SIGNIFICANT HABITATS
IN THE TROUT BROOK WATERSHED, ORANGE COUNTY, NEW YORK

Report to the towns of Chester, Monroe, Tuxedo, and Warwick,
Orange County, New York

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EXECUTIVE SUMMARY

Hudsonia biologists identified and mapped ecologically significant habitats in the Trout Brook watershed in the towns of Chester, Monroe, Tuxedo, and Warwick in spring and summer 2010. Through map analysis, aerial photograph interpretation, and field observations we created a large-format map showing the locations and configurations of these habitats in the watershed. Some of the habitats are rare or declining in the region or support rare species of plants or animals, while others are high quality examples of common habitats or habitat complexes. Among our more interesting finds were large unfragmented forests, one exceeding 1,000 ac (400 ha); extensive crest, ledge, and talus habitats, including numerous small oak-heath barrens; 17 intermittent woodland pools; seven calcareous wet meadows; and 14 seeps and springs (we expect there are many more). We also found the regionally-rare Virginia chain fern in an isolated high-elevation pool, eastern hognose snake on a crest in an open, upland hardwood forest, black bear in an upland mixed forest, and many forest interior-breeding birds such as scarlet tanager, wood thrush, black-throated green warbler, and northern waterthrush in the large forests of the Sterling and Bellvale highlands. The Trout Brook watershed is located within the “Highlands” Significant Biodiversity Area identified by New York State Department of Environmental Conservation, is part of several Priority Conservation Projects identified in the 2006 New York State Open Space Conservation Plan, has both core biological areas and potential wildlife corridors identified in the 2004 Orange County Open Space Plan, and includes three important biodiversity areas identified by the Metropolitan Conservation Alliance. We have found much to corroborate the importance of the Trout Brook watershed for regional biodiversity and for maintaining surface and groundwater resources in the Moodna Creek system.

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, offer both general and habitat-specific conservation recommendations, and provide instructions on how to use the habitat information for conservation planning, policy-making, and site-specific environmental reviews. The report includes an updated map of dams and culverts in the watershed, and an appendix identifying potential sites for riparian restoration projects to improve the streambank stability, habitat quality, and water quality of Trout Brook.

The habitat map and report, which contain ecological information unavailable from other sources, can help stakeholders in the Trout Brook watershed identify the areas with the greatest ecological significance, develop conservation goals, and establish conservation policies and practices to protect biodiversity resources while serving the social, cultural, and economic needs of the human community.

INTRODUCTION

Background

Forested watersheds, rural landscapes, and small towns in Orange County and surrounding areas are undergoing rapid change as farms, forests, and other undeveloped lands are converted to residential and commercial uses. Most of this development has occurred without knowledge of the biological resources that may be lost or harmed, or the potential impairment of water resources. The consequences include widespread habitat loss, degradation, and fragmentation; loss of native biodiversity; degradation of surface water and groundwater; and loss of ecosystem functions and services that support the natural and human communities.

Although many land use decisions in the region are necessarily made on a site-by-site basis, the long-term viability of biological communities, habitats, and ecosystems requires consideration of whole landscapes. The availability of general biodiversity information for large areas such as towns, counties, or watersheds will allow landowners, developers, municipal planners, and others to better incorporate biodiversity protection into day-to-day decision-making.

To address this need, Hudsonia Ltd., a nonprofit scientific research and education institute, 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.

Hudsonia has now completed town-wide habitat maps for nine Dutchess County towns as well as portions of several more towns in Dutchess and Ulster counties, New York. Past projects have been funded by a variety of private and public sources. Funding for this project was part of a settlement between the New York State Department of Environmental Conservation (NYS DEC) and a business corporation for violations of the Environmental Conservation Law. The Educational Foundation of America provided programmatic support to Hudsonia to further this and other projects of Hudsonia's Biodiversity Resources Center. We also received practical assistance with this project from many landowners and town representatives.

Andrew Meyer (biologist) conducted most of the work on this project in April through August 2010, with assistance from biologists Nava Tabak and Kristen Bell Travis. Through map analysis, aerial photograph interpretation, and field observation we created a map of ecologically significant habitats in the Trout Brook watershed. Some of these habitats are rare or declining in the region, some may support rare species of plants or animals, while others are high quality examples of common habitats or habitat complexes. The emphasis of this project was on identifying and mapping general habitat types; we did not conduct species-level surveys or map the locations of rare species.

Hudsonia hopes to extend the habitat mapping program to other parts of southeastern New York. To facilitate inter-municipal planning, we strive for consistency in the ways that we define and identify habitats and present the information for town use, but we also expect that our methods and products will improve 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 (Stevens and Broadbent 2002, Tollefson and Stevens 2004, Bell et al. 2005, Sullivan and Stevens 2005, Tabak et al. 2006, Reinmann and Stevens 2007, Knab-Vispo et al. 2008, Tabak and Stevens 2008, Bell and Stevens 2009, McGlynn et al. 2009, Deppen et al. 2009) without specific attribution. This report, however, addresses our findings and specific recommendations for the Trout Brook watershed. 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, watershed-wide, 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 riparian enhancement measures voluntarily. We also hope that the towns of the Trout Brook watershed will engage in proactive measures to ensure that future land development is planned with a view to long-term protection of the watershed's considerable biological resources and water quality.

What is Biodiversity?

The concept of biodiversity, or biological diversity, encompasses all of life and its processes. It includes ecosystems, biological communities, populations, species, and gene pools, 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 essential gases and nutrients, purifying water and air, producing and decomposing organic matter, sequestering carbon, and providing many other essential services. They also serve as the foundation of our natural resource-based economy.

The decline or disappearance of native species can be a symptom of environmental deterioration or collapses in parts of the ecosystem. While we do not fully understand the roles of all organisms in an ecosystem and cannot fully predict the consequences of the extinction of any particular species, 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. By illustrating the locations and configurations of ecologically significant habitats in the Trout Brook watershed, the habitat map that accompanies this report provides valuable ecological information that can be incorporated into local land use planning and decision making.

What is a Watershed?

A watershed is the area of land that drains to a common place. The Trout Brook watershed is a subbasin (or subwatershed) of the 180 mi^2 (466 km^2) Moodna Creek watershed, which drains much of eastern Orange County (Figure 1). The Trout Brook watershed encompasses the Trout Brook and its perennial and intermittent tributaries, as well as all of the land area from which water drains into these streams. From an ecological and water resources standpoint, watersheds are much better than municipal units for planning because of the hydrologic connections that tie the watershed landscapes together.

Study Area

The Trout Brook watershed, approximately 6.5 mi^2 (16.8 km^2), is located in southern Orange County in southeastern New York. This is the southernmost subwatershed of the Moodna Creek, a major tributary of the Hudson River. The Trout Brook mainstem flows 6.5 miles (10.4 km) from its headwaters in the southeastern hills of the study area to its junction with Seely Brook, just north of the intersection of Laroe and Sugar Mountain roads. Seely Brook joins Cromline Creek which flows through Tomahawk Lake and eventually into the Moodna.

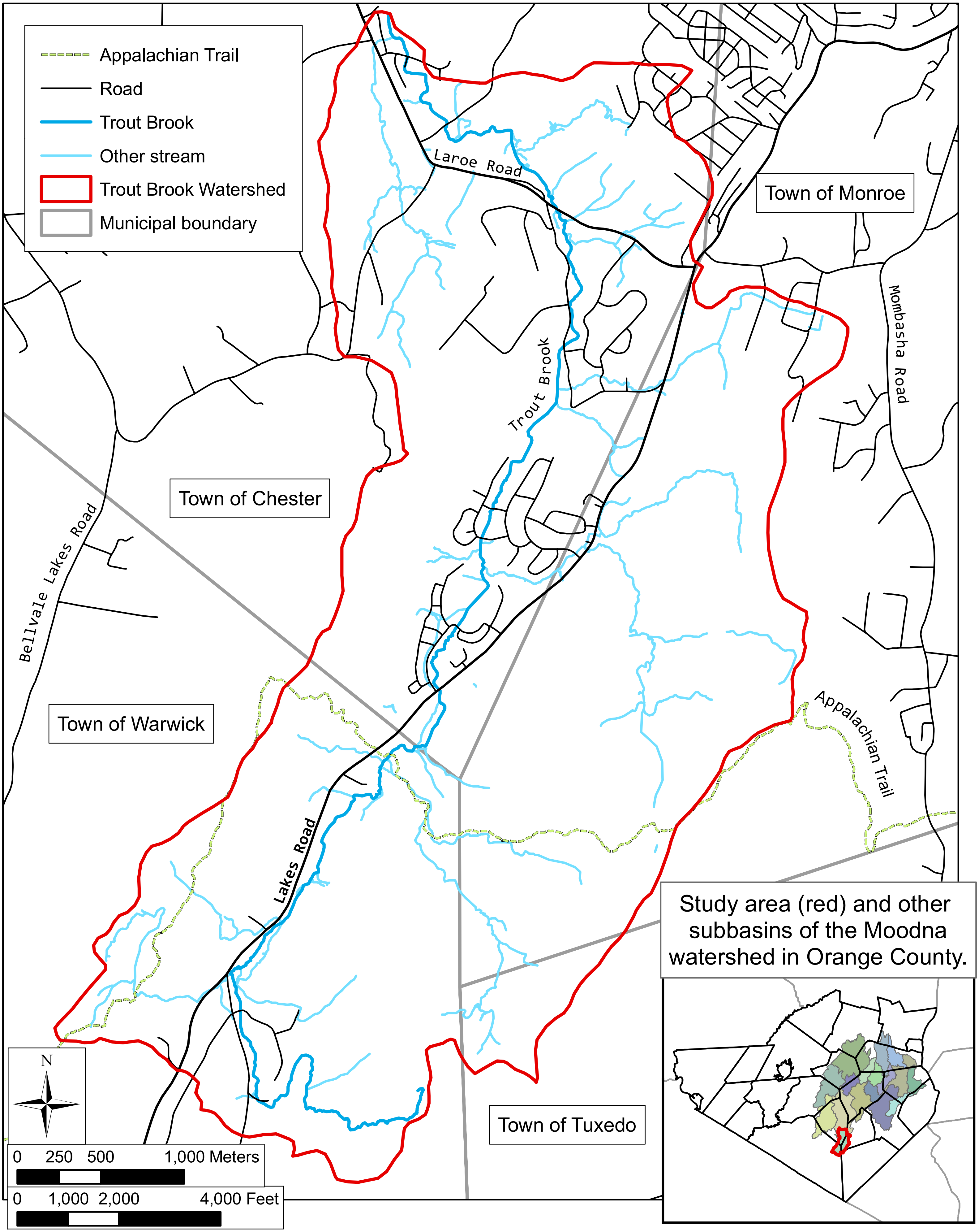


Figure 1. Trout Brook watershed and surrounding towns, Orange County, NY. Moodna watershed subbasin data on inset map from the Orange County Watershed Authority. Hudsonia Ltd., 2010.

The Trout Brook watershed is part of the Hudson Highlands physiographic region which extends from northern New Jersey through southern New York and into western Connecticut. In the southern half of the study area the Trout Brook lowland corridor is flanked by Bellvale Mountain on the west and Sterling Forest State Park on the east, each with large areas of substantially unfragmented forests and other high quality habitats (Figure 2). The northern half of the watershed also has several large forest patches, but is otherwise characterized by suburban development and farm fields.

Elevations in the watershed range from 460 ft (138 m) above mean sea level at the junction of Trout Brook and Seely Brook to 1386 ft (416 m) at the summit of an unnamed mountain in Sterling Forest. Other high peaks in the study area are at 1300 ft (390 m) in Sterling Forest, and 1294 ft (388 m) on the Bellvale Mountain ridge.

According to Fisher et al. (1970), much of the bedrock in the watershed is gneiss, amphibolite, and granite, but the Bellvale Mountain ridge is underlain by shale and sandstone, and just west of that near Gibson Hill Road is undifferentiated limestone, dolostone, sandstone, shale, and conglomerate. Surficial deposits are predominantly glacial till, but Cadwell et al. (1989) mapped a kame deposit extending about 0.5 miles into the watershed from the south, centered along Lakes Road. Areas of exposed bedrock include amphibolite and gneiss, and the shale and siltstone of the Bellvale Mountain ridge. The soils of the watershed fall into four main groups. The Bellvale Mountain and Sterling Forest highlands have medium-textured, well to excessively well drained, shallow soils of the Arnot-Swartswood-Hollis unit. The gently sloping areas of the Trout Brook valley bottom are predominantly Mardin-Erie soils—medium textured, deep, and moderately well-drained. The narrow alluvial and outwash plains adjacent to the Trout Brook mainstem have coarse-textured soils in the Otisville, Halsey, and Hoosic series, and finer soils of the Wayland and Middlebury series.

The watershed is largely forested. Most of the developed land is in residential uses clustered near Trout Brook. Some meadows in the northern section are regularly mowed. Other land uses include a private summer camp, a middle school, two northwest-southeast running utility corridors, and a municipl solid waste transfer station. The federal and state governments own substantial portions of the watershed in properties associated with the Appalachian Trail (455 ac [182 ha]) and Sterling Forest State Park (527 ac [211 ha]).

The Trout Brook watershed is located within the “Highlands” Significant Biodiversity Area of southeastern New York identified by the NYS DEC (Penhollow et al. 2006). The New York State Open Space Conservation Plan (NYS DEC 2006) includes the Trout Brook watershed lands in several Priority Conservation Projects, including: Turtle Conservation Sites, Schunnemunk Mountain/Moodna Creek/Woodcock Mountain, New York Highlands (including Greater Sterling Forest), Long Distance Trail Corridors, and Hudson River Estuary/Greenway Trail Corridor. The Orange County Open Space Plan has identified the southern half of the Trout Brook watershed as a core biological diversity area (Orange County Department of Planning 2004). The northwestern region of the watershed is noted as a possible wildlife corridor in the same plan, linking the core area in the southern watershed with a core area encircling Goosepond Mountain State Park. The Metropolitan Conservation Alliance designated three important biodiversity areas that intersect the Trout Brook watershed (Miller et al. 2005).

The Orange County Water Authority (OCWA) published the Moodna Creek Watershed Conservation and Management Plan in March 2010. The Plan describes existing conditions in the Moodna Creek watershed and many of the causes of water quality impairment, and offers a prioritized list of action items and recommendations for addressing the identified issues. The habitat map and this report help to carry out several of those recommendations, including: Research items A (research and inventory of all hydraulic constrictions), F (continue biological research and restoration), and H (inventory and repair areas endangered by erosion); Education/Outreach item B (educate and foster public understanding on the needs of biological resources including forests, wetlands, and other natural areas); Site Specific item C (identify potential riparian restoration and conservation projects); and Conservation item B (identify, protect, and manage important habitats) (Orange County Water Authority 2010).

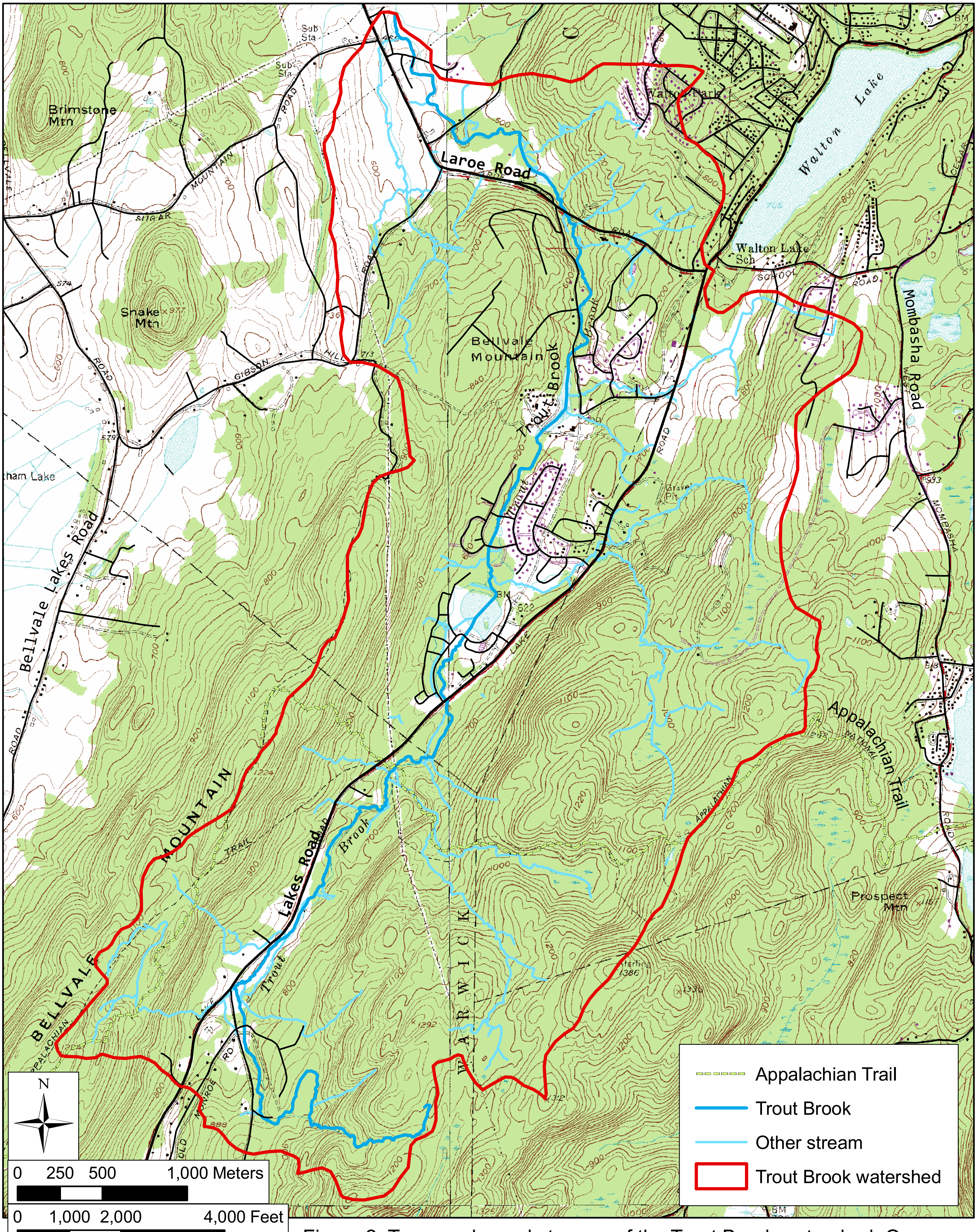


Figure 2. Topography and streams of the Trout Brook watershed, Orange County, New York. Base map is from USGS 7.5 minute quadrangles (Greenwood Lake, Monroe, Warwick, contour interval is 20 ft); stream overlay within the watershed was created by Hudsonia. Hudsonia Ltd., 2010.

Since 2004, the OCWA has conducted the Water Quality Biomonitoring Project, which provides water quality information from more than 160 sites throughout the county. From these data, Gruber et al. (2008) and Watershed Associates (2008) report on abundance and diversity of macroinvertebrates in streams in the county, including Trout Brook. Data from four samples collected from three stations in the Trout Brook watershed in 2004-2006 indicate that the stream may be one of the least impacted subbasins of the Moodna Creek watershed. However, the only re-sampled station, near the convergence with Seely Brook, showed a decline in the indicator status of the macroinvertebrate community to "significantly altered from the pristine state" from 2005 to 2006.

OCWA studies indicate that non-point source nutrient enrichment from impervious surfaces and pollutants associated with human activities are the primary causes of water quality degradation in the Moodna Creek watershed.

Black rat snake at edge of hardwood swamp, Sterling Forest State Park, July 2010

METHODS

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

Gathering Information and Predicting Habitats

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

- *1:40,000 scale color infrared stereoscopic aerial photograph prints* from the National Aerial Photography Program series taken in spring 1994, obtained from the U.S. Geological Survey. Viewed in pairs with a stereoscope, these prints ("stereo pairs") provide a three-dimensional view of the landscape and are extremely useful for identifying vegetation cover types, wetlands, streams, and cultural landscape features.
- *High-resolution (1 pixel = 2 ft [61 cm]) color infrared digital orthophotos* taken in spring 2001, obtained from the New York State GIS Clearinghouse website (http://www.nysgis.state.ny.us; accessed April 2010). We use these digital aerial photos for on-screen digitizing of habitat boundaries.
- *High-resolution (1 pixel = 1 ft [30 cm]) natural color digitial orthophotos* taken in spring 2007, obtained from the New York State GIS Clearinghouse website (http://www.nysgis.state.ny.us; accessed April 2010). We use these natural color photos to identify recent development and other recent disturbances in the landscape.

- *Bing maps (bing.com/maps)* web-based aerial photo resource. We use the photo images on this website to help verify habitat predictions and update developed features; some of the close-up aerial photos are more recent than our 2007 orthophotos.

- *U.S. Geological Survey topographic maps* (Greenwood Lake, Warwick, and Monroe 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 ledges, 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 Orange County, New York* (Olsson 1981). 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 location of crest, ledge, and talus habitats. Poorly and very poorly drained soils usually indicate the location of wetland habitats such as swamps, marshes, and wet meadows. The location of alkaline soils can be used to predict the occurrence of fens and calcareous wet meadows.

- *Geographic Information Systems (GIS) data*. We obtained most of our background GIS data from the Orange County GIS website, including municipal boundaries, roads, hydrography, contour intervals, parcel boundaries, bedrock units, and NYS Freshwater Wetlands data. Topographic information came from the Cornell University Geospatial Information Repository. We obtained soils data from the Natural Resources Conservation Service's website, and National Wetlands Inventory data from the US Fish and Wildlife Service website. We acquired Appalachian Trail data from the Appalachian Trail Conservancy website, published by the Appalachian Trail

Conservancy and National Park Service Appalachian Trail Park Office in 2007 (http://www.appalachaintrail.org; accessed March 2008). We obtained tax parcel data from the Orange County Office of Real Property Tax. The subbasins of the Moodna Creek watershed are from the Orange County Water Authority. We used ArcView 9.2 software (Environmental Systems Research Institute 2007) to examine these data layers together with the orthophoto images. Although we referred to wetlands, hydrography, soils, and geology data from other sources, all of the habitat data (including those for wetlands and streams) issuing from this project are original, derived from our own analysis of maps, aerial photos, and field observations.

Preliminary Habitat Mapping and Field Verification

We prepared a preliminary map of predicted habitats based on map analysis and stereo interpretation of aerial photographs. We digitized the predicted habitats onscreen over orthophoto images using ArcView 9.2 mapping software. In this process we also noted the places where our remote identifications were uncertain, and targeted those areas for field visits. We prioritized sites for field visits based both on opportunity (i.e., willing landowners and public property) and our need to answer questions regarding habitat identification or extent that could not be answered remotely. For example, distinctions between wet meadow v. calcareous (calcium-rich) wet meadow, and calcareous v. non-calcareous crests can only be made in the field. Before conducting field visits on private property, we contacted landowners (identified using tax parcel data) for permission to visit their land.

With the draft habitat 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 habitats that could not be identified remotely.

In addition to conducting field work on private land, we viewed habitats from adjacent properties, public roads, and other public access areas. Because the schedule of this project (and non-participating landowners) prevented us from conducting onsite field verification on every parcel in the study area, this prioritization strategy contributed to our efficiency and accuracy in carrying out this work.

We field checked approximately 28% of undeveloped land in the Trout Brook watershed. We mapped by remote sensing alone those areas that we did not see in the field, often extrapolating the findings from our field observations on adjacent parcels and in similar settings throughout the study area. We assume, however, that the field-checked areas of the habitat map 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 large habitat mapping projects we classify broad habitat types identifiable mainly by their vegetation, and other visible physical properties. Habitats exist as part of a continuum of intergrading characteristics, however, and drawing a line to separate two "habitats" often seems quite arbitrary. Furthermore, some distinct habitats are intermediates between two defined habitat types, and some habitat categories can be considered complexes of several habitats types. In order to maintain consistency within and among habitat mapping projects, we have developed certain mapping conventions (or rules) that we use to classify habitats and depict their boundaries. Some of these conventions are described in Appendix A. All of our mapped habitat boundaries should be considered approximations. Much of the watershed 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 areas that we consider to be non-significant habitats (e.g., structures, paved and gravel roads and driveways, other impervious surfaces, and small lawns, meadows, and woodlots) are shown as white (no symbol or color) on the habitat map. Areas that have been developed since 2007 (the most recent orthophoto date) were identified as such if we observed them in the field or if the available Bing photos were more recent than our orthophotos; it is likely, however, that we have underestimated the extent of developed land in the study area.

Final Mapping and Presentation of Data

We corrected and refined the preliminary map on the basis of our field observations to produce the final habitat map. We printed the final large-format habitat map at a scale of 1:10,000 using a Hewlett-Packard DesignJet 800PS plotter, on one sheet measuring 36 x 28 in. The GIS database that accompanies the map includes additional information about many of the mapped habitat units, such as the dates of field visits (including observations from adjacent properties and roads) and some of the plant and animal species observed in the field. The habitat map, GIS database, and this report have been presented to the four towns of the watershed for use in 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."*

RESULTS

Overview

The large-format Trout Brook watershed habitat map illustrates the diversity of habitats that occurs in the study area and the complexity of their configuration in the landscape. A reduction of the map is shown in Figure 3. Of the total 6.5 mi^2 (16.9 km^2) in the study area, approximately 81% is undeveloped land (i.e., without structures, pavement, roads, etc.). Existing development is generally concentrated along the Trout Brook corridor in the center of the watershed, where local roads and the stream entwine along the valley bottom. The largest areas of undeveloped land are large blocks in the western and eastern portion of the study area. The northern part of the study area, where existing development is more dispersed across the landscape, still has several large habitat patches. Figure 4 shows blocks of contiguous undeveloped habitat areas in various size categories, ranging from less than 25 ac to over 500 ac (<10 to > 200 ha). Forests (including both upland forest and hardwood and shrub swamp habitat types**)** cover extensive areas within these blocks, and represent approximately 75% of the study area. Four percent of the watershed is wetland. Some of the more notable habitats we documented include springs and seeps, intermittent woodland pools, oak-heath barrens, and several ridgetop marshes with interesting plant communities. In total, we identified 22 different habitat types in the watershed that we consider to be of ecological importance (Table 1).

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 in the past 250 years so they lack the structural complexity of mature forests. The hydrology of many wetlands in the study area has been extensively altered by excavation, filling, draining, and construction of dams and roads. Japanese barberry (an introduced invasive species) was a common component of the mesic upland forests of the watershed, and many red cedar woodlands had abundant non-native, invasive species such as Eurasian honeysuckles and multiflora rose. Although we have documented the location and extent of important habitats throughout the study area, only in a few cases have we provided information on the quality and condition of particular habitat units.

The New York Natural Heritage Program (NYNHP) has records of many significant communities and rare species from the Trout Brook watershed and surrounding landscapes. There are historic records for Allegheny woodrat as well as the plants large twayblade, Hooker's orchid, dragon's mouth orchid, and fairy wand in the Trout Brook watershed; the woodrat has not been positively identified since 1981, and the plant records date to the 19th and early 20th centuries. The NYNHP also has records of northern cricket frog, eastern worm snake, mottled darner, Carey's smartweed, terrestrial starwort, Bayard's adder's-mouth orchid, thickleaf orach, slender pinweed, and violet wood-sorrel in nearby watersheds. Several bat hibernacula have been recorded within three miles of the watershed, including one with a documented eastern small-footed myotis population. Eastern small-footed myotis is known from two other locations within ten miles of the watershed, and Indiana bat summer colonies have been recorded within four miles of Trout Brook (NYNHP 2010). Pied-billed grebe has been recorded in the Tuxedo topographic quadrangle of the Breeding Bird Atlas, in Sterling Forest State Park.

Pink lady-slippers near the Appalachian Trail, April 2010

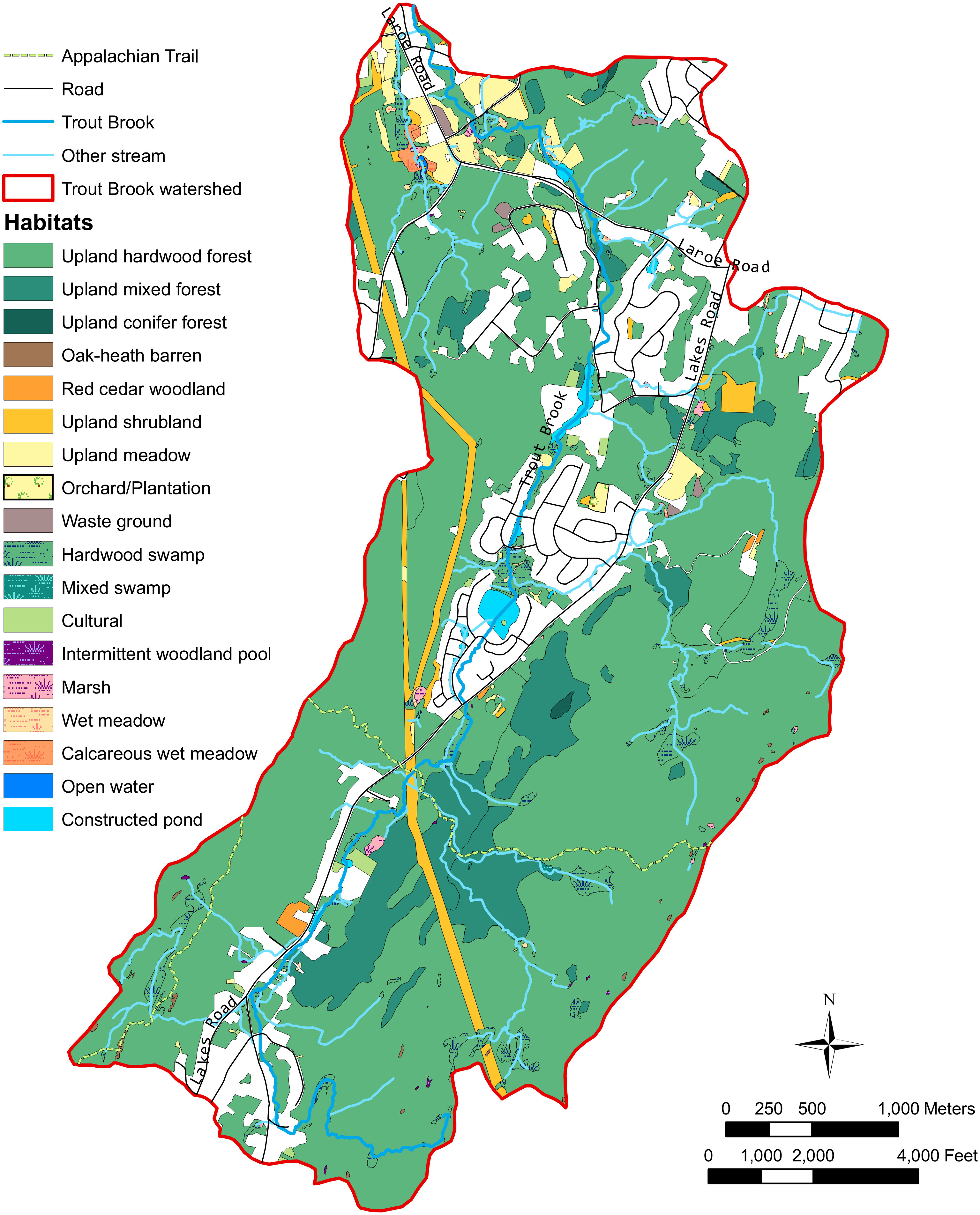


Figure 3. A reduction of the map illustrating ecologically significant habitats in the Trout Brook watershed, Orange County, New York, identified by Hudsonia Ltd. The developed areas and other non-significant habitats are shown in white. A large-format map is printed at a scale of 1:10,000.

Table 1. Ecologically significant habitats identified by Hudsonia in the Trout Brook watershed, cross-referenced to New York Natural Heritage Program (NYNHP) ecological community types (Edinger et al. 2002). Hudsonia Ltd., 2010.

HUDSONIA HABITAT TYPE	NYNHP ECOLOGICAL COMMUNITY TYPE	HUDSONIA HABITAT TYPE	NYNHP ECOLOGICAL COMMUNITY TYPE
Upland Habitats		**Wetland, Pond, and Stream Habitats**	
upland hardwood forest	Appalachian oak-hickory forest chestnut oak forest oak—tulip-tree forest rich mesophytic forest beech—maple mesophytic forest successional northern hardwoods successional southern hardwoods	hardwood & shrub swamp	red maple—hardwood swamp red maple—blackgum swamp shrub swamp impounded swamp highbush blueberry bog thicket floodplain forest
upland conifer forest	hemlock—northern hardwood forest pine—northern hardwood forest	mixed forest swamp	hemlock—hardwood swamp
upland mixed forest	hemlock—northern hardwood forest pine—northern hardwood forest	intermittent woodland pool	vernal pool
red cedar woodland	successional red cedar woodland	marsh	deep emergent marsh shallow emergent marsh impounded marsh reedgrass/purple loosestrife marsh
crest, ledge, & talus	cliff community shale cliff and talus community	wet meadow	shallow emergent marsh
calcareous crest, ledge, & talus	calcareous cliff community	calcareous wet meadow	shallow emergent marsh
oak-heath barren	pitch pine—oak-heath rocky summit	constructed pond	farm pond/artificial pond reservoir/artificial impoundment artificial pool
orchard/plantation	orchard spruce/fir plantation	open water	eutrophic pond
upland shrubland	successional shrubland	spring/seep	spring
upland meadow	successional old field pastureland	stream	rocky headwater stream marsh headwater stream confined river intermittent stream ditch/artificial intermittent stream
cultural	mowed lawn with trees mowed lawn		
waste ground	landfill/dump urban vacant lot		

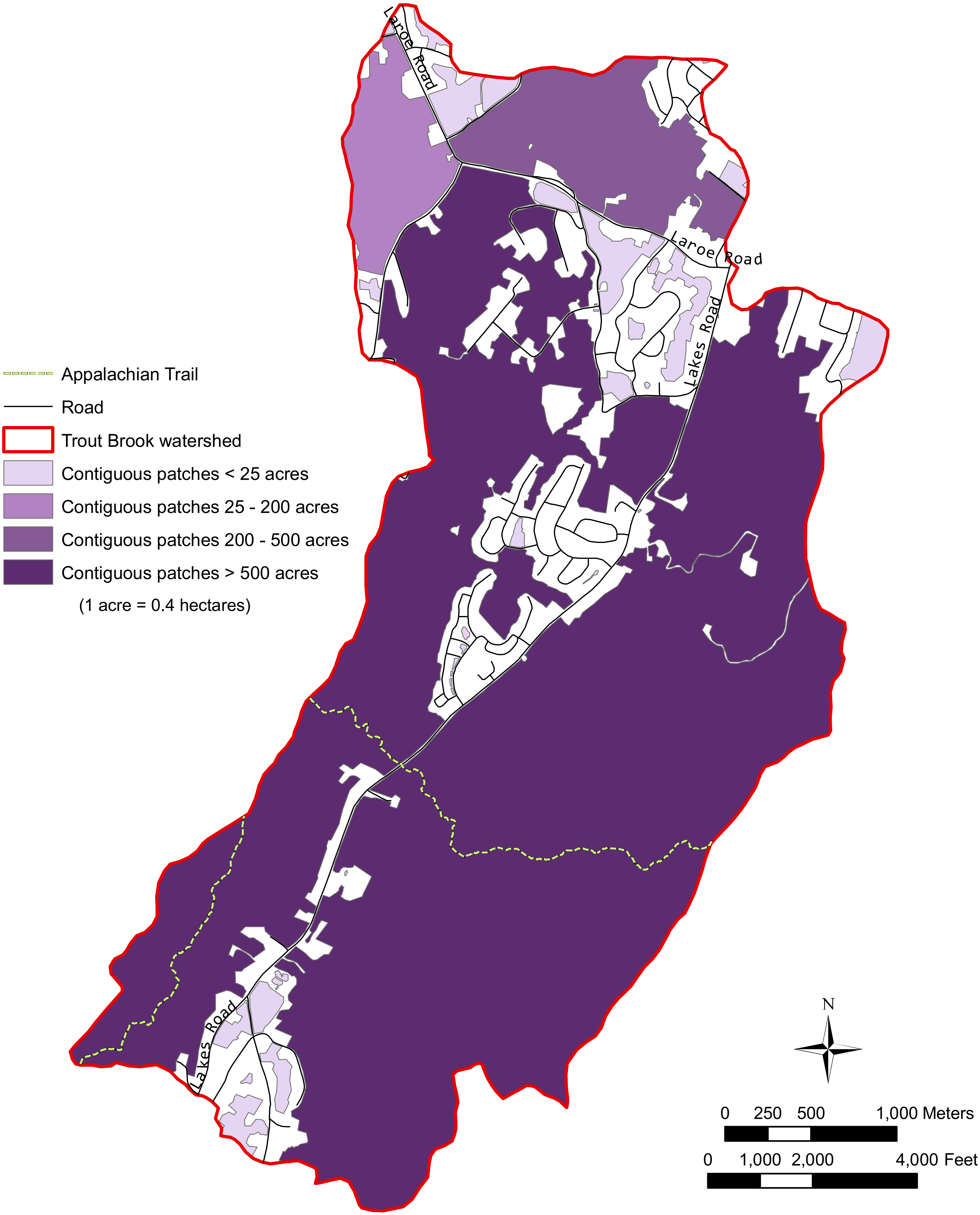


Figure 4. Contiguous habitat patches in the Trout Brook watershed, Orange County, New York. Developed areas and other non-significant habitats are shown in white. Hudsonia Ltd., 2010

HABITAT DESCRIPTIONS

In the following pages we describe some of the ecological attributes of the habitats identified in the watershed, and discuss some conservation measures that can help to protect these habitats and the species of conservation concern they may support. We have assigned a code to each habitat type (e.g., upland conifer forest = ucf; marsh = ma) that corresponds with the codes appearing on the large-format (1:10,000 scale) Trout Brook watershed habitat map. We have indicated 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 larger list of species of conservation concern associated with each habitat, including their statewide and regional conservation status. Species in this appendix could occur or are likely to occur in these habitats in Orange County, but are not necessarily present in the Trout Brook watershed. The alphanumeric codes used in Appendix C to describe the conservation status of rare species are explained in Appendix B. Appendix D gives the common and scientific names of all plants mentioned in this report.

UPLAND HABITATS

UPLAND FORESTS

Ecological Attributes

We classified upland forests into three general types for this project: hardwood forest, conifer forest, and mixed forest. We recognize that upland forests are 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.

<u>Upland Hardwood Forest (uhf)</u>

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.

Common trees of upland hardwood forests include maples (sugar, red), oaks (black, red, white, chestnut), hickories (shagbark, pignut), white ash, yellow birch, and black birch. Common understory species include maple-leaf viburnum, witch-hazel, mountain laurel, serviceberry (or shadbush), ironwood, Japanese barberry, lowbush blueberries, and a wide variety of wildflowers, sedges, ferns, and mosses. Rocky forests at higher elevations (generally above 800 ft along the southwest facing Bellvale Mountain ridge and above 1,000 ft in Sterling Forest) are often dominated by chestnut oak, red oak, and hickory species, and often have lowbush blueberries and huckleberry forming a dense understory, or are sometimes fairly open with scattered blueberries, abundant grasses, and exposed rock.

Eastern box turtle* spends most of its time in upland forests and meadows, finding shelter under logs and organic litter, and spotted turtle* uses upland forests for aestivation (summer dormancy) and travel. Many snake species, such as timber rattlesnake,* eastern hognose snake,* eastern rat snake,* eastern 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 seem to 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. Many small mammals are associated with upland hardwood forests, including eastern chipmunk, southern flying squirrel, and white-footed mouse. The native Allegheny woodrat was most recently recorded in the Trout Brook watershed in 1981, but has not been confirmed anywhere in New York since the 1980s. It once inhabited large boulder talus areas and nearby forests. Hardwood trees greater than 5 inches (12.5 cm) diameter-at-breast-height (dbh) (especially those with loose platy bark such as shagbark hickory) can be used by Indiana bat* and other bats for summer roosting and nursery colonies. Areas of the Trout Brook watershed are within summer migration distance (40 mi [64 km] [U.S. Fish and Wildlife Service 2006]) of an Indiana bat hibernation cave and there are summer roosting sites in nearby watersheds (NYNHP 2010).

Upland Conifer Forest (ucf)

This habitat includes naturally occurring upland forests with conifers representing more than 75% of the overstory, and is relatively rare in the watershed. Eastern hemlock, white pine, and eastern red cedar are typical species of naturally occurring conifer stands in the area. Different kinds of conifer forests play different ecological roles in the landscape. For example, forests of eastern red cedar tend to be short-lived and are 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 hemlock woolly adelgid infestations.

Conifer stands are used by many species of owls (e.g., barred owl,* great horned owl, long-eared owl,* short-eared owl*) and other raptors (e.g., Cooper's hawk* and sharp-shinned hawk*) for roosting and sometimes nesting. Pine siskin,* red-breasted nuthatch,* evening grosbeak,* purple finch,* black-throated green warbler,* and blackburnian warbler* nest in conifer stands. American woodcock* sometimes uses conifer stands for nesting and foraging. Conifer stands also provide important habitat for a variety of mammals, including eastern cottontail, red squirrel, and eastern chipmunk (Bailey and Alexander 1960). Some conifer stands provide winter shelter for white-tailed deer and can be especially important for them during periods of deep snow cover.

Upland Mixed Forest (umf)

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 often less densely shaded at ground level and tend to support a higher diversity and greater abundance of understory species than pure conifer stands. Mixed forests share many of the same ecological attributes of hardwood and conifer forests.

Forests and Water Resources

In addition to their wildlife habitat values, upland forests of all kinds provide essential protections to the quality and quantity of our surface and groundwater resources. They promote maximum infiltration of precipitation and snowmelt to the soils, thereby reducing sheet runoff at the surface—a major cause of soil erosion, stream scouring, and damaging floods—and increasing groundwater recharge. This helps to insure adequate groundwater volumes available to feed streams and wetlands during drier periods of the year (Wilder and Kiviat 2008). Also, forests are among the most effective kinds of land cover for long term carbon sequestration in above-ground and below-ground biomass. Maintenance and expansion of forested areas helps to offset carbon emissions to the atmosphere from other human activities (IPCC 2007).

Occurrence in the Trout Brook Watershed

Figure 5 illustrates the locations of forested areas (including both forested wetlands and forested uplands) in the study area, and the distribution of forest patches in various size categories, ranging from less than 25 ac to over 500 ac (<10 ha to >200 ha). One unfragmented forest patch in the eastern highlands was greater than 1,000 ac within the watershed. Two more forest patches, one along Bellville Mountain ridge and the other encompassing the southeastern highlands, covered more than 500 acres within the watershed. These three upland forest habitat units represent 71% of the forested land in the watershed, and over 53% of the entire watershed. The forest patches in the Sterling Forest highlands were part of much larger forests extending well beyond the watershed boundary.

Upland hardwood forest was the most widespread habitat type, accounting for 64% of the total land area of the Trout Brook watershed. Local areas of “rich forest,” supporting calcium-associated plant species, were found along Bellvale Mountain and in Sterling Forest State Park. Plants of these rich hardwood forests (but less common in other upland forests) include such species as basswood, wild columbine, birdsfoot violet, and yellow stargrass. We presume that virtually all forests in the watershed have been cleared or logged in the past and that no “virgin” stands remain. 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 study area that we did not observe during field work. Large areas of protected forest land along the Appalachian Trail and within the Sterling Forest State Park appeared virtually free of invasive plant species with the exception of Japanese barberry, which was widespread especially along intermittent streams.

Upland conifer and mixed forest patches ranged from less than 1 ac to 77 ac (< 0.4-30.4 ha) and most were distributed throughout the study area within upland hardwood tracts. The largest mixed forest patches were along the west-facing slopes of the eastern hills. The conifer stands observed in the field had white pine or eastern hemlock in the overstory, and were often embedded within more extensive areas of mixed forest. Eastern red cedar stands were characteristic of early-successional forests on abandoned farmland. Eastern hemlock was a major component of most mixed forest habitats.

Sensitivities/Impacts

Forests of all kinds are important habitats for wildlife. Extensive forested areas that are unfragmented by roads, driveways, trails, utility corridors, developed lots, or meadows are especially important for certain organisms, but are increasingly rare in the region. Fragmenting features pose many threats to wildlife and to the forest habitat itself. Paved and unpaved roads act as barriers which many species will not cross or cannot safely traverse (Forman and Deblinger 2000). For example, mortality from vehicles can significantly reduce the population densities of amphibians (Fahrig et al. 1995), and use of habitats near roads is reduced because many animals will not breed near traffic noise (Trombulak and Frissell 2000). House sites set back from roads by long driveways cause significant fragmentation of core forest areas, and development along roads may block important wildlife travel corridors between forested patches. Any new roadway (including driveways) can provide access to interior forest areas for nest predators (such as raccoon and opossum) and the brown-headed cowbird (a nest parasite) which reduce the reproductive success of many forest interior birds. Where dirt roads or trails cut through forest, vehicle, horse, and pedestrian traffic can harm tree roots and cause soil erosion. Runoff from roads can pollute nearby areas with road salt, heavy metals, and sediments (Trombulak and Frissell 2000). Forests are also susceptible to invasion by shade-tolerant non-native herbs and shrubs, which may easily be dispersed along roads and trails and by logging machinery, ATVs, and other vehicles.

In addition to fragmentation, forest habitats can be degraded in many other ways. Clearing the forest understory destroys habitat for birds such as wood thrush* which nests in dense understory vegetation, and hermit thrush or black-and white warbler* which nest on the forest floor. Selective logging can also damage the understory and cause soil erosion and sedimentation of streams. Soil compaction and removal of dead and downed wood and debris has several negative impacts, including the elimination of habitat for mosses, lichens, fungi, birds, amphibians, reptiles, small mammals, and insects. Human habitation has also led to the suppression of naturally occurring wildfires which can be important for some forest species and the forest ecosystem as a whole. See the Conservation Priorities section for recommendations on preserving the habitat values of large forests.

RED CEDAR WOODLAND (rcw)

Ecological Attributes

“Red cedar woodlands” feature an overstory of widely-spaced eastern red cedar trees and grassy meadow remnants between them. Red cedar is one of the first woody plants to colonize abandoned pastures 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 cedar trees are often widely spaced in young stands and denser in more mature stands. They tend to develop particularly dense stands in areas with calcareous (calcium-rich) soils. Other trees of this habitat include black cherry, red maple, and red oak. The understory vegetation is similar to that of upland meadow. 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. In more mature red cedar woodlands, where the meadow patches are smaller and shadier, wild grapes and invasive shrubs such as Japanese barberry, multiflora rose, and Eurasian honeysuckles are common. Red cedars can persist in these stands for many years even after a hardwood forest grows up around them. We mapped areas where abundant red cedar occurred under a canopy of hardwoods as “upland mixed forest.”

The juniper 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 reptiles 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. Red cedar woodlands may provide habitat for roosting raptors, such as northern harrier,* short-eared owl,* and northern saw-whet owl.* 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 Trout Brook Watershed

Red cedar woodlands in the watershed ranged in size from less than 0.5 ac to 5 ac (<0.2-2 ha). These habitats generally became established on abandoned pastures and hayfields, and most are near development now and maintained with some form of management (e.g., infrequent mowing).

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, however, and will ordinarily develop into young forest with the cedars gradually overtopped by deciduous trees. Except where a red cedar woodland habitat is known to support one or more rare species that depends on the semi-open woodland conditions, we do not recommend maintaining the habitat artificially (e.g., by selective cutting of competing 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 steeply-sloped rock fragments of various sizes that often accumulate at the bases of steep ledges and cliffs. We also included 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.

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, hackberry,* 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, hairgrass, bristly sarsaparilla, and rock polypody. Rare plants of non-calcareous crests include mountain spleenwort,* clustered sedge,* and slender knotweed.*

Northern hairstreak* (butterfly) occurs with oak species which are host plants for its larvae, and juniper 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,* eastern wormsnake,* and northern copperhead.* Ledge areas with southern to southeastern and southwestern exposure may provide winter den sites and spring basking rocks for timber rattlesnake* and other snakes of conservation concern. (We observed eastern hognose snake* on a forested crest in Sterling Forest State Park.) Northern slimy salamander* occurs in non-calcareous wooded talus areas. Breeding birds of crest habitats include hermit thrush, blackburnian warbler,* worm-eating warbler,* and cerulean warbler.* Bobcat* and fisher* use high-elevation crests and ledges for travel, hunting, and cover. Porcupine and bobcat use ledge and talus habitats for denning. Southern red-backed vole* is found in some rocky areas, and eastern small-footed myotis* (a bat) roosts in talus habitat. A winter hibernaculum of the eastern small-footed myotis (NYS Special Concern) has been found less than three miles from the Trout Brook watershed. Little is known about the roosting and hibernating habits of these bats, but they are known to use ledge and talus areas as summer roosting sites (Johnson and Gates 2008). Allegheny woodrat (NYS Endangered) uses large boulder talus areas; there are historic woodrat records in the study area, but the species was apparently extirpated from the state sometime in the 1980s.

Occurrence in the Trout Brook Watershed

Crest, ledge, and talus habitats occurred scattered throughout the southern and central portions of the watershed (Figure 6). Extensive rocky areas were mapped along the eastern and western sides of the Trout Brook valley, with few calcareous ledges and talus were interspersed with acidic rocky areas in the hilly parts of study area. Along the summits of the eastern and western hills were numerous small areas of oak-heath barren (a special kind of crest habitat described below). In the Trout Brook watershed, many of the crest, ledge, and talus habitats appeared to be mildly calcareous, with calcicoles (species associated with calcareous habitats) such as basswood, sedges in the Laxiflorae section, and wild columbine occurring sporadically, but usually not densely enough for us to identify the habitats as calcareous overall.

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. See the Conservation Priorities section for recommendations on preserving the habitat values of crest, ledge, and talus habitats.

OAK-HEATH BARREN (ohb)

Ecological Attributes

A subset of rocky crest habitats (see above), oak-heath barrens occur on hilltops and high slopes with exposed bedrock and shallow, acidic soils. Typically, vegetation is dominated by some combination of pitch pine, scrub oak, other oaks, and heath (Ericaceae) shrubs such as lowbush blueberries and black huckleberry. The large areas of exposed bedrock were of dolostone, shale, and siltstone in southern areas and amphibolite and gneiss in the northeast (Fisher et al 1970). The soils are extremely shallow, excessively well drained, and very nutrient poor (Olsson 1981). These ecosystems are maintained in part 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 typical barren species (which require full sunlight). Because oak-heath barrens are usually located in exposed areas with shallow soils, plants are susceptible to breakage from wind, ice, and winter storms to which crests are fully exposed (Thompson and Sarro 2008), which contributes to the sparse tree growth and shrubby, stunted character of oak-heath barren vegetation. Due to the open canopy, exposed rock, and dry soils, oak-heath barrens tend to have a more extreme microclimate than the surrounding forested habitat, and are often warmer in the spring and fall. Although these habitats seem inhospitable (in part due to exposure to extreme temperatures and short growing seasons [Thompson and Sarro 2008]), the plants and animals of oak-heath barrens are adapted to the harsh conditions. Dominant trees include pitch pine, chestnut oak, red oak, scarlet oak, and black birch; the shrub layer may include scrub oak, eastern red cedar, blueberries, black huckleberry, chokeberries, deerberry, and sweetfern. Common herbs include Pennsylvania sedge, poverty-grass, common hairgrass, little bluestem, and bracken. Lichens and mosses are sometimes abundant. There may be a continuous canopy of pitch pine or pitch pine-oak with a scrub oak understory, or the shrub layer (predominately scrub oak and heath shrubs) may dominate, with only scattered pines. Our definition of this habitat corresponds to Edinger et al.'s (2002) "pitch pine-oak forest" and "pitch pine-oak-heath rocky summit."

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

Occurrence in the Trout Brook Watershed

We mapped many small areas of oak-heath barren along the crests of the eastern and western highlands of the watershed, and there are additional areas of exposed rock (that we did not visit) that may support this habitat (Figure 6). The oak-heath barren patches ranged from <0.1 ac to 0.9ac (0.04 ha to 0.36 ha). These small barrens may be remnants of historically larger habitats once maintained by fire, which persist only where shallow soils inhibit invasion by other trees that would shade out the barrens species.

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 oak-heath 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 rare snakes tend to congregate on oak-heath barrens and other exposed crests at certain times of the year, the snakes are highly vulnerable to being

An oak-heath barren in the eastern highlands of the Trout Brook watershed, June 2010 killed or collected by poachers. Oak-heath barrens are disturbance-maintained ecosystems, and human suppression of wildfires has reduced or eliminated one of the key disturbances. The scarcity of fires enables other, less specialized forest species to colonize these areas. See the Conservation Priorities section for recommendations on protecting the habitat values of oak-heath barrens.

UPLAND SHRUBLAND (us)

Ecological Attributes

We use the term "upland shrubland" for shrub-dominated upland (non-wetland) habitats. In most cases, these are lands in transition between meadow and young forest, but they also occur along utility corridors maintained by cutting or herbicides, 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 may be dominated by non-native, invasive species such as Japanese barberry, Eurasian honeysuckles, Oriental bittersweet, and multiflora rose, or they may have more diverse plant communities with native grasses and forbs; native shrubs such as meadowsweet, gray dogwood, northern blackberry, and raspberries; and scattered seedlings and saplings of eastern red cedar, hawthorns, white pine, gray birch, red maple, quaking aspen, and oaks. Occasional large, open-grown trees (e.g., sugar maple, red oak, sycamore, white pine) left as shade for livestock or for ornament may be present. Many non-native, invasive plants tend to thrive in places with a history of agricultural use (up to 40-80 years or more before present) and fine soil texture (Lundgren et al. 2004, Johnson et al. 2006). Recently-logged areas tend to develop a shrub layer including abundant tree saplings and northern blackberry.

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 or aestivation (e.g., painted turtle, wood turtle,* spotted turtle,* and eastern box turtle*) or for foraging (eastern box turtle*). Many bird species of conservation concern nest in upland shrublands and adjacent upland meadow habitats, including brown thrasher,* blue-winged warbler,* golden-winged warbler,* prairie warbler,* yellow-breasted chat,* clay-colored sparrow,* field sparrow,* eastern towhee,* and northern harrier.* Extensive upland shrublands and those that form large complexes with meadow habitats may be particularly important for these breeding birds. Several species of hawks and falcons use upland shrublands and adjacent meadows for hunting small mammals such as meadow vole, white-footed mouse, and eastern cottontail.

Occurrence in the Trout Brook Watershed

Upland shrublands were scattered throughout the northern parts of the study area and along the utility corridor that hugs the western edge before crossing and exiting the watershed in the southeast corner. The shrubland units ranged from 0.1 ac to about 24 ac (<0.04-9.6 ha), and totaled almost 100 ac (40 ha) in the study area. Common species in the largest shrublands included blackberry, sweetfern, multiflora rose, gray dogwood, common buckthorn, Eurasian honeysuckles, and goldenrods.

Sensitivities/Impacts

Shrublands and meadows are closely related habitats. As in upland meadows, 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. Having a diversity of ages and structures in shrublands in the region may promote overall biological diversity, and can be achieved by rotational mowing and/or brush-hogging. To reduce the impacts of these 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.

UPLAND MEADOW (um)

Ecological Attributes

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

Several species of rare butterflies, such as Aphrodite fritillary,* dusted skipper,* Leonard's skipper,* swarthy skipper,* meadow fritillary,* and Baltimore* use upland meadows that support their particular host plants (violets for the fritillary, and native grasses such as little bluestem for the skippers). Upland meadows can be used for nesting by wood turtle,* spotted turtle,* box turtle,* painted turtle, and snapping turtle. Grassland-breeding birds, such as short-eared owl,* northern harrier,* upland sandpiper,* grasshopper sparrow,* vesper sparrow,* savannah sparrow,* eastern meadowlark,* and bobolink,* use extensive meadow habitats in the region 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 Trout Brook Watershed

Most meadows in the study were smaller than one acre. The largest meadow was the nine-acre capped Town of Monroe landfill, and there were several meadows over five acres in the northwestern portion of the study area in the vicinities of Gibson Hill, Laroe, and Bull Mill roads. The most common kinds of upland meadow were hayfields and horse pastures.

Halloween pennant, a common dragonfly of upland meadows, July 2010

Sensitivities/Impacts

Principal causes of meadow habitat loss in the region are the intensification of agriculture, regrowth of shrubland and forest after abandonment of agriculture, and residential development. Another threat to upland meadow habitats is the soil compaction and erosion caused by ATVs, 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. Farmlands where pesticides and artificial fertilizers are used may have a reduced capacity to support native biodiversity.

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 provide travel corridors for nest predators such as raccoon and striped skunk, and hunting perches for raptors (Wiens 1969). Large and contiguous meadow complexes (including upland, wet, and calcareous wet meadows), particularly lightly grazed pasture, carefully managed hayfields, or large meadows dominated by grasses, can be valuable nesting habitats for rare and uncommon grassland-breeding birds. It is important to note that "occurrence" differs from long term reproductive success. Although grassland species may be observed in smaller grasslands, in New York it is believed that to sustain long term breeding populations some of these species require grasslands hundreds of acres in size. There are no large meadows in the Trout Brook watershed, so grassland breeding birds are unlikely to nest here successfully. But the smaller upland and wet meadows will provide habitat for invertebrates, reptiles (nesting and aestivating), small mammals (foraging and shelter), large mammals (hunting), songbirds (foraging), and raptors (hunting). Meadows in the Trout Brook watershed could also serve as wildlife travel corridors or "stepping stones" between habitats.

While the ecological values of upland meadows are diverse and significant, it is important to remember that most upland meadows in this area were once upland forest, another very valuable habitat type in our region. Therefore, while focusing on the conservation of existing upland meadows with high biodiversity potential, landowners and others should also consider avoiding further conversion of forest to meadow and perhaps even allowing some meadows (particularly smaller ones, or those that are contiguous with areas of upland forest) to revert to forest cover.

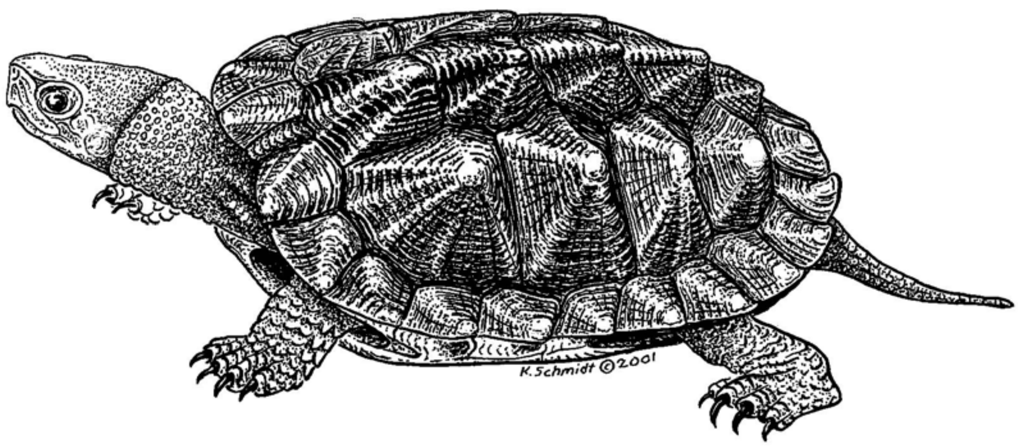
Beyond the ecological values of meadows, there are many other compelling reasons to conserve active and potential farmland. From a cultural and economic standpoint, maintaining the ability to produce food locally has obvious advantages in the face of unstable and unpredictable energy supplies, and the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

ORCHARD/PLANTATION (or/pl)

This habitat type includes actively maintained or recently abandoned vineyards, fruit orchards, tree farms, and plant nurseries. 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. The habitat value of active orchards or plantations is often compromised by frequent mowing, application of pesticides, and other human activities; we considered this an ecologically significant habitat type more for its future ecological values after abandonment than its current values. These habitats have some of the vegetation structure and ecological values of upland meadows and upland shrublands, and will ordinarily develop into young forests if they remain undisturbed after abandonment. We found just one orchard/plantation of 3.5 ac (1.5 ha) located in the center of the watershed between Kennedy Lane and Washington Road.

CULTURAL (c)

We define "cultural" habitats as areas that are significantly altered and intensively managed (e.g., mowed) but are not otherwise developed with pavement or structures. We consider them to be ecologically significant when they are adjacent to other ecologically significant habitats (i.e., when they are not entirely 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 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. Large individual ornamental or fruit trees can provide habitat for cavity-nesting birds such as eastern bluebird,* roosting bats (including Indiana bat*), and many other animals, and for mosses, liverworts, and lichens, potentially including rare species. Snakes, including rattlesnake, may bask in cultural areas. Of the different types of places mapped as "cultural," cemeteries are particularly well suited to provide habitat to a variety of species, since mature trees are often present, noise levels are minimal, and traffic is infrequent and slow. Many cultural areas have "open space" 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. Because cultural areas are already significantly altered, however, their habitat values are greatly diminished compared to those of relatively undisturbed habitats. Cultural habitats in the Trout Brook watershed included playing fields, large lawns, and cemeteries.



Wood turtle

WASTE GROUND (wg)

Waste ground is a botanists' term for land that has been severely altered by previous or current human activity, but lacks pavement or structures. Most waste ground areas have been stripped of vegetation and topsoil, or filled with soil or debris, and remain unvegetated or sparsely vegetated. This category encompasses a variety of highly altered areas such as dumps, unvegetated fill, landfill cover, construction sites, and abandoned lots. Although waste ground often has low habitat value, there are notable exceptions. Several rare plant species are known to inhabit waste ground environments, including rattlebox,* slender pinweed,* field-dodder,* and slender knotweed.* Rare lichens or mosses may potentially occur in some waste ground habitats. Several snake and turtle species of conservation concern, including eastern hognose snake,* and wood turtle* may use the open, gravelly areas of waste grounds for burrowing, foraging, or nesting habitat. Bank swallow* and belted kingfisher often nest in the stable walls of inactive or inactive portions of soil mines and occasionally in piles of soil or sawdust. Bare, gravelly, or otherwise open areas provide nesting grounds for spotted sandpiper, killdeer, and possibly whip-poor-will* or common nighthawk.* Little is known of the invertebrate fauna of waste grounds but this habitat might support rare species. Certain biodiversity values of waste ground will often increase over time as it develops more vegetation cover. Many waste ground sites, however, will have low habitat value compared to relatively undisturbed habitats. Waste ground habitats in the study area were either cleared house sites in residential developments or town properties (including landfills and material transfer stations). All waste grounds that we identified were small (less than 2.4 ac [1 ha]).

WETLAND HABITATS

SWAMPS

Ecological Attributes

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

Hardwood and Shrub Swamp (hs)

We combined deciduous forested and shrub swamps into a single habitat type because the two are often mixed and can be difficult to separate using remote sensing techniques. Red maple, green ash, black gum, American elm, and slippery elm are common trees of hardwood swamps in the region. Typical shrubs include alders, spicebush, winterberry holly, highbush blueberry, sweet pepperbush, and buttonbush. Skunk cabbage and Japanese stiltgrass are common herbaceous species of these swamps.

Mixed Forest Swamp (ms)

Mixed forest swamps have a canopy composed of 25-75% conifers. Eastern hemlock was the most common conifer in mixed forest swamps in the study area, often sharing the canopy with American elm and black birch. The shrub and herbaceous layers were typically less dense than in hardwood swamps, and included spicebush, Japanese barberry, and tussock sedge. Shading by the conifer trees sometimes creates a cooler microclimate than in other swamps, allowing snow and ice to persist longer into the early spring growing season. Conifers growing in wetlands frequently have very shallow root systems and are therefore prone to windthrow. The resulting tip-up mounds, root pits, and coarse woody debris all contribute to the habtitat's complex structure and microtopography.

Swamps are important to a wide variety of birds, mammals, amphibians, reptiles, and invertebrates, especially when swamp habitats are 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. We know of no occurrences in Orange County, but it could turn up here. Hardwood and shrub swamps along the floodplains of clear, low-gradient streams can be an important component of wood turtle* habitat. Other turtles such as spotted turtle* and box turtle* use swamps for summer foraging, drought refuge, overwintering, and travel corridors. Pools within swamps are used by several breeding amphibian species, and are the primary breeding habitat of blue-spotted salamander.* Four-toed salamander,* believed to be regionally rare or scarce, uses swamps with rocks or abundant moss-covered downed wood or woody hummocks. Ribbon snake* forages for frogs in swamps. Red-shouldered hawk,* barred owl,* great blue heron,* wood duck,* American black duck,* red-headed woodpecker,* prothonotary warbler,* Canada warbler,* and white-eyed vireo* nest in hardwood swamps.

Among the hardwood and shrub swamps that we visited in the Trout Brook watershed we noted two types—buttonbush pool and heath swamp—that are distinct from other typical swamps in the region. Several buttonbush pools were hydrologically isolated wetlands that may be valuable habitat for pool-breeding amphibians and other animals that depend on intermittent woodland pools (see habitat description below and Figure 7). The structural differences among these swamps and intermittent pools, however, may determine whether some species will use them (for more information on these habitats see Kiviat and Stevens 2001 and Bell et al. 2005).

- *Buttonbush pools* are swamps that are seasonally or permanently flooded and have a shrub-dominated flora with buttonbush normally the dominant plant (although buttonbush may appear and disappear over the years in a given location). Other shrubs such as highbush blueberry and swamp azalea may also be abundant. Shrubs typically occupy a perimeter zone encircling an open water pool in the center. These habitats 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.
- *Heath swamps* are small wetlands dominated by shrubs from the heath family such as highbush blueberry, swamp azalea, maleberry, and other shrubs such as sweet pepperbush, winterberry holly, spicebush, and buttonbush. Often, the shrubs grow on

hummocks with *Sphagnum* mosses and sedges. Scattered trees such as red maple, yellow birch, and black gum may also be present. The shrubs often occur in dense patches leaving only small areas of open water, though the water often persists in the wetland throughout the year. Many of the wetlands in the eastern and western highlands of the watershed can be classified as heath swamps.

We have not studied these kinds of swamps closely, but expect that buttonbush pools and heath swamps share many of the habitat values of other hardwood swamps and of intermittent woodland pools (described below). The unusual plant communities and perhaps other structural and chemical characteristics of these habitats. may invite organisms that are less common or absent in other swamps in the region.

Occurrence in the Trout Brook Watershed

Hardwood and shrub swamp was the most extensive wetland habitat type in the study area, totaling over 115 ac (46 ha). Swamps ranged in size from less than 1 to over 10 ac (< 0.4 to >4 ha), and were often contiguous with other wetland habitats such as marsh and wet meadow. Large swamps were in the high-elevation valleys of the eastern highlands of the watershed, or along streams in the northern area. Smaller swamps were widely scattered throughout the study area. Mixed forest swamps were uncommon and relatively small. We documented two small buttonbush pools in the study area. The buttonbush pools we mapped should be considered examples of the habitat rather than a complete inventory; there may be other swamps which we did not visit that would also fall into this category.

Swamps occurred in a variety of settings, such as on seepy slopes, along streams, in depressions, and as part of large wetland complexes. Common species included red maple, elm, green ash, black birch, black gum, winterberry holly, spicebush, sweet pepperbush, swamp azalea, highbush blueberry, skunk cabbage, cinnamon fern, and royal fern. Often *Sphagnum* mosses were abundant. The range of water depths was wide, with some swamps drying up completely in the summer months and others retaining relatively deep water. Swamps that are isolated from streams and other wetlands often have ecological roles similar to those of intermittent woodland pools—e.g., providing a seasonal source of water with fewer aquatic predators, breeding habitat for amphibians, and refuge for turtles (see intermittent woodland pool habitat description, below).

Buttonbush in a shrub-dominated hardwood swamp, June 2010

Sensitivities/Impacts

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 often overlooked in environmental reviews, but can have extremely high biodiversity values, and play similar ecological roles to those of intermittent woodland pools (see below). Some of the larger swamps are located on land protected from typical land uses because of state or federal ownership, but many other large swamps occur in unprotected areas. 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 surrounded by agricultural land are subject to runoff contaminated with agricultural chemicals, and those near roads and other developed areas often receive runoff high in sediments, petroleum hydrocarbons, and other toxins. 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. See the Conservation Priorities section for recommendations on preserving the habitat values of small, pool-like swamps (under intermittent woodland pools) and swamps within larger wetland complexes.

INTERMITTENT WOODLAND POOL (iwp)

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 or may not be surrounded by forest. Despite the small size of intermittent woodland pools, those that hold water through early summer can support amphibian diversity equal to or higher than that of much larger wetlands (Semlitsch and Bodie 1998, Semlitsch 2000). Seasonal drying and lack of a stream connection ensure that these pools do not support fish, which are major predators on amphibian eggs and larvae. The surrounding forest supplies the pool with organic detritus (in the form of dead tree leaves), which is the base of the pool's food web; the forest is also essential habitat for adult amphibians during the non-breeding season.

Intermittent woodland pools provide critical breeding and nursery habitat for wood frog,* Jefferson salamander,* marbled salamander,* and spotted salamander.* Reptiles such as spotted turtle,* 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. 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. Featherfoil* and false hop sedge* occur in intermittent woodland pools in the Hudson Valley. Large and small mammals use these pools for foraging and as water sources.

Occurrence in the Trout Brook Watershed

We mapped 17 intermittent woodland pools in the study area (Figure 7), nearly all in the eastern and western highlands. All of the mapped intermittent woodland pools were 0.2 ac (0.08 ha) or smaller**.** Common plant species included black gum, red maple, highbush blueberry, catbrier, and tussock sedge. A few intermittent woodland pools were parts of larger hardwood swamps. Because these pools are small and often difficult to identify on aerial photographs, we expect there are additional intermittent woodland pools that we did not map.

Sensitivities/Impacts

We consider intermittent woodland pools to be one of the most imperiled habitats in the region. Although they are widely distributed, the pools are small (often less than 0.1 ac [0.04 ha]) and their ecological importance is often undervalued. They are frequently drained or filled by landowners and developers, used as dumping grounds, treated for mosquito control, 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 most often excluded from federal and state wetland protection due to their small size, their intermittent surface water, and their isolation from other wetland and stream habitats. It is these very characteristics of size, isolation, and intermittency, however, which make woodland pools uniquely suited to species that do not reproduce or compete as successfully in larger wetland systems. See the Conservation Priorities section for recommendations on preserving the habitat values of intermittent woodland pools.

MARSH (ma)

Ecological Attributes

A marsh is a wetland that has standing water for most or all of the growing season and is dominated by herbaceous (non-woody) vegetation. Marshes often occur at the fringes of deeper water bodies (e.g., lakes and ponds), or in close association with other wetland habitats such as wet meadows or swamps. The edges of marshes, where standing water is less permanent, often grade into wet meadows. Cattail, tussock sedge, 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, water-shield, and common duckweed.

Several rare plant species are known from marshes in the region, including spiny coontail* and buttonbush dodder.* 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, spring peeper, and northern cricket frog.* Numerous bird species, including marsh wren,* common moorhen,* American bittern,* least bittern,* great blue heron,* Virginia rail,* king rail,* sora,* American black duck,* and wood duck* use marshes for nesting or as nursery habitat. Many raptors, wading birds, and mammals use marshes for foraging.

- A *"kettle pool"* is a pool-like wetland in a glacial kettle—a depression formed by the melting of a stranded block of glacial ice. Kettle pools are found in or near glacial outwash deposits (e.g., Hoosic gravelly sandy loam, Otisville gravelly sandy loam), and usually have deep peat or muck substrates. The one kettle pool that we identified in the study area had cattail, purple loosestrife, and ferns on a floating mat, with an open moat at the pool perimeter. The pool appeared to be spring-fed. The landowner reported seeing unidentified rails in the kettle pool. Hudsonia has found two state-listed rare plants (spiny coontail* and buttonbush dodder*), at least three regionally rare plants (the moss *Helodium paludosum*,* short-awn foxtail,* and pale alkali-grass*), and the regionally rare eastern ribbon snake* in kettle pools elsewhere in the Hudson Valley.

- An *"acidic crest marsh"* is a special kind of marsh occurring at high elevations in the eastern highlands. We identified three of these marshes in the study area, all above 1,200 ft. Unlike the lower elevation marshes in the watershed, which were often dominated by cattails and common reed, these habitats had species such as Virginia chain fern, bulrushes, soft rush, tussock sedge, blue flag, and abundant *Sphagnum* and other mosses, with highbush blueberry around the edges. They were often connected to heath swamps (a habitat described earlier).

Occurrence in the Trout Brook Watershed

We mapped 20 marshes in the Trout Brook watershed, including one kettle pool and three acidic crest marshes. Many of those we observed in the field were dominated by cattails and

Cattail-dominated marsh off Bull Mill Road, July 2010 tussock sedge, but common reed predominated in one marsh on the east side of Lakes Road. All marshes in the study area were smaller than 2 ac (0.8 ha).

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, 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. 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. See the Conservation Priorities section for recommendations on preserving the habitat values of marshes within larger wetland complexes.

WET MEADOW (wm)

Ecological Attributes

A wet meadow is a wetland dominated by herbaceous (non-woody) vegetation and lacking standing water for most of the year. 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, reed canary-grass, or tussock sedge, while others have a diverse mixture of wetland grasses, sedges, forbs, and scattered shrubs. Bluejoint, mannagrasses, woolgrass, soft rush, blue flag, sensitive fern, and marsh fern are some typical plants of wet meadows.

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

Occurrence in the Trout Brook Watershed

Wet meadows were largely confined to the northern portion of the watershed where they commonly occurred along the margins of swamps and streams and in low-lying areas within upland meadows. A large forested landscape in Sterling Forest had a group of seepage wet meadows with an open tree canopy. We identified 40 wet meadows in the study area, totaling 8.5 ac (3.4 ha) overall. Only four marshes were larger than 0.5 ac (0.2 ha). Common plant species included soft rush, sedges (Cyperaceae), sensitive fern, marsh fern, and wetland goldenrods.

Sensitivities/Impacts

Some wet meadows are able to withstand light grazing by livestock, but heavy grazing can destroy the soil structure, eliminate sensitive plant species, and invite non-native weeds. Frequent mowing causes similar negative consequences. Mowing when soils are dry, e.g., in late summer, is less damaging to the soils and the plant community. 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 section for recommendations on mowing practices and on preserving the habitat values of wet meadows within larger wetland complexes.

CALCAREOUS WET MEADOW (cwm)

Ecological Attributes

A calcareous wet meadow is a specific type of wet meadow habitat (see above) that is strongly influenced by calcareous (calcium-rich) groundwater or soils. These conditions favor the establishment of a calcicolous plant community, including such species as sweetflag, lakeside sedge, New York ironweed, rough-leaf goldenrod, and blue vervain. The vegetation is often lush and tall. Outside the study area, calcareous wet meadows often occur adjacent to fens, a special kind of wet meadow/low shrubby wetland fed by calcareous groundwater seepage. We identified no fens in the study area. Calcareous wet meadows may include some fen plant species, but can be supported by water sources other than groundwater seepage. Fens and calcareous wet meadows can be distinguished by factors such as hydrology (including beaver flooding and abandonment in calcareous wet meadows), vegetation structure, and plant community.

High quality calcareous wet meadows with diverse native plant communities are likely to support species-rich invertebrate communities, including phantom crane fly* and rare butterflies such as Dion skipper,* two-spotted skipper,* and Baltimore.* Eastern ribbon snake* and spotted turtle* use calcareous wet meadows for basking and foraging. Bog turtles* use calcareous wet meadows that are adjacent to fens for summer foraging and even nesting habitat. Many common wetland animals, such as green frog, pickerel frog, red-winged blackbird, and swamp sparrow use calcareous wet meadows.

Occurrence in the Trout Brook Watershed

We documented seven calcareous wet meadows in the study area, almost all of which occurred in a large wetland and upland meadow complex in the northwest corner of the watershed. The largest calcareous wet meadow was over four acres. Common species in this wetland included calcicoles such as small-flowered agrimony, New York ironweed, and blue vervain, as well as typical wet meadow plants such as woolgrass, goldenrods, sedges, and cattail. Calcareous wet meadows cannot be distinguished from other wet meadows by remote sensing because indicator plants must be identified in the field. Therefore it is likely that some of the mapped "wet meadows" we did not visit were actually calcareous wet meadows.

Sensitivities/Impacts

Calcareous wet meadows have sensitivities to disturbance similar to those of wet meadows (see above). They are particularly vulnerable to nutrient enrichment and siltation, which often facilitate the spread of invasive species. Like other small wetland habitats, calcareous wet meadows are often omitted from wetland maps and consequently overlooked in the environmental review of development proposals.

CONSTRUCTED POND (cp)

Ecological Attributes

Constructed ponds are water bodies created by humans by excavation or dams, either in existing wetlands or stream beds, or in upland terrain. Many of these ponds are deliberately created for recreation, watering livestock, irrigation, stormwater management, or aesthetics, but we also include those created inadvertently during mining operations, road construction, or other activities. Some are constructed near houses or other structures to serve as a source of water in the event of a fire, and some may serve to drain nearby wetland areas to render them buildable. If constructed ponds are not intensively managed by humans, they can be important habitats for some of the common and rare species associated with naturally formed open water habitats (see below).

Occurrence in the Trout Brook Watershed

Most of the water bodies in the study area were constructed ponds, and most of these were agricultural or ornamental ponds, or stormwater detention basins in the Trout Brook corridor. Most of the ornamental ponds were located within landscaped areas in close proximity to residences. We mapped 23 constructed ponds and most were smaller than 1 ac (<0.4 ha). Because of the potential value of constructed ponds as drought refuges and foraging areas for turtles and other wildlife, we mapped constructed ponds within developed areas as well as those surrounded by intact habitats.

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 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. Many of our Riparian Restoration recommendations (Appendix E) focus on restoring the buffers of these ponds to increase the habitat value of the ponds themselves and the water quality of the outlet streams. We expect that many of the ponds maintained for ornamental purposes are treated with herbicides and perhaps other pesticides, or contain introduced fish such as grass carp and various game and forage fishes. Since constructed ponds serve as habitat for a variety of common and rare species, these practices should be minimized whenever possible.

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.

OPEN WATER (ow)

Ecological Attributes

"Open water" habitats include naturally formed ponds and lakes, large pools lacking floating or emergent vegetation within marshes and swamps, and 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. Those with submerged aquatic vegetation can provide important habitat for aquatic invertebrates and fish. Spotted turtle* uses ponds and lakes during both drought and non-drought periods, and wood turtle* may overwinter and mate in open water areas. Northern cricket frog* is known to use circumneutral ponds in the Moodna Creek watershed. Wood duck,* American black duck,* osprey,* bald eagle,* American bittern,* and great blue heron* may use open water areas as foraging habitat. Pied-billed grebe* uses open water habitats bordered by emergent marsh, and has been recorded breeding in Sterling Forest in the Town of Tuxedo. Bats, mink, and river otter* also forage at open water habitats.

Occurrence in the Trout Brook Watershed

We mapped only one open water habitat in the watershed. It was under 1 ac (<0.4 ha) and occurred along an unnamed tributary to Trout Brook in the northern section of the study area.

Sensitivities/Impacts

The habitat values of natural open water areas can be 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, 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 impacts 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. See the Conservation Priorities section for recommendations on preserving the habitat values of open water within wetland complexes.

SPRINGS & SEEPS

Ecological Attributes

Springs and seeps are places where groundwater discharges to the ground surface, either at a single point (a spring) or diffusely (a seep). 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, while those from shallower sources flow intermittently. The habitats created at springs and seeps are determined in part by the hydroperiod and the chemistry of the soils and bedrock through which the groundwater flows before emerging. Springs and seeps are water sources for many streams, helping to maintain their cool water temperature, 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.

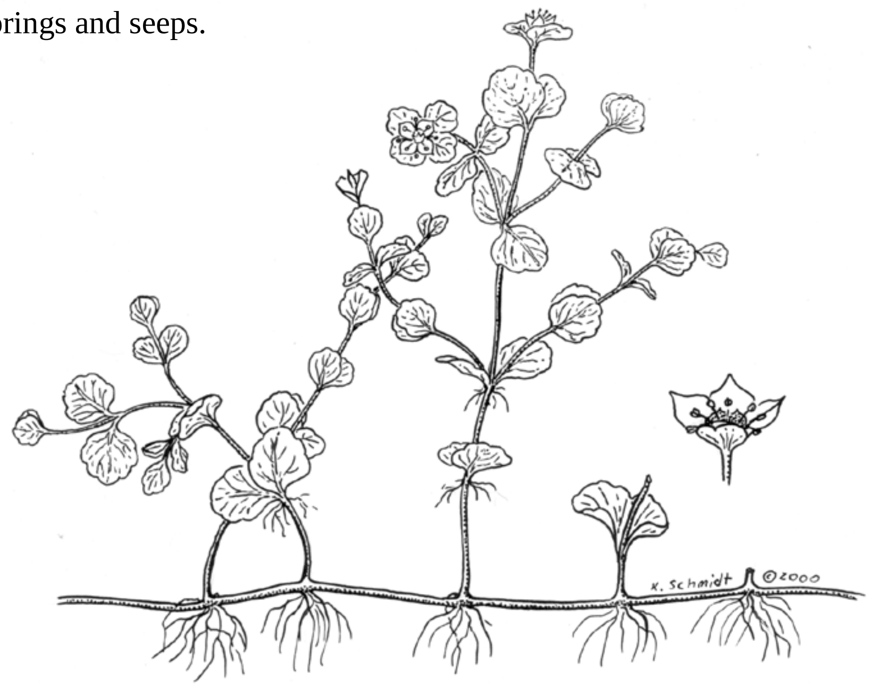
Very little is known about the ecology of seeps in the Northeast. Golden saxifrage is a plant more-or-less restricted to springs and groundwater-fed wetlands and streams. A few rare invertebrates are restricted to springs in the region, and the Piedmont groundwater amphipod* could occur in the area (Smith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

Occurrence in the Trout Brook Watershed

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 study area that we did not map. More detailed surveys of these habitats should be conducted as needed on a site-by-site basis. The 14 mapped springs and seeps were found in the upland hardwood forests of the eastern and western highlands and the northern portion of the watershed, and were often associated with a stream or a small wetland.

Sensitivities/Impacts

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



Golden saxifrage

STREAMS & RIPARIAN CORRIDORS

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 steep slopes. We did not map actual riparian corridors but instead mapped zones of a set width on either side of streams (Figure 8). These zones represent a minimum area surrounding the stream that is needed for effective protection of stream water quality and wildlife (see streams & riparian corridors in the Priority Habitats section). These 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, land uses in the watershed, and in some cases the size of the stream.

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

Rare plants of riparian areas in the region include cattail sedge,* Davis' sedge,* winged monkeyflower,* and goldenseal.* The fish and aquatic invertebrate communities of perennial streams may be diverse, especially in clean-water streams with unsilted bottoms. Brook trout* and slimy sculpin* are two native fish species that require clear, cool streams for successful spawning. Wild brook trout, however, are now confined largely to small headwater streams in the region, due to degraded water quality and competition from brown trout, a non-native species that has been stocked in many streams. The NYS DEC has classified Trout Brook as a trout stream (C[T]), and a 2000 survey verified the presence of brook trout and brown trout (Orange County Water Authority 2010).Wood turtle* uses perennial streams with deep pools and recumbent logs, undercut banks, or muskrat or beaver burrows. Perennial streams and their riparian zones, including sand and gravel bars, provide nesting or foraging habitat for many species of birds, such as spotted sandpiper, belted kingfisher, tree swallow, bank swallow, winter wren,* Louisiana waterthrush,* great blue heron,* and green heron. Red-shouldered hawk* and cerulean warbler* nest in areas with extensive riparian forests, especially those with mature trees. Bats, including Indiana bat,* use perennial stream corridors for foraging. Muskrat, beaver, 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 water bodies 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 Trout Brook Watershed

Trout Brook, a perennial stream for much of its length, is the unifying feature of the study area. Trout Brook is a tributary of Seely Brook, which flows into Cromline Creek, a tributary of Moodna Creek. Trout Brook originates on the western slope of an unnamed mountain in Sterling Forest State Park, flows west to the valley bottom, and then flows generally north through the center of the study area to the junction with Seely Brook. Trout Brook appears to have intermittent flow for the first 1.5 miles, and becomes perennial after junctions with several large tributaries. There are several other unnamed perennial streams in the watershed. The combined length of all perennial streams we mapped in the study area (including Trout Brook) was approximately 7.4 mi (11.8 km). Intermittent streams were numerous with a combined length of approximately 21.5 mi (34.3 km) (Figure 11). The Trout Brook mainstem has been substantially manipulated by dams and culverts; we identified 85 culverts and 8 impoundments along the mainstem and tributaries to the Trout Brook

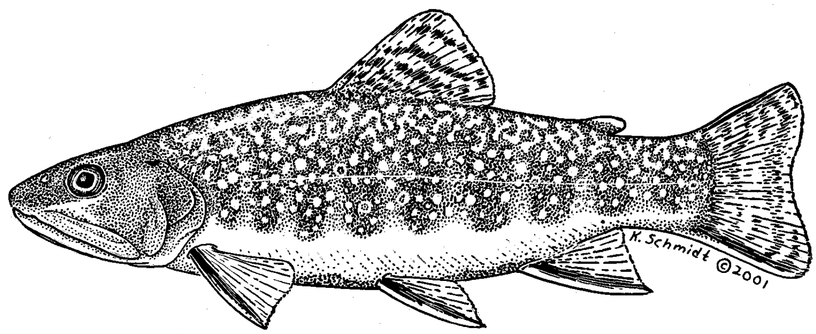
Sensitivities/Impacts

Removal of trees or other shade-producing vegetation along a stream can lead to elevated water temperatures that adversely affect aquatic invertebrate 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 both to stream and floodplain habitats. Removal of snags 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. 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. Research in Dutchess County has found impacts to water quality even in suburban and exurban watersheds with low-density human settlement and less than 10% impervious surface cover (Cunningham et al 2009). Road runoff often carries contaminants such as petroleum hydrocarbons, heavy metals, road salt, sand, and silt into streams. Applications of fertilizers and pesticides to agricultural fields, golf courses, lawns, and gardens in or near the riparian zone can degrade the water quality and alter the biological communities of streams. Construction, logging, soil mining, clearing for vistas, creating lawns, and other disruptive activities in and near riparian zones can interfere with riparian functions and adversely affect the species that depend on streams, riparian zones, and nearby upland habitats. See the Conservation Priorities section for recommendations on preserving the habitat values of streams and riparian corridors.

CONSERVATION PRIORITIES AND PLANNING

Many land use decisions are made at the local level and in recent years there have been growing efforts to improve biodiversity conservation by integrating ecological principles into municipal land use planning (Miller et al. 2008). Nationwide and in the Hudson Valley, many towns have begun including biodiversity concerns in their zoning and regulations (Miller et al. 2008, McElfish 2004). Most local land use decisions 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 making decisions on a site-by-site basis 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 extinction of species, the depletion of overall biodiversity, and the impairment of ecosystem function and services. We hope that landowners, developers, and town agencies will use the biological information on the habitat map and in this report to incorporate biodiversity conservation into better land use decisions.

Because biological communities, habitats, and ecosystems do not respect property or municipal boundaries, the best approach to biodiversity conservation is from the perspective of whole landscapes. The habitat map for the Trout Brook watershed facilitates this approach by illustrating the location and configuration of significant habitats throughout the watershed, which encompasses parts of the towns of Chester, Monroe, Tuxedo, and Warwick. The map provides an opportunity for these municipalities to conserve critical habitats in the watershed and to locate new development in the least sensitive places. Together with the information provided in this report, the map can be applied directly to conservation planning and decision-making at multiple scales. In the following pages, we outline recommendations for using the map and report for: 1) developing general strategies for biodiversity conservation; 2) identifying priorities for conservation, land use planning, and habitat enhancement; 3) planning and reviewing site-specific land use changes; and 4) initiating riparian restoration projects



Brook trout

GENERAL GUIDELINES FOR BIODIVERSITY CONSERVATION

We hope that the 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 towns will engage in proactive land use planning and conservation planning to ensure that future development is planned with a view to long-term protection of the valuable biological resources that still exist within the watershed.

A variety of regulatory and non-regulatory means can be employed by a municipality to achieve its conservation goals, including volunteer conservation efforts, master planning, zoning ordinances, watershed management plans, tax incentives, land stewardship incentives, permit conditions, land acquisition, conservation easements, and public education. Section 4 in the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001) provides additional information about these and other conservation tools. Several publications of the NYS DEC, Metropolitan Conservation Alliance, Pace University Land Use Law Center, and Environmental Law Institute describe some of the tools and techniques available to municipalities for conservation planning and practice. 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 adapted to the local zoning ordinance. The Southern Wallkill

Biodiversity Plan (Miller et al. 2005) offers twenty-four recommendations for land preservation and local land use planning in the Towns of Chester, Goshen, and Wallkill. The *Local Open Space Planning Guide* (NYS DEC and NYS Department of State 2004) describes how to take advantage of laws, programs, technical assistance, and funding resources available to pursue open space conservation, and provides contact information for relevant organizations. *Conserving Natural Areas and Wildlife in Your Community* (Strong 2008) describes the tools and resources available to municipalities to help protect their natural assets.

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

- **Protect large, contiguous, undeveloped tracts** wherever possible.
- **Plan landscapes with interconnected networks of undeveloped habitats** (preserve links and create new 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 water bodies 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, their site design, and their 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 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 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.

WATERSHED-WIDE BIODIVERSITY PLANNING

The Moodna Creek Watershed Conservation and Management Plan (Orange County Water Authority 2010) has gathered data, analyzed trends, and provided management recommendations for many of the environmental concerns in the larger watershed of which the Trout Brook is part. The Trout Brook watershed habitat map and this report complement the Moodna Creek plan by providing habitat information and management recommendations at a scale relevant to municipal planning. The habitat map illustrates the 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* 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, railroads, 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 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 corridors between them. The spotted turtle is just one example of a mobile species that depends on a mosaic of wetland and upland habitats and requires safe travel routes between those habitats. It is known to use marsh, fen, wet meadow, hardwood and shrub swamp, shrub pool, intermittent woodland pool, open water, and a variety of upland habitats within a single year (Fowle 2001).

The habitat map can also be used to identify priority habitats for conservation, including those that are rare or support rare species, or that seem particularly important to regional biodiversity. For instance, the oak-heath barrens and the large forest blocks in the high elevation ridges of the watershed may be of special importance to snakes of conservation concern. Figures 4-8 illustrate some of 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**)**.

PRIORITY HABITATS IN THE TROUT BROOK WATERSHED

Approximately 18% of the watershed has been developed for residential and commercial uses, however large areas of high-quality habitat still remain. These areas are not only important locally, but also contribute greatly to regional biodiversity. For example, the watershed is part of the "Highlands" Significant Biodiversity Area of southern New York identified by NYS DEC (Penhollow et al. 2006). This area is part of a large forested belt extending east across the Hudson River into Putnam and Dutchess counties (New York) and eastern Connecticut, and southwest into New Jersey and Pennsylvania. At the municipal scale, the Southern Wallkill Biodiversity Plan identifies several parts of the Trout Brook watershed as important biodiversity areas.

By employing a proactive approach to land use and conservation planning, the towns of the Trout Brook watershed have the opportunity to protect the integrity of its remaining biological resources for the long term. With limited financial resources to devote to conservation purposes, however, municipal agencies must decide how best to direct those resources to maximize conservation results. While it may be impossible to protect all significant habitats, there are reasonable ways to prioritize conservation efforts using the best available scientific information. Important 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 watershed. 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 these 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 are rare or declining in the region or statewide. Each of these 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 require additional habitat types for other life cycle stages, and these 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 needs to be protected or managed in order to 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. 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 Trout Brook watershed, Orange County, New York.

Priority Habitat	Associated Species or Group of Concern	Priority Conservation Zone	Rationale	References
Large forest	Forest interior-breeding birds	Unfragmented patches of at least 200-2500 ac (80-1,000 ha).	Includes the minimum areas required for sustainable breeding for a suite of forest birds.	Robbins et al. 1989, Rosenberg et al. 2003
Oak-heath barren and extensive crest/ledge/talus	Timber rattlesnake	1.5 mi (2.4 km) from oak-heath barren, including extensive crest/ledge/talus and surrounding contiguous forests.	A minimum radius of intact habitat from the den needed to protect all but the farthest ranging males.	Brown 1993
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
Perennial stream	Wood turtle	660 ft (200 m) from stream.	Encompasses most of the critical habitat, including hibernacula, nesting areas, spring basking sites, foraging habitat, and overland travel corridors.	Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997

LARGE FORESTS

Target Areas

Seventy-five percent of the Trout Brook watershed is forested. In general, forested areas with the highest conservation value include large forest tracts, mature and relatively undisturbed forests, and those with a low 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 the Trout Brook watershed are illustrated in Figure 5. The largest unfragmented forest blocks are in the eastern and western highlands. These areas were noted by Miller et al. (2005) for their habitat value for neotropical migrant birds and many other species and are the foundation of three of their important biodiversity areas. The New York Natural Heritage Program has records of many rare species and significant ecological communities from these areas (NYNHP 2010). Along Bellvale Mountain and in the Sterling Forest hills, 50% (750 ac [300 ha]) of the three largest forest patches are on federal or state land, and are thus conferred some protection from future development, but the remaining 50% are in private ownership with no official conservation

Looking northeast along Bellvale Mountain, April 2010 status that we know of. These highland areas had dry oak forest at higher elevations, along with extensive areas of crest and ledge.

In the north-central portion of the Trout Brook watershed forests were highly fragmented by roads and developed land uses. Lakes Road and its associated development represent the only substantial fragmenting feature of the large forest blocks in the central and southern watershed. Outreach and education to landowners along this road should stress ways of minimizing the impacts of fragmentation on private property. The forests at the northern boundary of the watershed are a small part of a much larger forest and have been identified as an important biodiversity area in the Southern Wallkill Biodiversity Plan (Miller et al. 2005).

Conservation Issues

Loss of forest and fragmentation of remaining forest are two of the most serious threats facing forest-adapted organisms (Davies et al. 2001, Saunders et al. 1992). The decline of extensive forests has been implicated in the declines of numerous "area-sensitive" species which require 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). In addition to reduced total area, fragmented forest has a larger proportion of edge habitat. Temperature, humidity, and light are altered near forest edges. Edge environments favor a set of disturbance-adapted species, including many nest predators and a nest 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,* black-throated blue 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 (80 ha) are considered highly suitable for breeding populations in our region (Rosenberg et al. 2003).

Although bird area requirements vary regionally and more 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 the Trout Brook watershed (e.g., black-throated blue warbler*). Large forests with rocky crests also provide habitat for several reptiles of conservation concern such as timber rattlesnake,* northern copperhead,* eastern rat snake,* and eastern racer,* as well as eastern hognose snake which we observed in the upland forests of the watershed (see sections on oak-heath barrens and crest, ledge, and talus, below).

Forest fragmentation can also inhibit or prevent animals from moving across the landscape, and can result in losses of genetic diversity and local extinctions in populations from isolated forest patches. For example, some species of frogs and salamanders are unable to disperse effectively through non-forested habitat due to desiccation and predation (Rothermel and Semlitsch 2002). Furthermore, 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). While the Trout Brook watershed has several large forest patches, Lakes Road and the development bordering it are significant fragmenting features. The best remaining connection between the eastern and western highlands occurs along the 1500 ft stretch where the Appalachian Trail and a utility corridor intersect Lakes Road, though wildlife still need to negotiate the road crossing. Much of the area surrounding this tenuous connection has been identified as having high open space resource value in the Orange County Open Space Plan (Orange County Department of Planning 2004).

Another threat to large forests in our region is the spread of invasive insect species. One example is the hemlock woolly adelgid, an aphid-like insect that has caused widespread mortality of hemlock forests in the Hudson Valley. Eastern hemlock is the major coniferous component of upland mixed forests in the Trout Brook watershed, and an adelgid infestation could eliminate hemlock occurrences. Exotic species such as the hemlock woolly adelgid are a major concern for the management of Sterling Forest State Park. Other potential threats include species such as the emerald ash borer and the Asian longhorned beetle. The emerald ash borer can infest all native ash species and can kill a tree in 2-4 years. In 2009 it was discovered in western New York in Cattaraugus County and in 2010 it has been found in other counties including Ulster County in the Hudson Valley (NYS DEC 2010). The Asian longhorned beetle threatens native maple, birch, and willow species and has the potential to greatly affect Hudson Valley ecosystems, as well as the timber, maple syrup, and nursery industries (APHIS 2008). Massachusetts has a large infestation, and the beetle has been found in New York City and on Long Island. A new state regulation limits the transportation of untreated firewood to less than 50 mi from its origin to limit the spread of these pests in New York (NYS DEC 2010).

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 Trout Brook watershed be considered priority areas for conservation and that efforts be taken to fully protect these habitats wherever possible. If new development in forested areas cannot be avoided, it should be concentrated near forest edges and near existing roads and other development so that as much forest area as possible is preserved without fragmentation. New roads or driveways should not extend into the interior of the forest and should not divide the habitat into smaller isolated patches. Some general guidelines for forest conservation include the following:

1. **Protect large, contiguous forested areas** wherever possible, and avoid development in forest interiors.
2. **Protect patches of forest types that are less common in the town regardless of their size**. These include mature 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 found an invasive insect infestation.

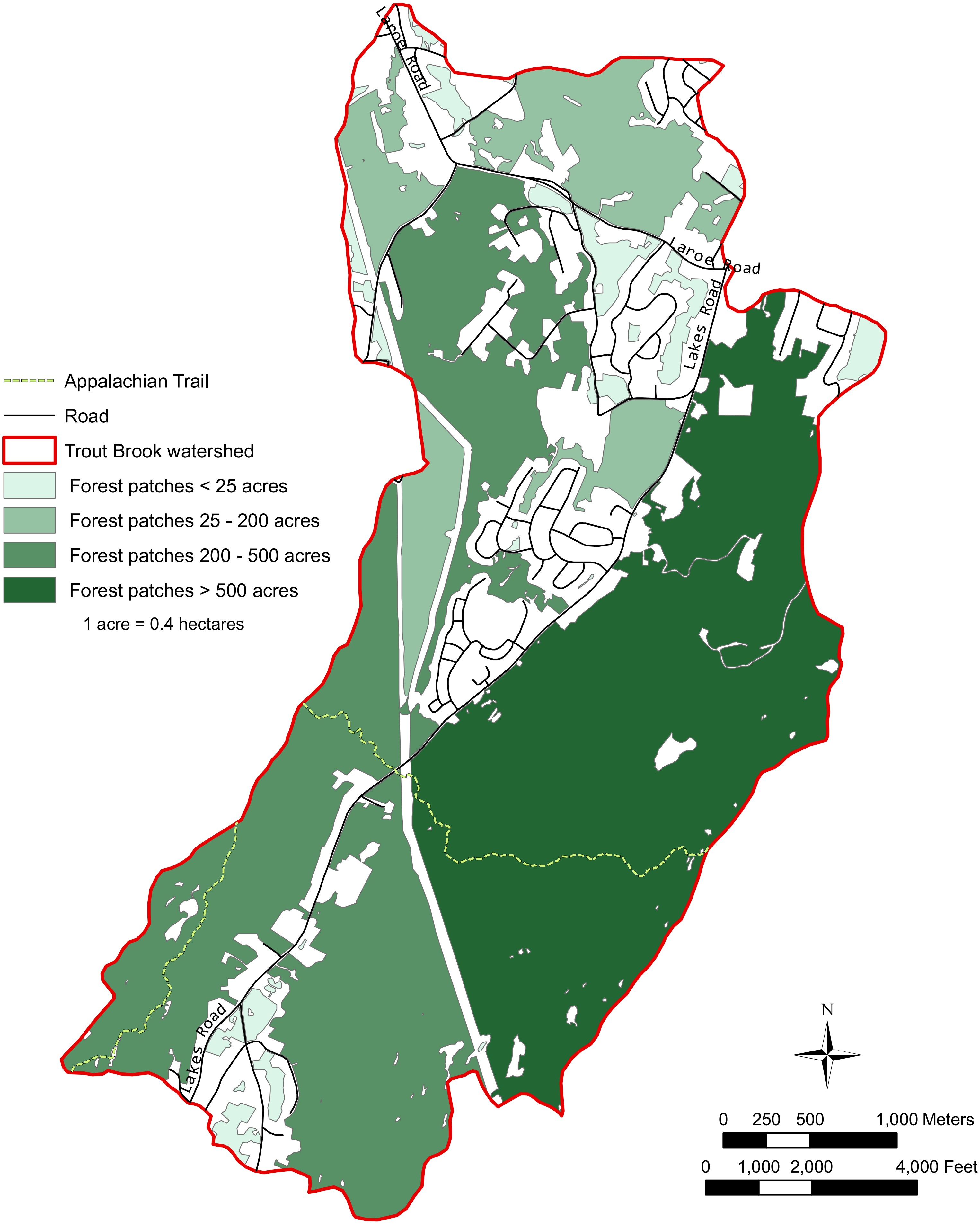


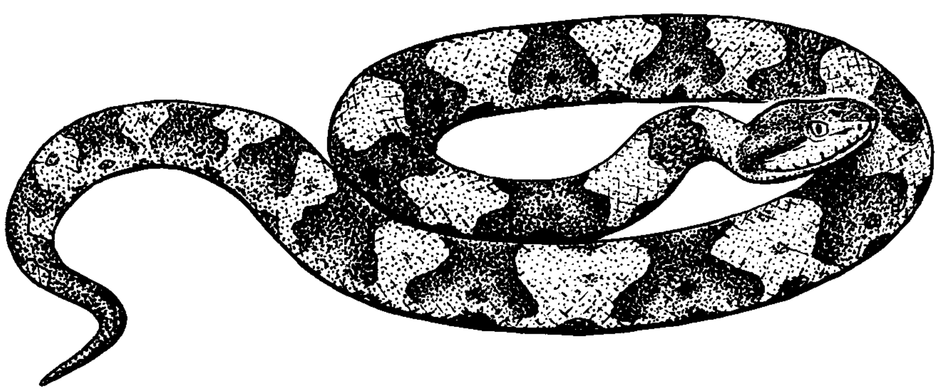
Figure 5. Contiguous forests patches (including conifer, hardwood, mixed forests in uplands and swamps) in the Trout Brook watershed, Orange County, New York. Hudsonia Ltd., 2010

OAK-HEATH BARREN, and other CREST/LEDGE/TALUS

Target Areas

We mapped many small areas of oak-heath barren in the eastern and western highlands of the watershed (Figure 6). The largest patch of oak-heath barren (0.9 ac [0.36 ha]) occurred along the Appalachian Trail on Bellvale Mountain. The small barrens in the watershed are probably remnants of historically larger habitats once maintained by fire; these likely persist because shallow soils and other factors inhibit colonization by taller tree species that would otherwise shade out oak-heath barren species.

Other crest, ledge, and talus habitats occurred throughout the study area on hill summits and slopes (Figure 6). In the western highlands there was one large ledge and talus slope that ran intermittently for more than a mile (taller than 30 ft [9 m] in some locations). The exposed bedrock in the extensive rocky areas of the highlands appeared to be largely acidic (as indicated by the plant community).



Copperhead

Conservation Issues

Oak-heath barrens are uncommon in the Hudson Valley. These are disturbance-adapted ecosystems, and human suppression of wildfires has eliminated one of the disturbances that historically maintained them. While these habitats are adapted to wind and ice disturbances, their plant communities are especially adapted to episodic fires. Without fire events, other forest species can colonize these areas, and eventually oak-heath barren specialists may be out-competed by the more typical species of rocky upland hardwood forests. Rare plants of oak-heath barrens include clustered sedge,* mountain spleenwort,* dwarf shadbush,* three-toothed cinquefoil,* and bearberry.* Several invertebrates of conservation concern rely on the plant species found in oak-heath barrens such as little bluestem, the larval host plant for several rare skippers.

Some rare and vulnerable reptile species depend on rocky habitats, including the exposed outcrops of oak-heath barrens. Snakes such as timber rattlesnake,* copperhead,* eastern hognose snake,* eastern rat snake,* and eastern racer* may den in oak-heath barrens and other crest, ledge, and talus habitats. Several of these species range far into the surrounding landscape to forage in forests and meadows. For instance, timber rattlesnakes and copperheads will travel on average 2 mi (3.2 km) and 0.4 mi (0.7 km), respectively, from their dens, and have been known to travel up to 4 mi (3.2 km) and 0.7 mi (1.2 km), respectively (Brown 1993; Fitch 1960). Timber rattlesnake populations have been declining in the northeastern U.S. due to loss or disturbance of habitat, collection of the snakes for live trade, and malicious killing (Brown 1993; Klemens 1993); copperhead populations are subject to similar threats. Eastern rat snakes and eastern racers travel similar distances from their den sites (Blouin-Demers and Weatherhead 2002; Todd 2000).

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

Recommendations

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

1. **Avoid disturbance of crest, ledge, and talus habitats wherever possible, and** concentrate any unavoidable development in a manner that maximizes the amount and contiguity of undisturbed rocky habitat. Minimize the extent of new roads through undeveloped land with extensive crest, ledge, and talus. Take special

measures to restrict the potential movement of snakes into developed areas, thereby minimizing the likelihood of human-snake encounters (which are often fatal for the snake) and road mortality.

2. **Maintain broad corridors** between crest, ledge, and talus habitats**.** Intervening areas between habitats provide travel corridors for species that migrate among different habitats for breeding, foraging, and dispersal.
3. **Consider the impacts of habitat disturbance** to crest, ledge, and talus when reviewing all applications for mining permits and other development proposals, keeping in mind that rare snakes typically travel long distances from their den sites.
4. **Educate construction workers, utility workers, and residents** about snake conservation and whom to contact to safely relocate snakes.

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

1. **Protect oak-heath barren and associated crest, ledge, and talus habitats.** All oak-heath barrens and their closely associated crest, ledge, and talus habitats should be protected from direct disturbances including, but not limited to, the construction of communication towers; mining; house, road, and driveway construction; and high intensity human recreation. Discourage hikers on public land from harming these habitats by littering, leaving the trail, or camping in these areas. Protecting these habitats protects breeding, basking, and (sometimes) denning areas for rare snakes and the habitats for other rare animals and plants.
2. **Protect critical adjoining habitats within 100 ft (30 m) of the 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 evade human activity. Disturbances in or near an oak-heath 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 an oak-heath 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 oak-heath 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 oak-heath barren habitats.

3. **Investigate prescribed burns as a management tool** for maintaining oak-heath barren habitats. These areas might benefit from prescribed burns that match the historic fire interval, intensity, and season. Such projects should only be designed and carried out by experts.

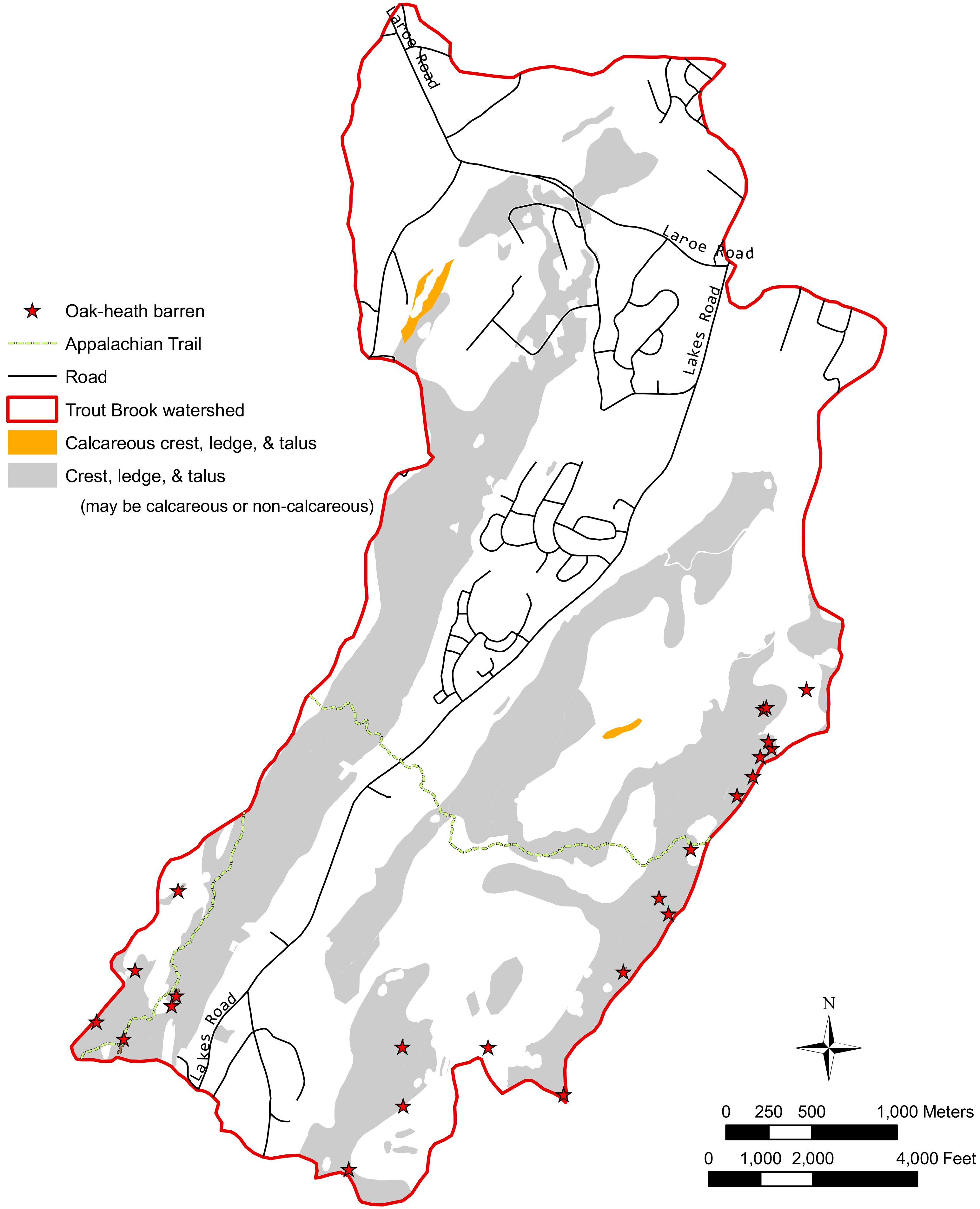


Figure 6. Generalized distribution of calcareous and non-calcareous crest, ledge, and talus (CLT) habitats and oak-heath barrens in the Trout Brook watershed, Orange County, New York. CLT locations identified from field observations and inferred from areas mapped as having shallow soils on steep slopes and crests in Olsson (1981). Hudsonia Ltd., 2010

INTERMITTENT WOODLAND POOLS

Target Areas

We identified and mapped 17 intermittent woodland pools in the study area (Figure 7), and there are likely to be others that we missed. We also mapped five “pool-like” swamps, which presumably have ecological functions similar to that of intermittent woodland pools; these include small, open-canopied swamps and buttonbush pools, which have a combination of intermittent woodland pool and swamp characteristics (see swamp habitat description). Each intermittent pool is important to preserve, but groups or networks of pools, as found in the eastern highlands for instance, 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 genetic material, and to recolonize sites where populations have recently disappeared.

Conservation Issues

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.* These amphibians can be used as the focus for conservation planning for intermittent woodland pools. Except for their relatively brief breeding and nursery seasons, these species are exclusively 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 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.

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 3,800 ft (1,160 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). Open fields and clearcuts are another barrier to forest-dwelling amphibians. Juveniles have trouble crossing open fields 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 individuals can disperse (Semlitsch 2000). A network of pools is essential to amphibians for several reasons. Each pool is different from the next in vegetation structure, plant community, and hydroperiod, so each may provide habitat for a different subset of pool-breeding species at different times. Also, different pools provide better or worse 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 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).

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 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 advise that intermittent woodland pools be permanently protected from development and disturbance of any kind including the construction of houses, roads, lawns, and permanent ponds within the pool depression. This zone of protection should include the pool basin up to the spring high water mark and all associated vegetation. The soil in and surrounding the pool should not be compacted in any manner and the vegetation, woody debris, leaf litter, and stumps or root crowns within the pool should not be removed.
2. **Protect all upland forest within 100 ft (30 m) of the intermittent woodland pool**. 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 system. This organic debris constitutes the base of the pool food web and provides attachment sites for amphibian egg masses.
3. **Maintain critical terrestrial habitat within 750 ft (230 m) of the pool**. The upland forests within 750 ft (230 m) or more of a woodland pool are critical foraging and shelter habitats for pool-breeding amphibians during the non-breeding season. Roads, development, logging, ATV use, and other activities within this terrestrial habitat can crush many amphibians and destroy the forest floor microhabitats that provide them with shelter and invertebrate food. Development within this zone can also prevent dispersal and genetic exchange between neighboring pools, thereby making local extinction more likely. A minimum of 75% of this zone should remain in contiguous (unfragmented) forest with an undisturbed forest floor. Wherever possible, forested connections between individual pools should be identified and maintained to provide overland dispersal corridors.
4. **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).

We also recommend the following for all development activity proposed within the critical terrestrial conservation 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 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, herbicides, 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. Ruts, for example, may also serve as larval habitats for undesirable species of mosquitoes.
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, turtles, and other small terrestrial animals. Soil test pits should be backfilled immediately after tests are completed.
5. **Schedule construction activities to occur outside the peak amphibian movement periods of spring and early summer (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.

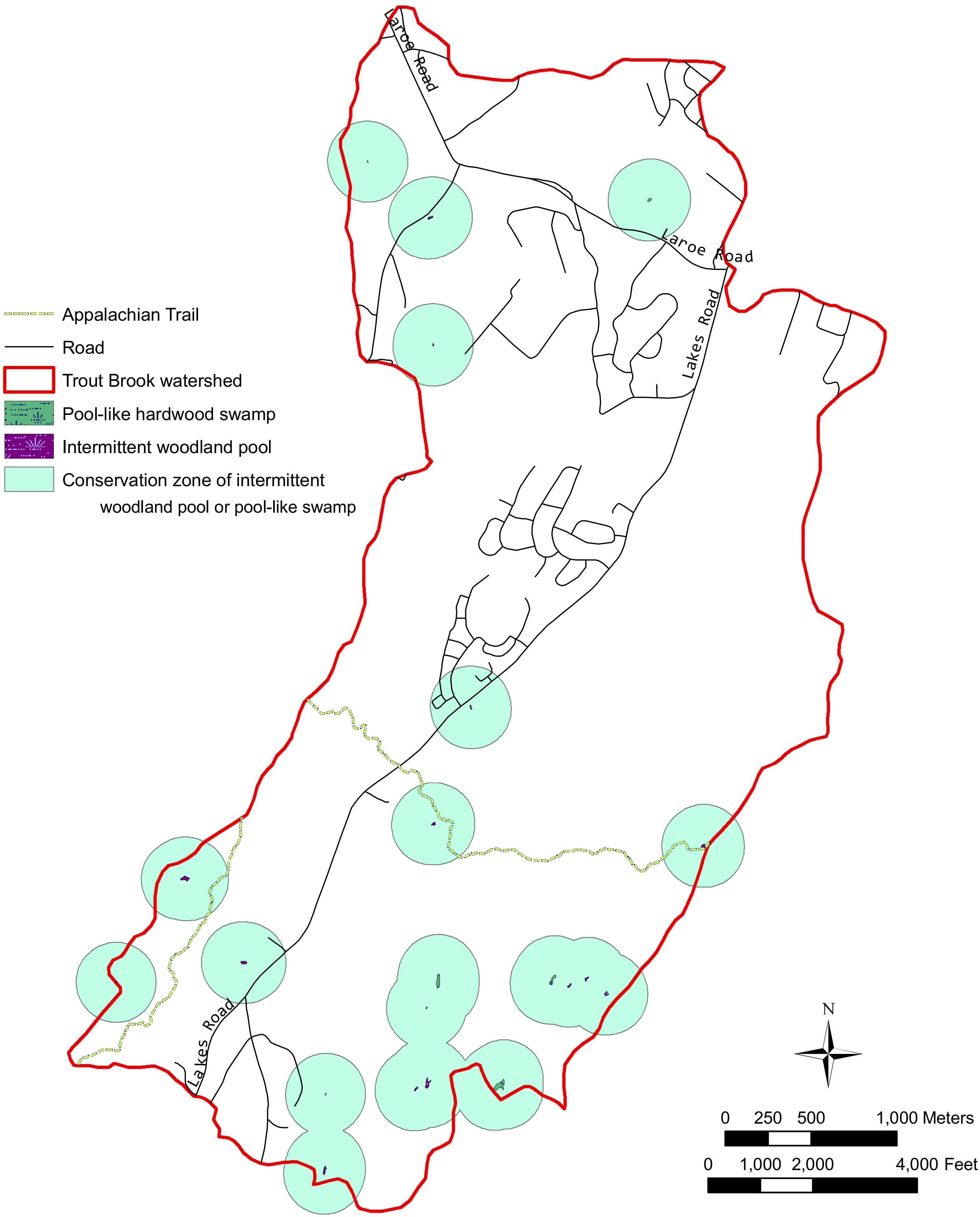


Figure 7. Intermittent woodland pools, pool-like swamps, and their conservation zones in the Trout Brook watershed, Orange County, New York. Pool conservation zones extend 750 ft (230 m) from wetland boundaries. Hudsonia Ltd., 2010

STREAMS AND RIPARIAN CORRIDORS

Target Areas

Trout Brook and the numerous smaller perennial and intermittent streams that feed it provide habitat for many native plants and animals (both resident and transient), and are important to the ecology of the entire stream watersheds (Figure 8).

Conservation Issues

Low-gradient, perennial streams can be essential core habitat for the wood turtle (NYS Special Concern). Wood turtle has been recorded in a nearby watershed (Nick Conrad, NYNHP, pers. comm.), and could occur in the Trout Brook watershed. 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 660 ft (200 m) or more of a core stream habitat (Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997). Human land uses within this habitat complex can have significant adverse effects on wood turtles and their habitats. These effects include habitat degradation from stream alteration; habitat fragmentation from culverts, bridges, roads, and other structures; the 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 (Lowe and Likens 2005), 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, provide wildlife habitat and travel corridors, 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 and restore 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.
    - 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. These conservation zones should remain 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.
    - In Appendix E we make specific recommendations for restoration at a few locations (Figure 9).
2. **Protect riparian wetland and non-wetland habitats.** All riparian wetlands adjacent to known or potential wood turtle streams should be protected from filling, dumping, drainage, impoundment, incursion by construction equipment, siltation, polluted runoff, and hydrological alterations. In addition, large, contiguous blocks of upland habitats (e.g., forests, meadows, and shrublands) within 660 ft (200 m) of a core wood turtle

stream should be preserved 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**. We have mapped the locations of dams and culverts in the watershed (Figure 9). Building on a dataset created by the Hudson River Estuary Program of the NYS DEC, we have updated the information to include bridges and culverts where mapped streams intersect with roads or where a stream has been channeled underground through a developed area. The dataset also includes dams and similar obstructions. In most cases, we have not mapped culverts where streams cross driveways because we were not able to verify them in the field. With our field work, we identified 66% more culverts than were in the original dataset, which was created using only remote sensing. The NYS DEC culvert data for the rest of the Moodna Creek watershed may be similarly underestimated.

   Undersized bridges and narrow 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 an overland route to reach their destination. Typically, this overland route involves crossing a road or other developed area, often resulting in road mortality. If a stream crossing completely blocks the passage of turtles, individuals can be cut off from important foraging or basking habitats, or be unable to interbreed with turtles of neighboring populations. Such barriers could significantly diminish the long-term viability of 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, although not specifically designed for wood turtles, may be an important first step to improving the connectivity of stream corridors (adapted from Singler and Graber 2005):

   - Use bridges and open-bottomed arches instead of culverts.
   - Use structures that span at least 1.2 times the full width of the stream so that one or both banks remain in a semi-natural state beneath the structure. This may 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 so as to maintain water depth and velocities at low flow that are comparable to those found in natural stream segments just upstream and downstream of the structure. Sharp drops in elevation at the inlet or outlet of the structure can be a physical barrier to passage of wood turtle and many 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 660 ft (200 m) wide stream conservation zone:
    - Prohibit the building of new roads crossing or adjoining wood turtle habitat complexes. This applies to public and private roads of all kinds, including driveways.
    - Keep vehicle speeds low on existing roads by installing speed bumps, low speed limit signs, and wildlife crossing signs.
5. **Maintain broad corridors between habitats and habitat complexes**. Broad, naturally-vegetated travel corridors should be maintained between individual habitats within a complex (e.g., between core stream habitats, foraging wetlands, and nesting areas) and between neighboring habitat complexes.
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 reduce the reproductive success of the turtles over the long term. We recommend that large areas of potential nesting habitat within the 660 ft (200 m) stream conservation zone (e.g., upland meadows, upland shrublands, waste ground with exposed gravelly soils) be protected from development and other disturbance.

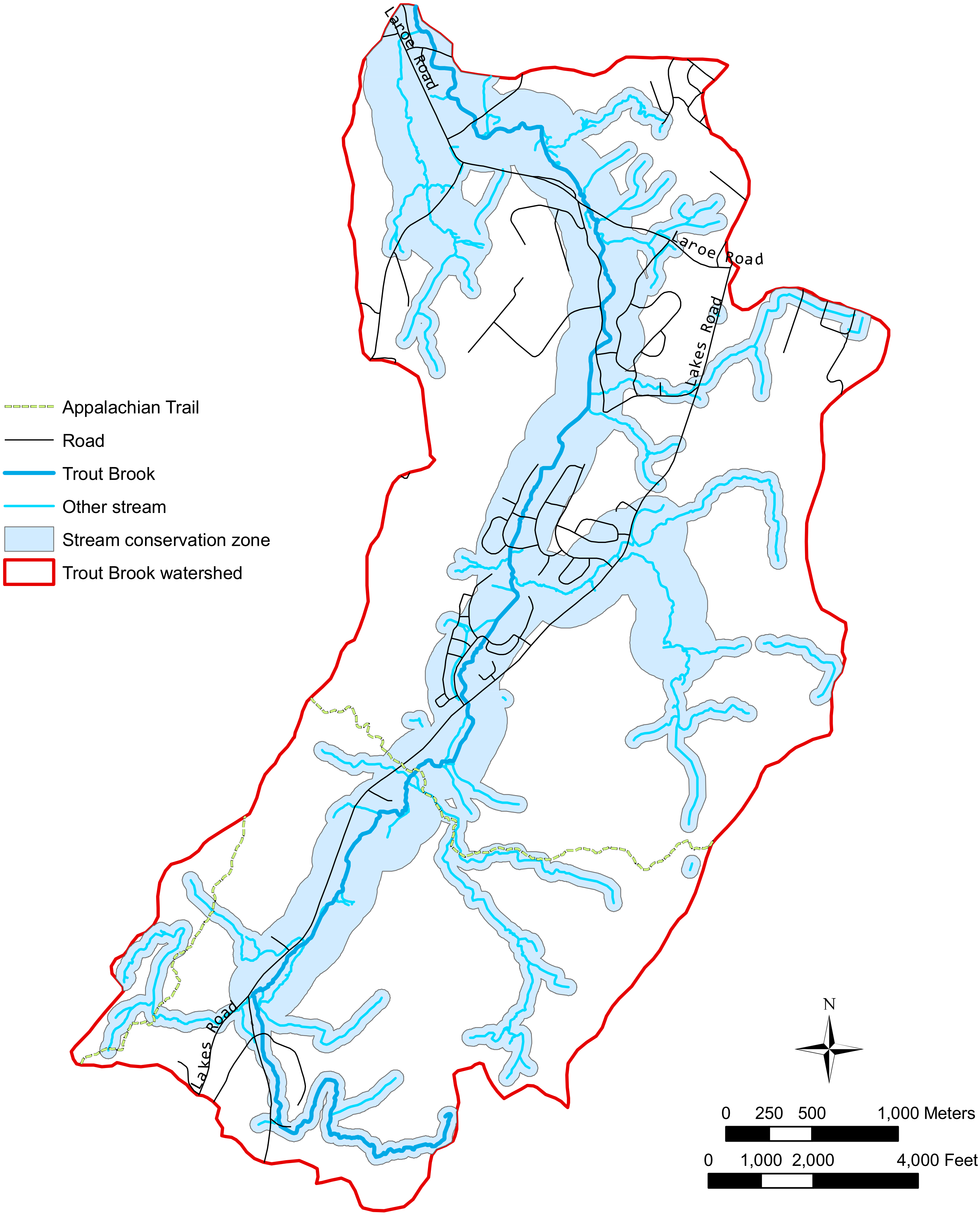


Figure 8. Streams and their associated conservation zones in the Trout Brook watershed, Orange County, New York. Conservation zones extend at least 160 ft (50 m) from stream edges, and 650 ft (200 m) from edges of large, perennial streams. Hudsonia Ltd., 2010

ENHANCEMENT OF DEVELOPED AREAS

A well-rounded biodiversity conservation approach in settled landscapes must also consider areas that are already developed. Although developed areas are much used by common wildlife species that are well-adapted to human activities and infrastructure (e.g., pigeon, starling, gray squirrel, raccoon, striped skunk, and various rodents), uncommon species can also inhabit or travel through developed areas if nearby habitats are suitable. Bats (including Indiana bat*) and certain species of birds (including eastern screech owl,* barn owl,* and Cooper's hawk*) will take advantage of individual trees, small groves, and structures in developed areas.

There are many landscape modifications and land use practices that can be applied to the developed parts of the watershed that would assist in the protection of species of conservation concern. In areas of concentrated development, some small areas may serve as buffers to intact habitats by moderating the effects of development, some may provide travel corridors for wildlife, and some may themselves provide habitat for certain species. Hudsonia did not map these small areas or isolated habitat features (such as individual trees or small groves) as significant habitats in their own right due to our mapping protocols at a watershed-wide scale (see Appendix A). However, the habitat map can help to focus habitat enhancement efforts on developed locations where they will achieve the greatest returns for biodiversity conservation.

Following are some examples of conservation measures for developed areas (adapted in part from Adams and Dove 1989, and Adams 1994). There are many additional ways in which urban and suburban areas can be modified to reduce their negative environmental impacts and even contribute positively to the natural environment, with many examples of their implementation to be found in European cities (Beatley 2000). The costs of implementing these measures and their effectiveness at particular locations will vary, and while some must be implemented by town agencies or other government entities, others can be practiced by private landowners. Town agencies can take a leading role in educating the general public about such actions and encouraging landowner participation.

ENHANCING HABITAT CHARACTERISTICS IN DEVELOPED AREAS

1. ***Preserve trees of a variety of species and age classes.*** Trees are an important component of the habitat of many wildlife species, and some species of plants and animals can use hedgerows as habitat corridors. Trees also provide services such as helping to moderate climate extremes, reducing wind velocities, controlling erosion, and abating noise.
   - Preserve large trees wherever possible, and especially those with exfoliating bark that might serve as summer roost sites for bats.
   - Plant a variety of native tree species along streets, and reduce the use of salt on roads to minimize damage to the trees.
   - Allow natural regeneration of trees where possible, to provide replacements for older or diseased 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, treefrogs, woodpeckers, and bats, and decomposing trees provide both habitat and a source of nutrients for plants.

2. ***Use native species for ornamental plantings.*** Native ornamental shrubs tend to support many times the number of native invertebrates and birds than non-native ornamentals (Tallamy 2007), and some non-native species become invasive. Use native species in plantings on public properties and encourage the use of native species on private property through landowner education programs. Many towns and counties create lists of recommended native plants for residents, and actively encourage the removal of non-native species. Obtain plants and propagules of native species from nurseries offering materials from local sources wherever possible, as genetic strains native to the region will be more suited to the regional climate and ecology.

3. ***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, 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. 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.

4. ***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, including woody plants wherever possible.
    - 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.

5. ***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 floodplain, and in some cases the 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).

6. ***Maximize onsite infiltration of rainwater and snowmelt.*** Impervious surfaces such as pavement and roofs alter hydrological patterns by preventing precipitation from infiltrating through the soil to groundwater, and instead promote overland flow to ditches, streams, and ponds. This effect prevents the recharge of groundwater and the filtration of pollutants by soil and vegetation, while increasing the likelihood of flooding, stream bank erosion, and surface water pollution (including sedimentation).
    - Encourage the use of pervious driveway materials in residential and commercial construction and renovation.
    - 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, and soil traps. The NYS DEC created the Better Site Design document (NYS DEC 2008) to offer guidance to developers and designers to reduce the impacts of stormwater. A national menu of stormwater BMPs can be found on the U.S. Environmental Protection Agency website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/).
- 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 suburban areas is road mortality. A study to identify roadways with the highest incidence of wildlife mortality could be used to direct the following measures to the places where they will be most effective. Community groups in the towns of Washington and Red Hook (Dutchess County, New York) have undertaken projects like this in recent years. The maps of conservation zones in this report could also inform such efforts (e.g., roads within conservation zones for intermittent woodland pools could be priorities for facilitating amphibian crossings).
    - Reduce speed limits and post wildlife crossing signs along 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, type of roadside vegetation, and distance of vegetation to the road's edge (Barnum 2003, Clevenger et al 2003).

2. ***Minimize noise and light pollution.*** High levels of noise and artificial light in cities and in residential and commercial areas can interfere with activities of many wildlife species.

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

3. ***Discourage human-subsidized predators, including domestic cats and dogs.*** Human-sponsored predators are species such as raccoon, opossum, and striped skunk, whose populations often burgeon in response to conditions created by humans. 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 (including bird flight paths) 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, curbs, or chain-link fences (excluding those designed to prevent access to pitfalls and other hazards), and design or modify them to have spaces or openings to allow safe passage. A design for the safe passage of some turtle species is described in Hartwig et al. (2009).

- 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.

REVIEWING SITE-SPECIFIC LAND USE PROPOSALS

In addition to watershed-wide 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 which ecologically significant habitats, if any, are located on and near the site in question.
2. Read the descriptions of those habitats in this report, including the "*Sensitivities/Impacts*" subsection for each habitat.
3. Consult figures 4-8 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, 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 streams, ponds, or wetlands.
- Using native species (from local stocks wherever possible) for ornamental plantings and in revegetation areas after site preparation.
- Locating developed features such that broad corridors of undeveloped land are maintained between important habitats on and off the site.

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 should be an integral part of the review process for any proposed land use change.

CONCLUSION

There are significant opportunities for biodiversity conservation in the rural and suburban landscapes of the Trout Brook watershed. Development pressure is increasing, however, and strategic land use and conservation planning are needed to ensure that species, communities, and ecosystems are protected for the long term, and that the free services provided by healthy ecosystems are conserved. The habitat map and this report will equip town agencies, landowners, and others with information about local habitats of ecological significance so that steps can be taken to protect the resources of greatest importance.

The position of the Trout Brook watershed within the Hudson Highlands corridor—which has been widely recognized by conservation agencies and organizations for its high ecological value—magnifies the importance of the area for biodiversity conservation. Records of numerous rare species of plants, amphibians, reptiles, mammals, and birds in and near the watershed attest to its significance for biological diversity. The large areas of unfragmented forest in the watershed are part of much larger forests extending beyond the watershed boundaries, and are likely to be important to area-sensitive wildlife such as black bear, bobcat, red-shouldered hawk, and forest-interior songbirds whose habitats are dwindling in the region. North-south oriented corridors in the Hudson Valley with significant elevation differences, such as the Trout Brook, may provide safe migration routes for wildlife and plants stressed by habitat loss and degradation associated with a warming climate. The intact habitats of the watershed likely contribute measurably to the water quality and habitat quality of Trout Brook, Seely Brook, Cromline Creek, Moodna Creek, and ultimately the Hudson River. The Trout Brook mainstem and tributaries, however, have been significantly altered by dams, culverts, hardening of streambanks, loss of floodplain and other riparian habitats, and polluted and sediment-laden runoff from pavement, lawns, and roadside ditches. Updating stormwater management along roads and in other developed areas, and establishing and maintaining well-vegetated streamside buffer zones could be accomplished incrementally, and would dramatically improve the condition of these streams and the downstream system. Larger projects such as decommissioning dams, redesigning and reinstalling culverts, or reintegrating the streams with their floodplains may require special funding or special timing (e.g., to coincide with a road reconstruction project). Riparian restoration projects such as these, as well as the conservation recommendations outlined in this report that pertain to habitats often thousands of feet from the Trout Brook itself, will increase the ecological services provided by a high quality stream, including flood retention and water filtration.

While it is fortunate that large habitat areas in the Trout Brook watershed and in the Highlands corridor in general are in public ownership or have other protected status, the even larger areas of privately-held lands warrant special conservation attention. Educating landowners and municipal officials, and incorporating biodiversity conservation into municipal procedures and standards for environmental reviews of land development projects may be the best first steps toward effective protection of sensitive habitats and water resources.

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 provides a bird’s-eye view of the landscape, illustrating the location and configuration of ecologically significant habitats. At the printed scale of 1:10,000, many interesting ecological and land use patterns emerge, including areas where rare habitats (such as oak-heath barrens and calcareous wet meadows) are concentrated, the location and extent of remaining unfragmented habitat blocks, as well as the patterns of habitat fragmentation caused by roads and private residential development. This kind of general information can help the towns consider where future development should be concentrated and where future conservation efforts should be targeted. An understanding of the significant ecological resources in the watershed will enable local decision makers to focus limited conservation resources where they will have the greatest impact.

At the site-specific scale, we hope the map will be used as a resource for routine deliberations over development proposals and other proposed land use changes. The map and report provide an independent body of information for environmental reviews, and will help raise questions about important biological resources that might otherwise be overlooked. We strongly emphasize, however, that the map has not been exhaustively field 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 the map should not be considered a substitute for additional 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. Because the natural landscape and patterns of human land use are dynamic, the towns should consider refining and/or updating the habitat map over time. Also, only a small portion of each of the four towns in the watershed is covered by this map and report; we would encourage extending the habitat mapping to the entire towns.

After presenting the completed habitat map, database, and report to the towns of the Trout Brook watershed, Hudsonia hopes to have the opportunity to assist town officials, landowners, and other interested individuals and groups in interpreting the map, understanding the ecological resources of the watershed, and devising ways to integrate this new information into land use planning and decision making. We also hope that stream restoration projects will be undertaken in the watershed, including the sites identified in Appendix E as having potential for restoration.

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

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 locations of potential bedrock exposures inferred from the mapped locations of shallow soils (<20 inches [50 cm]) on steep slopes (>15%) in Olsson (1981). 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. All other rocky areas (both non-calcareous and unknown bedrock) were mapped simply as “crest, ledge and talus.” While some wetlands can include rock outcrops, we did not show the crest, ledge, and talus overlay over wetlands because such wetlands are likely to support species other than those described in the crest, ledge, and talus section of the report.

Cultural. We define “cultural” habitats as areas that are significantly altered and intensively managed (e.g., mowed), but are not otherwise developed with wide pavement or structures. These include playing fields, cemeteries, and large gardens and lawns. 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.

Developed areas. Habitats surrounded by or intruding into developed land (buildings, paved and gravel roads, and parking areas) were identified as ecologically significant and mapped only if their dimensions exceeded 50 m (165 ft) in all directions, or if they seemed to provide important connections to other large habitat areas. Exceptions to this protocol 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, and also provide important hydrological connections. Lawns near buildings and roads were mapped as developed; large lawns not adjacent to buildings, and adjacent to significant habitats, were mapped as “cultural” habitats.

Intermittent woodland pools. Intermittent woodland pools are best identified in the spring when the pools are full of water and occupied by invertebrates and breeding amphibians. The presence of fairy shrimp is often a good indicator that the standing water is intermittent. For those intermittent woodland pools we visited in late summer and fall, we relied on general physical features of the site to distinguish them from isolated swamps. We classified those wetlands with an open basin as intermittent woodland pools and those dominated by trees or shrubs as swamps, but the two often serve similar ecological functions. Many intermittent woodland pools can also be mapped remotely since they have a distinct signature on aerial photographs, and are readily visible within areas of deciduous forest if the photographs are 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 ponds. We distinguish between the habitat categories “open water” and “constructed pond” based mostly on the degree to which the water body and its shorelines are managed. Most small to medium-size bodies of open water in our region were probably created by damming or excavation, and were mapped as constructed ponds where their shorelines are regularly managed. Those water bodies that we mapped as “open water” habitat included natural lakes and ponds with unmanaged shorelines; large, substantially unvegetated pools within marshes and swamps; and ponds that were probably constructed but are now surrounded by unmanaged vegetation.

Springs & seeps. Springs and seeps are difficult to identify by remote sensing. We mapped only the very few we happened to see in the field and those that were either identified on soils maps or have an identifiable signature on topographic maps. We expect there were many more springs and seeps in the Trout Brook watershed that we did not map. The presence of most seeps and springs must be determined by site visits.

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 wetlands, and when they flowed underground for relatively short distances (e.g., under roads or small developments). We expect there were additional intermittent streams that we did not map, and we recommend these be added to the database as information becomes available. Because it was often difficult to distinguish between perennial and intermittent streams based on aerial photograph and map interpretation, these distinctions were made using our best judgment. Roadside ditches were mapped as streams only if they were visibly connected to another mapped stream or visibly flowed into a mapped wetland. We mapped these ditches as “streams” because they function as such from a hydrological perspective, conveying water and other substances into wetlands, ponds, and streams. Other streams that were channelized or diverted by humans were mapped when observed in the field or on aerial photos.

Upland forests. 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, and because they are more suitable for general planning purposes for non-biologists (e.g., members of planning boards). Hardwood and coniferous trees are generally distinguishable in aerial photos taken in the spring, although tamarack and dead 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 (where identifiable) were mapped as boundaries of adjacent forested habitat areas, since they can be significant fragmenting features.

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

Wetlands. We mapped wetlands remotely using topographic maps, soils data, and stereoscopic 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 study area, including those that were isolated from other habitats by development. Along stream corridors and in other low-lying areas with somewhat poorly drained soils, it was often difficult to distinguish between upland forest and hardwood swamp without the benefit of onsite soil data. These areas were characterized by moist, fine-textured soils with common upland trees in the canopy, often dense thickets of vines and shrubs (e.g., Japanese barberry, Eurasian honeysuckle) in the understory, and facultative wetland and upland species of shrubs, forbs, and graminoids.

Appendix B. Explanation of ranks of species of conservation concern listed in Appendix C. Explanations of New York State Ranks and New York Natural Heritage Program Ranks are from the New York Natural Heritage Program website, (http://www.dec.ny.gov/animals/29386.html), accessed in 2010.

NEW YORK STATE RANKS

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

ANIMALS

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

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

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

PLANTS

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

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

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

NEW YORK NATURAL HERITAGE PROGRAM RANKS – ANIMALS AND PLANTS

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

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

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

S4 Apparently secure in New York State.

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

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

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

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

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

REGIONAL STATUS (HUDSON VALLEY) – ANIMALS AND PLANTS

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

BIRDS - PARTNERS IN FLIGHT PRIORITY SPECIES LISTS

The Partners in Flight (PIF) WatchList is a list of landbirds considered to be of highest conservation concern, excluding those already designated as endangered under the federal Endangered Species Act. The WatchList is compiled jointly by several federal and private associations, including the Colorado Bird Observatory, the American Bird Conservancy, Partners in Flight, and the U.S. Fish and Wildlife Service. The current PIF WatchList is based on a series of scores assigned to each species for seven different aspects of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, population trend, and "area importance" (relative abundance of the species within a physiographic area compared to other areas in the species' range). Scores for each of these factors range from 1 (low priority) to 5 (high priority), and reflect the degree of the species' vulnerability associated with that factor. Species are assigned "**High Regional Priority**" if their scores indicate high vulnerability in a physiographic area (delineated similarly to the physiographic areas used by the Breeding Bird Survey), and "**High Continental Priority**" if they have small and declining populations, limited distributions, and deteriorating habitats throughout their entire range. The most recent WatchList was updated in August 2003. We include birds from the lists for physiographic areas # 17 (Northern Ridge and Valley) and # 9 (Southern New England).

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

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

Appendix C. Species of conservation concern potentially associated with habitats in the Trout Brook watershed. 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), **NYS DEC 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 **high conservation priorities** at the continental (PIF1) and regional (PIF2) level. These ranks are explained in Appendix B.

UPLAND HARDWOOD FOREST		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
blunt-lobed grape fern (E, S2S3)	marbled salamander (SC, S3, SGCN)	wood thrush (PIF1, SGCN)
silvery spleenwort (RG)	mountain dusky salamander (RG)	hermit thrush (SGCN)
Back's sedge (T)	red salamander (RG)	cerulean warbler (SC, PIF1, SGCN)
narrow-leaved sedge (E, S1)	eastern box turtle (SC, S3, SGCN)	Canada warbler (PIF1, SGCN)
pinesap (RG)	eastern wormsnake (SC, S2)	Kentucky warbler (S2, PIF1, SGCN)
American ginseng (RG)	eastern racer (SGCN)	black-and-white warbler (PIF2)
red baneberry (RG)	eastern rat snake (SGCN)	black-throated blue warbler (SGCN)
poke milkweed (RG)	northern goshawk (SC, S3N, SGCN)	black-throated green warbler (RG)
lopseed (RG)	red-shouldered hawk (SC, SGCN)	worm-eating warbler (SGCN)
leatherwood (RG)	Cooper's hawk (SC, SGCN)	hooded warbler (RG)
hackberry (RG)	sharp-shinned hawk (SC, SGCN)	ovenbird (RG)
violet wood-sorrel (T)	broad-winged hawk (RG)	scarlet tanager (PIF2, SGCN)
Hooker's orchid (E, S1)	ruffed grouse (SGCN)	southern bog lemming (RG)
puttyroot (E, S1)	American woodcock (PIF1, SGCN)	Indiana bat (E, S1, SGCN)
Vertebrates	barred owl (RG)	black bear (RG)
wood frog (RG)	whip-poor-will (SC, PIF2, SGCN)	bobcat (RG)
spotted salamander (RG)	eastern wood-pewee (PIF2)	New England cottontail (SC, S1S2, SGCN)
Jefferson salamander (SC, SGCN)	Acadian flycatcher (S3)	fisher (RG)
blue-spotted salamander (SC, SGCN)		

UPLAND CONIFER FOREST		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
pinesap (RG)	sharp-shinned hawk (SC, SGCN)	red-breasted nuthatch (RG)
Hooker's orchid (E, S1)	American woodcock (PIF1, SGCN)	black-throated green warbler (RG)
Vertebrates	long-eared owl (S3, SGCN)	Blackburnian warbler (PIF2)
blue-spotted salamander (SC, SGCN)	short-eared owl (E, S2, PIF1, SGCN)	evening grosbeak (RG)
red salamander (RG)	barred owl (RG)	purple finch (PIF2)
Cooper's hawk (SC, SGCN)		

RED CEDAR WOODLAND		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
Carolina whitlow-grass (T, S2)	spotted turtle (SC, S3, SGCN)	short-eared owl (E, S2, PIF1, SGCN)
yellow wild flax (T, S2)	wood turtle (SC, S3, SGCN)	whip-poor-will (SC, PIF2, SGCN)
Bicknell's sedge (T, S3)	eastern box turtle (SC, S3, SGCN)	eastern bluebird (RG)
Indian grass (RG)	eastern hognose snake (SC, S3, SGCN)	brown thrasher (PIF2, SGCN)
Hooker's orchid (E, S1)	ruffed grouse (SGCN)	golden-winged warbler (SC, PIF1, SGCN)
Invertebrates	black-billed cuckoo (SGCN)	blue-winged warbler (PIF1, SGCN)
juniper hairstreak (butterfly) (RG)	northern saw-whet owl (S3)	eastern towhee (PIF2)
	long-eared owl (S3, SGCN)	

NON-CALCAREOUS CREST/LEDGE/TALUS		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
mountain spleenwort (T, S2S3)	brown elfin (butterfly) (RG)	copperhead (S3, SGCN)
Bradley's spleenwort (E, SH)	juniper hairstreak (butterfly) (RG)	timber rattlesnake (T, S3, SGCN)
whorled milkweed (RG)	northern hairstreak (butterfly) (S1S3, SGCN)	turkey vulture (RG)
blunt-leaf milkweed (RG)	gray hairstreak (butterfly) (RG)	golden eagle (E, SHB, S1N, SGCN)
rock sandwort (RG)	Horace's duskywing (butterfly) (RG)	whip-poor-will (SC, PIF2, SGCN)
goat's-rue (RG)	swarthy skipper (butterfly) (RG)	black vulture
slender knotweed (R, S3)	Leonard's skipper (butterfly) (RG)	common raven (RG)
dittany (RG)	cobweb skipper (butterfly) (RG)	winter wren (RG)
Torrey's mountain-mint (E, S1)	dusted skipper (butterfly) (S3)	eastern bluebird (RG)
Allegheny-vine (RG)	***Vertebrates***	hermit thrush (RG)
devil's bit (T, S1S2)	Fowler's toad (SGCN)	Blackburnian warbler (PIF2)
stiff-leaf aster (RG)	northern slimy salamander (RG)	cerulean warbler (SC, PIF1, SGCN)
Bicknell's sedge (T, S3)	marbled salamander (SC, S3, SGCN)	worm-eating warbler (PIF1, SGCN)
bronze sedge (RG)	eastern box turtle (SC, S3, SGCN)	small-footed bat (SC, S2, SGCN)
clustered sedge (T, S2S3)	eastern rat snake (SGCN)	boreal redback vole (RG)
reflexed sedge (E, S2S3)	eastern racer (SGCN)	porcupine (RG)
Invertebrates	eastern hognose snake (SC, S3, SGCN)	fisher (RG)
Edward's hairstreak (butterfly) (S3S4)	eastern worm snake (SC, S2, SGCN)	bobcat (RG)
striped hairstreak (butterfly) (RG)		

CALCAREOUS CREST/LEDGE/TALUS		
Plants	***Plants (cont.)***	***Invertebrates***
purple cliffbrake (RG)	Dutchman's breeches (RG)	anise millipede (RG)
walking fern (RG)	pellitory (RG)	juniper hairstreak (butterfly) (RG)
smooth cliffbrake (T, S2)	northern blazing-star (T, S2)	***Vertebrates***
wall-rue (RG)	small-flowered crowfoot (T, S3)	eastern hognose snake (SC, S3, SGCN)
woolly lip fern (E, SH)	roundleaf dogwood (RG)	eastern racer (SGCN)
yellow wild flax (T, S2)	Bicknell's sedge (T, S3)	eastern rat snake (SGCN)
Carolina whitlow-grass (T, S2)	Emmons' sedge (S3)	copperhead (S3, SGCN)
hairy rock-cress (RG)	side-oats grama (E, S1)	
yellow harlequin (S3)		

OAK-HEATH BARREN		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
three-toothed cinquefoil (RG)	Leonard's skipper (butterfly) (RG)	common raven (RG)
dwarf shadbush (RG)	Edward's hairstreak (butterfly) (S3S4)	hermit thrush (RG)
slender pinweed (T, S2)	***Vertebrates***	Nashville warbler (RG)
bronze sedge (RG)	copperhead (S3, SGCN)	prairie warbler (PIF1, SGCN)
clustered sedge (T, S2S3)	timber rattlesnake (T, S3, SGCN)	field sparrow (PIF2)
Invertebrates	turkey vulture (RG)	vesper sparrow (SC, SGCN)
brown elfin (butterfly) (RG)	golden eagle (E, SHB, S1N, SGCN)	eastern towhee (PIF2)
cobweb skipper (butterfly) (RG)	whip-poor-will (SC, PIF2, SGCN)	

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

UPLAND MEADOW

Plants
purple milkweed (S2S3)
Bush's sedge (S3)
narrow-leaved sedge (E, S1)
Invertebrates
Baltimore (butterfly) (RG)
meadow fritillary (RG)
Aphrodite fritillary (butterfly) (RG)
dusted skipper (butterfly) (S3)
Invertebrates (cont.)
Leonard's skipper (butterfly) (RG)
swarthy skipper (butterfly) (RG)
Vertebrates
spotted turtle (SC, S3, SGCN)
eastern box turtle (SC, S3, SGCN)
wood turtle (SC, S3, SGCN)
northern harrier (T, S3B, S3N, SGCN)
upland sandpiper (T, S3B, PIF1, SGCN)
Vertebrates (cont.)
sedge wren (T, S3B, PIF2, SGCN)
eastern bluebird (RG)
savannah sparrow (RG)
vesper sparrow (SC, SGCN)
grasshopper sparrow (SC, PIF2, SGCN)
Henslow's sparrow (T, S3B, PIF1, SGCN)
bobolink (SGCN)
eastern meadowlark (SGCN)

WASTE GROUND

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

SWAMP

wood horsetail (RG)
blunt-lobed grape fern (E, S2S3)
false hop sedge (R, S2)
thicket sedge (T, S1)
straw sedge (E, S1)
swamp lousewort (T, S2)
winged monkey-flower (R, S3)
terrestrial starwort (T)
small yellow lady-slipper (E, SH)
Long's bittercress (T, S2)
Carey's smartweed (T)
Plants (cont.)
swamp cottonwood (T, S2)
Invertebrates
phantom cranefly (RG)
Vertebrates
blue-spotted salamander (SC, SGCN)
four-toed salamander (SGCN)
spotted turtle (SC, S3, SGCN)
wood turtle (SC, S3, SGCN)
eastern box turtle (SC, S3, SGCN)
great blue heron (RG)
American bittern (SC, SGCN)
Vertebrates (cont.)
wood duck (PIF2)
Virginia rail (RG)
American woodcock (PIF1, SGCN)
red-shouldered hawk (SC, SGCN)
barred owl (RG)
willow flycatcher (SGCN)
white-eyed vireo (RG)
eastern bluebird (RG)
prothonotary warbler (S2, PIF1, SGCN)
Canada warbler (PIF1, SGCN)
northern waterthrush (RG)

BUTTONBUSH POOL/KETTLE SHRUB POOL

Plants
Helodium paludosum (moss) (RG)
buttonbush dodder (E, S1)
spiny coontail (T, S3)
pale alkali-grass (RG)
short-awn foxtail (RG)
Vertebrates
wood frog (RG)
blue-spotted salamander (SC, S3, SGCN)
Jefferson salamander (SC, S3, SGCN)
marbled salamander (SC, S3, SGCN)
spotted salamander (RG)
Vertebrates (cont.)
spotted turtle (SC, S3, SGCN)
eastern ribbon snake (SGCN)
wood duck (PIF2)
American black duck (PIF1, SGCN)

MARSH

Plants
false hop sedge (R, S2)
straw sedge (E, S1)
buttonbush dodder (E, S1)
spiny coontail (T (S3)
winged monkey-flower (R, S3)
terrestrial starwort (T)
Invertebrates
black dash (butterfly) (RG)
bronze copper (butterfly) (RG)
Invertebrates (cont.)
mulberry wing (butterfly) (RG)
Vertebrates
northern cricket frog (E, S1, SGCN)
northern leopard frog (RG)
southern leopard frog (SC, S2S3)
spotted turtle (SC, S3, SGCN)
American bittern (SC, SGCN)
least bittern (T, S3B, S1N, SGCN)
great blue heron (RG)
Vertebrates (cont.)
wood duck (PIF2)
pied-billed grebe (T, S3B, S1N, SGCN)
American black duck (PIF1, SGCN)
northern harrier (T, S3B, S3N, SGCN)
king rail (T, S1B, PIF1, SGCN)
Virginia rail (RG)
sora (RG)
common moorhen (RG)
marsh wren (RG)

WET MEADOW

Plants
straw sedge (E, S1)
yellow flatsedge (E, S1)
terrestrial starwort (T)
Carey's smartweed (T)
Invertebrates
Baltimore (butterfly) (RG)
mulberry wing (butterfly) (RG)
black dash (butterfly) (RG)
two-spotted skipper (butterfly) (RG)

Invertebrates (cont.)
meadow fritillary (butterfly) (RG)
bronze copper (butterfly) (RG)
eyed brown (butterfly) (RG)
Milbert's tortoiseshell (butterfly) (RG)
phantom cranefly (RG)
Vertebrates
southern leopard frog (SC, S2S3)
eastern ribbonsnake (RG, SGCN)

Vertebrates (cont.)
spotted turtle (SC, S3, SGCN)
American bittern (SC, SGCN)
northern harrier (T, S3B, S3N, SGCN)
Virginia rail (RG)
American woodcock (PIF1, SGCN)
sedge wren (T, S3B, PIF2, SGCN)
Henslow's sparrow (T, S3B, PIF1, SGCN)
southern bog lemming (RG)

FEN/CALCAREOUS WET MEADOW

Plants
wood horsetail (RG)
slender lady's-tresses (RG)
rose pogonia (RG)
spreading globeflower (R, S3)
scarlet Indian paintbrush (E, S1)
grass-of-Parnassus (RG)
Kalm's lobelia (RG)
bush aster (T, S2)
fringed gentian (RG)
swamp lousewort (T, S2)
roundleaf sundew (RG)
bog valerian (E, S1S2)
terrestrial starwort (T)
Carey's smartweed (T)
buckbean (RG)

Plants (cont.)
swamp birch (T, S2)
alder-leaf buckthorn (RG)
Schweinitz's sedge (R, S2S3)
handsome sedge (T, S1)
Bush's sedge (S3)
twig rush (RG)
ovate spikerush (E, S2S2)
showy lady-slipper (RG)
small yellow lady-slipper (E, SH)
Invertebrates
Gammarus pseudolimnaeus (amphipod) (RG)
Pomatiopsis lapidaria (snail) (RG)
forcipate emerald (dragonfly) (S1, SGCN)
phantom cranefly (RG)
eyed brown (butterfly) (RG)

Invertebrates (cont.)
silver-bordered fritillary (butterfly) (RG)
two-spotted skipper (butterfly) (RG)
Dion skipper (butterfly) (S3)
Baltimore (butterfly) (RG)
mulberry wing (butterfly) (RG)
black dash (butterfly) (RG)
Vertebrates
northern leopard frog (RG)
southern leopard frog (SC, S2S3)
bog turtle (E, S2, SGCN)
spotted turtle (SC, S3, SGCN)
eastern ribbonsnake (SGCN)
northern harrier (T, S3B, S3N, SGCN)
sedge wren (T, S3B, PIF2, SGCN)

INTERMITTENT WOODLAND POOL

Plants
Virginia chain fern (RG)
false hop sedge (R, S2)
terrestrial starwort (T)
featherfoil (T, S2)
Invertebrates
black dash (butterfly) (RG)
mulberry wing (butterfly) (RG)

Invertebrates (cont.)
springtime physa (snail) (RG)
Vertebrates
wood frog (RG)
Jefferson salamander (SC, SGCN)
marbled salamander (SC, S3, SGCN)
four-toed salamander
spotted salamander (RG)

Vertebrates (cont.)
spotted turtle (SC, S3, SGCN)
wood turtle (SC, S3, SGCN)
wood duck (PIF2)
American black duck (PIF1, SGCN)
northern waterthrush (RG)

OPEN WATER/CONSTRUCTED POND

Plants
spiny coontail (T, S3)
Vertebrates
northern cricket frog (E, S1, SGCN)
spotted turtle (SC, S3, SGCN)
wood turtle (SC, S3, SGCN)

Vertebrates (cont.)
American bittern (SC, SGCN)
great blue heron (RG)
wood duck (PIF2)
American black duck (PIF1, SGCN)

Vertebrates (cont.)
pied-billed grebe (T, S3B, S1N, SGCN)
osprey (SC, SGCN)
bald eagle (T, S2S3B, SGCN)
river otter (SGCN)

SPRING/SEEP

Plants
devil's-bit (T, S1S2)
Bush's sedge (S3)

Invertebrates
Piedmont groundwater amphipod (SGCN)
gray petaltail (dragonfly) (SC, S2, SGCN)
tiger spiketail (dragonfly) (S1, SGCN)

Vertebrates
northern dusky salamander (RG)
mountain dusky salamander (RG)
spring salamander (RG)
northern red salamander (SGCN)

STREAM & RIPARIAN CORRIDOR		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
winged monkey-flower (R, S3)	mocha emerald (dragonfly) (S2S3, SGCN)	wood turtle (SC, S3, SGCN)
riverweed (T, S2)	sable clubtail (dragonfly) (S1, SGCN)	great blue heron (RG)
spiny coontail (T, S3)	ostrich fern borer (moth) (SGCN)	American black duck (PIF1, SGCN)
swamp rose-mallow (RG)	***Vertebrates***	wood duck (PIF2)
goldenseal (T, S2)	creek chubsucker (fish) (RG)	red-shouldered hawk (SC, SGCN)
cattail sedge (T, S1)	bridle shiner (fish) (RG)	American woodcock (PIF1, SGCN)
Davis' sedge (T, S2)	brook trout (fish) (SGCN)	bank swallow (RG)
Invertebrates	slimy sculpin (fish) (RG)	winter wren (RG)
Marstonia decepta (snail) (RG)	mountain dusky salamander (RG)	cerulean warbler (SC, PIF1, SGCN)
brook floater (mussel) (T, S1, SGCN)	spring salamander (RG)	Louisiana waterthrush (SGCN)
Pisidium adamsi (fingernail clam) (RG)	northern red salamander (SGCN)	northern waterthrush (RG)
Sphaerium fabale (fingernail clam) (RG)	northern leopard frog	river otter (SGCN)
arrowhead spiketail (dragonfly) (S2S3, SGCN)	northern dusky salamander (RG)	Indiana bat (E, S1, SGCN)

Appendix D. Common and scientific names of plants mentioned in this report. Most scientific names follow the nomenclature of Mitchell and Tucker (1997).

Common Name	Scientific Name	Common Name	Scientific Name
agrimony, small-flowered	*Agrimonia parviflora*	dodder, buttonbush	*Cuscuta cephalanthi*
alder, speckled	*Alnus incana*	dodder, field	*Cuscuta campestris*
alder, smooth	*Alnus serrulata*	dogwood, gray	*Cornus foemina* ssp. *racemosa*
alkali-grass, pale	*Puccinellia distans*	dogwood, roundleaf	*Cornus rugosa*
Allegheny-vine	*Adlumia fungosa*	duckweed, common	*Lemna minor*
arrowhead, broad-leaved	*Sagittaria latifolia*	elm, American	*Ulmus americana*
arum, arrow	*Peltandra virginica*	elm, slippery	*Ulmus rubra*
ash, green	*Fraxinus pennsylvanica*	featherfoil	*Hottonia inflata*
ash, white	*Fraxinus americana*	fern, cinnamon	*Osmunda cinnamomea*
aspen, quaking	*Populus tremuloides*	fern, fragile	*Cystopteris fragilis*
aster, bush	*Aster borealis*	fern, maidenhair	*Adiantum pedatum*
aster, stiff-leaf	*Aster linariifolius*	fern, marsh	*Thelypteris palustris*
azalea, swamp	*Rhododendron viscosum*	fern, royal	*Osmunda regalis*
baneberry, red	*Actaea spicata* ssp. *rubra*	fern, sensitive	*Onoclea sensibilis*
barberry, Japanese	*Berberis thunbergii*	fern, Virginia chain	*Woodwardia virginica*
basswood	*Tilia americana*	fern, walking	*Asplenium rhizophyllum*
bearberry	*Arctostaphylos uva-ursi*	flag, blue	*Iris versicolor*
birch, black	*Betula lenta*	flax, yellow wild	*Linum sulcatum*
birch, gray	*Betula populifolia*	foxtail, short-awn	*Alopecurus aequalis*
birch, swamp	*Betula pumila*	gentian, fringed	*Gentianopsis crinita*
birch, yellow	*Betula alleghaniensis*	ginseng, American	*Panax quinquefolius*
bittersweet, Oriental	*Celastrus orbiculatus*	globeflower, spreading	*Trollius laxus*
blackberry, northern	*Rubus allegheniensis*	goat's-rue	*Tephrosia virginiana*
black gum	*Nyssa sylvatica*	goldenrod, rough-leaf	*Solidago patula*
bladdernut	*Staphylea trifolia*	goldenrod, stiff-leaf	*Solidago rigida*
blueberry, highbush	*Vaccinium corymbosum*	goldenseal	*Hydrastis canadensis*
blueberry, early lowbush	*Vaccinium pallidum*	grama, side-oats	*Bouteloua curtipendula*
blueberry, late lowbush	*Vaccinium angustifolium*	grass-of-Parnassus	*Parnassia glauca*
bluegrass, Kentucky	*Poa pratensis*	grass, reed canary	*Phalaris arundinacea*
bluejoint	*Calamagrostis canadensis*	grass, Indian	*Sorghastrum nutans*
bluestem, little	*Schizachyrium scoparium*	hackberry	*Celtis occidentalis*
bracken	*Pteridium aquilinum*	hairgrass, common	*Deschampsia flexuosa*
breeches, Dutchman's	*Dicentra cucullaria*	hair-rush	*Bulbostylis capillaris*
buckbean	*Menyanthes trifoliata*	harlequin, yellow	*Corydalis flavula*
buckthorn, alder-leaf	*Rhamnus alnifolia*	hawthorn	*Crataegus*
buckthorn, common	*Rhamnus cathartica*	hemlock, eastern	*Tsuga canadensis*
butterflyweed	*Asclepias tuberosa*	hickory, pignut	*Carya glabra*
butternut	*Juglans cinerea*	hickory, shagbark	*Carya ovata*
buttonbush	*Cephalanthus occidentalis*	holly, winterberry	*Ilex verticillata*
catbrier	*Smilax*	honeysuckle, Eurasian	*Lonicera* x *bella*
cattail	*Typha*	horsetail, wood	*Equisetum sylvaticum*
cedar, eastern red	*Juniperus virginiana*	huckleberry, black	*Gaylussacia baccata*
cherry, black	*Prunus serotina*	ironweed, New York	*Vernonia noveboracensis*
chokeberry, black	*Aronia melanocarpa*	ironwood	*Carpinus caroliniana*
chokeberry, red	*Aronia arbutifolia*	knotweed, Japanese	*Fallopia japonica*
cinquefoil, three-toothed	*Potentilla tridentata*	knotweed, slender	*Polygonum tenue*
cliffbrake, purple	*Pellaea atropurpurea*	lady's-tresses, slender	*Spiranthes lacera*
cliffbrake, smooth	*Pellaea glabella*	lady-slipper, showy	*Cypripedium reginae*
columbine, wild	*Aquilegia canadensis*	lady-slipper, pink	*Cypripedium acaule*
coontail, spiny	*Ceratophyllum echinatum*	lady-slipper, large yellow	*Cypripedium calceolus* var. *pubescens*
cottonwood, eastern	*Populus deltoides*	leatherwood	*Dirca palustris*
cottonwood, swamp	*Populus heterophylla*	lobelia, Kalm's	*Lobelia kalmii*
crowfoot, small-flowered	*Ranunculus micranthus*	lopseed	*Phryma leptostachya*
deerberry	*Vaccinium stamineum*	lousewort, swamp	*Pedicularis lanceolata*
devil's-bit	*Chamaelirium luteum*	mannagrass	*Glyceria*
dittany	*Cunila origanoides*	maple, red	*Acer rubrum*

(CONTINUED)

Common Name	Scientific Name	Common Name	Scientific Name
maple, sugar	*Acer saccharum*	sedge, Bicknell's	*Carex bicknellii*
may-apple	*Podophyllum peltatum*	sedge, bronze	*Carex aenea*
meadowsweet	*Spiraea alba* var. *latifolia*	sedge, Bush's	*Carex bushii*
milkweed, blunt-leaf	*Asclepias amplexicaulis*	sedge, cattail	*Carex typhina*
milkweed, poke	*Asclepias exaltata*	sedge, clustered	*Carex cumulata*
monkey-flower, winged	*Mimulus alatus*	sedge, Davis'	*Carex davisii*
(a moss)	*Helodium paludosum*	sedge, false hop	*Carex lupuliformis*
moss, peat	*Sphagnum*	sedge, handsome	*Carex formosa*
mountain-mint, blunt	*Pycnanthemum muticum*	sedge, lakeside	*Carex lacustris*
mountain-mint, Torrey's	*Pycnanthemum torrei*	sedge, Pennsylvania	*Carex pensylvanica*
oak, black	*Quercus velutina*	sedge, reflexed	*Carex retroflexa*
oak, chestnut	*Quercus montana*	sedge, Schweinitz's	*Carex schweinitzii*
oak, red	*Quercus rubra*	sedge, tussock	*Carex stricta*
oak, scarlet	*Quercus coccinea*	serviceberry	*Amelanchier*
oak, scrub	*Quercus ilicifolia*	shadbush, dwarf	*Amelanchier stolonifera*
oak, white	*Quercus alba*	skunk-cabbage	*Symplocarpus foetidus*
orangeweed	*Hypericum gentianoides*	smartweed, Carey's	*Persicaria careyi*
paintbrush, scarlet Indian	*Castilleja coccinea*	spicebush	*Lindera benzoin*
pellitory	*Parietaria pennsylvanica*	spike-muhly	*Muhlenbergia glomerata*
pepperbush, sweet	*Clethra alnifolia*	spikerush, ovate	*Eleocharis obtusa* v. *ovata*
pine, pitch	*Pinus rigida*	spleenwort, ebony	*Asplenium platyneuron*
pine, white	*Pinus strobus*	spleenwort, maidenhair	*Asplenium trichomanes*
pinesap	*Monotropa hypopithys*	spleenwort, mountain	*Asplenium montanum*
pinweed, slender	*Lechea tenuifolia*	spleenwort, silvery	*Deparia acrostichoides*
pogonia, rose	*Pogonia ophioglossoides*	stargrass, yellow	*Hypoxis hirsuta*
polypody, rock	*Polypodium virginianum*	St. Johnswort, shrubby	*Hypericum prolificum*
poverty-grass	*Danthonia spicata*	sweetfern	*Comptonia peregrina*
prickly-ash, American	*Zanthoxylum americanum*	sweetflag	*Acorus calamus*
raspberry, red	*Rubusidaeus*	sycamore	*Platanus occidentalis*
raspberry, black	*Rubus occidentalis*	terrestrial starwort	*Callitriche terrestris*
rattlebox	*Crotalaria sagittalis*	twig-rush	*Cladium mariscoides*
reed, common	*Phragmites australis*	valerian, bog	*Valeriana uliginosa*
riverweed	*Podostemum ceratophyllum*	vervain, blue	*Verbena hastata*
rock-cress, hairy	*Arabis hirsuta* var. *pycnocarpa*	viburnum, maple-leaf	*Viburnum acerifolium*
rose, multiflora	*Rosa multiflora*	violet	*Viola*
rose-mallow, swamp	*Hibiscus moscheutos*	violet, birdsfoot	*Viola pedata*
rush, toad	*Juncus bufonius*	wall-rue	*Asplenium ruta-muraria*
rush, soft	*Juncus effusus*	water-plantain	*Alisma triviale*
sandwort, rock	*Minuartia michauxii*	water-shield	*Brasenia schreberi*
sarsaparilla, bristly	*Aralia hispida*	whitlow-grass, Carolina	*Draba reptans*
loosestrife, purple	*Lythrum salicaria*	willow	*Salix*
saxifrage, golden	*Chrysosplenium americanum*	witch-hazel	*Hamamelis virginiana*
sedge, Back's	*Carex backii*	wood-sorrel, violet	*Oxalis violacea*
		woolgrass	*Scirpus cyperinus*

Appendix E. Some locations with potential for streamside restoration in the Trout Brook watershed.

This report provides many recommendations for restoring and maintaining the habitats of the Trout Brook watershed (see the habitat descriptions as well as the Stream and Riparian Corridors and Enhancement of Developed Areas sections.) Here we provide site-specific examples of locations in the Trout Brook watershed that would benefit from direct riparian restoration and management (Figure 9).

The Orange County Soil & Water Conservation District may be able to assist with stream restoration projects. The Hudson River Estuary Program's Watersheds and Streams Program is another source for tools and services for municipalities, organizations, and individuals seeking to protect water resources. The Watersheds and Streams Program coordinates the "Trees for Tribs" Initiative, which offers free native trees and shrubs for qualifying projects in the Hudson River Estuary watershed within the state from the Verrazano Narrows Bridge to the Troy Dam. The Estuary Program's Riparian Buffer Coordinator can assist with plant selection, designing a planting plan, site preparation, project installation, and other technical information to improve the chances of success for your project. In addition, if the project site is accessible to small machinery and the planting is of adequate size, the Estuary Program's Riparian Buffer Coordinator will pre-dig all planting holes.

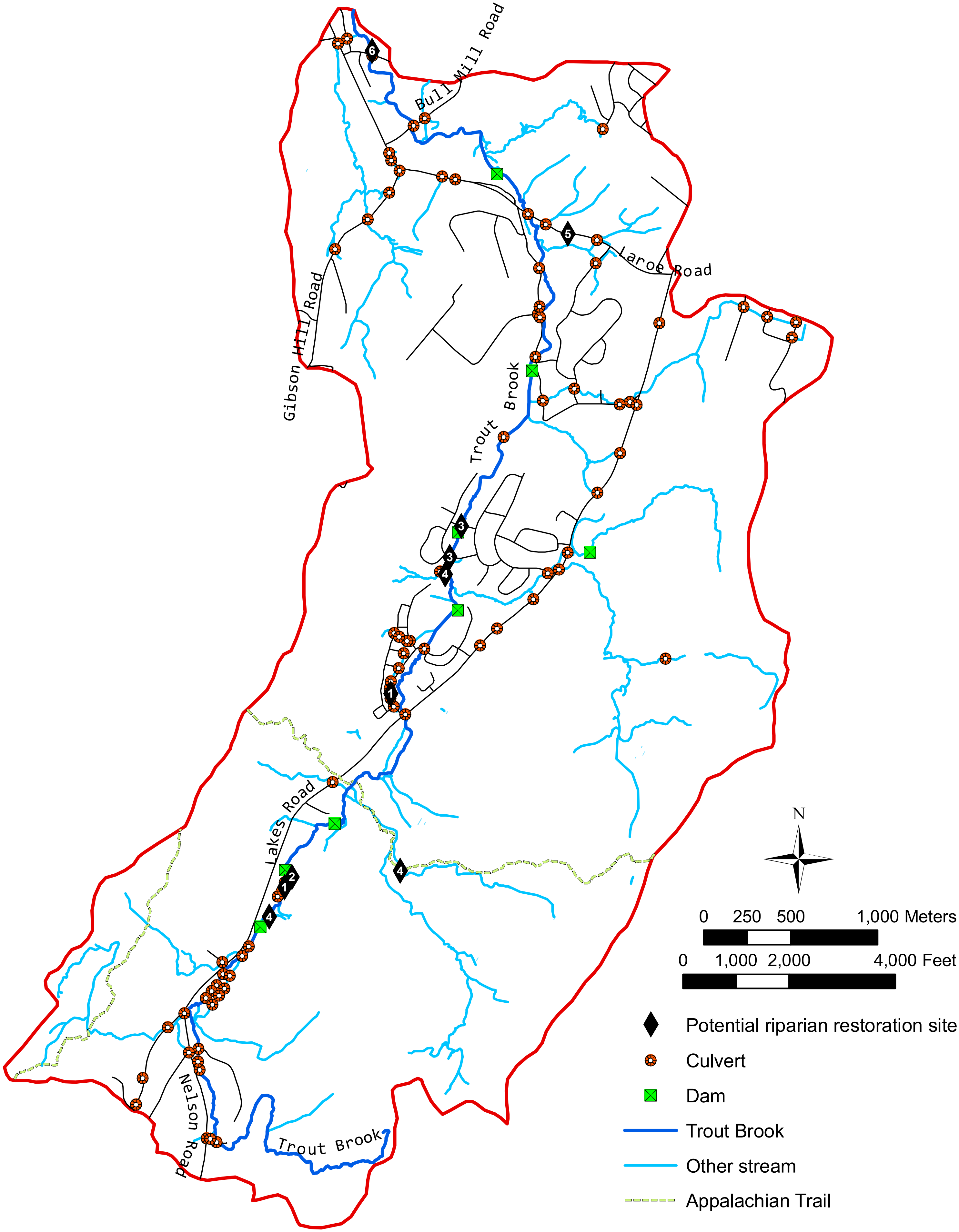

Figure 9. Dams, culverts, and potential riparian restoration sites within the Trout Brook watershed. Numbered sites are described in Appendix E. Hudsonia Ltd., 2010.

1. Various locations along Trout Brook and other streams
Restoration action: Plant riparian buffer along Trout Brook
Recommendation: Restore a vegetated, unmowed buffer (100+ ft wide where possible) with tree and shrub plantings. A stream buffer will have numerous positive impacts for the stream including reducing the stream water temperature, reducing surface runoff into the stream, and reducing the contaminant content of the runoff from the surrounding lawn and parking lots.

Trout Brook at Greenwood Lake Middle School

Trout Brook impoundments along Lily Pond Lane

2. Greenwood Lake Middle School
Restoration action: Modify barriers to wildlife movement
Recommendation: At intervals along the fence, create passageways (partial openings) designed to allow free and safe movement of wildlife between the water body and upland habitat areas, while preventing human passage.

Fence at Greenwood Lake Middle School

3. Various locations along Trout Brook and other streams
Restoration action: Install systems to prevent direct runoff into streams
Recommendation: Install stormwater basins or other devices to maximize water infiltration to the soils and to prevent road runoff from directly entering the floodplain, riparian wetland, or stream.

Wilson Road along Trout Brook

Wilson Road along Trout Brook

Tyler Street
at Trout Brook

4. Various locations along Trout Brook and other streams
Restoration action: Clear streams and floodplains of trash
Recommendation: Remove trash from streams and floodplains, and reuse, recycle, or otherwise dispose of it properly. Trash can pose safety hazards for humans and wildlife, leach toxins into the ground and water, and create visual blight.

Trash in Trout Brook, south of Greenwood Lake Middle School

Trash in floodplain, south of Wilson Road

5. Laroe Rd, Town of Chester
Restoration action: Plant swales where roadside ditches have been widened
Recommendation: Revegetate the graded roadsides quickly with a seed mix of native forbs and graminoids to slow movement of water, and to reduce soil erosion and sedimentation of nearby streams.

Roadside near Laroe and Sugar Loaf Mountain roads

Roadside near Laroe and Gibson Hill roads

6. Trout Brook north of Able Noble Drive, Town of Chester
Restoration action: Restore natural course of straightened stream
Recommendation: Allow the stream to meander at will within the floodplain, perhaps letting the stream carve a channel to the west (where there is no riprap). If the riprap is causing erosion on the opposite bank and/or increasing water temperatures, interplant riprap with native shrub willow and dogwood species. If shrubs are not desired, replant with Virginia creeper or other low-growing woody species.

Trout Brook north of Able Noble Drive