich biological diversity of these towns and the region.

MCA analyzed species distribution, habitat requirements, and habitat distribution throughout their study area, and delineated the Eastern Westchester Biotic Corridor to encompass the areas where Category I species were most concentrated and where an array of key intact habitats still persists. Methods were replicated for the Bedford addendum (LaBruna and Klemens 2007). The EWBC is a broad swath that necessarily includes developed areas, but can help to focus conservation attention on the remaining areas of intact habitat.

The EWBC assessment reported many species of conservation concern in Pound Ridge including river otter,* bobcat*, northern dusky salamander,* eastern ribbon snake,* bog turtle,* bobolink,* and American woodcock,* (see Miller and Klemens [2002] Table 1 for full species list). While WPPR stood out as both a hub and biodiversity hotspot, Trinity Lake was identified as having the highest bird diversity throughout the three towns, and was particularly important for migrating warblers. The EWBC report stresses the importance of maintaining the "spokes" of conserved land radiating from the biodiversity hubs so that the landscape remains permeable to wildlife and the hubs do not become isolated habitat areas. Landscape permeability in Pound Ridge was found to be relatively high for Westchester County due to the high proportion of forest and the relatively low population density.

Although landscape-scale conservation is the big-picture goal for many conservation efforts, most land use decisions are still made on a local scale. Therefore, we encourage towns such as Pound Ridge, Lewisboro, and North Salem to keep the larger landscape in mind when considering townwide planning issues and site-specific environmental reviews, and to prioritize the conservation of areas of highly-connected ecologically significant habitats.

Priority Habitats in Pound Ridge

While large areas of the town have been developed for residential uses, large areas of high-quality habitat yet remain. These areas are not only important locally but also contribute greatly to regional biodiversity. The WPRR by itself has been designated one of the NYSDEC Significant Biodiversity Areas (Penhollow et al. 2006), which are selected areas of the Hudson Valley that stand out for their intact biological communities, the presence of rare or declining species, or an array of regionally important habitats. A large swath of the town lies within the Eastern Westchester Biotic Corridor, a concept designed by Miller and Klemens (2002) to build upon the 4,700-ac (1,900 ha) core habitat of the WPRR. The corridor spans the towns of North Salem, Lewisboro, Pound Ridge, and Bedford, and encompasses an extensive array of intact habitats, wildlife, and plants (see *Landscape-Scale Conservation*, above). Areas of Pound Ridge that are outside the EWBC are also important for local and regional biodiversity, with the large tracts of intact forest, numerous woodland pools and pool complexes, and such special places as the Henry Morgenthau Preserve, the Zofnass Preserve, and the Mianus River Gorge.

Animals of conservation concern known to occur in Pound Ridge include but are limited to marbled salamander,* northern dusky salamander,* Fowler's toad,* spotted turtle,* wood turtle,* eastern box turtle,* eastern worm snake,* eastern ribbon snake,* eastern hognose snake,* northern copperhead,* American woodcock,* red-shouldered hawk,* Cooper's hawk,* northern goshawk,* American kestrel,* brown thrasher,* wood thrush,* worm-eating warbler, * Canada warbler,* cerulean warbler, * and scarlet tanager* (Miller and Klemens 2002; McGowan and Corwin 2008; https://www.dec.ny.gov/animals/7140.html, Anonymous, pers. comm.).

By employing a proactive approach to land-use and conservation planning, the Town of Pound Ridge has the opportunity to protect the integrity of remaining biological resources for the long term. With limited funds, time, and attention to devote to conservation purposes, however, municipal agencies must decide how best to direct those resources to maximize conservation outcomes. While it is impossible to protect all significant habitats, there are reasonable ways to prioritize conservation efforts using the best available scientific information. Important

Figure 5. Eastern Westchester Biotic Corridor in North Salem, Lewisboro, and Pound Ridge (Miller and Klemens 2002), and Bedford extension (LaBruna and Klemens 2007). Hudsonia Ltd, 2021.

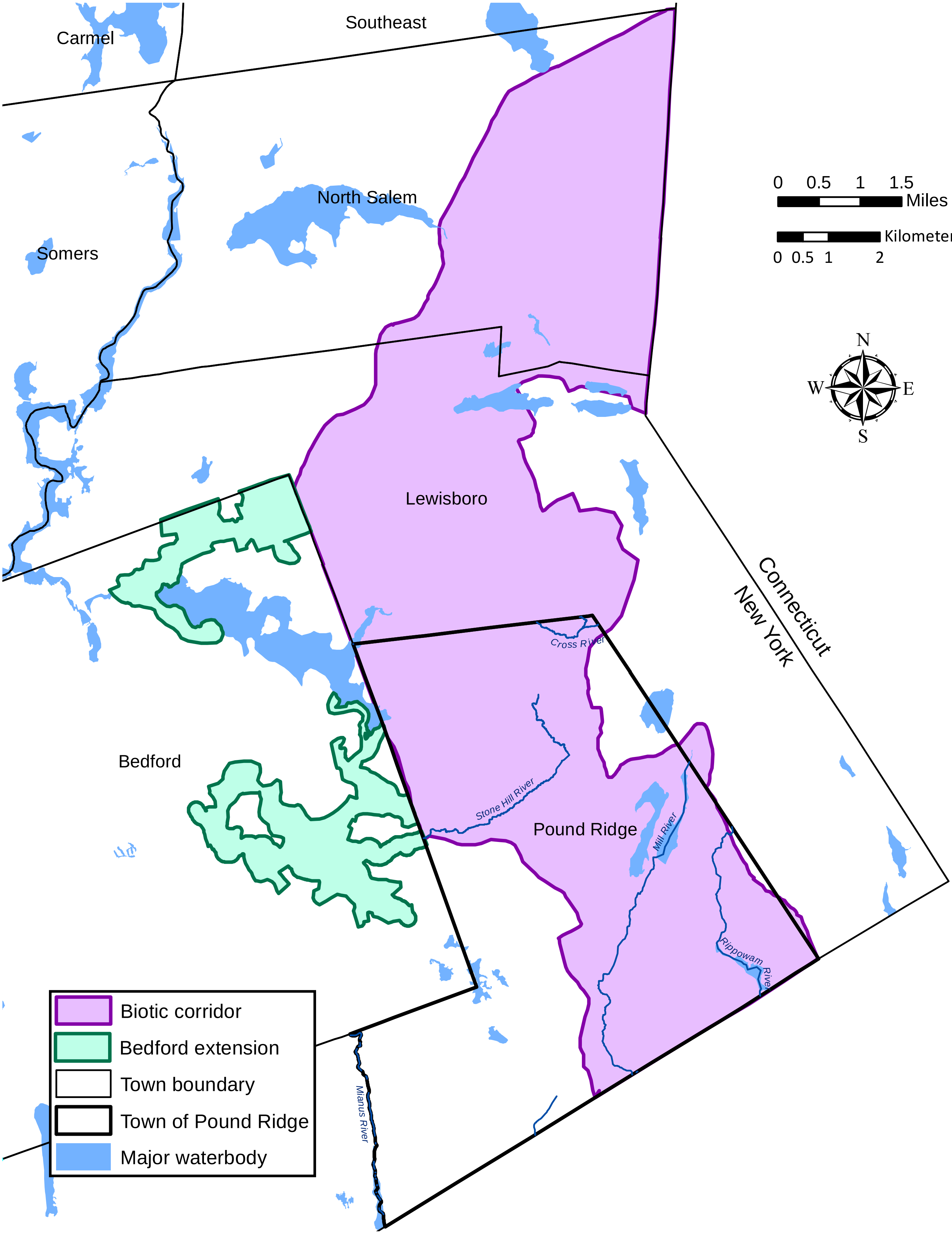
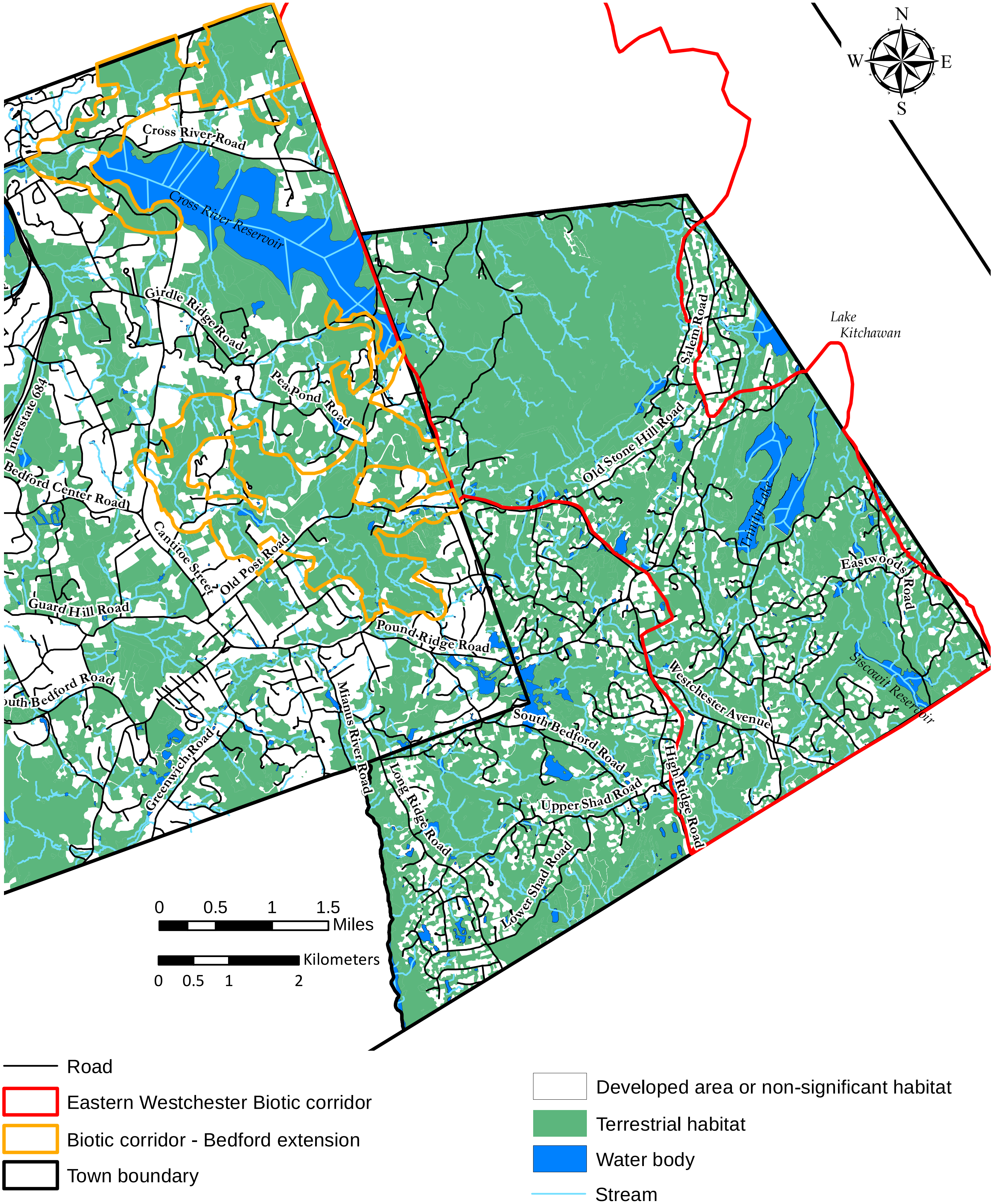


Figure 6. Habitat patches in the towns of Pound Ridge and Bedford, as identified and mapped by Hudsonia and the Bedford Conservation Board. Hudsonia Ltd, 2021.



considerations in prioritizing such efforts include preserving the most sensitive habitat types, high quality habitat units, and a variety of habitats well-connected and well-distributed over the landscape. Below we highlight some habitat types that we consider "priority habitats" for conservation in the town. It must be understood, however, 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 is a subset of those with more urgent conservation needs.

We used the requirements of a selected group of species to help identify some of the areas where conservation efforts might yield the greatest return for biological diversity. For each of the "priority habitat" types, we chose a species or group of species that have large home ranges, specialized habitat needs, or acute sensitivity to disturbance (see Table 2). Many of these are rare or declining in the region or statewide. Each of the species or groups requires a particular habitat type for a crucial stage in its life cycle (e.g., hibernation, breeding), and those "core habitats" typically form the hub of the animal's habitat complex. In many cases, the focal species also requires additional habitat types for other life history needs, and these habitats are typically located within a certain distance of the core habitat. This distance defines the extent of the species' habitat complex and, therefore, the minimum area that must be protected or managed in order to protect the local population and conserve the species. We call this the "conservation zone" and discuss the size of this zone in the "Conservation Issues" and "Recommendations" subsections for each priority habitat description. (The conservation zone distances are measured from the outer periphery of the core habitat, not from its center.) We used findings in scientific literature to estimate the priority conservation zone for the species of concern (Table 2). If the habitats of the highly sensitive species of concern are protected, many other rare and common species that occur in the same habitats will also be protected.

Table 2. Priority habitats, species of concern, and associated priority conservation zones identified by Hudsonia in the Town of Pound Ridge, Westchester County, New York, 2021.

Priority Habitat	Associated Species or Group of Concern	Priority Conservation Zone	Rationale	References
Large forest	Forest interior-breeding birds	Unfragmented patches of at least 130+ ac (53+ ha)	Required for high probability of supporting breeding hermit and wood thrush in a 60% forested landscape.	Rosenberg et al. 2003
Rocky barrens and extensive crest/ledge/talus	Northern copperhead, eastern ratsnake, northern black racer	Extensive crest/ledge/talus, and 3,300 ft (1,000 m) zone around barrens habitats	Includes habitat essential for denning, nesting, basking, foraging, and dispersal.	Fitch 1960, Todd 2000, Blouin-Demers and Weatherhead 2002
Intermittent woodland pool	Pool-breeding amphibians	750 ft (230 m) from pool.	Area of non-breeding season habitat considered critical for sustaining populations.	Madison 1997, Semlitsch 1998, Calhoun and Klemens 2002, Veysey et al. 2011
Fen	Rare plants	entire watershed of the fen and connected wetlands	Land uses within the watershed affect the quality and quantity of surface water and groundwater feeding fen, which affect plant populations.	Kiviat and Stevens 2001
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	820 ft (250 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, Tingley et al. 2009

Large Forests

Target Areas

Rich bottomland forest with abundant forest herbs

In general, forested areas (including both upland forest and swamp) 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 corridors or patches that could be used as "stepping stones," are also valuable in a landscape context. The largest forest areas in Pound Ridge are illustrated in Figure 7. The largest forest by far, at 2,800 ac (1,130 ha), was in the WPRR in northern Pound Ridge. Two forest patches totaled between 400 and 500 ac (160 and 200 ha): one surrounding the Zofnass Preserve in southwestern Pound Ridge, and another in the Eastwoods area around the Siscowit Reservoir. Two other patches, around Trinity Lake and Mill River Reservoir, were separated only by the reservoir, and were in fact contiguous with each other to the north in the Town of Lewisboro. If combined, these two forest patches (343 ac and 189 ac [139 ha and 76 ha]), which are separated in some places by as little as 100 ft (30 m) across Mill River Reservoir, would form one forest block of 532 ac (215 ha). Three other forest patches fell between 200 and 250 ac (81 and 101 ha), a critical threshold for several forest-breeding birds of our region (Rosenberg et al. 2003; see below). One of these contained the Bye Preserve and a high-quality hardwood-hemlock ravine east thereof; another was a long, narrow band of forest that lay along the Mianus River in the Mianus Gorge, and connected with more contiguous forest to the west in the Town of North Castle, and to the north in the Town of Bedford. Finally, eight other forest patches scattered about town were between 100 and 200 ac (40 – 81 ha).

Conservation Issues for Selected Focal Species

Loss and fragmentation of forests are the 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 sustain local populations. 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 1979, 1980; Ambuel and Temple 1983, Wilcove 1985, Hill and Hagan 1991, Lampila et al. 2005). In addition to reduced total area, fragmented forest has a larger proportion of edge habitat. Temperature, humidity, and light are altered near forest edges, and edge environments favor a set of disturbance-adapted species, including many nest predators and a brood parasite (brown-headed cowbird) of forest-breeding birds (Murcia 1995). Large forests, particularly those that are more round and less linear, support forest species that are highly sensitive to disturbance and predation along forest edges. For example, a study of forest breeding birds in mid-Atlantic states found that black-and-white warbler,* cerulean warbler,* worm-eating warbler,* and Louisiana waterthrush* were rarely found in forests smaller than 247 ac (100 ha). The study suggested that the minimum forest area these birds require for sustainable breeding ranges from 370 ac (150 ha) for worm-eating warbler* to 2,470 ac (1,000 ha) for black-throated blue warbler (Robbins et al. 1989). For wood thrush,* only forest patches larger than 200 ac (81 ha) are considered highly suitable for breeding populations in our region (Rosenberg et al. 2003). Although bird area requirements vary regionally and locally (Rosenberg et al. 1999, 2000), these area figures demonstrate the need to preserve large forests for these birds, some of which we observed during our field work in Pound Ridge (e.g., red-shouldered hawk,* Louisiana waterthrush,* wood thrush*). Large forests with rocky crests

Eastern box turtle, a NYS Species of Special Concern also provide habitat for several reptiles of conservation concern such as northern copperhead,* eastern ratsnake,* and northern black racer* (see section on crest/ledge/talus and rocky barren, below).

Forest fragmentation can also inhibit or prevent animals from moving across the landscape, and can result in losses of genetic diversity and local extirpation of 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). Road mortality of migrating amphibians and reptiles can result in reduced population densities (Fahrig et al. 1995) or changes in sex ratios in local populations (Marchand and Litvaitis 2004).

Another threat to forests in our region is the spread of invasive insect species. One example is the hemlock woolly adelgid, which has caused widespread mortality of hemlock forests in the Hudson Valley. While we did not observe signs of stand-wide decline in most locations, most hemlock forests of this latitude are expected to be severely impacted in the near future. Other threats include the emerald ash borer (already widespread in Pound Ridge) and the Asian long-horned beetle. The emerald ash borer can infest all native ash species and can kill a tree in two to four years; it has already killed many ash trees in the town. The Asian long-horned beetle threatens native maple, birch, and willow trees and has the potential to greatly affect the forestry, maple syrup, and nursery industries (NISIC 2018). It is known from New York City and Long Island (NYSDEC 2018). Transporting of untreated firewood is limited by law to less than 50 miles from its origin to limit the spread of these pests in New York (NYSDEC 2012).

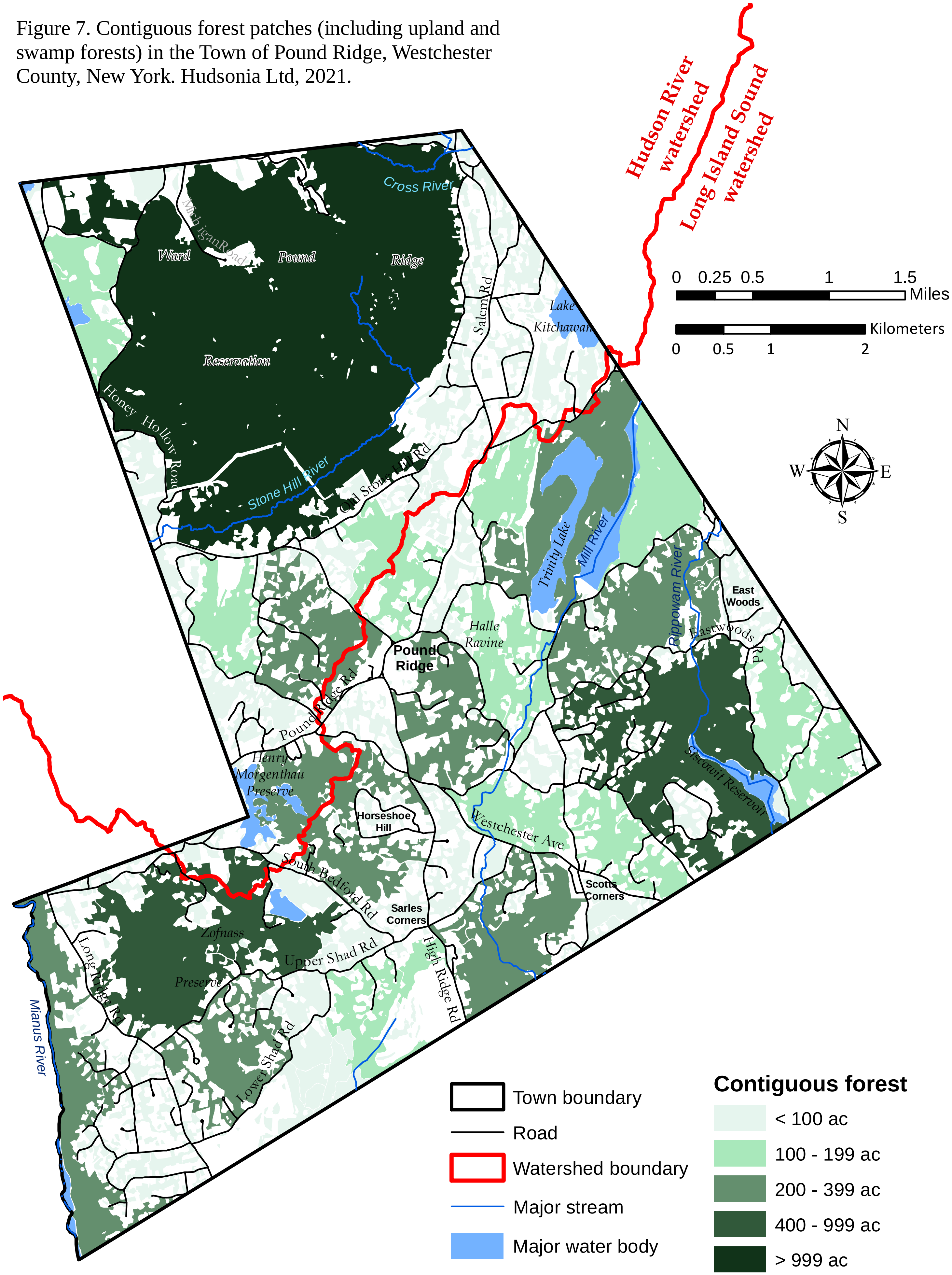
In addition to their tremendous values for wildlife, forests are perhaps the most effective type of land cover for sustaining clean and abundant surface water (in streams, lakes, ponds, and wetlands) and groundwater. Forests with intact canopy, understory, ground vegetation, and floors (i.e., organic 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.

Recommendations

We recommend that the remaining blocks of large forest within the Town of Pound Ridge be considered priority areas for conservation, and that efforts be made to fully protect those areas wherever possible. If new development in the large forested areas cannot be avoided, concentrating it near forest edges and near existing roads and other development will help to preserve as much unfragmented forest area as possible. Locating new roads or driveways near forest edges instead of the forest interiors will avoid dividing 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 and logging in forest interiors.
2. **Protect patches of forest types that are less common in the town regardless of their size**. These include mature forests (and old-growth, if any is present), natural conifer 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**. Consult with an invasive species expert if you think you have an infestation of an invasive insect species, as treatment procedures vary by species.

Figure 7. Contiguous forest patches (including upland and swamp forests) in the Town of Pound Ridge, Westchester County, New York. Hudsonia Ltd, 2021.



Crest/Ledge/Talus and Rocky Barrens

Target Areas

Rocky barrens and other crest, ledge, and talus areas were particularly concentrated in the WPRR (especially along the southern and western ridge, including the Pound Ridge escarpment) and in and around the Zofnass Preserve in southwestern Pound Ridge (Figure 8). We observed calcareous crest and ledge, specifically marble, in a few locations west and southwest of Trinity Lake. Overall, we mapped approximately 1,740 ac (700 ha) of known and potential crest, ledge, and talus habitat, or 12% of the town. Within those areas we also mapped 36 rocky barrens, all but ten of which were in the WPRR. All were smaller than 1 ac (0.4 ha). Two concentrations of rocky barrens occurred on the south and western rims of WPRR: one of six barrens within 1 mi (1.5 km) of each other, and one of 15 barrens within 1 mi (1.5 km) of each other.

Conservation Issues for Selected Focal Species

Some rare and vulnerable snakes depend on rocky habitats, including the exposed outcrops of crest/ledge and rocky barrens. Snakes such as northern copperhead,* eastern ratsnake,* and northern black racer* den in crest, ledge, and talus habitats and range far into the surrounding landscape to forage in forests and meadows. Copperheads, for instance, will travel on average 0.4 mi (0.7 km) from their dens and have been known to travel up to 0.7 mi (1.2 km) (Fitch 1960). Eastern ratsnakes and northern black racers travel similar distances from their den sites (Blouin-Demers and Weatherhead 2002; Todd 2000). Northern copperhead and other snakes are vulnerable to loss or disturbance of habitat, collection for live trade, and malicious killing (Klemens 1993). Perhaps one of the greatest threats to the sensitive animals associated with crest/ledge/talus and rocky 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 successful 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 extirpation.

Eastern ratsnake, a snake of rocky forests and barrens

Rocky barrens are uncommon in the Hudson Valley but are best represented in the high-elevation areas of the Catskills, Shawangunks, Taconics, and Hudson Highlands. They are disturbance-maintained ecosystems (ice, fire, wind, ice), but human suppression of wildfires has eliminated one of the disturbances that historically maintained them. The plant communities of some rocky barrens, such as oak-heath barrens, are especially adapted to episodic fires. Without fire events, other forest species can colonize these areas, and eventually barren specialists may be out-competed by the more typical species of rocky upland hardwood forests.

Recommendations

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

1. **Avoid direct alteration 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. **Protect large forested areas around crest, ledge, and talus habitats.**

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

5. **Educate construction workers and residents** about snake conservation and whom to contact to safely relocate snakes encountered on a construction site or in a residential yard.

Particular measures for conservation of rocky barrens and their associated rare species include:

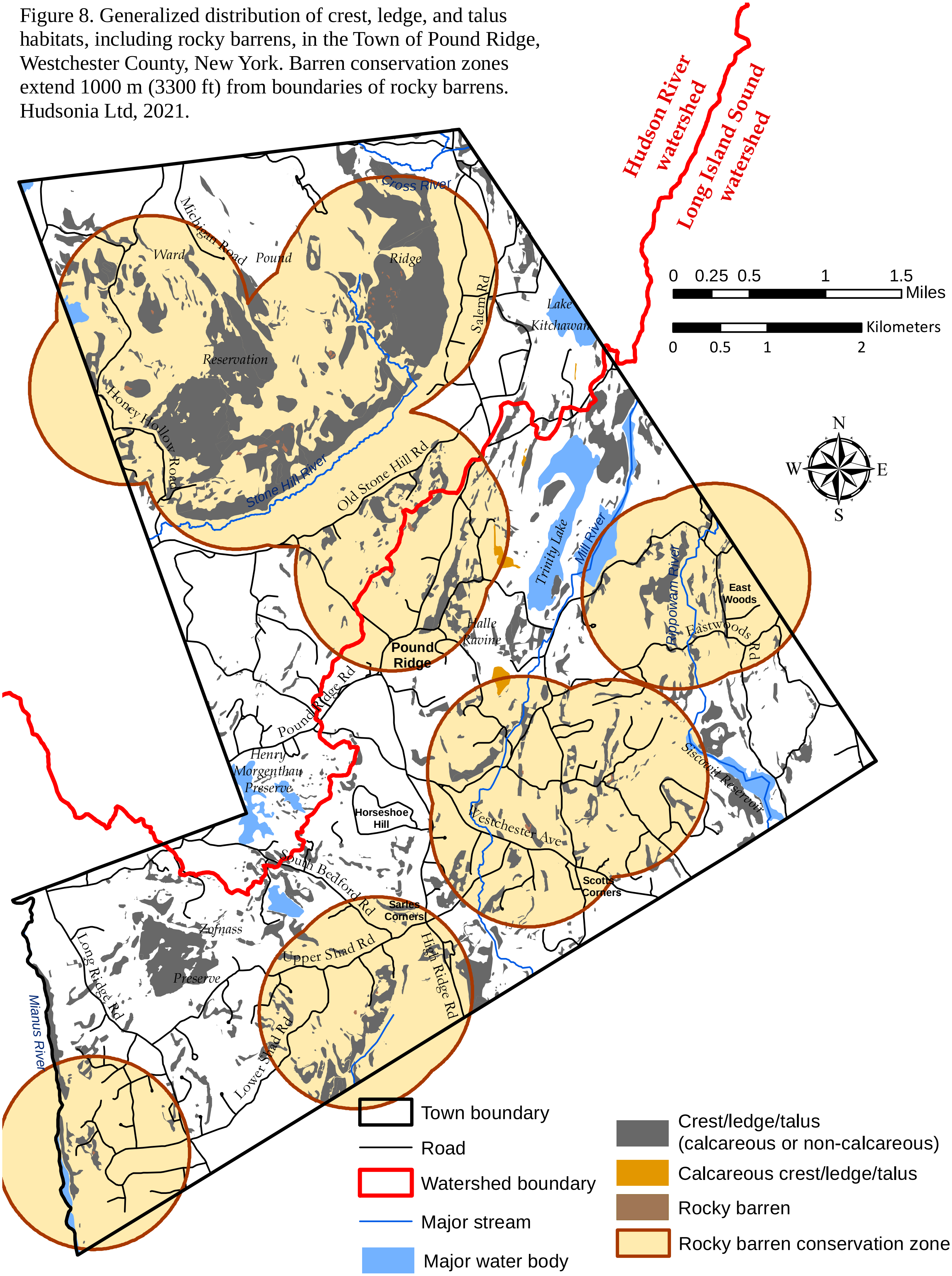
1. **Protect rocky barrens and associated crest, ledge, and talus habitats.** Avoid direct alterations including, but not limited to, the construction of communication towers; mining; house, road, and driveway construction; and high intensity human recreation. Protecting these habitats protects denning and basking areas for rare snakes and specially-adapted plants.

2. **Protect critical adjoining habitats within 100 ft (30 m) of rocky barrens** (and larger contiguous areas wherever possible)**.** Basking reptiles and other organisms that are sensitive to human disturbances use these barrens, but the paucity of similar habitat types on the landscape limits the ability of some organisms to avoid human activity. Disturbances in or near a rocky barren can force out sensitive species and provide an avenue for the establishment of invasive plants. Because these habitats have shallow soils, they are particularly sensitive to trampling or ATV use that can wear away soils and damage plant root systems. For these reasons we recommend that habitats within at least 100 ft (30 m) of a rocky barren be considered critical components of the barren habitat. Avoid new development of any kind, including roads and high-use hiking trails, within this 100-ft zone. Protecting larger areas of contiguous habitat surrounding rocky barrens will not only protect potential foraging habitats and travel corridors for rare species, but may also help support the ecological and natural disturbance processes (e.g., fire) that help sustain the rocky barren habitats.

3. **Maintain broad corridors between rocky barrens and nearby crest, ledge, and talus habitats** to provide travel routes for species that migrate among different rocky habitats for breeding, foraging, and dispersal.

4. **Protect critical adjoining habitats (ledges, forests, meadows) within 3,300 ft (1,000 m) of the rocky barrens.** Habitats within this zone should be considered critical components of the barren habitat "complex" that may be used for foraging and travel by northern copperhead and other snakes of conservation concern. As much as possible, avoid new development of any kind, including roads and driveways within this 0.6-mi zone. If development cannot be avoided, it should be concentrated in a manner that maximizes the amount and contiguity of undisturbed habitat. Protecting large areas of contiguous habitat surrounding the barrens will not only protect potential foraging habitats and travel corridors, but may also help support the ecological and natural disturbance processes (e.g., fire) that help sustain the barrens habitats.

Figure 8. Generalized distribution of crest, ledge, and talus habitats, including rocky barrens, in the Town of Pound Ridge, Westchester County, New York. Barren conservation zones extend 1000 m (3300 ft) from boundaries of rocky barrens. Hudsonia Ltd, 2021.



Intermittent Woodland Pools & Pool-Like Swamps

Target Areas

We identified and mapped 96 intermittent woodland pools in the town (Figure 9), and there are likely to be others that we missed. We also mapped 68 pool-like swamps with presumed ecological functions similar to those of intermittent woodland pools. Buttonbush pools are another wetland that share some characteristics of intermittent woodland pools, namely intermittent standing water and hydrological isolation (see "Buttonbush Pool" habitat description), and so we include the only mapped buttonbush pool here. We refer to the combined set of intermittent woodland pools, pool-like swamps, and buttonbush pool as *woodland pools*.

While each woodland pool may be important to preserve, groups or networks of pools (which are found throughout the town) and their surrounding forests are particularly valuable from a habitat perspective. Groups of pools can support amphibian and reptile metapopulations—groups of small populations that are able to exchange individuals and recolonize sites where populations have recently disappeared. We define a pool complex as groupings in which each pool is within the conservation zone (750 ft [230 m]) (see below) of one or more other pools. Five such complexes consisted of five or more pools embedded in unfragmented habitat (mostly forest); one of these, in the WPRR, had 35 woodland pools, and two others had nine pools each.

Pool-like swamp. Note shrubs and trees emergent from pooled water.

Conservation Issues for Selected Focal Species

Because they lack fish and certain other predators, intermittent woodland pools provide crucial breeding and nursery habitat for several amphibian species that cannot successfully reproduce in other wetlands, including several of the mole salamanders (Jefferson salamander,* marbled salamander,* spotted salamander*) and wood frog.* We use these as the focal species for conservation planning for intermittent woodland pools. Except for their relatively brief breeding season and egg and larval stages, these species are terrestrial and require the deep shade, thick 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 the intermittent woodland pool is the minimum area considered necessary to support populations of amphibians that breed in intermittent woodland pools (Calhoun and Klemens 2002). Disturbance of vegetation or soils within this area—including the direct loss of pool and forest habitats, alteration of the pool hydroperiod, and degradation of pool water quality or forest floor habitat quality—can have significant adverse effects on amphibians.

Wood frog, an obligate pool breeder

Pool-breeding amphibians are especially vulnerable to upland habitat fragmentation because of their annual movement patterns. 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 vulnerable to vehicle mortality where roads or driveways cross their travel routes. Roads, especially dense 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). A New Hampshire study found that road density within 1,000 m was the best predictor of egg mass abundance (a proxy for population size) for wood frog and spotted salamander (Veysey et al. 2011).

Open fields and clearcuts are another barrier to forest-dwelling amphibians. Juveniles have trouble crossing open areas due to a high risk of desiccation and predation in those exposed environments (Rothermel and Semlitsch 2002).

Populations of these amphibian species depend not only on a single woodland pool, but on a forested landscape dotted with such wetlands among which individual animals 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-associated species at different times. Also, different pools provide different habitat each year, due to their internal characteristics and those of their watersheds, and year-to-year variations in precipitation and air temperatures. To preserve the full assemblage of species in the landscape, a variety of pools and upland forest connections between pools must be present to connect local populations (Semlitsch and Bodie 1998). 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 their key foraging and wintering habitats in the surrounding upland forests, and the forested migration corridors between individual pools and pool complexes (Gibbons 2003).

Roads, and especially heavily travelled roads, pose an extreme hazard to the amphibians that migrate from uplands to wetlands during the breeding season, including not only the pool-breeding amphibians mentioned above, but also American toad, spring peeper, gray treefrog, and sometimes other species such as four-toed salamander. On rainy nights in early spring you will see droves of these frogs, toads, and salamanders hopping and crawling across roads on their way to their wetland breeding habitats. Many of them are killed by motor vehicles, and the mortality rate is especially high on roads with heavy traffic. While American toad, spring peeper, and gray treefrog will breed in a great variety of wetlands and ponds, the pool-breeding amphibians have much more specialized habitat needs, requiring the isolated, fish-free pools that dry up during the summer. Jefferson, Jefferson complex, and marbled salamanders are all listed as NYS Species of Special Concern because of the vulnerable status of the New York populations, and road mortality is a particular concern for these species.

For this reason, we identified the road locations in Pound Ridge where amphibian crossings might be especially concentrated because of the presence of one or more nearby woodland pools. Figure 10 shows the places where woodland pools are located within 750 ft (230 m) of a road, and forest occupies the opposite side of the road. The "highest priority" road segments shown in Figure 10 are those with two or more pools nearby on one side of the road, or those with a large area of forest or a forested corridor on the opposite side of the road from the pool(s). Those are the road segments that might have the highest numbers of amphibians attempting to cross during springtime breeding migrations. The purpose of this mapping is to alert the town to the places where these vulnerable animals might benefit most from road closings on key nights in the spring, or assistance from volunteers who are trained and willing to help the animals cross safely. The Amphibian Migrations and Road Crossings Project of the NYSDEC Hudson River Estuary Program trains volunteers to assist the salamanders, frogs, and toads and gather important data on the locations of key habitats.

Recommendations

To help protect pool-breeding amphibians and the habitat complexes they require, we recommend the following protective measures be applied to all intermittent woodland pools, buttonbush pools, and pool-like swamps (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 dumped in. We recommend that intermittent woodland pools be permanently protected from development and disturbance of any kind. 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. **Avoid channeling runoff from roads and developed areas** (including overflow from stormwater ponds) into intermittent woodland pools. Such runoff carries substances harmful to amphibians (such as road salt and nitrate) to the pools, and alters pool water volumes (see below).

3. **Protect all upland forest within 100 ft (30 m) of the intermittent woodland pool**. During the spring and early summer this zone provides important shelter for high densities of adult and recently metamorphosed salamanders and frogs. 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 ecosystem. This organic debris constitutes the base of the pool food web and provides attachment sites for amphibian egg masses.

4. **Maintain critical terrestrial habitat within 750 ft (230 m) of the pool**. The upland forests within 750 ft 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 crush many amphibians and destroy the forest floor microhabitats that provide the amphibians with shelter and invertebrate food. Development within this zone can also prevent dispersal and genetic exchange between neighboring pools, thereby making local extirpation more likely. At least 75% of this zone should remain in unfragmented forest with an undisturbed forest floor. Wherever possible, forested connections among nearby pools should be maintained to provide overland dispersal corridors.

We also recommend the following for all development activity 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 die. To minimize these potential adverse impacts:
    - Locate no new roads and driveways with projected traffic volumes in excess of 5-10 vehicles per hour within 750 ft (230 m) of the pool.
    - Regardless of traffic volumes, limit the total length of roads and driveways within 750 ft of a woodland pool to the greatest extent possible and tightly cluster any new development to minimize forest fragmentation. .
    - Use gently sloping curbs or no-curb alternatives to reduce barriers to amphibian movement.
    - Use 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, near wetlands and known amphibian migration routes to facilitate amphibian movements under roads. Use special outward-facing “curbing” 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 sediments, nutrients, and other pollutants. 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. Activities such as groundwater extraction (e.g., from wells) or the redirection of natural surface water flows can reduce the pool hydroperiod below the threshold required for successful egg and larval development. Increasing impervious surfaces or channeling stormwater runoff toward

pools can increase the pool hydroperiod, which can also adversely affect the ability of amphibians to reproduce successfully. Protective measures include the following:

- Do not use intermittent woodland pools for stormwater detention, either temporarily or permanently.
- Aggressively treat stormwater throughout the development site, using methods that allow for the maximum infiltration and filtration of runoff, including grassy swales, filter strips, "rain gardens," and oil-water separators in paved parking lots. Direct all stormwater away from nearby woodland pools.
- Avoid or minimize the use of pesticides and fertilizers within the woodland pool's watershed. If mosquito control is necessary, limit it to the application of bacterial larvicides, which appear at this time to have lesser negative impacts on non-target pool biota than other methods. Avoid using de-icing salts such as sodium chloride where they will pollute surface runoff into amphibian breeding pools. These salts cannot be removed from water or soils by means of treatment methods currently in use.
- Maintain both surface water runoff and groundwater inputs to intermittent woodland pools at pre-construction levels. Carefully design stormwater management systems in the pool's watershed to avoid changes (either increases or decreases) in seasonal pool depths, volumes, and hydroperiods.
- 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 and (sometimes) 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. Backfill soil test pits immediately after tests are completed.

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

For recommendations on protecting intermittent woodland pools in working forests, both for forest management planning and for harvest operations, see Calhoun & DeMaynadier (2004). Other resources for conservation of small wetlands in New York are listed on the NYSDEC website (http://www.dec.ny.gov/docs/remediation_hudson_pdf/hrebswres.pdf).

Figure 9. Woodland pools, including intermittent woodland pools, pool-like swamps, and buttonbush pools, in the Town of Pound Ridge, Westchester County, New York. Pool conservation zones extend 750 ft (230 m) from pool boundaries. Hudsonia Ltd, 2021.

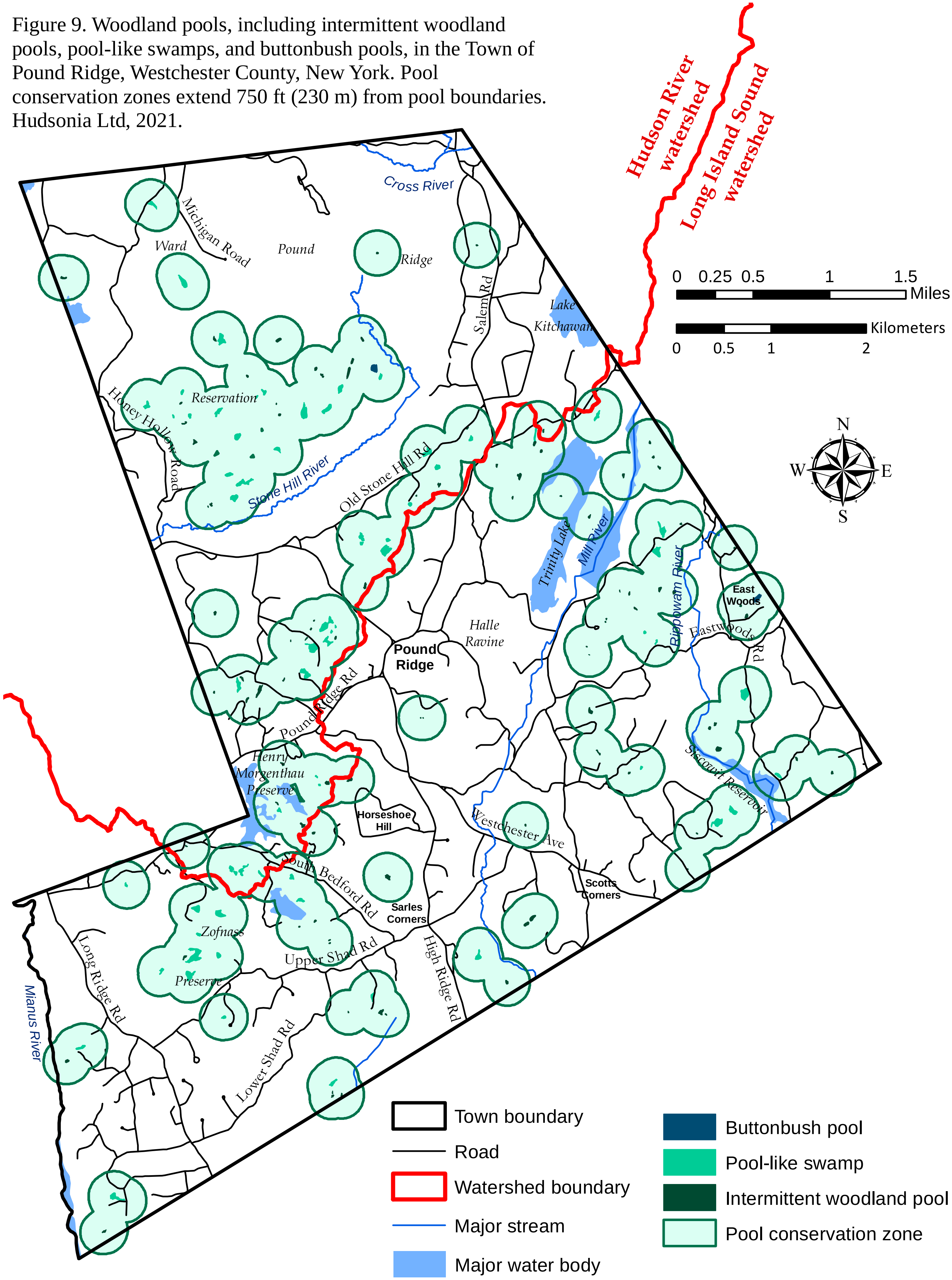
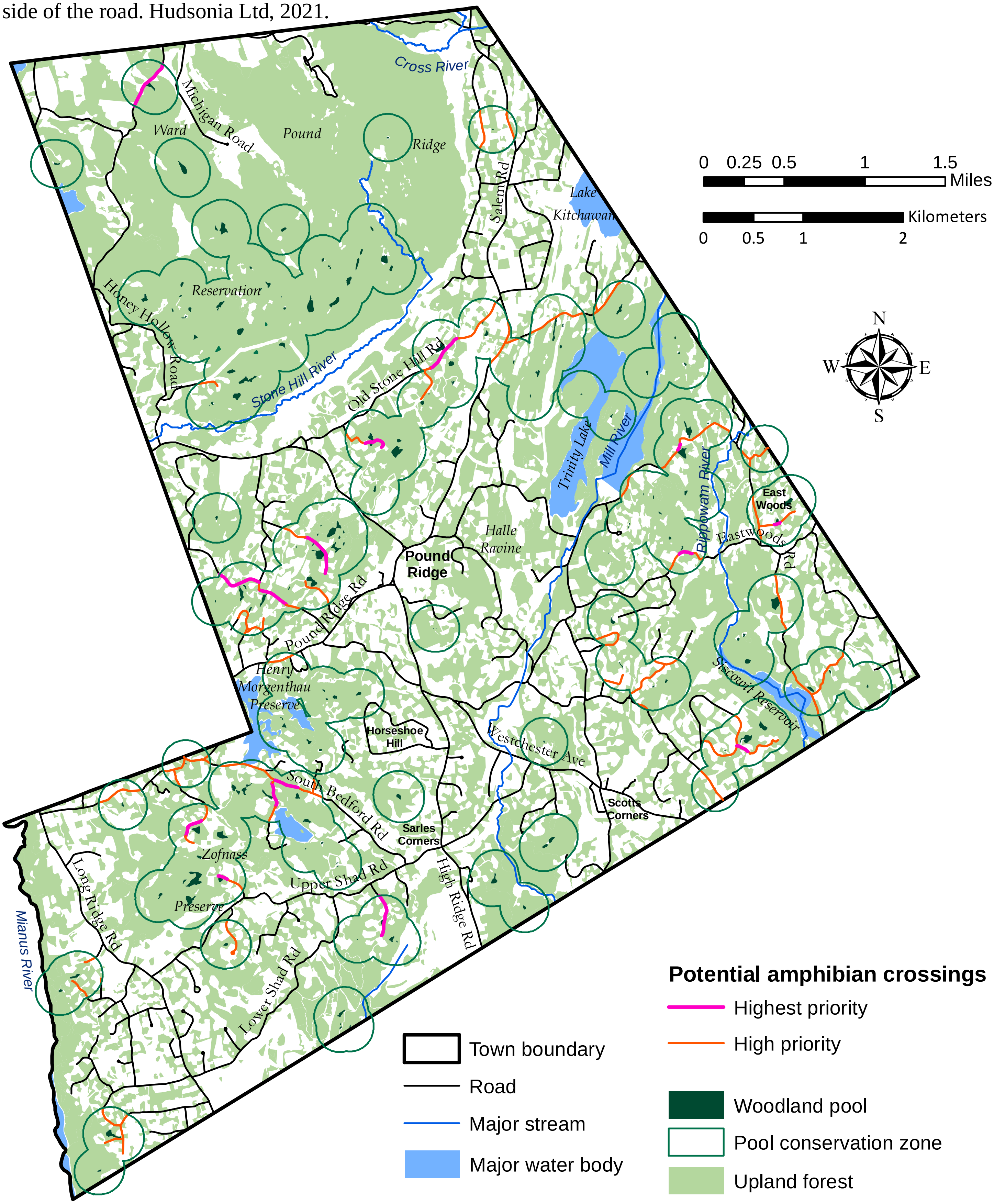


Figure 10. Road segments where spring-time crossings of pool-breeding amphibians may be concentrated in the Town of Pound Ridge, Westchester County, New York. The mapped segments are within the conservation zones (750 ft [230 m]) of one or more woodland pools and have upland forest on the opposite side of the road. Hudsonia Ltd, 2021.



Fens

Target Areas

We mapped 12 fens in the Town of Pound Ridge (Figure 11), all in the vicinity of the band of Inwood marble that runs north to south from Lake Kitchawan to the intersection of Eastwoods and Fancher roads (see Figure 2). There may be additional fens in areas that we did not see in the field. All of the fens were small; the two largest were between 0.5 and 0.6 ac (0.2 – 0.25 ha). Several were clustered together in wetland complexes, so that, overall, there were five distinct fen clusters, or complexes. One such cluster occurred in the Isaacson Preserve, and another in the Thalheim Preserve. The largest concentration of fen habitats occurred within a shrub swamp-forested swamp complex, in a utility corridor on water company land.

Grass pink, a regionally rare orchid of fens and bogs

Conservation Issues for Selected Focal Species

Fens and calcareous wet meadows are uncommon in the northeastern US and many provide important habitat for plant and animal species of conservation concern (see Appendix A). One of the most imperiled species associated with fens in the region is the bog turtle,* listed as Endangered in New York and Threatened on the federal list. Fens are the core habitat of the bog turtle in southeastern New York. While bog turtles are believed to be extirpated (or nearly so) in Westchester and Rockland counties, it is still possible that some of the higher-quality fens in the Town of Pound Ridge could support bog turtles now or in the future.

Fens are home to numerous regionally- and statewide-rare plants whose persistence depends on the particular environmental conditions of fens. At least 12 state-listed rare plants are found almost exclusively in fen habitats, including handsome sedge,* Schweinitz's sedge,* brown bog sedge (which we found in Pound Ridge),* bog valerian,* scarlet Indian paintbrush,* spreading globeflower,* and swamp birch.* Fens are maintained by mineral-rich, calcareous groundwater seepage. Alterations to the quality or quantity of groundwater or surface water feeding the fen, due to nearby development or human activities, including use of fertilizers or pesticides, can render the habitats unsuitable for many of the plants of conservation concern found in fens. Direct disturbance to the fens themselves can, of course, also alter fen plant communities and threaten populations of rare plants.

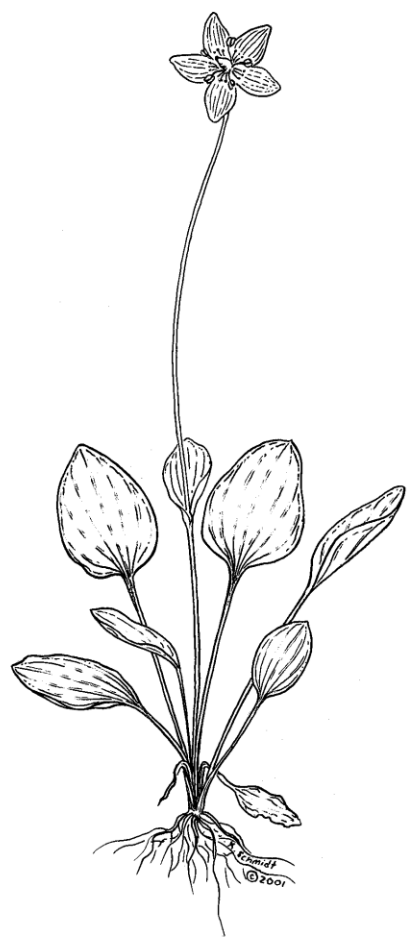
Recommendations

Conservation of fens requires attention not only to the fen itself, but also to surrounding land uses. Because some of the high quality fen complexes (and their associated conservation zones) in Pound Ridge cross multiple privately owned parcels, fen conservation also requires coordinating across property boundaries. We recommend protecting the wetland complexes and prohibiting disturbance and development within the watershed of the fen. This buffer may be crucial to safeguarding wetland habitat quality and hydrology, which is critical for protecting rare plant populations. To protect the rare plants and unusual biological communities of fens, we recommend the following:

1. **Protect the wetland footprint**. Within the entire wetland, not just those portions identified as "fen," avoid the following:
    - Development of any kind.
    - Wetland draining, ditching, tiling, filling, excavation, stream diversion, or construction of impoundments.
    - Herbicide, pesticide, or fertilizer application.
    - Mowing or cutting of vegetation (except as part of an approved fen management plan).
    - Delineation of lot lines for development, even if the proposed building or structure will not be in the wetland.
2. **Establish a 300 ft buffer zone**. This will help prevent or minimize the effects of human activities that could indirectly destroy or degrade the fen habitat over the short or long term. Within this zone, avoid the following:
    - Development of roads, residences, driveways, parking lots, sewer lines, utility lines, stormwater or sedimentation basins, or other structures.

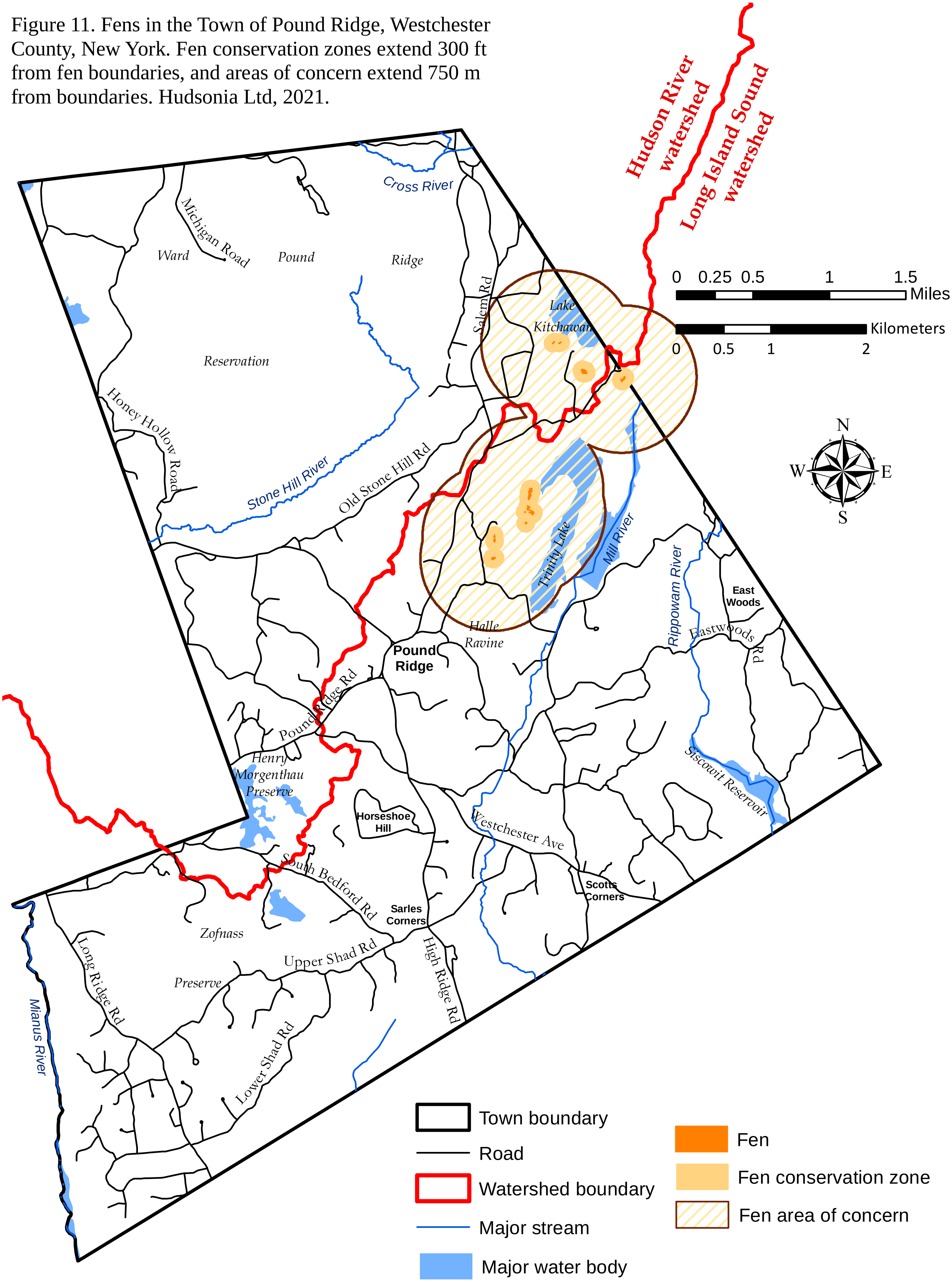
- Mining.
- Herbicide, insecticide, other pesticide, or fertilizer application.
- Farming (with the exception of light to moderate grazing).
- Stream bank stabilization (e.g., rip-rap or other hardening).

3. Assess potential impacts within at least 2500 ft (750 m) of the fen. Despite the distance, development activities (construction of impervious surfaces, installation of septic systems, mining) occurring within the drainage basin of the fen or at least one-half mile from the fen boundary may adversely affect the groundwater or surface water feeding the fen, and alter the very sensitive biological community.



Grass-of-Parnassus, a fen indicator plant

Figure 11. Fens in the Town of Pound Ridge, Westchester County, New York. Fen conservation zones extend 300 ft from fen boundaries, and areas of concern extend 750 m from boundaries. Hudsonia Ltd, 2021.



Wetland Complexes

Target Areas

A wetland complex is any group of adjacent and nearby swamps, marshes, wet meadows, ponds, other wetland types, or streams. Characteristics that lend especially high biodiversity value to wetland complexes are large size, inclusion of a wide variety of wetland types, and intact (undeveloped) upland habitat between wetlands.

Eastern spring beauty in a hardwood swamp

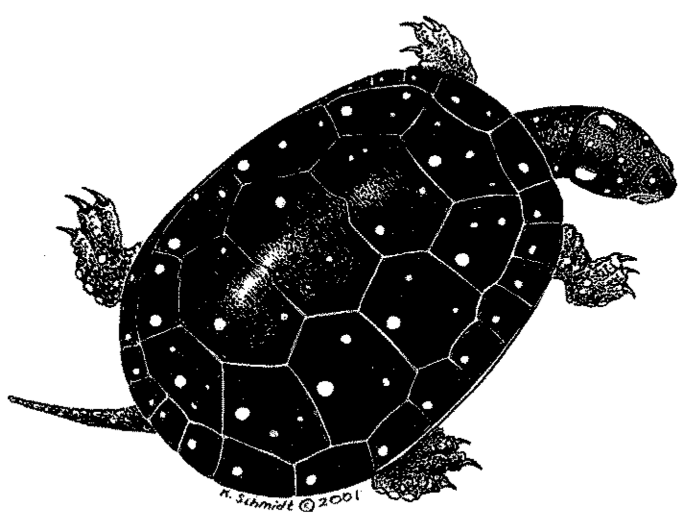
Large and varied wetland complexes occurred throughout the town (Figure 12). Hardwood swamps were the most common wetland type and reached the largest size, excepting open waterbodies. Two of the largest wetlands were hardwood swamps at the base of the Pound Ridge escarpment: one along the Stone Hill River (116 ac [47 ha]), and one along the Cross River (77 ac [31 ha]). The Eastwoods area has numerous large wetland complexes, and also, interestingly, the band of Inwood marble corresponds with a band of large wetland complexes, including two of the largest in the town: at the north end, a 109-ac (44-ha) complex consisting of extensive hardwood swamp, marshes, fens, and Lake Kitchawan; and at the south end, a 47-ac (19-ha) hardwood swamp.

Conservation Issues

Many animals move among several types of wetland and upland habitats to fulfill their life needs. For instance, the spotted turtle* (NYS Species of Special Concern) is a highly mobile species that depends on a variety of habitats to survive and reproduce. It is known to use marsh, fen, wet meadow, hardwood and shrub swamp, buttonbush pool, intermittent woodland pool, and open water habitats within a single year (Fowle 2001). Furthermore, although it requires wetlands, the spotted turtle may spend up to three-quarters of its time in uplands during the active season. 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). The spotted turtle exemplifies mobile wildlife species that depend on a mosaic of wetland and upland habitats and require safe travel routes between those habitats.

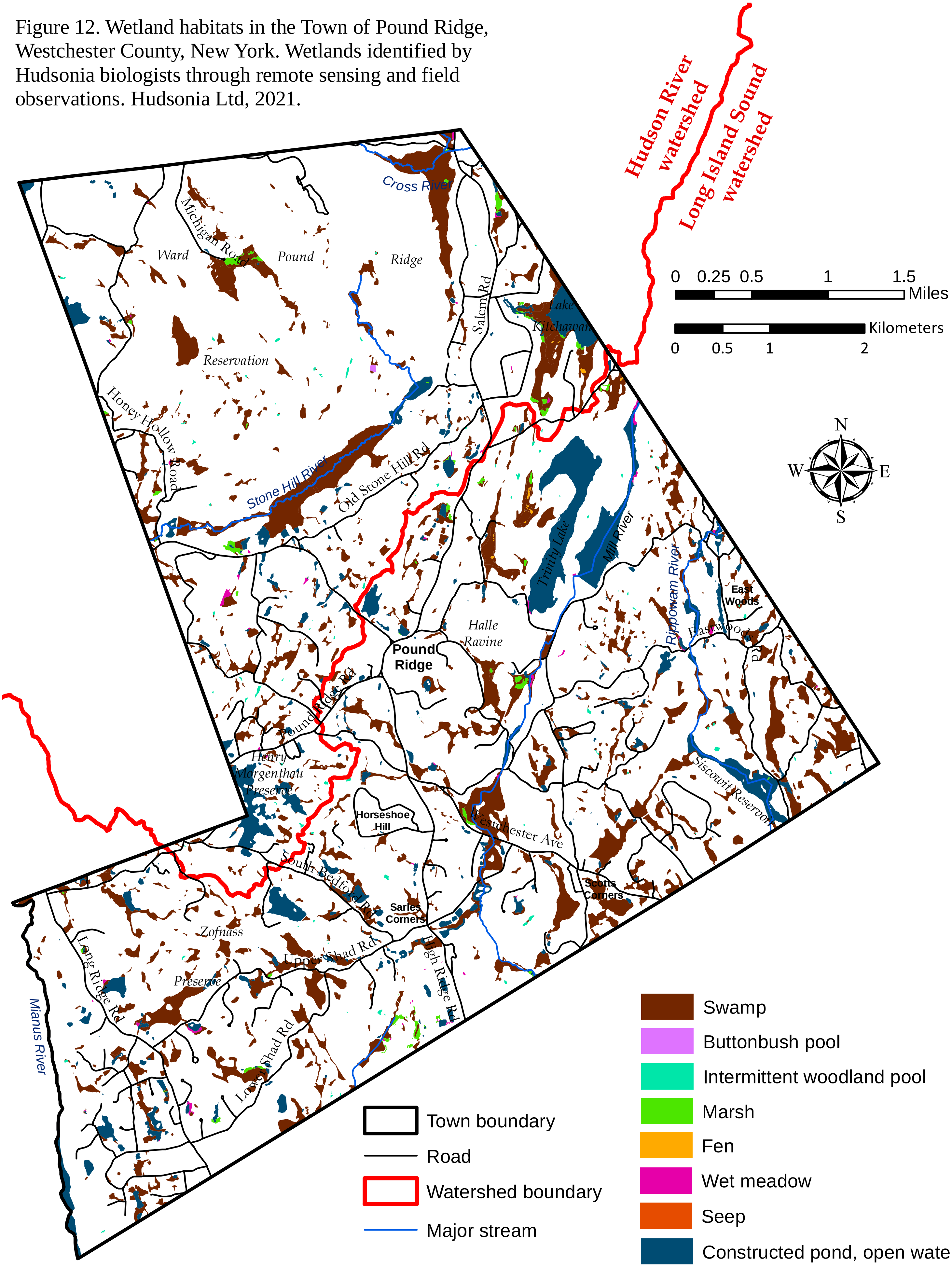
Recommendations

1. **Protect intermittent woodland pools, pool-like swamps, buttonbush pools, and their conservation zones** as described in previous sections of this report. These habitats are used by spotted turtle* and many other species of conservation concern.
2. **When those habitats are located within 1,500 ft (460 m) of a swamp, marsh, or wet meadow, protect the intervening upland habitats as much as possible**. These upland areas encompass spotted turtle travel corridors, and nesting, summer aestivation, and basking sites.
3. **Protect from disturbance the potential spotted turtle nesting habitat areas within 390 ft (120 m) of all the wetlands**. Spotted turtle usually nests in open (unforested) sites such as fields or lawns, but sometimes also in sedge tussocks in wetlands.



Spotted turtle requires a whole complex of wetland and upland habitats

Figure 12. Wetland habitats in the Town of Pound Ridge, Westchester County, New York. Wetlands identified by Hudsonia biologists through remote sensing and field observations. Hudsonia Ltd, 2021.



Streams and Riparian Corridors

Target Areas

The Cross River, Stone Hill River, Mill River, and Mianus River are the largest perennial streams in Pound Ridge (Figure 13). There are also numerous smaller perennial streams and myriad intermittent streams throughout the town. Both the streams themselves and the riparian habitats provide habitat for many plants and animals—both resident and transient—and are important to the ecology of the entire stream watersheds.

Conservation Issues for Selected Focal Species

Low gradient, perennial streams can be essential core habitat for the wood turtle (NYS Species of Special Concern). Wood turtles use streams with overhanging banks, muskrat burrows, submerged logs, or other underwater shelter for overwintering. In early spring, they use logs and stream banks for basking. In late spring and summer, wood turtles (especially females) move into and beyond the adjacent riparian zone 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 turtle populations requires protecting not only their core habitat (the perennial stream), but also their riparian wetland and upland foraging habitats, upland nesting areas, and the migration corridors between these habitats. The wood turtle habitat complex can encompass the wetland and upland habitats within 820 ft (250 m) or more of a core stream habitat (Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997, Tingley et al. 2009). Human land uses within this habitat complex can have significant adverse effects on wood turtles and their habitats, including habitat degradation from stream alteration; habitat fragmentation from culverts, bridges, roads, and other structures; direct loss of wetland habitat; degraded water quality 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 smaller perennial and intermittent streams that feed them, and on the condition of land and water throughout the watershed. To help protect water quality and habitat in small streams, the adjoining lands (soil and vegetation) should be protected to at least 160 ft (50 m) on each side of the stream. This conservation zone provides a buffer for the stream and can filter sediment, nutrients, and contaminants from runoff, stabilize stream banks, prevent channel erosion, contribute organic material, regulate microclimate, and preserve other ecosystem processes (Saunders et al. 2002).

Recommendations

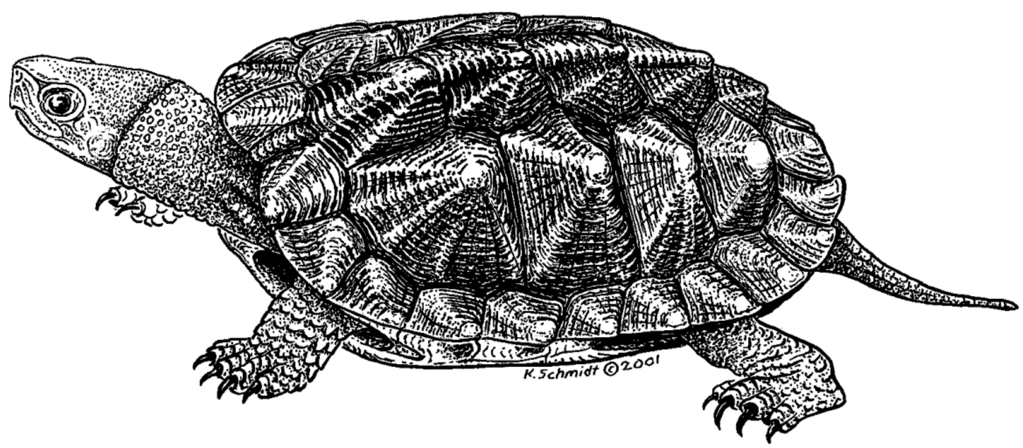
To help protect wood turtles and the habitat complexes they require, we recommend the following measures:

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 riprap, concrete), construction of dams or artificial weirs, vehicle crossing (e.g., construction or logging equipment, ATVs), and the clearing of natural stream bank vegetation. These activities can destroy key hibernation and basking habitats for the wood turtle.
    - Avoid direct discharge of stormwater runoff, chlorine-treated wastewater, agricultural by-products, and other potential pollutants.
    - 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 streams, regardless of whether or not they are used by wood turtles. Keep these zones naturally vegetated and undisturbed by construction, conversion to impervious surfaces, cultivation and livestock use, pesticide and fertilizer application, and installation of septic leachfields or other waste disposal facilities.
2. **Protect riparian wetland and upland habitats.** Protect all riparian wetlands adjacent to known or potential wood turtle streams from filling, dumping, drainage, impoundment, incursion by construction equipment, siltation, polluted runoff, water withdrawals, and hydrological alterations. In addition, preserve large, contiguous blocks of upland habitats (e.g., forests, meadows, and shrublands) within 820 ft (250 m) of a core wood turtle stream to the greatest extent possible to provide basking, foraging, and nesting habitat, and safe travelways for this species. Special efforts may be needed 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, however, are often omitted from state, federal, and site-specific wetland maps and are frequently overlooked in the environmental reviews of development proposals.

3. **Minimize impacts from new and existing stream crossings**. Undersized bridges and narrow or suspended culverts may be significant barriers to wood turtle movement along their core stream habitats. Wood turtles may shy away from passing beneath or entering such structures, and instead choose a hazardous overland route to reach their destination. Typically, this overland route involves crossing a road or other developed area, often resulting in the death of the turtle. 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 diminish the long-term viability of wood turtle 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 may offer important first steps 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 encourage the safe 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.
    - Construct the substrate within the structure of natural materials and match the texture and composition of upstream and downstream substrates. If possible, install the crossing in a manner that does not disturb the natural substrate of the stream bed.
    - If the stream bed must be disturbed during construction, design the final elevation and gradient of the structure bottom 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 passage by wood turtles and other stream organisms.
4. **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 820 ft (250 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, low speed limit signs, and wildlife crossing signs.

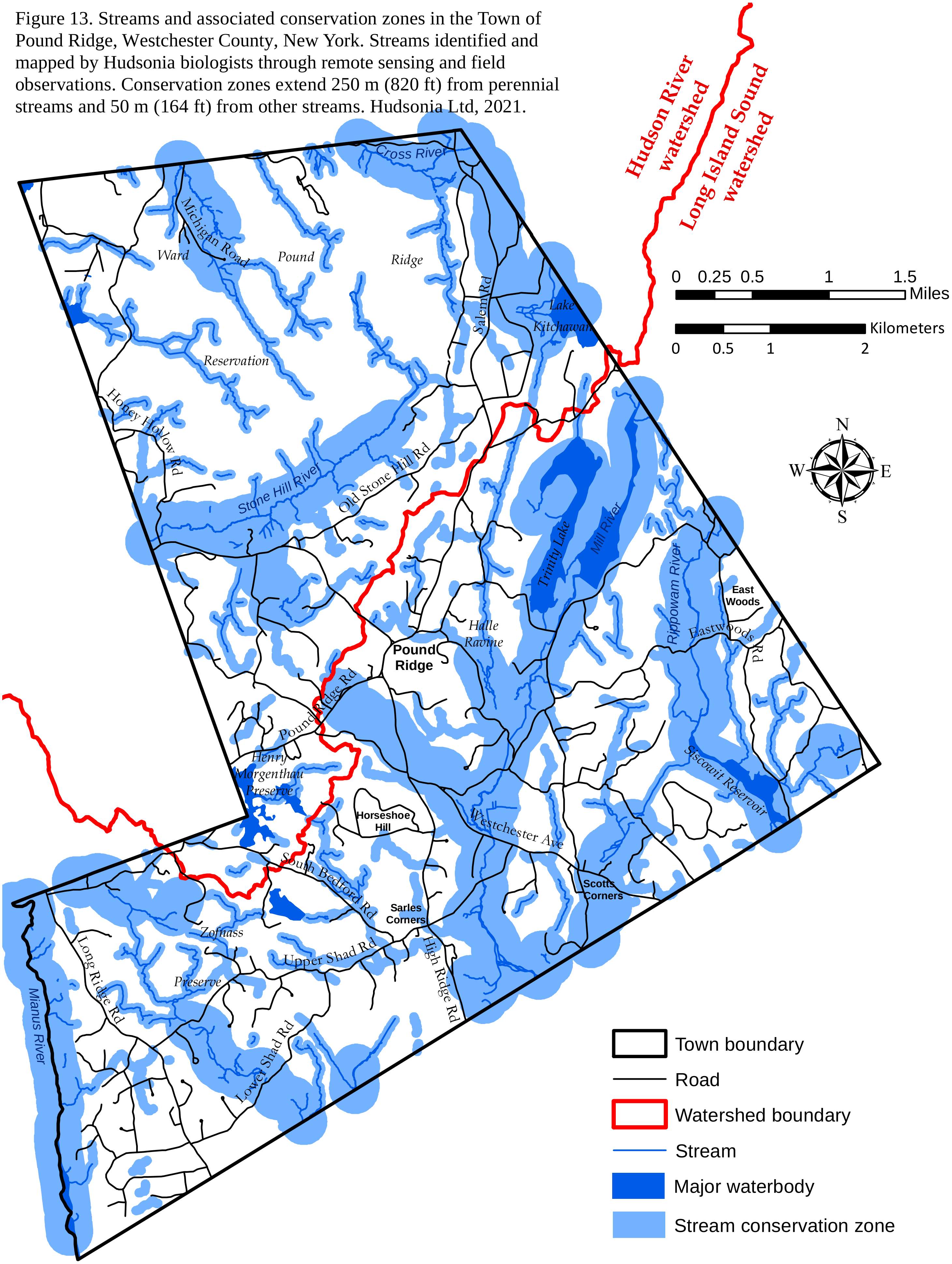
5. **Maintain broad corridors between habitats and habitat complexes**. Broad, naturally vegetated corridors between individual habitats within a complex (e.g., between core stream habitats, foraging wetlands, and potential nesting areas) and between neighboring habitat complexes will provide safe travelways for the turtles and other wildlife.

6. **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 820 ft (250 m) stream conservation zone (e.g.,upland meadows, upland shrublands, waste ground with exposed gravelly or sandy soils) be protected from development and other disturbance. Management of known or potential nesting habitat may be necessary to keep it open.



Wood turtle uses a variety of habitats in the vicinity of perennial streams

Figure 13. Streams and associated conservation zones in the Town of Pound Ridge, Westchester County, New York. Streams identified and mapped by Hudsonia biologists through remote sensing and field observations. Conservation zones extend 250 m (820 ft) from perennial streams and 50 m (164 ft) from other streams. Hudsonia Ltd, 2021.



Enhancement of Settled Areas

Conservation measures can be employed on land parcels of any size, including every half-acre, two-acre, or larger residential lot. Although human-settled areas are much used by common wildlife species that are well-adapted to human activities and infrastructure (e.g., rock pigeon, European starling, gray squirrel, raccoon, striped skunk), uncommon species can also inhabit or travel through developed areas if nearby habitats are suitable. Bats, for example, will roost in small forest patches in suburban neighborhoods, and box turtle* sometimes nests in lawns and gardens.

There are many landscape modifications and land-use practices that can be applied to the more developed parts of Pound Ridge that would assist in the protection of species of conservation concern. In areas of concentrated development, some small areas of habitat 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.

Following are some examples of conservation measures for developed areas (adapted in part from Adams and Dove 1989, and Adams 1994). There are many additional ways in which settled areas can be modified to reduce their negative environmental impacts and even contribute positively to the natural environment; many examples of their implementation can be found in European cities (Beatley 2000). The costs of implementing these measures and their effectiveness at particular locations will vary and, while some must be implemented by town agencies or other government entities, others can be employed 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. ***Leave woodlots intact, and preserve trees of a variety of species and age classes.*** Trees are an important component of the habitat of many wildlife species, and many species of plants and animals can use small woodlots and hedgerows as habitat corridors. Trees also provide services such as moderating climate extremes, reducing wind velocities, controlling erosion, and abating noise.

- Leave forested lots in forest, even if being selectively harvested. A complex array of forest patches and corridors offers habitat for species that use such patchy habitats, and provides travel corridors between larger habitat blocks in the region
- Allow natural processes, such as tree death, tree fall, and forest floor decay, to play out in wooded areas. These processes help preserve natural levels of nutrient cycling and organic matter buildup, and form the basis for the forest food web.
- 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 de-icing salts 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, bats, cavity-nesting birds, and certain amphibians; decomposing trees provide both habitat and a source of nutrients for plants.

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 native wildflower meadows, perennial gardens, or ornamental woodlands. Lawns are usually maintained with motorized lawn mowers and leaf-blowers, which contribute to air and noise pollution. Wildflower meadows will not only help to support native animals, but their maintenance requires less mowing, and thus produces fewer carbon emissions to the atmosphere. Use of native species in ornamental plantings is important, as native ornamental shrubs tend to support many times the number of native invertebrates and birds that non-native ornamentals do (Tallamy 2007), and some non-native ornamentals are aggressive invasives that threaten nearby habitats. While the choice to maintain lawns in residential areas is often one of personal taste or safety, public education and landowner incentives can promote native plant 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.***
    - Avoid or minimize the use of pesticides and fertilizers in and near ponds.
    - 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 streambanks and floodplains help to prevent erosion, moderate flooding, and protect water quality. They enhance the 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 the soil, and instead promote rapid overland flow to ditches, streams, and ponds. This 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.
    - 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 New York State Stormwater Management Design Manual can be found on the NYS DEC website (https://www.dec.ny.gov/chemical/29072.html).
    - Encourage the collection of rainwater for use in gardens and lawn areas.

Minimizing Disturbance to Resident and Migratory Biota

1. ***Minimize the impacts of roads on wildlife.*** One of the greatest immediate threats to wildlife in settled 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. (For example, roads within conservation zones for intermittent woodland pools could be priorities for facilitating amphibian crossings.)
    - Reduce speed limits and post wildlife crossing signs along road segments where wildlife crossings are concentrated.
    - 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. Information about wildlife crossings is provided online by agencies such as the U.S. Department of Agriculture and U.S. Department of Transportation.
    - Modify the immediate roadside areas to promote safer wildlife crossings. Factors to be considered include the location of barriers such as guardrails, types 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 residential areas can be a deterrent to many wildlife species. While some noise and lights are inevitable in settled environments, certain sources can be minimized. Below are examples of measures that could be incorporated into municipal codes to help reduce harm to wildlife from noise and light pollution.
    - Require that outdoor lights be directed downward (rather than outward or upward) to minimize light pollution in offsite and overhead areas.
    - Encourage the use of motion-sensors, so that outdoor lights are on only when needed.
    - 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."
    - Prohibit the use of fireworks to minimize wildlife disturbance.

3. ***Discourage human-subsidized predators.*** Human-sponsored predators are species such as raccoon, opossum, and striped skunk, whose populations often burgeon in response to conditions created by humans. These species are serious predators on bird eggs and nestlings, turtle eggs, and other wildlife. Domestic cats and dogs can be similarly disruptive to native

wildlife. In addition, human interference with the habits and diets of wild animals affects population dynamics and can lead to nuisance behavior.

- Properly secure trash receptacles and compost piles.
- Feed pets indoors, and do not intentionally feed wildlife.
- Supervise cats and dogs when they are outdoors, and keep cats indoors if possible.

4. ***Include biodiversity considerations in development planning.***

- Plan for lower-disturbance human activities/developments adjacent to intact habitats, and establish undisturbed buffer zones outside of sensitive habitat areas.
- Consider wildlife travel routes in the placement of developments and buildings.
- Fence, fill in, or cover pitfall hazards such as window wells, soil test pits, and in-ground pools that can trap small mammals, amphibians, and reptiles.
- In critical habitat areas, identify potential barriers to wildlife movement, such as stone walls or chain-link fences (excluding those designed to prevent access to pitfalls), and design or modify them to have spaces or openings to allow safe passage.
- 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.

CONCLUSION

Pound Ridge is home to an impressive diversity of high-quality, large habitat patches and unusual habitat types. The WPRR holds a 2,000+-ac (800+-ha) upland forest block, and three other forest patches exceeding 400 ac (160 ha). On the WPRR plateau and elsewhere throughout town, crest, ledge, and talus habitat is extensive, and includes numerous rocky barrens. Intermittent woodland pools and pool-like swamps are myriad, and in one location form an intact complex of 35 pools. Over the town's marble bedrock, rare habitats such as fens and calcareous crest, ledge, talus are present and of high quality in some cases. Numerous large, intact wetland complexes, many surrounded by upland forest, feed the town's network of intermittent and perennial streams.

There are significant opportunities for biodiversity conservation throughout the town, but 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 habitats and species.

The map accompanying this report shows the location and extent of common, uncommon, and rare habitats. This kind of general information can help the town consider where future development should be concentrated and where future conservation efforts should be targeted. An understanding of the significant ecological 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 by landowners and developers who are contemplating new land uses, and as a resource for town agencies 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 verified 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 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 noted, and additional ecological values should be assessed. Based on this information, decisions can be made about the need for rare species surveys or other assessments of biological resources. Detailed, up-to-date ecological information is essential to making informed decisions about specific development proposals.

After presenting the completed habitat map, database, and report to the Town of Pound Ridge, Hudsonia hopes to assist town officials, landowners, and other interested individuals and groups 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 and water resources. We hope that the information contained in the habitat map and in this report will help the Town of Pound Ridge 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 natural communities, and protect the ecological patterns and processes that support us and the rest of the living world.

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APPENDICES

Appendix A. Mapping conventions for defining and delineating habitat types.

Buttonbush pool. These are fairly deep-flooding, isolated from perennial streams, and have a shrub-dominated flora with buttonbush normally the dominant plant.

Crest, ledge, and talus. Because crest, ledge, and talus habitats are usually embedded within other habitat types (most commonly upland forest), we depicted them as an overlay on the base habitat map. Except for the most exposed ledges, these habitats have no distinct signatures on aerial photographs and were therefore mapped based on a combination of field observations and inference based on topographic and soils signatures. 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. Rocky areas not known to be calcareous (i.e., of both non-calcareous and unknown bedrock) were mapped simply as “crest, ledge, and talus.”

Cultural. We define “cultural” habitats as areas that are significantly altered and intensively managed (e.g., mowed) but not otherwise developed with structures or wide pavement. These include playing fields, cemeteries, large gardens, and large lawns if surrounded by developed areas on fewer than three sides. It was sometimes difficult to distinguish extensive lawns from upland meadows using aerial photos, so in the absence of field verification some large lawns may have been mapped as upland meadow instead of cultural habitat.

Developed area. Buildings, parking lots, paved and gravel roads, and lawns were mapped as “developed.” Habitat areas surrounded by or intruding into developed land were identified as ecologically significant and mapped only if their dimensions exceeded 165 ft (50 m) in all dimensions, or if they seemed to provide important connections to other large habitat areas. Exceptions to this convention were wetlands within developed areas. 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 adjacent to significant habitats were mapped as “cultural” habitats.

Fens. Fens are identified by their distinctive plant communities and the frequent presence of small rivulets. They are most likely to occur over calcareous bedrock. Fens are only identifiable in the field, though suspected fens may sometimes be identified from aerial photographs.

Intermittent woodland pool and pool-like swamp. Intermittent woodland pools are generally recognizable throughout the year (except under deep snow cover), but are most obvious in the spring when the pools are full of water and occupied by invertebrates and breeding amphibians. 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 hydrologically isolated wetlands with an open basin as intermittent woodland pools and those dominated by trees or shrubs as pool-like swamps (a subcategory of swamps), but the two often serve similar ecological functions. A few wetlands that had only an ephemeral (very brief and minor) stream connection to waterbodies were classified as isolated pools, as they may be free of fish in most years. 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. Intermittent woodland pools located within areas of conifer forest, 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 pond. These two classifications apply to ponded areas without emergent vegetation. We distinguish between "open water" and "constructed pond" based mostly on the degree to which the waterbody and its shorelines are managed. Most small to medium open waterbodies in our region were created by damming or excavation and were mapped as constructed ponds because of a developed or manicured shoreline and/or likely management of the pond, such as applications of herbicides. On the other hand, we mapped as "open water" the large and substantially unvegetated pools within marshes and swamps, as well as artificial ponds and reservoirs that are now surrounded by unmanaged vegetation.

Springs & seeps. Springs and seeps are difficult to identify by remote sensing, so their presence is ordinarily determined by field observations.We mapped only those we happened to see in the field and the few that were either identified on soils maps or had an identifiable signature on topographic maps or aerial photographs. We expect there were many more springs and seeps in the Town of Pound Ridge that we did not map. Seeps were mapped as an overlay on other habitat types.

Streams. We created a stream 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, and when they flowed underground for relatively short distances (e.g., under roads or small developed areas). 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. It was often difficult to distinguish between perennial and intermittent streams based on aerial photograph and map interpretation, but 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 mapped ditches as "streams" because they function as such from a hydrological perspective.

Upland forest. We mapped just three types of upland forests: hardwood, mixed, and conifer forest. Although these forests are extremely variable in 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 and 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 overstory trees. Our "upland forest" types include non-wetland forests of all ages, at all elevations, and of all species mixtures. Grass and dirt roads within forest (where identifiable) were mapped as boundaries of adjacent forested habitat areas, since they can act as significant fragmenting features.

Upland meadow and upland shrubland. We mapped upland meadows divided by fences, tree-lines, and hedgerows as separate polygons (to the extent that these features were visible on aerial photographs or observed in the field), because such dividing features can serve as perching sites for birds of prey and shelter for other predators that reduce success rates of grassland-breeding bird species. Because oldfields 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.

Wetland. We mapped wetlands remotely using topographic maps, soils data, and aerial photographs. In the field, we identified wetlands primarily by the predominance of hydrophytic vegetation and easily visible indicators of surface hydrology (Environmental Laboratory 1987). We did not examine soil profiles. 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, and including those that do and do not fall under federal, New York State, or Pound Ridge wetland jurisdiction.

Appendix B. Explanation of ranks of species of conservation concern. Explanations of New York State ranks and New York Natural Heritage Program ranks are from the New York Natural Heritage Program (Schlesinger 2017) and the New York State Department of Environmental Conservation (https://www.dec.ny.gov/animals/7494.html). The Species of Greatest Conservation Need are listed and explained at https://www.dec.ny.gov/animals/9406.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 Endangered, Threatened, and Rare 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 that meet one or both 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 that meet one or both 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 that 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 3,000 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

Each element is assigned a state rank reflecting the rarity within New York State as determined by the New York Natural Heritage Program. These ranks carry no legal weight.

S1 **Critically Imperiled—**Critically imperiled in New York State because of extreme rarity (often 5 or fewer occurrences), or because of some factor(s) such as very steep declines making it especially vulnerable to extinction or extirpation from the state.

S2 **Imperiled—**Imperiled in New York State because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3 **Vulnerable—**Vulnerable in New York State due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation from the state.

SH Historically known from New York State, but not seen in the past 15-20 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

This list is part of New York's current Comprehensive Wildlife Conservation Strategy. For the development of the State Wildlife Action Plan, SGCN and additional nominated species were filtered through a model that evaluated their current status based on factors including abundance and population trends. The list includes:

- 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 of special concern ™
- species ranked S1 or S2 by the New York Natural Heritage Program. ™
- estuarine and marine SGCN as determined by New York Department of Environmental Conservation, Bureau of Marine Resources staff
- species identified as Wildlife Species of Regional Conservation Concern in the northeastern US.™

A subset of the SGCN are the "High Priority" species for which it is believed that conservation action is needed in the next ten years. These species are experiencing a population decline, or have identified threats that may put them in jeopardy, and are in need of timely management intervention or they are likely to reach critical population levels in New York.

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 Appendix C we denote all species with regional ranks (rare, scarce, declining, vulnerable) with a single code (RG). Species with New York State, New York Natural Heritage Program, or SGCN 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.

BIRDS - PARTNERS IN FLIGHT PRIORITY SPECIES LISTS

Partners in Flight is a network of more than 150 partner organizations throughout the Western Hemisphere that are engaged in science, research, planning, and policy development related to landbird conservation. PIF's goals are to maintain healthy bird populations, in natural numbers, in intact habitats and ecosystems; keep species from becoming threatened or endangered through proactive measures and science-based planning; promote full life-cycle conservation of migratory birds throughout the Western Hemisphere; and promote the value of birds as indicators of environmental health and human quality of life. PIF maintains a Watch List of landbird species of highest conservation concern. Inclusion on the list is based on assessments of each species for population size and trends, breeding and non-breeding distribution, and threats to the species in their breeding and non-breeding habitats. The most recent version of the list includes 86 species of highest conservation concern at the continental (range-wide) scale (Rosenberg et al. 2016). Eleven species are listed in Bird Conservation Region (BCR) 30, which encompasses the Town of Pound Ridge. Watch List species are assigned to one of three categories:

Red Watch List: species with extremely high vulnerability due to small populations and ranges, high level of threats, and rangewide declines.

Yellow Watch List: species that are vulnerable due to small ranges or populations and moderate threats.

Tan Watch List: species that are in steep decline.

Appendix C. Species of conservation concern potentially associated with habitats in the Town of Pound Ridge. These are not comprehensive lists, but merely a sample of the species of conservation concern known to use these habitats in the region. The letter codes given with each species name denote its conservation status. Codes include **New York State ranks** (E, T, R, SC), **New York Natural Heritage Program ranks** (S1, S2, S3), **NYSDEC Species of Greatest Conservation Need** (SGCN) and **Hudsonia's regional ranks** (RG). For birds, we also indicate those species listed by **Partners in Flight** as of **continental importance** on the **Red Watch List** (PIFr), **Yellow Watch List** (PIFy), or **Tan Watch List** (PIFt). These ranks are explained in Appendix B.

UPLAND HARDWOOD FOREST		
Plants	***Vertebrates*** (cont.)	***Vertebrates*** (cont.)
ambiguous sedge (E, S3)	marbled salamander (SC, S3, SGCN)	wood thrush (PIFy, SGCN)
red pinesap (S3?, RG)	four-toed salamander (RG)	cerulean warbler (SC, S3?B, SGCN)
silvery spleenwort (RG)	eastern box turtle (SC, S3, SGCN^{HP})	Canada warbler (SGCN^{HP})
American ginseng (S3S4)	eastern worm snake (SC, S2, SGCN)	Kentucky warbler (S2, PIFy, SGCN^{HP})
red baneberry (RG)	northern black racer (SGCN)	black-throated green warbler (RG)
poke milkweed (RG)	eastern ratsnake (SGCN)	worm-eating warbler (SGCN)
lopseed (RG)	northern goshawk (SC, S3S4B,S3N, SGCN)	hooded warbler (RG)
winter grape (E, S1)	red-shouldered hawk (SC, S4B, SGCN)	ovenbird (RG)
leatherwood (RG)	Cooper's hawk (SC, S4)	scarlet tanager (SGCN)
black cohosh (RG)	sharp-shinned hawk (SC, S4)	northern long-eared bat (T, S1, SGCN)
Vertebrates	broad-winged hawk (PIF2, RG)	black bear (RG)
wood frog (RG)	ruffed grouse (SGCN)	bobcat (RG)
spotted salamander (RG)	American woodcock (SGCN)	New England cottontail (SC, S1S2, SGCN^{HP})
Jefferson salamander (SC)	whip-poor-will (SC, PIFy, S3, SGCN^{HP})	fisher (RG)
blue-spotted salamander (SC, GCN^{HP})	Acadian flycatcher (S3)	

UPLAND CONIFER FOREST		
Plants	***Vertebrates*** (cont.)	***Vertebrates*** (cont.)
red pinesap (S3?, RG)	Cooper's hawk (SC, S4)	red-breasted nuthatch (RG)
common rattlebox (S1,E)	sharp-shinned hawk (SC, S4)	black-throated green warbler (RG)
Vertebrates	American woodcock (SGCN)	purple finch (RG)
blue -spotted salamander (SC, SGCN^{HP})		

RED CEDAR WOODLAND		
Plants	***Vertebrates***	***Vertebrates*** (cont.)
yellow wild flax (T, S2)	wood turtle (SC, S3, SGCN^{HP})	whip-poor-will (SC, PIFy, S3, SGCN^{HP})
whorled milkweed (R, S3)	eastern box turtle (SC, S3, SGCN^{HP})	eastern bluebird (RG)
butterflyweed (RG)	eastern hognose snake (SC, S3, GCN^{HP})	brown thrasher (S3S4B, SGCN^{HP})
Invertebrates	ruffed grouse (SGCN)	golden-winged warbler (SC, PIFr, S3, SGCN^{HP})
olive hairstreak (butterfly) (RG)	black-billed cuckoo (PIFy, SGCN)	blue-winged warbler (SGCN)
spotted turtle (SC, S3, SGCN^{HP})		

CALCAREOUS CREST/LEDGE/TALUS		
Plants	***Plants*** (cont.)	***Invertebrates***
purple cliffbrake (RG)	yellow corydalis (R, S3)	anise millipede (RG)
walking fern (RG)	black cohosh (RG)	olive hairstreak (butterfly) (RG)
wall-rue (RG)	pellitory (RG)	***Vertebrates***
Emmons' sedge (R, S3)	northern blazing-star (T, S2)	eastern hognose snake (SC, S3, SGCN^{HP})
Bicknell's sedge (R, S3)	small-flowered crowfoot (R, S3)	northern black racer (SGCN)
yellow wild flax (T, S2)	roundleaf dogwood (RG)	eastern ratsnake (SGCN)
Allegheny-vine (RG)		northern copperhead (S3, SGCN)

(continued)

Appendix C (cont.)

NON-CALCAREOUS CREST/LEDGE/TALUS		
Plants	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
Bicknell's sedge (R, S3)	olive hairstreak (butterfly) (RG)	northern copperhead (S3, SGCN)
clustered sedge (T, S2S3)	northern hairstreak (butterfly) (S2S4, SGCN)	turkey vulture (RG)
reflexed sedge (T, S2S3)	gray hairstreak (butterfly) (RG)	whip-poor-will (SC, PIFy, S3, SGCN[HP])
blunt-leaf milkweed (RG)	Horace's duskywing (butterfly) (RG)	black vulture (RG)
rock sandwort (RG)	swarthy skipper (butterfly) (RG)	common raven (RG)
goat's-rue (RG)	Leonard's skipper (butterfly) (RG)	winter wren (RG)
slender knotweed (R, S3)	***Vertebrates***	eastern bluebird (RG)
dittany (RG)	Fowler's toad (SGCN)	cerulean warbler (SC, S3?B, SGCN)
Torrey's mountain-mint (E, S1)	northern slimy salamander (RG)	worm-eating warbler (SGCN)
stiff-leaved aster (RG)	marbled salamander (SC, S3, SGCN)	eastern small-footed bat (SC, S1S3, SGCN)
Invertebrates	eastern box turtle (SC, S3, SGCN[HP])	southern red-back vole (RG)
Edward's hairstreak (butterfly) (S3S4)	eastern ratsnake (SGCN)	fisher (RG)
striped hairstreak (butterfly) (RG)	northern black racer (SGCN)	bobcat (RG)
brown elfin (butterfly) (RG)	eastern hognose snake (SC, S3, SGCN[HP])	

ROCKY BARREN		
Plants	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
clustered sedge (T, S2S3)	Edward's hairstreak (butterfly) (S3S4)	common raven (RG)
dwarf shadbush (RG)	***Vertebrates***	prairie warbler (PIFy, SGCN)
Invertebrates	copperhead (S3, SGCN)	field sparrow (PIFt)
brown elfin (butterfly) (RG)	turkey vulture (RG)	vesper sparrow (SC, SGCN)
Leonard's skipper (butterfly) (RG)	whip-poor-will (SC, PIFy, SGCN)	

UPLAND SHRUBLAND		
Plants	***Vertebrates*** (cont.)	***Vertebrates*** (cont.)
stiff-leaf goldenrod (RG)	spotted turtle (SC, S3, SGCN[HP])	blue-winged warbler (SGCN)
shrubby St. Johnswort (T, S2)	eastern box turtle (SC, S3, SGCN[HP])	golden-winged warbler (SC, PIFr, S3, SGCN[HP])
butterflyweed (RG)	wood turtle (SC, S3, SGCN[HP])	prairie warbler (PIFy, SGCN)
Invertebrates	ruffed grouse (SGCN)	yellow-breasted chat (SC, S2?B, SGCN[HP])
Aphrodite fritillary (butterfly) (RG)	black-billed cuckoo (PIFy, SGCN)	vesper sparrow (SC, S3, SGCN[HP])
Leonard's skipper (butterfly) (RG)	whip-poor-will (SC, PIFy, S3, SGCN[HP])	field sparrow (PIFt)
Vertebrates	brown thrasher (S3S4B, SGCN[HP])	grasshopper sparrow (SC, S3, SGCN[HP])
wood frog (RG)	white-eyed vireo (RG)	eastern towhee (PIF2)
		New England cottontail (SC, S1S2, SGCN[HP])

UPLAND MEADOW		
Plants	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
small-flowered agrimony (R, S3)	Aphrodite fritillary (butterfly) (RG)	sedge wren (T, S3, SGCN[HP])
Bush's sedge (R, S3)	northern oak hairstreak (S2S4, SGCN)	eastern bluebird (RG)
common rattlebox (E, S1)	Leonard's skipper (butterfly) (RG)	savannah sparrow (RG)
stiff-leaved goldenrod (T, S2)	swarthy skipper (butterfly) (RG)	vesper sparrow (SC, S3, SGCN[HP])
Baltimore (butterfly) (RG)	spotted turtle (SC, S3, SGCN[HP])	grasshopper sparrow (SC, S3, SGCN[HP])
meadow fritillary (butterfly) (RG)	eastern box turtle (SC, S3, SGCN[HP])	bobolink (SGCN[HP])
	wood turtle (SC, S3, SGCN[HP])	eastern meadowlark SGCN[HP])

SWAMP		
Plants	***Vertebrates***	***Vertebrates*** (cont.)
swamp cottonwood (T, S2)	blue-spotted salamander (SC, SGCN[HP])	Virginia rail (RG)
swamp lousewort (T, S2S3)	four-toed salamander (RG, SGCN[HP])	American woodcock (SGCN)
winged monkey-flower (R, S3)	spotted turtle (SC, S3, SGCN[HP])	red-shouldered hawk (SC, S4B, SGCN)
purple milkweed (S2S3, T)	wood turtle (SC, S3, SGCN[HP])	white-eyed vireo (RG)
false hop sedge (T, S2)	eastern box turtle (SC, S3, SGCN[HP])	eastern bluebird (RG)
Invertebrates	great blue heron (RG)	Canada warbler (SGCN[HP])
phantom cranefly (RG)	American bittern (SC, S4, SGCN)	Louisiana waterthrush (SGCN)

(continued)

Appendix C (cont.)

INTERMITTENT WOODLAND POOL		
Plants	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
Virginia chain fern (RG)	springtime physa (snail) (RG)	spotted salamander (RG)
false hop sedge (T, S2)	***Vertebrates***	spotted turtle (SC, S3, SGCN^{HP})
featherfoil (T, S2)	wood frog (RG)	wood turtle (SC, S3, SGCN^{HP})
Invertebrates	Jefferson salamander (SC)	American black duck (S3, SGCN^{HP})
black dash (butterfly) (RG)	marbled salamander (SC, S3, SGCN)	Louisiana waterthrush (SGCN)
mulberry wing (butterfly) (RG)	four-toed salamander (RG, SGCN^{HP})	
BUTTONBUSH POOL		
Plants	***Vertebrates***	***Vertebrates*** (cont.)
Helodium paludosum (moss) (RG)	wood frog (RG)	spotted salamander (RG)
pale alkali-grass (RG)	blue-spotted salamander (SC, SGCN^{HP})	spotted turtle (SC, S3, SGCN^{HP})
short-awned foxtail (RG)	Jefferson salamander (SC)	common ribbon snake (SGCN)
	marbled salamander (SC, S3, SGCN)	American black duck (S3, SGCN^{HP})
MARSH		
Plant	***Vertebrates***	***Vertebrates*** (cont.)
winged monkey-flower (R, S3)	Atlantic coast leopard frog (SGCN)	pied-billed grebe (T, S3, S1N, SGCN)
Invertebrates	southern leopard frog (SC)	American black duck (S3, SGCN^{HP})
black dash (butterfly) (RG)	spotted turtle (SC, S3, SGCN^{HP})	king rail (T, S1, SGCN^{HP})
bronze copper (butterfly) (RG)	American bittern (SC, S4, SGCN)	Virginia rail (RG)
mulberry wing (butterfly) (RG)	least bittern (T, S3, S1N, SGCN)	common moorhen (RG)
	great blue heron (RG)	marsh wren (RG)
WET MEADOW		
Invertebrates	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
Baltimore (butterfly) (RG)	bronze copper (butterfly) (RG)	spotted turtle (SC, S3, SGCN^{HP})
mulberry wing (butterfly) (RG)	eyed brown (butterfly) (RG)	American bittern (SC, S4, SGCN)
black dash (butterfly) (RG)	phantom cranefly (RG)	Virginia rail (RG)
two-spotted skipper (butterfly) (RG)	***Vertebrates***	American woodcock (SGCN)
meadow fritillary (butterfly) (RG)	common ribbon snake (RG, SGCN)	sedge wren (T, S3, SGCN^{HP})
FEN		
Plants	***Plants*** (cont.)	***Invertebrates*** (cont.)
wood horsetail (RG)	round-leaved sundew (RG)	Dion skipper (butterfly) (S3)
twig-rush (RG)	small-flowered agrimony (R, S3)	Baltimore (butterfly) (RG)
Schweinitz's sedge (T, S2S3)	buckbean (RG)	mulberry wing (butterfly) (RG)
Bush's sedge (R, S3)	alder-leaf buckthorn (RG)	black dash (butterfly) (RG)
slender lady's-tresses (RG)	***Invertebrates***	***Vertebrates***
rose pogonia (RG)	*Gammarus pseudolimnaeus* (amphipod) (RG)	Atlantic coast leopard frog (SGCN)
spreading globeflower (R, S3)	*Pomatiopsis lapidaria* (snail) (RG)	southern leopard frog (SC)
scarlet Indian paintbrush (E, S1)	phantom cranefly (RG)	bog turtle (E, S2, SGCN^{HP})
grass-of-Parnassus (RG)	eyed brown (butterfly) (RG)	spotted turtle (SC, S3, SGCN^{HP})
fringed gentian (RG)	silver-bordered fritillary (butterfly) (RG)	common ribbon snake (SGCN)
swamp lousewort (T, S2S3)	two-spotted skipper (butterfly) (RG)	sedge wren (T, S3, SGCN^{HP})
OPEN WATER/CONSTRUCTED POND		
Invertebrates	***Vertebrates*** (cont.)	***Vertebrates*** (cont.)
dusky dancer (S1, SGCN)	wood turtle (SC, S3, SGCN^{HP})	pied-billed grebe (T, S3, S1N, SGCN)
Vertebrates	American bittern (SC, S4, SGCN)	osprey (SC, SGCN)
spotted turtle (SC, S3, SGCN^{HP})	great blue heron (RG)	bald eagle (T, S2S3, SGCN)
	American black duck (S3, SGCN^{HP})	river otter (SGCN)

(continued)

Appendix C (cont.)

SPRING/SEEP		
Plants	***Invertebrates***	***Vertebrates***
Bush's sedge (R, S3)	Piedmont groundwater amphipod (SGCN)	northern dusky salamander (RG)
devil's-bit (T, S1S2)	gray petaltail (dragonfly) (SC, S2, SGCN)	
	tiger spiketail (dragonfly) (S1, SGCN)	
STREAM & RIPARIAN CORRIDOR		
Plants	***Invertebrates*** (cont.)	***Vertebrates*** (cont.)
winged monkey-flower (R, S3)	*Sphaerium fabale* (fingernail clam) (RG)	Atlantic coast leopard frog (SGCN)
riverweed (T, S2)	arrowhead spiketail (dragonfly) (S2S3, SGCN)	northern dusky salamander (RG)
cattail sedge (T, S1)	tiger spiketail (S1, SGCN)	wood turtle (SC, S3, SGCN[HP])
Davis' sedge (T, S2)	mocha emerald (dragonfly) (S2S3, SGCN)	great blue heron (RG)
small-flowered agrimony (S3)	sable clubtail (dragonfly) (S1, SGCN)	American black duck (S3, SGCN[HP])
false-mermaid (RG)	ostrich fern borer (moth) (SGCN)	American woodcock (SGCN)
swamp rose-mallow (RG)	***Vertebrates***	bank swallow (RG)
may-apple (RG)	creek chubsucker (fish) (RG)	winter wren (RG)
Invertebrates	bridle shiner (fish) (RG)	cerulean warbler (SC, S3?B, SGCN)
Marstonia decepta (snail) (RG)	brook trout (fish) (SGCN)	Louisiana waterthrush (SGCN)
brook floater (mussel) (T, S1, SGCN)	slimy sculpin (fish) (RG)	river otter (SGCN)
Pisidium adamsi (fingernail clam) (RG)	southern leopard frog (SC)	northern long-eared bat (T, S1, SGCN)

Appendix D. Common and scientific names of plants mentioned in this report. Most scientific names follow the nomenclature of Weldy et al. (2021).

Common Name	Scientific Name	Common Name	Scientific Name
agrimony, small-flowered	*Agrimonia parviflora*	cinquefoil, shrubby	*Dasiphora fruticosa*
alder	*Alnus*	cliffbrake, purple	*Pellaea atropurpurea*
alkali-grass, pale	*Puccinellia distans*	cliffbrake, smooth	*Pellaea glabella* ssp. *glabella*
Allegheny-vine	*Adlumia fungosa*	cohosh, black	*Actaea racemosa*
arrowhead, broad-leaved	*Sagittaria latifolia*	columbine, wild	*Aquilegia canadensis*
arrowwood, northern	*Viburnum dentatum* var. *lucidum*	cottonwood, swamp	*Populus heterophylla*
arum, arrow	*Peltandra virginica*	cranberry, large	*Vaccinium macrocarpon*
ash	*Fraxinus*	crowfoot, small-flowered	*Ranunculus micranthus*
ash, black	*Fraxinus nigra*	deerberry	*Vaccinium stamineum*
ash, green	*Fraxinus pennsylvanica*	devil's-bit	*Chamaelirium luteum*
ash, white	*Fraxinus americana*	dittany	*Cunila origanoides*
aspen, quaking	*Populus tremuloides*	dogwood, gray	*Cornus foemina* ssp. *racemosa*
aster, stiff-leaf	*Ionactis linariifolia*	dogwood, roundleaf	*Cornus rugosa*
azalea, swamp	*Rhododendron viscosum*	dogwood, silky	*Cornus amomum* ssp. *obliqua*
baneberry, red	*Actaea rubra*	duckweed, common	*Spirodela polyrrhiza*
barberry, Japanese	*Berberis thunbergii*	duckweed, lesser	*Lemna minor*
basswood, American	*Tilia americana* var. *americana*	elm, American	*Ulmus americana*
beech, American	*Fagus grandifolia*	elm, slippery	*Ulmus rubra*
birch	*Betula*	false-mermaid	*Floerkea proserpinacoides*
birch, black	*Betula lenta*	featherfoil	*Hottonia inflata*
birch, gray	*Betula populifolia*	fern, cinnamon	*Osmunda cinnamomea*
birch, swamp	*Betula pumila*	fern, fragile	*Cystopteris fragilis*
birch, yellow	*Betula alleghaniensis*	fern, maidenhair	*Adiantum pedatum*
bittersweet, oriental	*Celastrus orbiculatus*	fern, marginal wood	*Dryopteris marginalis*
blackberry, northern	*Rubus allegheniensis*	fern, marsh	*Thelypteris palustris* var. *pubescens*
bladdernut	*Staphylea trifolia*	fern, royal	*Osmunda regalis* var. *spectabilis*
blazing-star, northern	*Liatris aspera*	fern, sensitive	*Onoclea sensibilis*
bloodroot	*Sanguinaria canadensis*	fern, Virginia chain	*Woodwardia virginica*
blueberry	*Vaccinium*	fern, walking	*Asplenium rhizophyllum*
blueberry, highbush	*Vaccinium corymbosum*	flag, blue	*Iris versicolor*
bluegrass, Kentucky	*Poa pratensis* ssp. *pratensis*	flax, yellow wild	*Linum sulcatum*
bluestem, little	*Schizachyrium scoparium* var. *scoparium*	foxtail, short-awned	*Alopecurus aequalis* var. *aequalis*
bracken	*Pteridium aquilinum* var. *latiusculum*	gentian, fringed	*Gentianopsis crinita*
buckbean	*Menyanthes trifoliata*	ginger, wild	*Asarum canadense*
buckthorn, alder-leaved	*Rhamnus alnifolia*	ginseng, American	*Panax quinquefolius*
buckthorn, glossy	*Frangula alnus*	globeflower, spreading	*Trollius laxus*
bulrush, hard-stemmed	*Schoenoplectus acutus* var. *acutus*	goat's-rue	*Tephrosia virginiana*
butterflyweed	*Asclepias tuberosa* ssp. *interior*	goldenrod	*Solidago*
butternut	*Juglans cinerea*	goldenrod, stiff-leaved	*Solidago rigida*
buttonbush	*Cephalanthus occidentalis*	goldenseal	*Hydrastis canadensis*
cattail	*Typha*	grape, winter	*Vitis vulpina*
cedar, eastern red	*Juniperus virginiana* var. *virginiana*	grass, poverty	*Danthonia spicata*
cherry, black	*Prunus serotina*	grass, reed canary	*Phalaris arundinacea*
chokeberry	*Aronia*	grass-of-Parnassus	*Parnassia glauca*

(continued)

Appendix D. (cont.)

Common Name	Scientific Name	Common Name	Scientific Name
gum, black	*Nyssa sylvatica*	pepperbush, coast	*Clethra alnifolia*
hackberry, northern	*Celtis occidentalis*	pine	*Pinus*
hairgrass, common	*Avenela flexuosa*	pine, eastern white	*Pinus strobus*
harlequin, yellow	*Corydalis flavula*	pine, pitch	*Pinus rigida*
hawthorn	*Crataegus*	pine, red	*Pinus resinosa*
hemlock, eastern	*Tsuga canadensis*	pine, scotch	*Pinus sylvestris*
hickory, mockernut	*Carya tomentosa*	pinesap, red	*Monotropa hypopithys*
hickory, pignut	*Carya glabra*	pink, grass	*Calopogon tuberosus* var. *tuberosus*
hickory, shagbark	*Carya ovata*	plant, pitcher	*Sarracenia purpurea*
holly, winterberry	*Ilex verticillata*	pogonia, rose	*Pogonia ophioglossoides*
honeysuckle, Bell's	*Lonicera* x *bella*	polypody, rock	*Polypodium virginianum*
horsetail, wood	*Equisetum sylvaticum*	pond-lily, fragrant	*Nymphaea odorata* ssp. *odorata*
huckleberry, black	*Gaylussacia baccata*	pond-lily, yellow	*Nuphar advena* ssp. *advena*
iris, yellow	*Iris pseudacorus*	poplar, tulip	*Liriodendron tulipifera*
jewelweed, orange	*Impatiens capensis*	prickly-ash, American	*Zanthoxylum americanum*
Joe-Pye-weed, spotted	*Eutrochium maculatum* var. *maculatum*	rattlebox, common	*Crotalaria sagittalis*
knotweed, slender	*Polygonum tenue*	reed, common	*Phragmites australis*
lady's-tresses, slender	*Spiranthes lacera* var. *gracilis*	riverweed	*Podostemum ceratophyllum*
laurel, mountain	*Kalmia latifolia*	rose, multiflora	*Rosa multiflora*
leatherleaf	*Chamaedaphne calyculata*	rose-mallow, swamp	*Hibiscus moscheutos* ssp. *moscheutos*
leatherwood	*Dirca palustris*	rush, soft	*Juncus effusus*
locust, black	*Robinia pseudoacacia*	sandwort, rock	*Minuartia michauxii* var. *michauxii*
loosestrife, purple	*Lythrum salicaria*	sarsaparilla, bristly	*Aralia hispida*
lopseed	*Phryma leptostachya*	saxifrage, golden	*Chrysosplenium americanum*
lousewort, swamp	*Pedicularis lanceolata*	sedge, ambiguous	*Carex amphibola*
mannagrass	*Glyceria*	sedge, Bicknell's	*Carex bicknellii*
maple	*Acer*	sedge, bottle-shaped	*Carex utriculata*
maple, red	*Acer rubrum*	sedge, brown bog	*Carex buxbaumii*
maple, sugar	*Acer saccharum*	sedge, Bush's	*Carex bushii*
may-apple	*Podophyllum peltatum*	sedge, cattail	*Carex typhina*
meadowsweet	*Spiraea alba* var. *latifolia*	sedge, clustered	*Carex cumulata*
milkweed, blunt-leaf	*Asclepias amplexicaulis*	sedge, Davis'	*Carex davisii*
milkweed, poke	*Asclepias exaltata*	sedge, Emmons'	*Carex albicans* var. *emmonsii*
milkweed, purple	*Asclepias purpurascens*	sedge, false hop	*Carex lupuliformis*
milkweed, whorled	*Asclepias verticillata*	sedge, handsome	*Carex formosa*
monkey-flower, winged	*Mimulus alatus*	sedge, inland	*Carex interior*
(a moss)	*Helodium paludosum*	sedge, lakeside	*Carex lacustris*
mountain-mint, Torrey's	*Pycnanthemum torrei*	sedge, Pennsylvania	*Carex pensylvanica*
nettle, false	*Boehmeria cylindrica*	sedge, reflexed	*Carex retroflexa*
oak	*Quercus*	sedge, Schweinitz's	*Carex schweinitzii*
oak, black	*Quercus velutina*	sedge, Swan's	*Carex swanii*
oak, chestnut	*Quercus montana*	sedge, tussock	*Carex stricta*
oak, red	*Quercus rubra*	sedge, woolly-fruited	*Carex lasiocarpa* ssp. *americana*
oak, scarlet	*Quercus coccinea*	shadbush, dwarf	*Amelanchier spicata*
oak, scrub	*Quercus ilicifolia*	skunk-cabbage	*Symplocarpus foetidus*
oak, white	*Quercus alba*	spicebush	*Lindera benzoin*
paintbrush, scarlet Indian	*Castilleja coccinea*	spikemoss, hidden	*Selaginella eclipes*
pellitory	*Parietaria pennsylvanica*	spleenwort, ebony	*Asplenium platyneuron* var. *platyneuron*

(continued)

Appendix D. (cont.)

Common Name	Scientific Name	Common Name	Scientific Name
spleenwort, maidenhair	*Asplenium trichomanes* ssp. *trichomanes*	viburnum, maple-leaf	*Viburnum acerifolium*
spleenwort, mountain	*Asplenium montanum*	vine, mile-a-minute	*Persicaria perfoliata*
spleenwort, silvery	*Deparia acrostichoides*	violet	*Viola*
spruce, Norway	*Picea abies*	wall-rue	*Asplenium ruta-muraria*
St. Johnswort, shrubby	*Hypericum prolificum*	water-plantain	*Alisma triviale*
sundew, round-leaved	*Drosera rotundifolia*	water-shield	*Brasenia schreberi*
sweetfern	*Comptonia peregrina*	whitlow-grass, Carolina	*Draba reptans*
sycamore	*Platanus occidentalis*	willow	*Salix*
twig-rush	*Cladium mariscoides*	witch-hazel	*Hamamelis virginiana*
valerian, bog	*Valeriana uliginosa*	woolgrass	*Scirpus cyperinus*