SIGNIFICANT HABITATS
IN THE TOWN OF BEEKMAN, DUTCHESS COUNTY, NEW YORK

Report to the Town of Beekman

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EXECUTIVE SUMMARY

Hudsonia biologists identified and mapped ecologically significant habitats in the Town of Beekman during the period March 2008-July 2009. 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 town. Some of the habitats are rare or declining in the region or support rare species of plants or animals, while others are high quality examples of common habitats or habitat complexes. Among our more interesting finds (including those from an earlier study conducted October 2003-October 2005; Sullivan and Stevens 2005) were 17 fens and many calcareous wet meadows; three buttonbush pools and three kettle shrub pools; 95 intermittent woodland pools; ten patches of oak-heath barren; several conifer and mixed forest swamps; many extensive wetland complexes; large areas of contiguous upland meadow including three areas greater than 150 ac (60 ha); three contiguous forest areas greater than 1,000 ac (400 ha), and four contiguous forest areas of 500 - 1,000 acres (200-400 ha)

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, provide specific conservation recommendations, and delineate five areas in Beekman that may serve as suitable units for conservation planning. We also provide instructions on how to use this report and the habitat map for conservation planning and policy-making, and for site-specific environmental reviews.

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

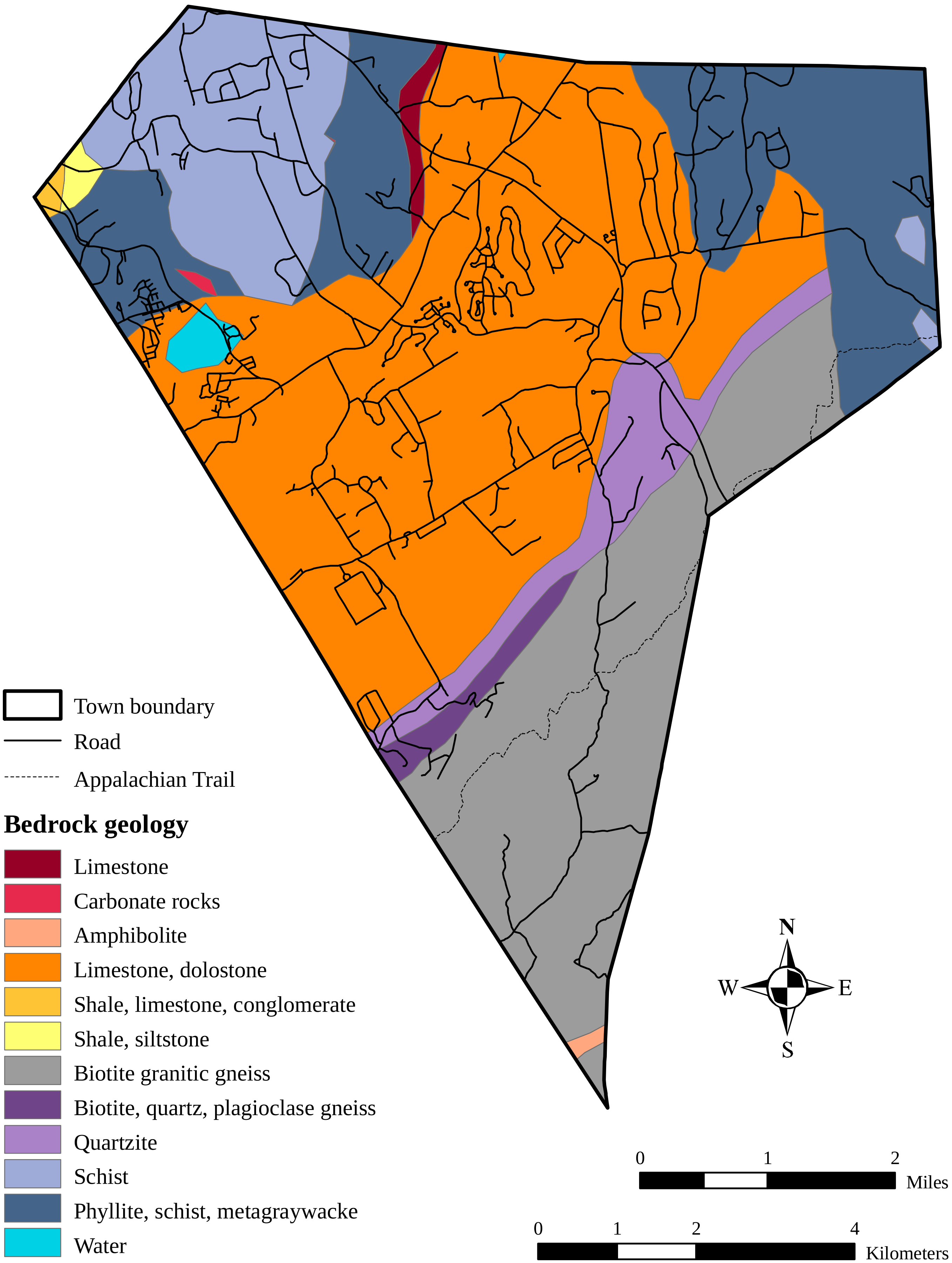


Figure 1. Generalized bedrock geology in the Town of Beekman, Dutchess County, New York. Warm colors (red, orange, yellow) indicate bedrock that is at least partially calcareous, and cool colors (gray, blue, purple) indicate predominantly acidic bedrock. Geology data from Fisher et al. 1970. Hudsonia Ltd., 2009.

METHODS

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

Gathering Information and Predicting Habitats

During many years of habitat studies in the Hudson Valley, Hudsonia has found that, with careful analysis of map data and aerial photographs, we can accurately predict the occurrence of many habitats that are closely tied to topography, geology, and soils. We use combinations of map features (e.g., slopes, bedrock chemistry, and soil texture, depth, and drainage) and features visible on stereoscopic aerial photographs (e.g., exposed bedrock, vegetation cover types) to predict the location and extent of ecologically significant habitats. In addition to previous studies conducted by Hudsonia biologists and others in Beekman (Sullivan and Stevens 2005, Kiviat 2007) and biological data provided by the New York Natural Heritage Program, we used the following resources for this project:

- *1:40,000 scale color infrared stereoscopic aerial photograph prints* from the National Aerial Photography Program series taken in spring 1994 and 1995, 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 = 7.5 in [19 cm]) color infrared digital orthophotos* taken in spring 2004, obtained from the New York State GIS Clearinghouse website (http://www.nysgis.state.ny.us; accessed January 2008). We use these digital aerial photos for on-screen digitizing of habitat boundaries.

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

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

- *Soil Survey of Dutchess County, New York* (Faber 2002). 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 several of our GIS data layers from the New York State GIS Clearinghouse, including municipal boundaries, roads, and hydrological features. The Dutchess County Environmental Management Council (EMC) provided us with bedrock geology, surficial geology, and state-regulated wetlands data. National Wetlands Inventory data prepared by the U.S. Fish and Wildlife Service was obtained from their website. We obtained soils data from the Natural Resources Conservation Service (NRCS) 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.appalachiantrail.org; accessed March 2008). We also obtained 10 ft (3 m) contour data from the Dutchess Land Conservancy, and tax parcel data from the Dutchess County Office of Real Property Tax. We used ArcView 9.2 software (Environmental Systems Research Institute 2006) to examine these data layers together with the orthophoto images.

Preliminary Habitat Mapping and Field Verification

We prepared a preliminary map of predicted habitats based on map analysis and stereo interpretation of aerial photographs. We digitized the predicted habitats onscreen over the orthophoto images using ArcView 9.2 mapping software. With these draft maps in hand we conducted field visits to as many of the mapped habitat units as possible to verify or correct their presence and extent, to assess their quality, and to identify habitats that could not be identified remotely.

The habitats in a 2,000 meter wide corridor along Fishkill Creek in the Town of Beekman (approximately 3,900 ac [1,600 ha]) were mapped by Hudsonia staff in 2003-2005 as part of a larger stream corridor mapping project (Sullivan and Stevens 2005). During our preliminary mapping of the remainder of the town, we combined our current work with this map, and updated a few aspects of the stream corridor map by remote means only (i.e., no field work was conducted in the corridor area). The updates were largely limited to areas along the boundary with the current map, with only a few types of updates made throughout the corridor area (e.g., road locations and names). For more details about updates to the map in the Fishkill Creek corridor see Appendix A.

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

We field checked approximately 67% of undeveloped land in the Town of Beekman, exclusive of the previously mapped Fishkill Creek corridor (over 8,500 acres [3,400 ha]). We used remote sensing alone to map habitats in areas that we did not see in the field, but we also extrapolated the findings from our field observations to adjacent parcels and similar settings throughout the town. We assume that areas of the habitat map that were field-checked are generally more accurate than areas we did not visit.

Defining Habitat Types

Habitats are useful for categorizing places according to apparent ecological function, and are manageable units for scientific inquiry and for land use planning. For these town-wide habitat mapping projects we classify broad habitat types that are identifiable largely 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 Town of Beekman was only mapped remotely, and even the field-checked habitat boundaries were sketched without 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 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 2004 (the orthophoto date) were identified as such only if we observed them in the field, so it is likely that we have underestimated the extent of developed land in the town. In the Fishkill Creek corridor, we updated the areas developed between 2000 and 2004 remotely using the spring 2004 orthophotos.

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 included in the final map (and our town-wide map analysis) the Fishkill Creek corridor section that was mapped in 2003-2005, and printed the final large-format habitat map at a scale of 1:10,000 on three sheets (36 x 36, 36 x 37, and 36 x 39 in) using a Hewlett Packard DesignJet 800PS plotter. We also printed the entire town map on a single sheet (36 x 39 in) at a scale of 1:17,500. 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 Town of Beekman for use in conservation and land use planning and decision-making. We request that any maps printed from this database for public viewing be printed at scales no larger than 1:10,000, and that the habitat map data be attributed to Hudsonia Ltd. Although the habitat map was carefully prepared and extensively field-checked, there are inevitable inaccuracies in the final map. Because of this, we request that the following caveat be printed prominently on all maps:

> *"This map is suitable for general land use planning, but is 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 Town of Beekman habitat map illustrates the diversity of habitats that occur in the town and the complexity of their configuration in the landscape. A reduction of the completed habitat map is shown in Figure 2. Of the total 30 mi^2 (78 km^2) in the town, approximately 75% is undeveloped land (i.e., without structures, paved roads, manicured lawns, etc.). Existing development is generally dispersed along main roads in the central (Fishkill Creek valley) and western parts of the town, so that undeveloped land has been fragmented into discontinuous and irregular shaped patches. Figure 3 shows blocks of contiguous undeveloped habitat areas within the town that are less than 100, 100-500, 500-1,000, and greater than 1,000 ac (approximately <40, 40-200, 200-400, and >400 ha). Several types of common habitats cover extensive areas within these blocks. For example, approximately 50% of the town is forested (including both upland forest and hardwood and shrub swamp habitat types), 13% is upland meadow (active agricultural areas and other managed and unmanaged grassland and forb-dominated habitats), and 9% is wetland. Some of the more unusual habitats we documented include fens, buttonbush and kettle shrub pools, and oak-heath barrens. In total, we identified 26 different habitat types in the town 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 town has been extensively altered by filling, draining, and construction of dams and roads. Purple loosestrife and common reed (introduced invasive species) were common and sometimes dominant plants in marshes and wet meadows and on moist disturbed soils throughout the town. Although we have documented the location and extent of important habitats throughout the town, only in some cases have we provided information on the quality and condition of the habitat units.

Table 1. Ecologically significant habitats identified by Hudsonia in the Town of Beekman, Dutchess County, New York, 2008-2009.

Upland Habitats	Wetland Habitats
Upland hardwood forest Upland conifer forest Upland mixed forest Red cedar woodland Crest/ledge/talus Calcareous crest/ledge/talus Oak-heath barren Upland shrubland Upland meadow Orchard/plantation Cultural Waste ground	Hardwood & shrub swamp Mixed forest swamp Conifer swamp Intermittent woodland pool Kettle shrub pool[1] Buttonbush pool[1] Marsh Wet meadow Calcareous wet meadow Fen Constructed pond Open water Spring/seep Stream

[1]Described as subcategories of hardwood and shrub swamp.

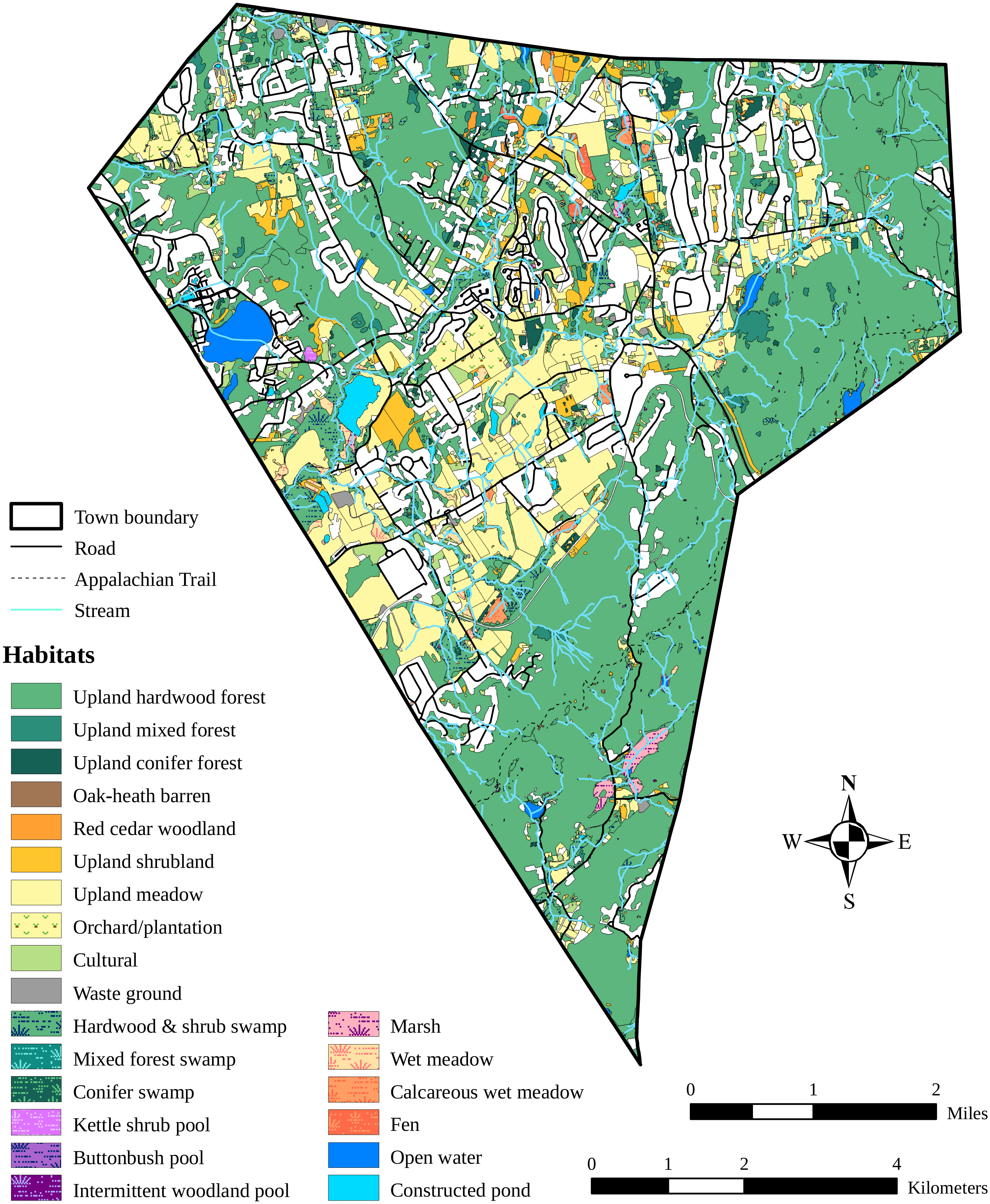


Figure 2. A reduction of the map illustrating the ecologically significant habitats in the Town of Beekman, Dutchess County, New York, identified and mapped by Hudsonia Ltd. in 2003-2005 and 2008-2009. Developed areas and other non-significant habitats are shown in white. The large-format map is printed in three sections at a scale of 1:10,000.

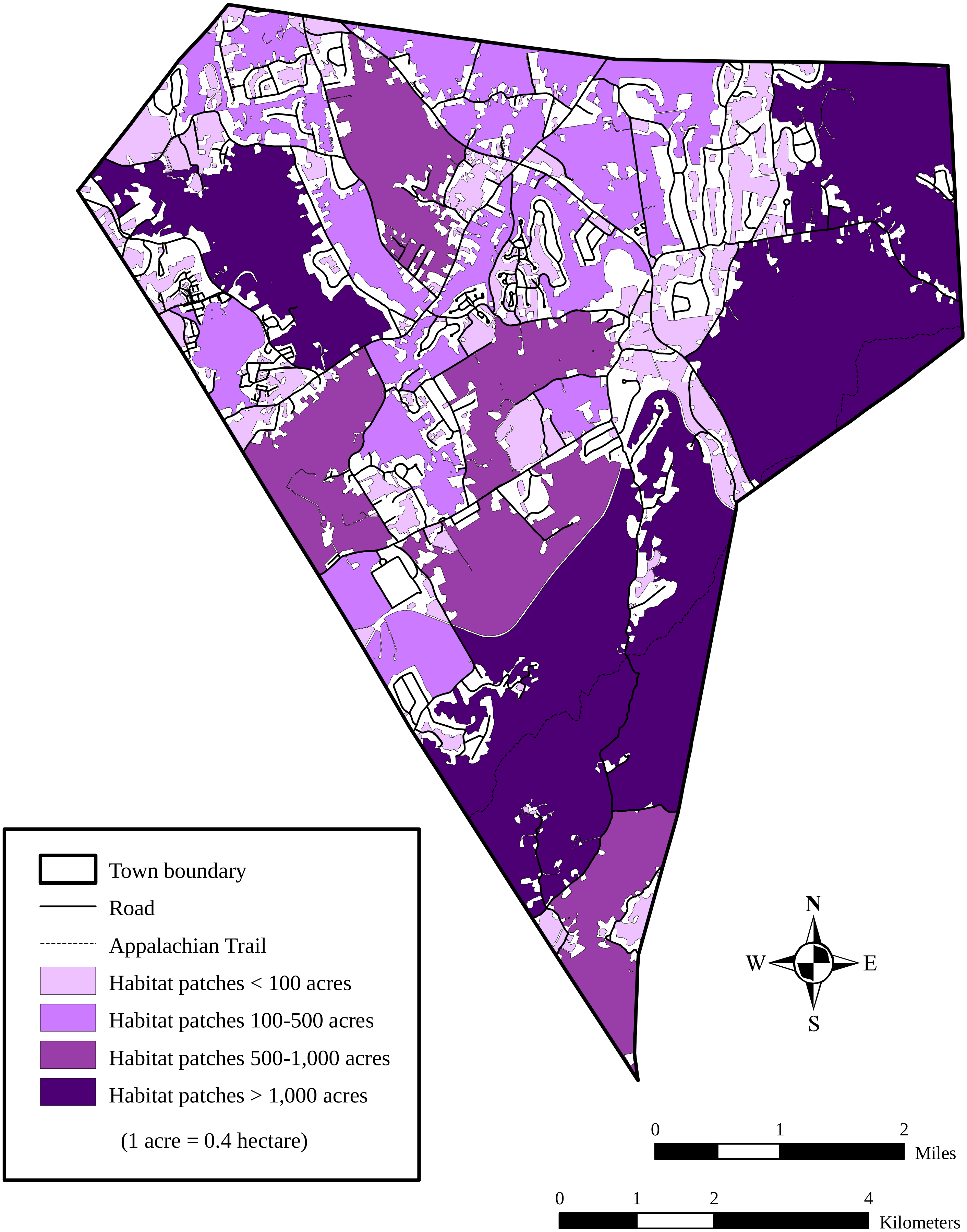


Figure 3. Contiguous habitat patches in the Town of Beekman, Dutchess County, New York. Developed areas and other non-significant habitats are shown in white. Hudsonia Ltd., 2009.

HABITAT DESCRIPTIONS

In the following pages we describe some of the ecological attributes of the habitats identified in the town, and discuss some conservation measures that can help to protect these habitats and the species of conservation concern they may support. 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) Town of Beekman habitat map sheets. 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 rare species associated with each habitat, including their statewide and regional conservation status. Species in this appendix could or are likely to occur in these habitats, but are not necessarily present in them. The letter codes used in Appendix C to describe the conservation status of rare species are explained in Appendix B. Appendix D gives the common and scientific names of all plants mentioned in this report.

UPLAND HABITATS

UPLAND FORESTS

Ecological Attributes

We classified upland forests into three general types for this project: hardwood forest, conifer forest, and mixed forest. We recognize that upland forests are 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, black birch, and black locust. Common understory species include maple-leaf viburnum, witch-hazel, serviceberry (or shadbush), Japanese barberry, honeysuckle, lowbush blueberries, and a wide variety of wildflowers, sedges, ferns, and mosses. Rocky forests at higher elevations are often dominated by chestnut oak, red oak, and hickory species. Eastern box turtle* spends most of its time in upland forests and meadows, finding shelter under logs and organic litter, and spotted turtle* and Blanding's turtle* use upland forests for aestivation (summer dormancy) and travel. Many snake species, such as 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 may require large forest-interior areas to nest successfully and maintain populations in the long term. Large mammals such as black bear,* bobcat,* and fisher* also require large expanses of forest. Many small mammals are associated with upland hardwood forests, including eastern chipmunk, southern flying squirrel, and white-footed mouse. Hardwood trees greater than 5 inches (12.5 cm) in diameter (especially those with loose platy bark such as shagbark hickory and black locust) can be used by Indiana bat* for summer roosting and nursery colonies. Areas of Beekman are within summer migration distance of an Indiana bat hibernation cave (Kiviat 2007) and there are summer roosting sites in the town.

<u>Upland Conifer Forest (ucf)</u>

This habitat includes naturally occurring upland forests with more than 75% cover of conifer trees, and conifer plantations with pole-sized (approximately 5-10 in [12-25 cm] diameter at breast height) to mature trees (greater than 10 in [>25cm]). 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 are 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 less densely shaded at ground level and tend to support a higher diversity and greater abundance of understory species than pure conifer stands.

Occurrence in the Town of Beekman

Figure 4 illustrates the locations of forested areas (including both forested wetlands and uplands) in the town, and the distribution of forest patches that were less than 100, 100-500, 500-1,000, and greater than 1,000 ac (approximately <40, 40-200, 200-400, and >400 ha). There were three forest patches in the eastern highlands greater than 1,000 ac. The largest patch (1,730 ac [700 ha]) occurred on Depot Hill west of Depot Hill Road, and the other two patches were east of Depot Hill Road and and between Route 55 and Gardner Hollow Road. All three of these forest patches extend beyond the town's boundary to comprise even larger forest areas.

There were four forest patches between 500 and 1,000 ac, two in the eastern highlands and two west of Beekman Road. Seven forest patches between 100 and 500 ac were scattered throughout the town.

Upland hardwood forest was the most widespread habitat type, accounting for 45% of the total land area of the town. Local areas of “rich forest,” supporting calcium-associated plant species, were found throughout the town. At some high elevations, exposed areas on and around Depot Hill and other hilltops throughout the town, the forest was dominated by chestnut oak and red oak with blueberries and black huckleberry in the understory. We presume that virtually all forests in the town 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 town that we did not observe during field work. Large areas of protected forest land along the Appalachian Trail appeared relatively free of invasive species.

Upland conifer and mixed forest patches ranged from <1 to 38 ac (< 0.4-15 ha) and most were distributed throughout the town within upland hardwood tracts. Most of the observed natural conifer forests were composed of white pine and/or eastern red cedar, and these 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 stands were observed in mixed forests along the Appalachian Trail in the Nuclear Lake area. There were also several small conifer plantations which were mapped as upland conifer 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, residential lots, or meadows are especially important for certain organisms, but are increasingly rare in the region. Fragmenting features pose many threats to wildlife and the forest itself. Paved and unpaved roads act as barriers which many species will not cross or cannot safely cross (Forman and Deblinger 2000). For example, mortality from vehicles can significantly reduce the population densities of amphibians (Fahrig et al. 1995). Use of habitats near roads is reduced because many animals will not breed near traffic noise (Trombulak and Frissell 2000). Houses set back from roads by long driveways cause significant fragmentation of core forest areas while development along roads may block important wildlife travel corridors between forested patches. The roadway itself 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 black-and white warbler* which nests 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, less common trees of this habitat include gray birch, red maple, quaking aspen, and red oak. The understory vegetation is similar to that of upland 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. 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 occured under a canopy of hardwoods as "upland mixed forest."

Rare plants of red cedar woodlands in the region include Carolina whitlow-grass,* yellow wild flax,* and Bicknell's sedge.* The olive hairstreak* (butterfly) uses red cedar as a larval host. Open red cedar woodlands with exposed gravelly or sandy soils may be important nesting habitat for several reptile species of conservation concern, including wood turtle,* spotted turtle,* eastern box turtle,* and eastern hognose snake.* These 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 Town of Beekman

Red cedar woodlands in the town ranged in size from <0.3 to 6 ac (<0.1-2 ha). These habitats generally developed on abandoned pastures and hayfields; most were found in valleys and on low hills, particularly in the north central portion of the town.

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, however, a transitional habitat, 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 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 olive hairstreak* occurs on crests with its host eastern red cedar. Rocky habitats with larger fissures, cavities, and exposed ledges may provide shelter, den, and basking habitat for eastern hognose snake,* eastern worm snake,* 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. Northern slimy salamander* occurs in non-calcareous wooded talus areas. Breeding birds of crest habitats include 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 bat* roosts in talus habitat.

Occurrence in the Town of Beekman

Crest, ledge, and talus habitats occurred throughout the town, mostly on hills and ridges (Figure 5). Extensive rocky areas were mapped in the eastern highlands including on Depot Hill and hills in the vicinity of Nuclear Lake, where there were some large ledges (two in particular estimated at 30 ft [10 m] tall) and talus slopes. Large areas of crest, ledge, and talus were also mapped on other hills throughout the town, including on Clapp Hill in the northwestern corner of the town. Calcareous ledges and talus were interspersed with acidic rocky areas in the hilly parts of town. Rock outcrops were sparse in the valleys, where the majority of them were calcareous. In the eastern highlands we found ten small areas of oak-heath barren (a rocky habitat described below).

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 habitat (see above), oak-heath barrens occur on hilltops and high slopes with exposed non-calcareous 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 blueberry and black huckleberry. Schist, gneiss, and quartzite are among the common types of exposed bedrock. The soils are extremely thin, excessively well drained, and very nutrient poor. These ecosystems are maintained by episodic fire events, which limit colonization by species that are not fire-adapted, help certain plant species such as pitch pine regenerate, return nutrients to the soil, and prevent the overgrowth of trees that can shade out 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 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 much warmer microclimate than the surrounding forested habitat, especially 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, and scarlet oak; the shrub layer may include scrub oak, eastern red cedar, blueberries, black huckleberry, deerberry, and sweetfern. Common herbs include Pennsylvania sedge, poverty-grass, common hairgrass, little bluestem, and bracken. Lichens and mosses are sometimes abundant. Our definition of this habitat corresponds to Edinger et al.'s (2002) "pitch pine-oak forest" and "pitch pine-oak-heath rocky summit." There may be a continuous canopy of pitch pine or pitch pine-oak with a scrub oak understory, or the shrub layer (predominately scrub oak and heath shrubs) may dominate, with only scattered pines.

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 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 Town of Beekman

We mapped ten small areas of oak-heath barren in the eastern highlands of Beekman, and there are additional areas of exposed rock that may support this habitat (Figure 5). The largest patch of oak-heath barren (0.5 ac [0.2 ha]) was somewhat atypical, having a relatively dense shrub layer including young black birch and black cherry. (We found pitch pine in only one patch of oak-heath barren in the town.) These small barrens may be remnants of historically larger habitats once maintained by fire, which persist because shallow soils inhibit invasion by taller tree species 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 killed or collected by poachers. Oak-heath barrens are disturbance-maintained ecosystems. Human suppression of wildfires has eliminated one the disturbances that maintains them. 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 be more diverse, including some invasive species as well as 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) 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, eastern cottontail, and New

England cottontail.* The latter species, a candidate for federal threatened or endangered listing, was once common in the Northeast. The Hudson Valley east of the Hudson River and northwestern Connecticut are believed to be a very important part of the remaining range of this species; we do not know if it is extant in Beekman.

Occurrence in the Town of Beekman

Upland shrublands were widely distributed throughout agricultural parts of the town, and ranged from less than 0.1 to about 32 ac (<0.04-13 ha), totaling just over 420 ac (170 ha) in the town. Common species in the largest shrublands included multiflora rose, gray dogwood, common buckthorn, Eurasian honeysuckle, goldenrods, and wild bergamot.

Sensitivities/Impacts

Shrublands and meadows are closely related habitats. Having a diversity of ages and structures in these habitats may promote overall biological diversity, and can be achieved by rotational mowing and/or brush-hogging. To reduce the impacts of these management activities on birds, mowing should be timed to coincide with the post-fledging season for most birds (e.g., October and later), and only take place every few years, if possible. Prescribed or spontaneous fires can also maintain shrublands and grasslands. 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.

Upland shrubland

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. Upland meadows are typically dominated by grasses and forbs, with less than 20% shrub cover. The ecological values of these habitats can differ widely according to the types of vegetation present and the disturbance histories (e.g., tilling, mowing, grazing, pesticide applications). 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,* striped hairstreak, 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 Blanding's turtle, 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,* Henslow's 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 Town of Beekman

Upland meadow accounted for 15% of the total town area. Figure 6 illustrates the location and distribution of meadow habitats in the town (including upland meadow, wet meadow, and calcareous wet meadow), showing those areas that were smaller than 25, 25-50, 50-100, and greater than 100 ac (approximately <10, 10-20, 20-40, and >40 ha). This figure does not include upland shrublands or fens, which in some cases had large patches of herbaceous cover. The highest density of meadows was in the large valleys (e.g., along Fishkill Creek, Frog Hollow Brook, Flat Rock Brook, Whaley Lake Stream, Gardner Hollow Brook, and several of their tributaries), but meadows were found throughout the town in places of recent or current agricultural land uses. Fences and hedgerows that divide fields can significantly alter the habitat value for many birds. If these are treated as fragmenting features, then the largest contiguous meadow measured 88 ac (36 ha; Figure 6B); if hedgerows and fences were ignored, the largest meadow covered 182 ac (74 ha). The most common kinds of upland meadow were hayfields and pastures (mostly for horses). Less intensively managed upland meadows were much less common. Although we did not designate them as a separate habitat, some upland meadows in Beekman were calcareous, with species such as wild bergamot.

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. The dramatic decline of grassland-breeding birds in the Northeast has been attributed to the loss of large patches of suitable meadow habitat; many of these birds need large meadows that are not divided by fences or hedgerows which can harbor predators (Wiens 1969). Mowing of upland meadows during the bird nesting season can cause extensive mortality of eggs, nestlings, and fledglings. Another threat to upland meadow habitats is the soil compaction and erosion caused by ATVs, 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. Whereas horse pastures have open space, scenic, and biodiversity values, those that are used intensively have little current value for native biodiversity but are included in this meadow category because of their potential habitat value if left unmanaged. See the Conservation Priorities section for recommendations for maintaining high-quality large meadow habitats.

Upland meadow

ORCHARD/PLANTATION (or/pl)

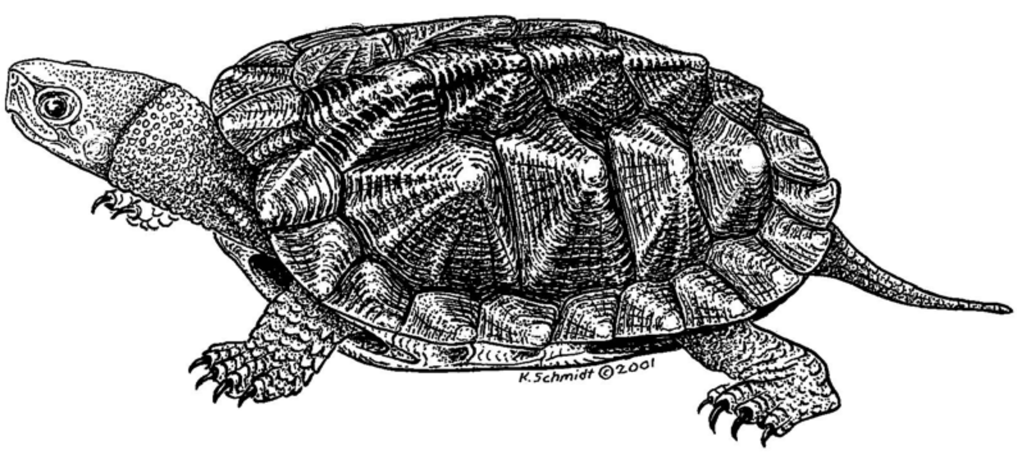
This habitat type includes actively maintained or recently abandoned fruit orchards, tree farms, and plant nurseries. Conifer plantations with larger, older trees were mapped as “upland conifer forest,” and those that had been partially harvested and colonized by shrubs were mapped as “upland shrubland.” Christmas tree farms are potential northern harrier* nesting habitat. Fruit orchards with old trees are 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. In the Town of Beekman, orchard/plantation areas ranged from less than 0.1 to 43 ac (<0.04-17 ha). Most were apple orchards, the largest of which were along Clapp Hill Road and Mill 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 its nursery colonies), and many other animals, and for mosses, liverworts, and lichens, potentially including rare species. Of the different types of places mapped as “cultural,” cemeteries are particularly well suited to provide habitat to a variety of species, since mature trees are often present, noise levels are minimal, and 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 Beekman included playing fields, riding rings, cemeteries, and large lawns. They ranged in size from less than 0.1 to 17 ac (<0.04 -7 ha).

WASTE GROUND (wg)

Waste ground is a botanist’s 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 active and abandoned sand and gravel mines, rock quarries, mine tailings, 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,* Blanding’s turtle,* 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. The biodiversity value 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. The largest waste ground area in Beekman was an apparent mine covering 11 ac (4.5 ha) west of Green Haven Road (in the Fishkill Creek corridor). Most other waste grounds were relatively small.



Wood turtle

WETLAND HABITATS

SWAMPS

Ecological Attributes

A swamp is a wetland dominated by woody vegetation (trees or shrubs). We mapped three general types of swamp habitat in the town: hardwood and shrub swamp, mixed forest swamp, and conifer 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, American elm, slippery elm, and swamp white oak are common trees of hardwood swamps in the region. Typical shrubs include silky dogwood, alders, shrubby willows, nannyberry, northern arrowwood, winterberry holly, highbush blueberry, and buttonbush. Tussock sedge and skunk cabbage are two common herbaceous species of these swamps.

Conifer Swamp (cs)

Conifer swamp is a type of forested swamp where conifer species are dominant, which we defined as occupying 75% or more of the tree canopy. In this region, the usual conifer species of swamps are eastern hemlock and eastern red cedar, and occasionally white pine or eastern tamarack. A dense evergreen canopy has a strong influence on the understory plant community and structure of these swamps. The shrub and herbaceous layers are typically sparse and low in species diversity. Shading also creates a cooler microclimate, allowing snow and ice to persist longer into the early spring growing season. Sphagnum mosses may be abundant. Conifers growing in wetlands frequently have very shallow root systems and are therefore prone to windthrow. The resulting tip-up mounds, root pits, and coarse woody debris all contribute to the habitat's complex structure and microtopography.

Mixed Forest Swamp (ms)

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

Swamps are important to a wide variety of birds, mammals, amphibians, reptiles, and invertebrates, especially when swamp habitats are contiguous with other wetland 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. Hardwood and shrub swamps along the floodplains of clear, low-gradient streams can be an important component of wood turtle* habitat. Other turtles such as spotted turtle* and box turtle* frequently use swamps for summer foraging, drought refuge, overwintering, and travel corridors. Pools within swamps are used by several breeding amphibian species, and are the primary breeding habitat of blue-spotted salamander.* Four-toed salamander,* believed to be regionally rare or scarce, uses swamps with rocks or abundant moss-covered downed wood or woody hummocks. Ribbon snake* forages in swamps for frogs. 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 Beekman we noted two particular types with exceptional habitat value: buttonbush pool and kettle shrub pool. Both are more or less hydrologically isolated wetlands that may be valuable habitat for pool-breeding amphibians and other animals that depend on intermittent woodland pools (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, swamp azalea, and willows may also be abundant. In some cases an open water moat entirely or partly surrounds a shrub thicket in the middle of the pool, which may include small trees such as red maple or green ash. In other cases the shrub stands may occupy the outer portions of the pool while the center has open water. These pools are typically isolated from streams, though some may have a small, intermittent inlet and/or outlet. Standing water is normally present in winter and spring but often disappears by late summer, or remains only in isolated puddles.

- *Kettle shrub pools* are wetlands dominated by shrub species and located in a glacial kettle—a depression formed by the melting of a stranded block of glacial ice. In many instances, the flora of kettle-shrub pools is dominated by buttonbush and they have many of the characteristics of buttonbush pools. Kettle shrub pools are found in or near glacial outwash soils (e.g., Hoosic gravelly loam), and they have deep peat or muck substrates. 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 shrub pools in nearby towns.

Kettle shrub pools and buttonbush pools are used by spotted turtle,* wood duck,* mallard, and American black duck,* and are the typical core habitats for the Blanding's turtle,* a Threatened species in New York.

Occurrence in the Town of Beekman

Hardwood and shrub swamp was the most extensive wetland habitat type in the town (Figure 10), totaling nearly 930 ac (376 ha). Swamps ranged in size from less than 1 to over 160 ac (< 0.4-64 ha), and were often contiguous with other wetland habitats such as marsh, wet meadow, and open water (including beaver ponds). The largest swamp was on a floodplain along the western portion of Fishkill Creek.[1] Other large swamps were along Flat Rock Brook, west of South Green Haven Road (south of the railroad tracks), between Clapp Hill and Alary Roads, and west of the Victoria Estates development (between Route 55 and Beekman Poughquag

[1] Some of the areas mapped as swamps in the Fishkill Creek floodplain include non-wetland areas of riparian forests that are strongly influenced by flooding regimes (see figure 5 in Sullivan and Stevens 2005).

Road). Smaller swamps were widely scattered throughout the town. Mixed forest swamps and conifer swamps were uncommon in the town (and relatively small), and most were dominated by eastern red cedar. We documented two small buttonbush pools in the town. One pool was located north of Andrews Road (at the northwestern town boundary) and the other just west of Depot Hill Road. Three kettle shrub pools were located in the vicinity of Sylvan lake, all with buttonbush in their flora; two were small (less than 0.5 ac [0.2 ha]) and the other covered more than 6 ac (2.4 ha). The buttonbush and kettle shrub pools we mapped in Beekman should be considered examples of these habitats rather than a complete inventory; there may be other swamps which we did not visit that fall into these categories.

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, winterberry holly, spicebush, common buckthorn, skunk cabbage, cinnamon fern, and tussock sedge. 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 may 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). Several of the small swamps in the eastern highlands can be classified as “heath swamps,” with highbush blueberry, swamp azalea, yellow birch, blackgum, and sphagnum mosses dominant in their flora. Although we did not designate them as a separate habitat type, some swamps in the town were calcareous, with floras typical of calcareous wetlands.

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). Many of the larger swamps are located in low-elevation areas where human land uses are also concentrated. They can easily be damaged by alterations to the quality or quantity of surface water runoff, or by disruptions of groundwater sources that feed them. Swamps that are surrounded by agricultural land are subject to runoff contaminated with agricultural chemicals, and those near roads and other developed areas often receive runoff high in sediment and 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 in 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.

Ribbon snake

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 Blanding's turtle,* 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 Town of Beekman

We mapped 95 intermittent woodland pools in the town (Figure 7), where they were particularly abundant in the forested eastern highlands and loosely scattered in the northwest portion of the town. All the mapped intermittent woodland pools in the town were 0.6 ac (0.24

ha) or smaller**.** Common plant species included black gum, red maple, highbush blueberry, marsh fern, and tussock sedge. Many 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 often excluded from federal and state wetland protection due to their small size, their intermittent surface water, and their isolation from other wetland 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 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. Pied-billed grebe* also uses this habitat and is known to occur in Beekman. Many raptors, wading birds, and mammals use marshes for foraging.

Occurrence in the Town of Beekman

We mapped 60 marsh areas in the town. Marshes were frequently contiguous with or embedded in hardwood swamps or wet meadows. Many of the marshes we observed in the field were dominated by common reed and cattail, and a few were influenced by beaver activity. In some cases we mapped areas of open water within marshes as a distinct habitat (see below). In areas where beavers are active, the location and extent of open water is likely to change from year to year. Most marshes in the town were small (<4 ac [1.6 ha]). Three large marshes occurred in a relatively undisturbed complex of wetlands near the intersection of Grape Hollow and Depot Hill roads. The largest of the three measured 36 acres (15 ha), and had beaver lodges and large areas with standing dead trees and shrubs. Dominant vegetation in these marshes included white pond-lily, yellow pond-lily, and water-shield.

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, and are found in several marshes in the town. Noise and direct disturbance from human activities can discourage breeding activities of marsh birds. Because many animal species of marshes depend equally on surrounding upland habitats for their life history needs, protection of the ecological functions of marshes must go hand-in-hand with protection of the surrounding habitats. The largest marshes in Beekman are very lake-like and could have similar sensitivities as open water habitats (see habitat description below). 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 Town of Beekman

Wet meadows were widely distributed primarily in the valleys of the town, and commonly occurred along the margins of swamps and marshes and in low-lying areas within upland meadows. We mapped 248 wet meadows, for a total of 164 ac (66 ha). Most were relatively small. The larger wet meadows (as large as 10 ac [4 ha]) were often closely associated with perennial streams such as Fishkill Creek and Frog Hollow. Common plant species included common reed, sensitive fern, goldenrods, and sedges.

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. Calcareous wet meadows often occur adjacent to fens (see below) and 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 cranefly* and rare butterflies such as Dion skipper,* two-spotted skipper,* and Baltimore.* Eastern ribbon snake* and spotted turtle* use calcareous wet meadows for basking and foraging. 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 Town of Beekman

We documented 45 calcareous wet meadows in the town (Figure 9), totaling nearly 74 ac (30 ha). Most were smaller than 2 ac (0.8 ha) and were scattered along streams or at the headwaters of streams in the central portion of the town. Large calcareous wet meadows were found in Frog Hollow, along Route 216, and along Hynes Road. Common species in these wetlands included sensitive fern, sedges, cattail, sweet flag, tall meadow rue, shrubby cinquefoil, skunk cabbage, blue vervain, purple loosestrife, small-flowered agrimony,* and goldenrods. Some plants of conservation concern in these wetlands include fringed gentian* and swamp birch.* 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. Most of the calcareous wet meadows in the town were contiguous with swamps, upland meadows, or fens.

Sensitivities/Impacts

Calcareous wet meadows have sensitivities to disturbance similar to those of wet meadows (see above) and fens (see below). They are particularly vulnerable to nutrient enrichment and siltation, which often facilitate the spread of invasive species. Like various small wetland habitats, they are often omitted from wetland maps and consequently overlooked in the environmental review of development proposals. Where calcareous wet meadows occur adjacent to fens used by bog turtles,* the turtles use both habitats. Therefore, calcareous wet meadows near suitable fens warrant the same level of protection as fens for potential bog turtle* habitat. See the Conservation Priorities section for recommendations on preserving the habitat values of fens and calcareous wet meadows.

FEN (f)

Ecological Attributes

A fen is a low shrub- and herb-dominated wetland that is fed by calcareous groundwater seepage. Fens almost always occur in areas influenced by carbonate bedrock (e.g., limestone and marble), and are identified by their low, often sparse vegetation and their distinctive plant community. Tussocky vegetation and small seepage rivulets are often present, and some fens have substantial areas of bare mineral soil or organic muck. Typical plants of fens include shrubby cinquefoil, alder-leaf buckthorn,* red-osier dogwood, autumn willow, sage-leaved willow, Kalm's lobelia, grass-of-Parnassus,* bog goldenrod, spike-muhly, sterile sedge, porcupine sedge, yellow sedge, and woolly-fruit sedge.

Fen is a rare habitat type because of the limited distribution of carbonate bedrock, soils, and groundwater seepage, and the historic alteration of wetlands. Fens support many species of conservation concern, including rare plants, invertebrates, reptiles, and breeding birds. More than 12 state-listed rare plants are found almost exclusively in fen habitats, including handsome sedge,* Schweinitz's sedge,* bog valerian,* scarlet Indian paintbrush,* spreading globeflower,* and swamp birch.* Rare butterflies such as Dion skipper* and black dash,* as well as rare dragonflies, such as forcipate emerald* and Kennedy's emerald,* are largely restricted to fen habitats. Other uncommon invertebrates, including phantom cranefly,* can also be found in fens. Fens comprise the core habitat for the endangered bog turtle* in southeastern New York, and are also used by other reptiles of conservation concern such as the spotted turtle* and eastern ribbon snake.* The rare sedge wren* nests almost exclusively in shallow, sedge-dominated wetlands such as fens. Large open fens, especially those associated with extensive meadow complexes, can also be important hunting grounds and potential nesting areas for northern harrier.*

Occurrence in the Town of Beekman

We mapped 17 fens in Beekman; most were located in the north central portion of the town in the valleys of Fishkill Creek and some of its tributaries. Two small fens occurred at the northern boundary of the town east of Susan Drive and in the southern part of town between Green Haven Road and Stagecoach Pass (Figure 9). Most fens were smaller than 2 ac (<0.8 ha). The largest mapped fens include both patches of open fen and areas of transition between fen and swamp. The quality of fens varied greatly—some were exemplary while others were overgrown with tall forbs and shrubs. Fens were generally located in valleys within or along the margins of larger swamps, marshes, or calcareous wet meadows. Because fens are difficult to identify by remote sensing we expect there are unmapped fens in areas we did not visit. Unmapped fens could occur in low-elevation areas with calcareous bedrock or soils, including edges or interiors of calcareous wet meadows, swamps, marshes, or wet meadows, or upper edges of stream floodplains and at the bases of ridges. In particular, the south central part of Beekman (Frog Hollow and north of Route 216) has the potential to support additional unmapped fens.

Sensitivities/Impacts

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

CONSTRUCTED POND (cp)

Ecological Attributes

Constructed ponds are water bodies that have been excavated or dammed by humans, either in existing wetlands or stream beds, or in upland terrain. Many of these ponds are deliberately created for fishing, watering livestock, irrigation, swimming, boating, and aesthetics. Some are constructed near houses or other structures to serve as a source of water in the event of a fire. We also include the water bodies created during mining operations in the constructed pond category. If constructed ponds are not intensively managed by humans, they can be important habitats for many of the common and rare species that are associated with naturally formed open water habitats (see below). We have classified naturally formed water bodies that are now intensively managed by humans as constructed ponds to better represent their habitat values.

Occurrence in the Town of Beekman

Most of the water bodies in the town were constructed ponds, and most of these were agricultural or ornamental ponds, or detention basins. Ornamental ponds were usually located within landscaped areas in close proximity to residences. We mapped 170 constructed ponds and the majority were smaller than 1 ac (<0.4 ha). The largest constructed pond (58 ac [23 ha]), located between Beekman and Green Haven roads, was created during gravel mining. 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. Constructed ponds with substantial cover of emergent vegetation (e.g., cattail, purple loosestrife, common reed) were mapped as marsh.

Sensitivities/Impacts

The habitat values of constructed ponds vary depending on the landscape context and the extent of human disturbance. In general, the habitat value is higher when the ponds have undeveloped 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. We expect that many of the ponds maintained for ornamental purposes are treated with herbicides and perhaps 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 impacts 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. Open water areas sometimes support submerged aquatic vegetation that can provide important habitat for aquatic invertebrates and fish. Spiny coontail* is known from many calcareous ponds in Dutchess County. 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. Wood duck,* American black duck,* pied-billed grebe,*osprey,* bald eagle,* American bittern,* and great blue heron* may use open water areas as foraging habitat. Bats, mink and river otter* also forage at open water habitats.

Occurrence in the Town of Beekman

Of the 44 open water habitat units we mapped in the town, most were smaller than 1 ac (0.4 ha). The largest open water area was Sylvan Lake (120 ac [49 ha]). While Sylvan Lake is classified in this study as an open water habitat, it has some characteristics of our "constructed pond" habitat type: over 70% of its shoreline is developed and it appears to be managed for recreational purposes, both of which affect its ecological value. Other large open water areas include Furnace Pond (which straddles the towns of Beekman and Union Vale), Lake Delany (just south of Sylvan Lake), Ludington Lake, Nuclear Lake (which extends into Pawling), and the Prison Reservoir. Some of the open water areas we mapped were created by beaver activity. Areas of open water within beaver wetlands are dynamic habitats that expand or contract according to beaver activity, and are often transitional to marshes or wet meadows.

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, use of motorized watercraft, and runoff from roads, lawns, and agricultural areas. Aquatic weed control, which may include harvesting, herbicide application, or introduction of grass carp, is an especially important concern in open water habitats, and the potential negative impacts should be assessed carefully before any such activities are undertaken (Heady and Kiviat 2000, Kiviat 2009). Because open water areas are often within larger wetland and stream complexes, any disturbance to the habitat may have far-reaching 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, and they help maintain the cool water temperature of streams, which is an important habitat characteristic for certain rare and declining fishes, amphibians, and other aquatic organisms. Springs and seeps also serve as water sources for animals during droughts and in winters when other water sources are frozen.

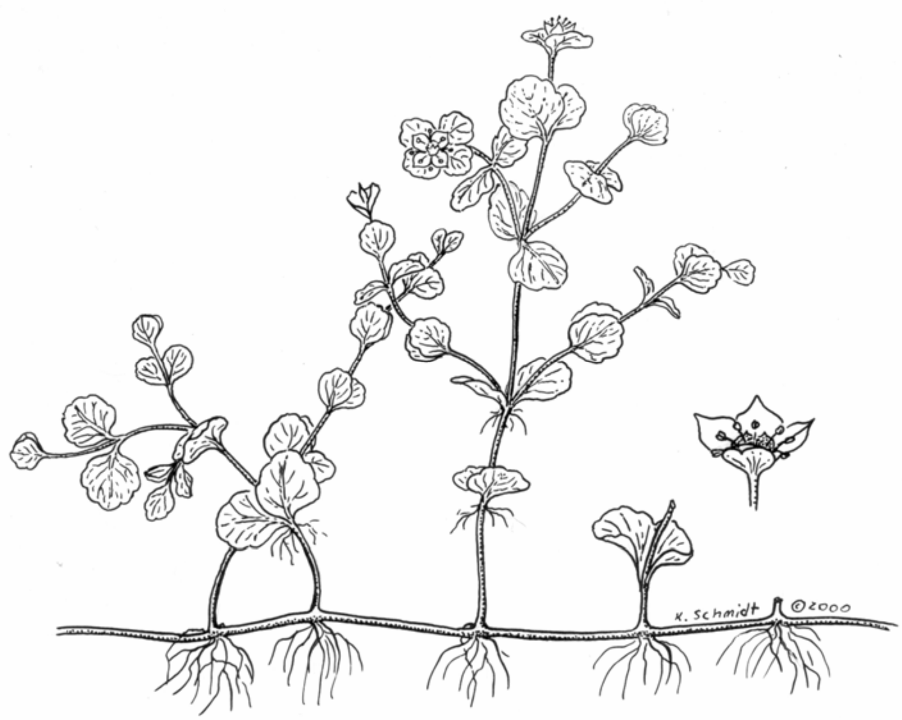
Very little is known about the ecology of seeps in the Northeast. Golden saxifrage is a plant more-or-less restricted to springs and groundwater-fed wetlands and streams. A few rare invertebrates are restricted to springs in the region, and the Piedmont groundwater amphipod* could occur in the area (Smith 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 Town of Beekman

Because the occurrence of springs and seeps is difficult to predict by remote sensing, we mapped only those we saw in the field and those that had a distinct signature on one of our map sources. We expect there are many more springs and seeps in the town that we did not map. More detailed surveys of these habitats should be conducted as needed on a site-by-site basis. We did not map springs and seeps within fens, but all mapped fens were substantially fed by groundwater seepage. Most of the mapped springs and seeps were found in the upland hardwood forests of the eastern highlands or scattered in the northwestern portion of the town, and were often associated with a stream or small wetlands.

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 11). 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, and land uses in the watershed, and 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. 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 Town of Beekman

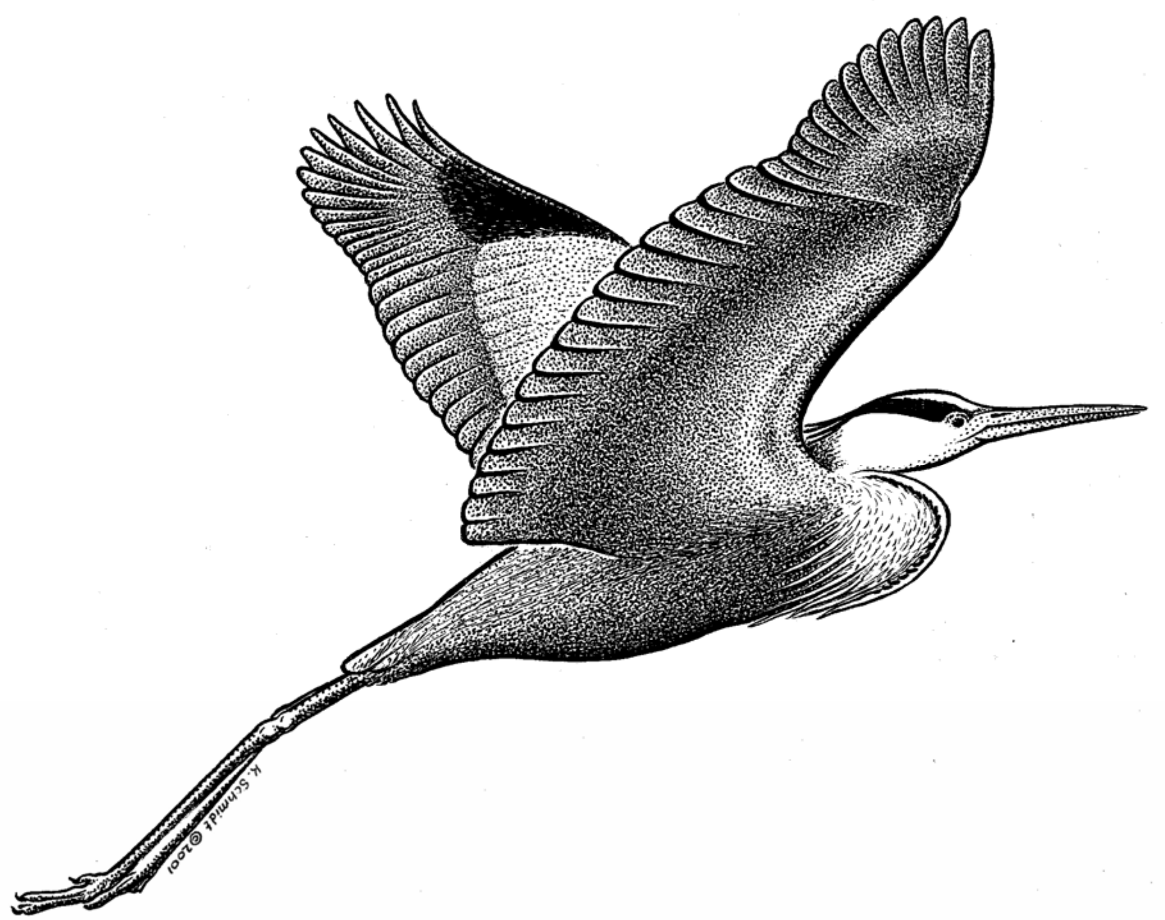
Perennial streams and their riparian corridors occupy the major valleys in the town. The largest stream in Beekman was Fishkill Creek. Whaley Lake Stream, Frog Hollow Brook, and Gardner Hollow Brook followed in size, and Whortlekill Creek, Flat Rock Brook, and several other unnamed streams are also perennial. These perennial streams are tributaries of Fishkill Creek, which ultimately flows into the Hudson River. A perennial stream near the town’s northern boundary flows from around Route 55 westward in to Jackson Creek and then into Sprout Creek. An unnamed perennial stream that crosses Pepper Hill Road flows south into Stump

Pond Creek and thence into the Croton River, another tributary to the Hudson. Some intermittent and small perennial streams in the eastern highlands drain generally eastward into the Swamp River, which flows into the Tenmile River, a tributary of the Housatonic River in Connecticut. The combined length of perennial streams we mapped in the town was approximately 43 mi (69 km). Intermittent streams were very numerous with a combined length of approximately 84 mi (135 km) (Figure 11).

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. Stream corridors are prone to invasion by Japanese knotweed, an introduced plant that is spreading in the region (Talmage and Kiviat 2004).

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



Great blue heron

CONSERVATION PRIORITIES AND PLANNING

Most local land use decisions in the Hudson Valley are made on a site-by-site basis, without the benefit of good ecological information about the site or the surrounding lands. The loss of biological resources from any single development site may seem trivial, but the cumulative 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.

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 Beekman habitat map facilitates this approach by illustrating the location and configuration of significant habitats throughout the town. The map, together with the information provided in this report, can be applied directly to land use and conservation planning and decision making at multiple scales. In the following pages, we outline recommendations for: 1) developing general strategies for biodiversity conservation; 2) using the map to identify priorities for town-wide conservation, land use planning, and habitat enhancement; and 3) using the map as a resource for reviewing site-specific land use proposals.

GENERAL GUIDELINES FOR BIODIVERSITY CONSERVATION

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

A variety of regulatory and non-regulatory means can be employed by a municipality to achieve its conservation goals, including volunteer conservation efforts, master planning, zoning ordinances, tax incentives, land stewardship incentives, permit conditions, land acquisition, conservation easements, and public education. Section 4 in the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001) provides additional information about these and other conservation tools. Several publications of the Metropolitan Conservation Alliance, the Pace University Land Use Law Center, and the Environmental Law Institute describe some of the tools and techniques available to municipalities for conservation planning. For example, *Conservation Thresholds for Land-Use Planners* (Environmental Law Institute 2003) synthesizes information from the scientific literature to provide guidance to 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 *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. A recent publication from Cornell and NYS DEC, *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 regulations and incentives designed to protect specific types of habitat, the town can also apply some general practices on a town-wide basis to foster biodiversity conservation.

The examples listed below are adapted from the *Biodiversity Assessment Manual* (Kiviat and Stevens 2001).

- **Protect large, contiguous, undeveloped tracts** wherever possible.
- **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.

TOWN-WIDE BIODIVERSITY PLANNING

The Beekman 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 3) and maintain corridors between them.

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, fens and associated wetlands in Beekman may support some of the few remaining populations of bog turtle* in the region. Figures 4-11 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 3**)**.

Finally, we have delineated five Conservation Areas (Figure 12) that may serve as suitable units for town-wide or local conservation planning. The habitat map and this report are practical tools that will help the town select areas for protection and identify sites for new development where the ecological impacts will be minimized. The map can also be used with the habitat maps of adjacent towns—East Fishkill (completed) and Dover (currently in progress)—for conservation planning across town boundaries.

PRIORITY HABITATS IN BEEKMAN

Although approximately 25% of land in the town has been developed for residential and commercial uses, large areas of high-quality habitat still remain. These large areas are not only important locally, but also contribute greatly to regional biodiversity. For example, the eastern highlands of the town are part of the "Highlands" Significant Biodiversity Area (SBA) of southeastern New York identified by the New York State Department of Environmental Conservation. This area is part of a large forested green belt extending west across the Hudson River into Orange and Rockland counties (New York), into New Jersey and Pennsylvania, and east into Connecticut. The Beekman portion of the Highlands SBA also serves as a forested connection between two other Significant Biodiversity Areas straddling the Town of Beekman (Penhollow et al. 2006).

By employing a proactive approach to land use and conservation planning, the Town of Beekman has 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 sensitive habitat types, high quality habitat units, and a variety of habitats well-connected and well-distributed over the landscape. Below we highlight some habitat types that we consider "priority habitats" for conservation in the town. It must be understood, however, that we believe all the habitat areas depicted on the large-format habitat map are ecologically significant and worthy of conservation attention. The list of priority habitats below is a subset of 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, they 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 Town of Beekman, Dutchess 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 200-2,470 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	Rare reptiles	Oak-heath barren, extensive crest/ledge/talus and surrounding contiguous forests.	Includes habitat essential for denning, nesting, basking, foraging, and dispersal.	Brown 1993, Todd 2000, Blouin-Demers and Weatherhead 2002
Large meadow	Grassland-breeding birds	Unfragmented patches greater than 25 ac (10 ha).	Required for maintaining viable breeding populations.	Herkert 1994, Vickery et al. 1994, Walk and Warner 1999
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
Potential Blanding's turtle core habitat wetlands	Blanding's turtle	3,300 ft (1,000 m) from core habitat pool.	Encompasses most of the critical habitat, including nesting areas, summer foraging wetlands, drought refuge pools, and overland travel corridors.	Kiviat 1997, Hartwig et al. 2009
Fen (and calcareous wet meadow)	Bog turtle	2,500 ft (750 m) from fen.	Represents the reported overland distance traveled between wetlands within a habitat complex; encompasses the recommended "Bog turtle Conservation Zone" aimed at protecting habitat integrity.	Eckler and Breisch 1990, Klemens 2001
Wetland complex	Spotted turtle	Minimum upland zone of 400 ft (120 m) beyond outermost wetlands in a complex.	Corresponds to maximum reported distance of nests from the nearest wetland.	Joyal et al. 2001
Perennial stream	Wood turtle	660 ft (200 m) from stream.	Encompasses most of the critical habitat, including hibernacula, nesting areas, spring basking sites, foraging habitat, and overland travel corridors.	Carroll and Ehrenfeld 1978, Harding and Bloomer 1979, Buech et al. 1997, Foscarini and Brooks 1997

LARGE FORESTS

Target Areas

In general, forested areas with the highest conservation value include large forest tracts, mature and relatively undisturbed forests, and those with a lower proportion of edge to interior habitat. Smaller forests that provide connections between other forests, such as corridors or patches that could be used as "stepping stones," are also valuable in a landscape context. The largest forest areas are illustrated in Figure 4. The three largest forest patches (greater than 1,000 ac [>400 ha]) are found along the Appalachian Trail. The largest patch (1,730 ac [700 ha]) occurs on Depot Hill west of Depot Hill Road; the other two are east of Depot Hill Road and between Route 55 and Gardner Hollow Road. Four forest patches between 500 and 1,000 ac (200-400 ha) are located at the southern tip of the town, at the northeastern corner of the town, between Sylvan Lake and Martin roads, and between Baker Road and Route 55. Except for the latter two patches, these forests are part of larger contiguous forests that extend into the towns of East Fishkill, Union Vale, Dover, and Pawling. Seven forest patches between 100 and 500 ac (40-200 ha) are scattered throughout the town. Extensive areas of crest and ledge occurred in most of these forests.

Dry oak forest prevailed in high elevation, exposed areas on and around the eastern highlands and other high hilltops throughout the town, and was dominated by chestnut oak and red oak with blueberries and black huckleberry in the understory. Some particularly large red oak, white oak, red maple, shagbark hickory and tulip trees in the eastern highlands and northern parts of town measured as large as 50 inches (127 cm) in diameter.

Hudsonia published a habitat map for the town of East Fishkill in 2001, is in the process of mapping the Town of Dover, and hopes to map other adjacent areas in the near future. This growing regional map will enable town officials and private landowners to plan strategically across town boundaries to conserve large forested areas. The level of fragmentation of forest patches in the Town of Beekman is quite variable; for example, forests in the Depot Hill area are fragmented by lower density development (in some places only a dirt road) than those in the western part of town, and thus present better opportunities for species to move between forest patches.

Conservation Issues

Loss of forest and fragmentation of remaining forest are the two most serious threats facing forest-adapted organisms. The decline of extensive forests has been implicated in the declines of numerous “area-sensitive” species, which require many hundreds or thousands of acres of contiguous forest to 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. The nesting success of many species of forest birds is reduced by forest fragmentation (Lampila et al. 2005). 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 Beekman (e.g., red-shouldered hawk,* Louisiana waterthrush,* cerulean 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* (see section 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).

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. While hemlock forests are relatively uncommon in Beekman, infestation could eliminate hemlock occurrences. 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 tree species and can kill a tree in two to four years. It was recently discovered in western New York in Cattaraugus County, where quarantines have been established, and in other nearby areas outside the state's borders (NYS DEC 2009). The Asian longhorned beetle threatens native maple, birch, and willow trees and has the potential to greatly affect the forestry, maple syrup, and nursery industries (APHIS 2008). It has been found in New York City and on Long Island, and there is a large invasion in Massachusetts. A recently created 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 2009).

In addition to their tremendous values for wildlife, forests are perhaps the most effective type of land cover for sustaining clean and abundant surface water (in streams, lakes, ponds, and wetlands) and groundwater. Forests with intact canopy, understory, ground vegetation, and floors (i.e., organic duff and soils) are extremely effective at promoting infiltration of precipitation (Bormann et al. 1969, Likens et al. 1970, Bormann et al. 1974, Wilder and Kiviat 2008), and may be the best insurance for maintaining groundwater quality and quantity, and for maintaining flow volumes, temperatures, water quality, and habitat quality in streams.

Recommendations

We recommend that the remaining blocks of large forest within the Town of Beekman 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 an infestation of an invasive insect species, as treatment procedures vary by species.

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

Target Areas

We mapped ten relatively small areas of oak-heath barren in the eastern highlands of Beekman (most were on Depot Hill), and there are additional areas of exposed rock that may support this habitat (Figure 5). The largest patch of oak-heath barren (0.5 ac [0.2 ha]) was somewhat atypical, having a relatively dense shrub layer that included black birch saplings. The small barrens in Beekman are probably remnants of historically larger habitats once maintained by

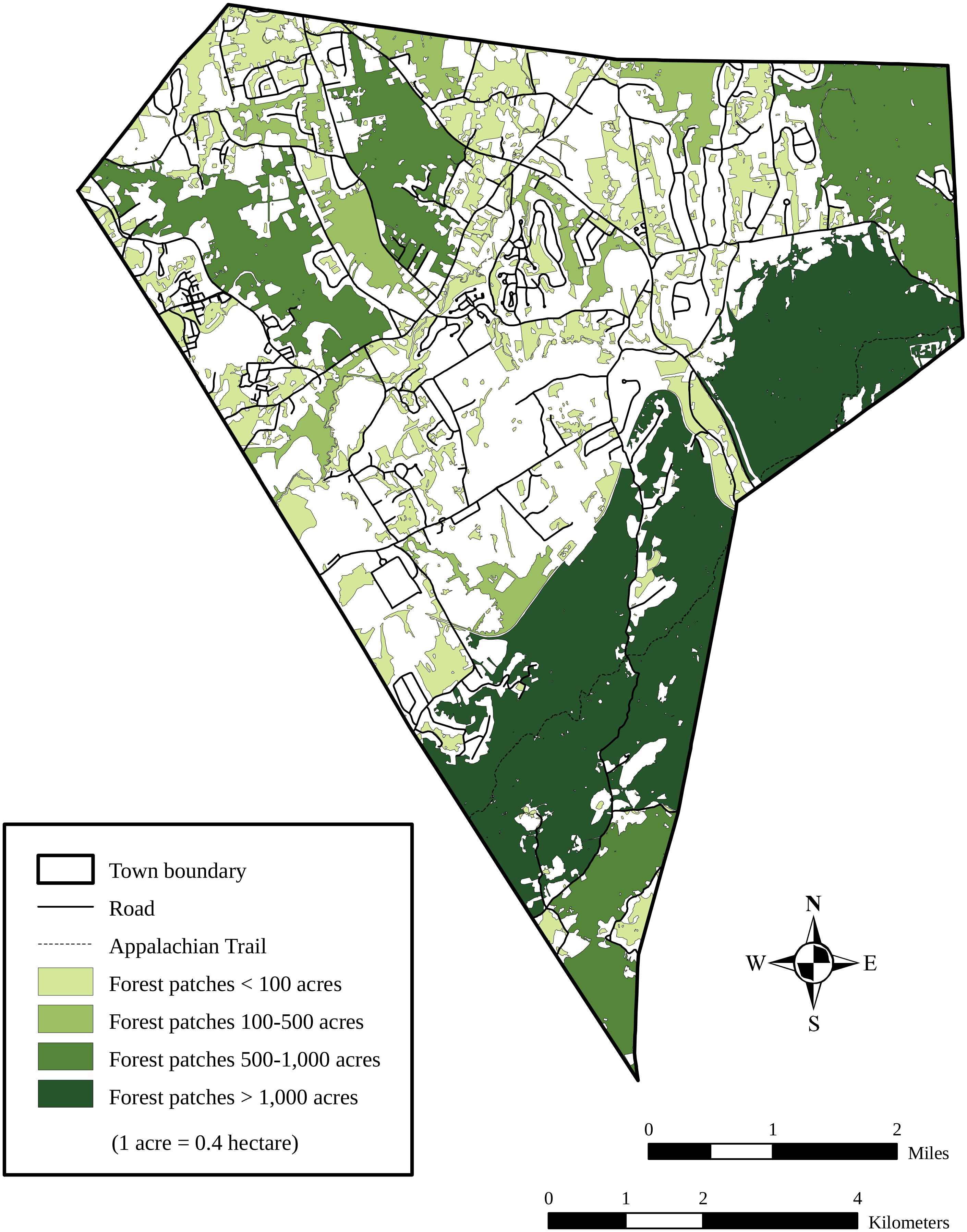


Figure 4. Contiguous forest patches (including hardwood, conifer, and mixed forests in uplands and swamps) in the Town of Beekman, Dutchess County, New York. Hudsonia Ltd., 2009.

fire that persist because shallow soils and other factors inhibit colonization by taller tree species that would otherwise shade out oak-heath barren species.

Other crest, ledge, and talus habitats occurred throughout the town in close association with hills and ridges (Figure 5). The bedrock in the extensive rocky areas in the eastern highlands was largely acidic. In the vicinity of Nuclear Lake there were some extensive talus slopes and ledges (two ledges in particular estimated at 30 ft [9 m] tall). The few bedrock outcrops in the valleys were mostly calcareous.

Conservation Issues

Oak-heath barrens are uncommon in the Hudson Valley. These are disturbance-maintained ecosystems (ice, fire, wind), and human suppression of wildfires has eliminated one of the disturbances that historically maintained them. The plant communities of oak-heath barrens are especially adapted to episodic fires. Without fire events, other forest species can colonize these areas, and eventually oak-heath barren specialists may be out-competed by the more typical species of rocky upland hardwood forests. 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 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 and crest, ledge, and talus and oak-heath barrens (including far-ranging rare reptiles) is the fragmentation of large rocky forested areas and associated habitat complexes. The construction of houses, roads, and other structures in these habitats can isolate populations by preventing migration, dispersal, and genetic exchange. This, in turn, can limit the ability of these populations to adapt to changing climatic or other environmental conditions and make them more prone to local extinction.

Recommendations

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

1. **Avoid disturbance of crest, ledge, and talus habitats wherever possible, and** concentrate any unavoidable development in a manner that maximizes the amount and contiguity of undisturbed rocky habitat. Minimize the extent of new roads through undeveloped land with extensive crest, ledge, and talus. Take special measures to restrict the potential movement of snakes into developed areas, thereby minimizing the likelihood of human-snake encounters (which are often fatal for the snake) and road mortality.
2. **Maintain broad corridors** between crest, ledge, and talus habitats**.** Intervening areas between habitats provide travel corridors for species that migrate among different habitats for breeding, foraging, and dispersal.
3. **Consider the impacts of habitat disturbance** to crest, ledge, and talus when reviewing all applications for Mined Lands permits and other development proposals, keeping in mind that rare snakes typically travel long distances from their den sites.
4. **Educate construction workers and residents** about snake conservation and whom to contact to safely relocate 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. Protecting these habitats protects denning and basking areas for rare snakes and the habitat’s specially adapted 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.

Dry oak crest

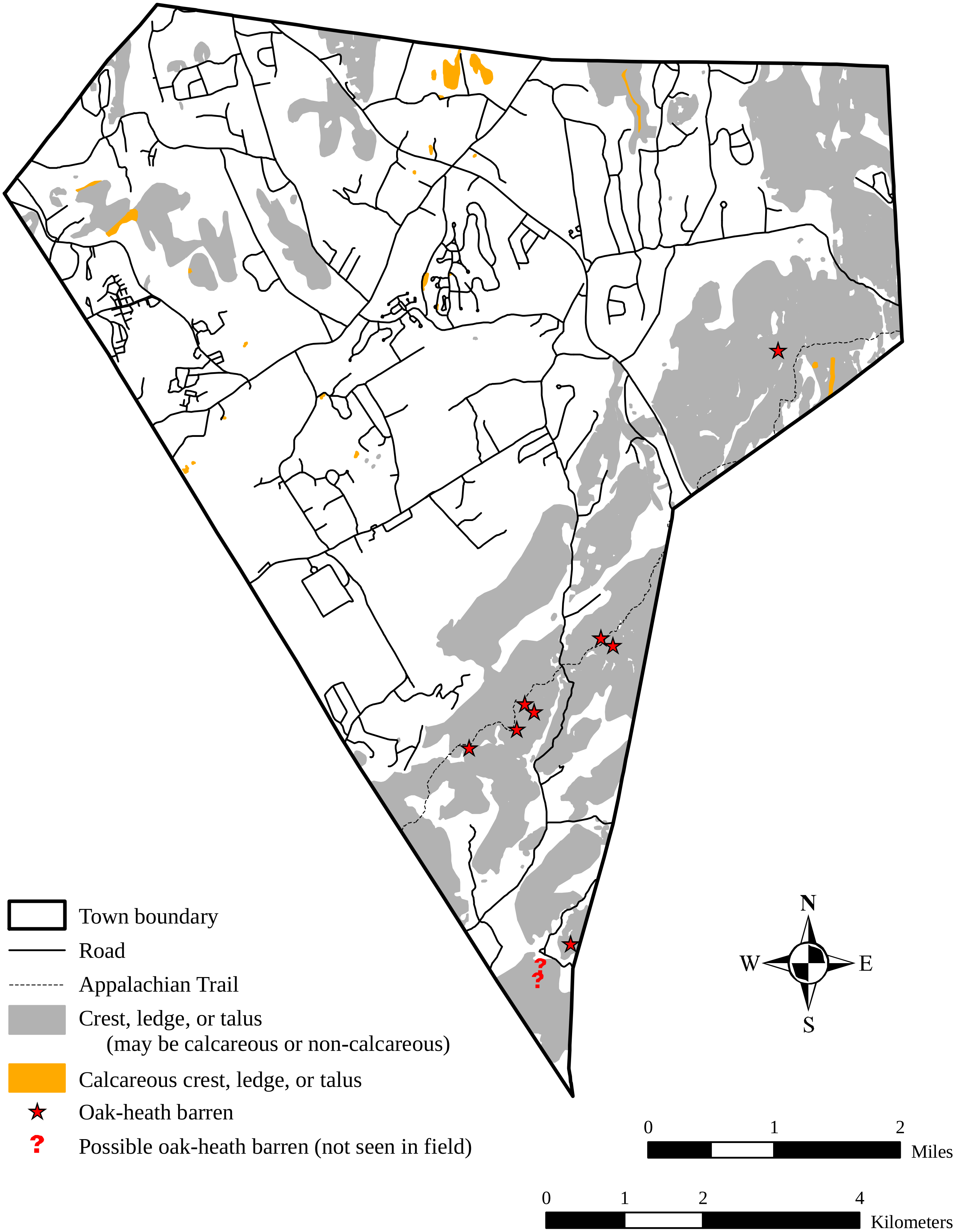


Figure 5. Generalized distribution of calcareous and non-calcareous crest, ledge, and talus habitats, oak-heath barrens, and possible oak-heath barrens (not field-verified) in the Town of Beekman, Dutchess County, New York. Locations identified from field observations and inferred from areas mapped as having shallow soils on steep slopes and crests in Faber (2002). Hudsonia Ltd., 2009.

LARGE MEADOWS

Target Areas

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. (Cultivated fields have little current value as nesting habitat, but may regain habitat value when used as pasture or hayfields and managed as grassland bird habitat.) In Beekman, the largest meadow complexes were found in the central valley of Fishkill Creek. For grassland breeding birds, fences and hedgerows (including lines or narrow patches of trees and/or shrubs) may fragment meadow areas into smaller patches (see below). When fences and hedgerows are not treated as fragmenting features, the largest contiguous meadow complex in the town, located between Frog Hollow and Green Haven roads, measured 182 ac (74 ha) and included a large area of upland meadow with several acres of wet meadow and calcareous wet meadow. The general area surrounding Route 216, Green Haven Road, Frog Hollow Road and Sugar Lane has a concentration of large contiguous meadows, including three additional large meadow complexes that measured more than 100 ac (40 ha) each (Figure 6A). When fences and hedgerows are treated as fragmenting features, the largest single meadow in the town totaled nearly 88 ac (35 ha; Figure 6B).

Smaller upland and wet meadows that could potentially serve as wildlife travel corridors or "stepping stones" between nearby habitats are also important, as are upland shrublands with relatively sparse shrub cover.

Conservation Issues

While there can be significant habitat value in small patches of upland meadow (e.g., plants, for invertebrates, and small mammals), large grassy patches are especially important for grassland-breeding birds. There are eight state-listed grassland-breeding bird species: short-eared owl (Endangered); upland sandpiper, sedge wren, Henslow's sparrow, and northern harrier (Threatened); and horned lark, grasshopper sparrow, and vesper sparrow (Species of Special Concern). Several other grassland-breeding birds are considered regionally rare in the Hudson Valley. While short-eared owl is not known to breed in the Hudson Valley, it uses large grasslands in the region as foraging habitats during winter, as do other raptors, some birds that breed further north, and many non-migratory birds. Grassland-breeding birds have declined dramatically in the Northeast in recent decades due, apparently, to habitat loss, as suitable meadows have been fragmented and overtaken by regrowth of forest, converted to row crops, or lost to residential and commercial development (Askins 1993, Brennan and Kuvlesky 2005). Area requirement studies for grassland birds are very limited in the Northeast and area requirements for specific species vary between studies, but the consistent finding is that these species require relatively large unfragmented grasslands. A study in grassland barrens in Maine found that grassland-breeding birds were more likely to nest in grasslands of 25 to 500+ ac (10-200+ ha) (Vickery et al. 1994). In the Midwest, grasshopper sparrow, savannah sparrow, and Henslow's sparrow rarely occurred in grasslands as small as 2.5 ac (1 ha) (Herkert 1994). 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 these birds require grasslands hundreds and thousands of acres in size. Fences and hedgerows can reduce nesting success for grassland-breeding birds by providing cover and perching sites for raptors and other species that prey on the birds or their eggs (Wiens 1969). Figure 6 illustrates how meadow patch sizes differ when hedgerows and fences are taken into account as fragmenting features. Although the town has over 1,000 areas of wet and upland meadows in total, only 21 of these are larger than 25 ac (10 ha) and just six are 50 ac (20+ ha) or larger. Meadows in Beekman may not be large enough to support breeding grasshopper sparrow, Henslow's sparrow, or upland sandpiper populations (Vickery et al.1994), but may support breeding populations of species with smaller area requirements. Because grassland birds have very specific habitat requirements for nesting, their survival in the northeastern U.S. may ultimately depend on active farmland and open space management (Askins 1993).

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

Recommendations

In cases where grassland owners have flexibility in their mowing and grazing practices, Massachusetts Audubon (http://www.massaudubon.org) has the following management suggestions for minimizing harm to grassland birds in meadows of the Northeast:

1. **Mowing after August 1** will avoid much of the nesting, nursery, and fledging seasons; if mowing must occur before then, leave some unmowed strips or patches. Mowing in fall is even less disruptive (some birds continue breeding into August or September).
2. **Mowing each field only once every 1-3 years**, or doing rotational mowing so that each part of a field is mowed once every 3 years, can maintain habitat for nesting birds and butterflies.
3. **On an active farm, leaving some fields out of production each year** provides wildlife habitat. Alternatively, hayfields mowed early in the season can be rotated annually with those that are mowed late in the season.
4. **Removing fences or hedgerows between smaller fields** enlarges the habitat area for grassland breeding birds.
5. **Raising mower blades six inches or more, using flushing bars, and avoiding night mowing** when birds are roosting all help reduce bird mortality.
6. **Light grazing**, if livestock are rotated among fields throughout the season, can be beneficial.
7. If planned and executed carefully, **burning grasslands every two to six years** can improve habitat quality for grassland birds.

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

Beyond the ecological values 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 town's landscape.

INTERMITTENT WOODLAND POOLS

Target Areas

We identified and mapped 95 intermittent woodland pools in the town (Figure 7), and there are likely to be others that we missed. Additionally, we mapped 20 "pool-like" swamps, with ecological functions similar to that of intermittent woodland pools; these include small kettle shrub pools 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 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 season and egg and larval stages, 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

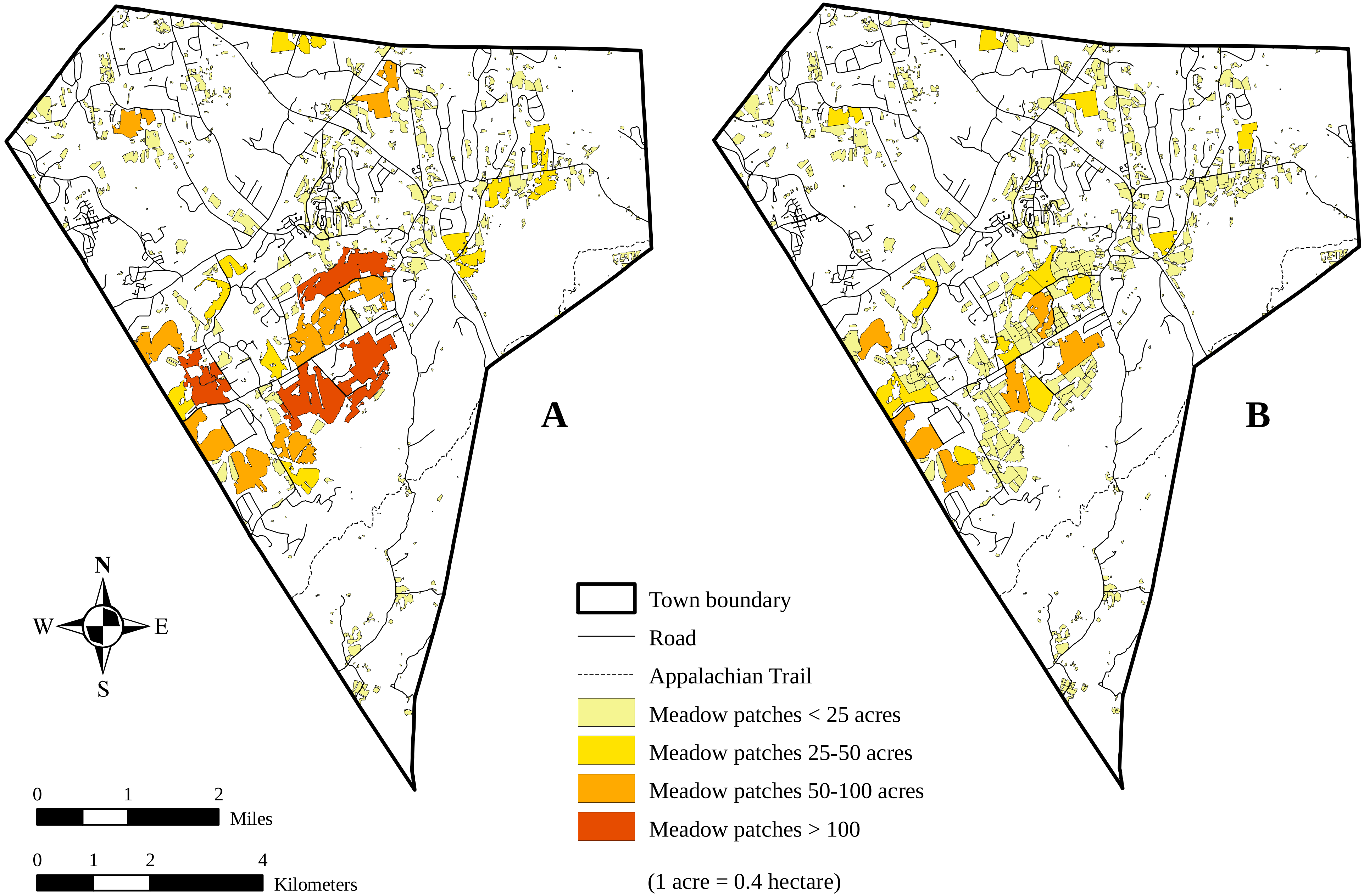


Figure 6. Contiguous meadow habitats (including upland meadow, wet meadow, and calcareous wet meadow) in the Town of Beekman, Dutchess County, New York. A) Contiguous meadow patches without consideration of fences or hedgerows as fragmenting features; B) contigous meadow patches shown with fences and hedgerows as fragmenting features. Both maps include active agricultural areas and other managed and unmanaged meadow habitats. Hudsonia Ltd., 2009.

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 3,835 ft (1,169 m) from a breeding pool (Calhoun and Klemens 2002). Both salamanders and frogs are vulnerable to vehicle mortality where roads or driveways cross their travel routes. Roads, especially dense networks of roads or heavily-traveled roads, have been associated with reduced amphibian populations (Fahrig et al. 1995, Lehtinen et al. 1999, Findlay and Bourdages 2000). 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 habitat zone (750 ft [230 m]) of an intermittent woodland pool:

1. **Avoid or minimize the potential adverse affects of roads to the greatest extent possible**. Pool-breeding salamanders and frogs are especially susceptible to road mortality from vehicular traffic, predation, and desiccation. Curbs and other structures associated with roads frequently intercept and funnel migrating amphibians into stormwater drains where they may be killed. To minimize these 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 affects 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. 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.

Intermittent woodland pool

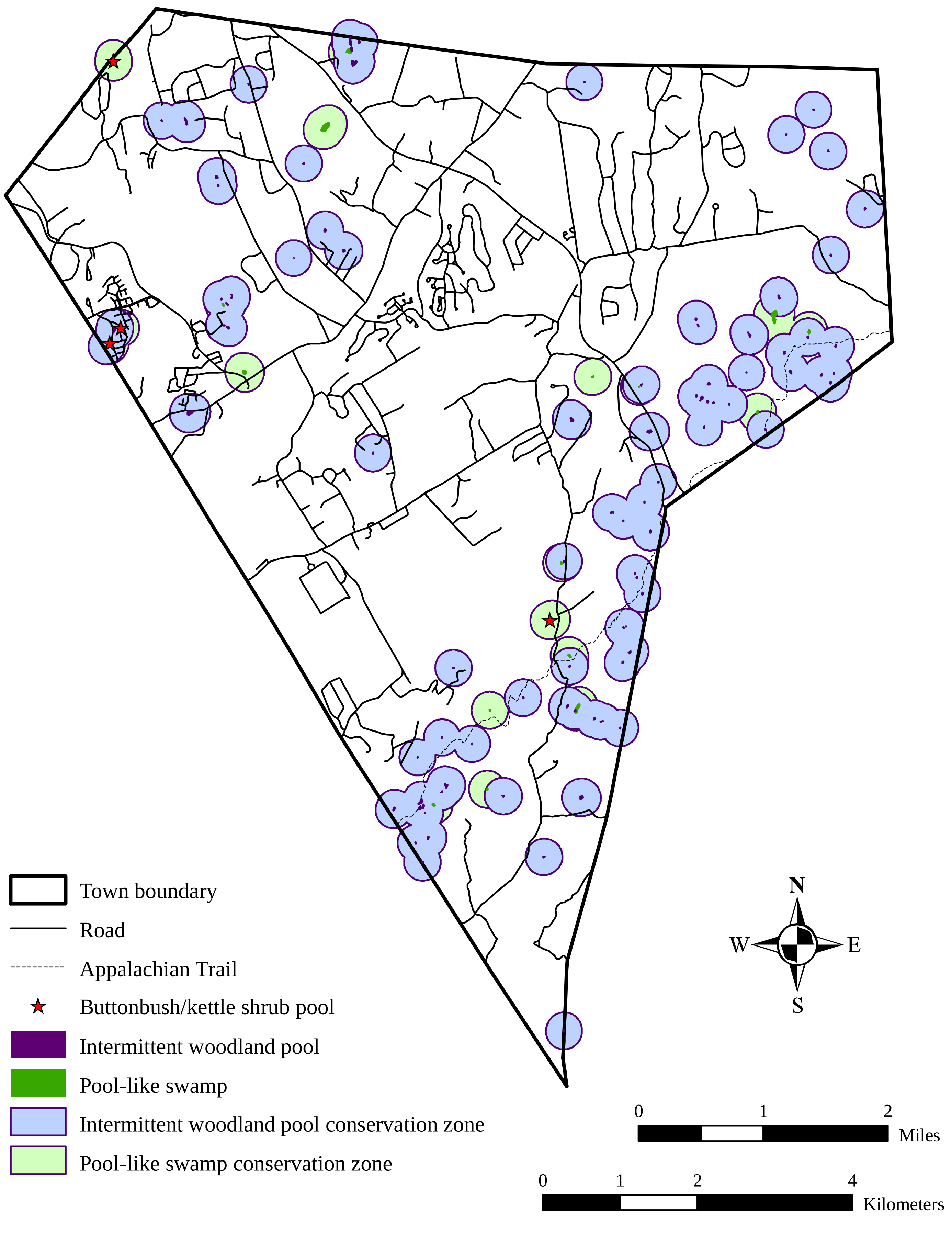


Figure 7. Intermittent woodland pools, pool-like swamps, and their associated conservation zones in the Town of Beekman, Dutchess County, New York. Small buttonbush and kettle shrub pools are types of pool-like swamps. Pool conservation zones extend 750 ft (230 m) from wetland boundaries. Hudsonia Ltd., 2009.

POTENTIAL BLANDING'S TURTLE CORE HABITAT WETLANDS

Target Areas

Two potential Blanding's turtle core habitat wetlands have been identified in the town (Hartwig et al. 2009). One wetland is an shrub swamp (2.8 ac [1.1 ha]) located south of Clapp Hill Road just east of the intersection with Andrews Road. The second wetland is a high quality kettle shrub pool (6.3 ac [2.6 ha]) between Sylvan Lake Road and Doherty Park (Figure 8).

Conservation Issues

Kettle shrub pools are the typical core wetlands used by the Blanding's turtle* (NYS Threatened) in Dutchess County. Swamps with structural characteristics similar to kettle shrub pools (such as buttonbush pools) may also be used as core habitat. The two wetlands described above were identified by Hudsonia in a previous study of Blanding's turtle habitat in Dutchess County as potential core wetland habitats in Beekman (Hartwig et al. 2009). Detailed assessments of other wetlands as potential Blanding's turtle core habitat (such as other mapped kettle shrub and buttonbush pools) were beyond the scope of this habitat mapping project. See Hartwig et al. (2009) for more information on Blanding's turtle habitats and conservation.

Blanding's turtle populations have not been documented in the Town of Beekman, but there is one historical record of a Blanding's turtle found in the town. The turtles are known to occur in the adjacent towns of LaGrange and East Fishkill. We consider the two core wetland habitats in northwestern Beekman to have potential for supporting populations of this species. The Blanding's turtle typically spends winter, spring, and fall in its core wetland (Kiviat 1997), but during the active season (ca. April – October), it also uses other nearby wetlands, including emergent marshes, swamps, intermittent woodland pools, and lakes, for foraging, rehydrating, and resting. Females nest in open upland habitats with (usually) coarse-textured, well-drained soil (often gardens, agricultural fields, utility rights-of-way, soil mines, etc.), in late spring to early summer. During drought periods and during the nesting season migrations, individuals may move into constructed ponds or other water bodies that retain standing water. Maintaining a Blanding's turtle population requires protecting not only the core wetland habitat (e.g., kettle shrub pool or buttonbush pool), but also the associated foraging and drought refuge wetlands, the upland nesting areas, and the upland areas between these habitats.

The day-to-day and seasonal overland movements of the Blanding's turtles to reach important foraging areas, nesting sites, overwintering areas, and refuge habitats extend to 3,300 ft (1,000 m) and sometimes farther from a core wetland habitat. In the Northeast and elsewhere in their range, movements of 6,600 feet (2,000 m) and more have been documented on numerous occasions (Joyal et al. 2000, 2001; Fowle 2001). These long distance movements enable turtles to select alternative habitats as habitat quality or social dynamics change, and to breed with individuals from neighboring populations. Therefore, to define the potential extent of the habitat complex used by a Blanding's turtle population, we delineated 3,300-ft (1,000-m) and 6,600-ft (2,000-m) zones around each core wetland habitat (Figure 8; Hartwig et al. 2009). The 1,000-m "Conservation Zone" encompasses the wetlands that the turtles would use regularly on a seasonal basis, most of the nesting areas, and most of the travel corridors. One can expect turtles regularly in this zone throughout the active season (March through October). The 2000-m "Area of Concern" includes the landscape in which Blanding's turtle makes long-distance movements to explore new wetlands, seek mates, or nest. One can expect a few turtles from a particular core wetland in this zone each year. Within these zones, potential Blanding's turtle habitats include both wetlands and upland nesting habitats, as well as the travel corridors between them. The conservation zone of a potential core habitat wetland near the town's border with Union Vale extends well into Beekman, and the Area of Concern of the pools in northwestern Beekman is contiguous with the Area of Concern of pools mapped in the adjacent towns of LaGrange and Union Vale (Figure 8).

Land development and other human uses within this habitat complex can have significant adverse effects on the turtles and their habitats, including the direct loss of wetland habitat (small, unregulated wetlands are especially vulnerable); degraded water quality from surface runoff containing fertilizers, pesticides, and other toxic substances; altered wetland hydroperiod and water depth from groundwater extraction or stormwater diversion; habitat fragmentation from roads and developed land uses; collecting of turtles and their eggs; and increased nest predation by human-subsidized predators. Road mortality of nesting females and other individuals migrating between wetlands or dispersing to new habitats is one of the greatest threats to Blanding's turtle populations (Kiviat and Stevens 2003).

Recommendations

The protection of habitats with the potential to support Blanding's turtle populations is crucial to the recovery of this species. To help protect Blanding's turtles and the habitat complexes they require, we recommend the following measures adapted from Hartwig et al. (2009; see for more details):

Within the 6,600-ft (2,000-m) Area of Concern:

1. **Protect wetland habitats** from physical, chemical, or unnatural hydrological disturbance.
2. **Maintain the spatial and temporal patterns of surface water and groundwater** entering and leaving wetlands.
3. **Maintain broad corridors of undeveloped land** within the Area of Concern between all 1,000 m (3,300 ft) Conservation Zones.
4. **Minimize the extent of new roads**.
5. **Maintain broad buffer zones** (e.g., at least 30 m [100 ft] width) of natural soil and vegetation around all wetlands, including unregulated wetlands.
6. **Minimize or eliminate pesticide use.**
7. **Educate landowners** about the Blanding's turtle and its conservation.

Further recommendations for the 3,300-ft (1,000-m) Conservation Zone include:

1. **Protect nesting areas**. Blanding's turtles typically nest in upland meadow or open shrublands, habitats that also tend to be prime targets for development.
2. **Consider the impacts on water quality, hydrology, and habitat disturbance** to turtle habitat complexes when reviewing all applications for any permits or land use changes.
3. **Identify high-priority areas for special protection,** e.g., for acquisition of land or establishment of conservation easements.
4. **Identify all potential pitfall hazards**, and design or modify them to prevent the entrapment of turtles.
5. **Identify potential barriers to turtle movement**, remove or modify them.
6. **Educate construction crews and eventual residents on how to look for and safely move turtles**.

In addition to the recommendations above, we recommend that no buildings, pavement, roads, or other structures be constructed within 660 ft (200 m) of potential core habitats. Blanding's turtle activity (basking, aestivation, short-distance travel) is most concentrated in this area. The vegetated buffer will also protect the wetland's ecological functions.

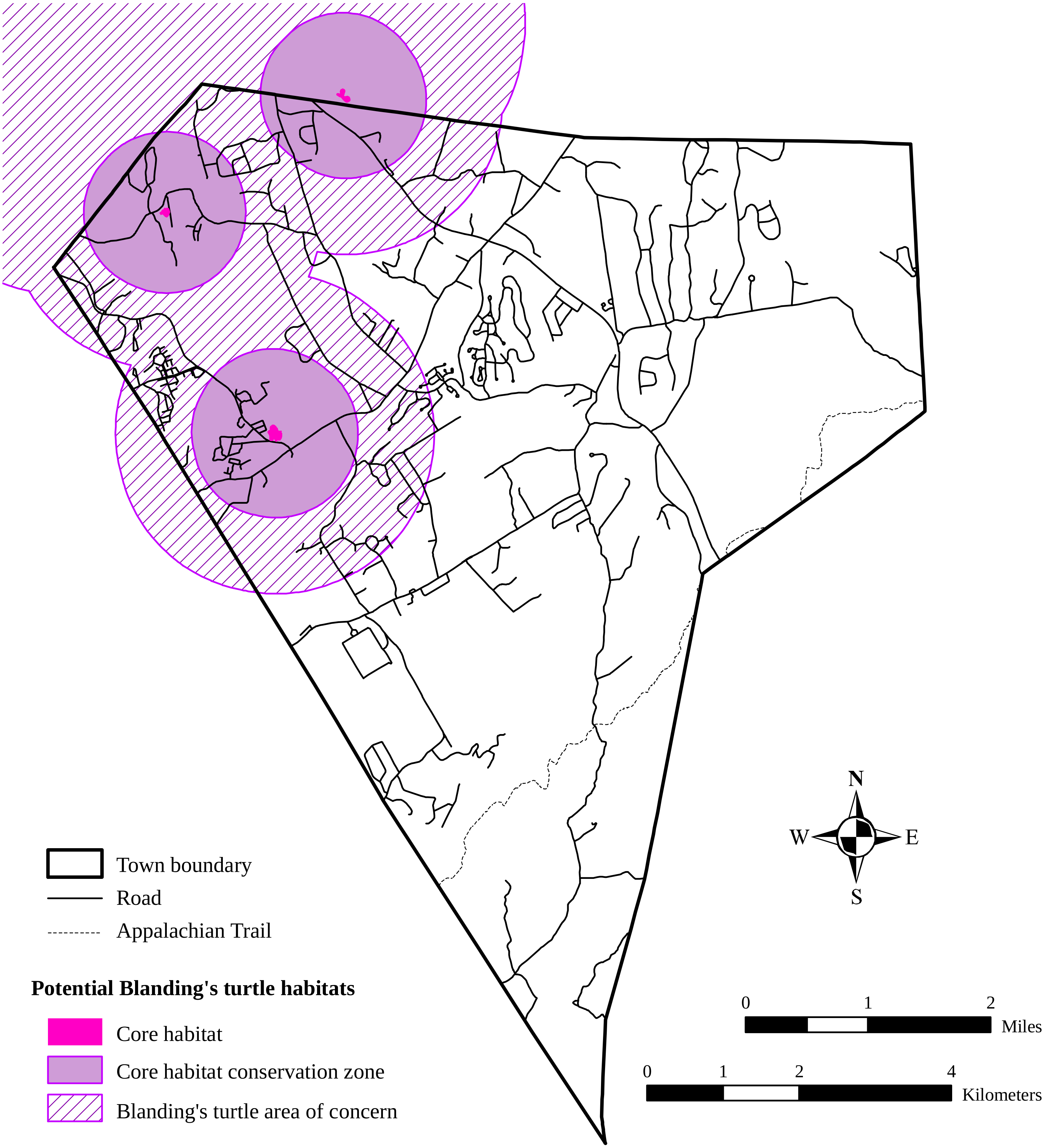


Figure 8. Potential Blanding's turtle habitats and their associated conservation zones and areas of concern in the Town of Beekman, Dutchess County, New York. Core habitats were identified and assessed as part of a study of Blanding's turtle habitats in southern Dutchess County (Hartwig et al. 2009). Conservation zones for core habitat extend 3,300 ft (1,000 m) from edges of core wetlands; areas of concern extend 6,600 ft (2,000 m) from edges of core wetlands. Included are a core habitat and conservation zone in adjacent Union Vale and contiguous areas of concern in adjacent Union Vale and LaGrange. Hudsonia Ltd., 2009.

FENS AND CALCAREOUS WET MEADOWS

Target Areas

We mapped 17 fens and 45 calcareous wet meadows in Beekman (Figure 9); many were concentrated in the north central part of town. These habitats can only be confidently distinguished from other wet meadow habitats by field observations, however, so we suspect that there are additional fens and calcareous wet meadows on properties that we did not visit. We have flagged some possible (not confirmed) fen locations with question marks on the habitat map. Unmapped fens could occur in low-elevation areas with calcareous bedrock or soils, including edges or interiors of calcareous wet meadows, swamps, marshes, or wet meadows, or upper edges of stream floodplains and at the bases of ridges. In particular, the south central part of Beekman (on either side of Route 216) has the potential to support additional fens and calcareous wet meadows.

Conservation Issues

Fens and calcareous wet meadows are uncommon in the northeastern U.S. and many provide important habitat for plant and animal species of conservation concern (see Appendix C). One of the most imperiled species associated with fens in Dutchess County is the bog turtle,* listed as Endangered in New York and Threatened on the federal list. Fens are the core habitat of the bog turtle in Dutchess County, and the entire wetland matrix in which some fens occur is considered potential bog turtle habitat. In particular, calcareous wet meadows that are adjacent to fens provide good habitat for bog turtle. Few of the remaining fens in this region currently support bog turtle populations, apparently due to degradation of the fens and the surrounding landscapes (and perhaps due to illegal collecting of the species). Bog turtle has been rediscovered recently in Orange County, but is believed to be extinct (or nearly so) in Westchester and Rockland counties. There are historical records of bog turtles in the town and any of the high-quality fens could serve as bog turtle habitat. We recommend, therefore, that all fens, adjacent calcareous wet meadows, and the larger wetlands of which they are part be considered potential bog turtle habitat (Klemens 2001) and that the special protective measures discussed below be implemented to safeguard the integrity of these sensitive areas.

Fens are maintained by calcareous groundwater seepage. Alterations to the quality or quantity of groundwater or surface water feeding the fen can alter the soil characteristics, vegetation structure, or plant community composition, and can render the habitat unsuitable for bog turtle and other species of conservation concern. Thus, even if the fen itself is not disturbed directly, it can be severely affected by activities in surrounding areas. Furthermore, although bog turtles spend most of their lives in fens and associated wetlands, they also require safe travel corridors between fens for dispersal and migration. In New York, bog turtles may travel overland 2,500 ft (760 m), or nearly one-half mile, between individual wetlands within a habitat complex (Eckler and Breisch 1990). Maintaining connections to other wetland habitats within a one-half mile radius of a known or potential bog turtle habitat may be crucial to sustaining the long-term genetic viability of bog turtle populations and the ability of individuals to relocate as habitat quality changes.

Recommendations

The Town of Beekman has numerous fens and, along with neighboring towns, is in a position to implement a conservation plan with far-reaching consequences for biodiversity in the region. Conservation of fens requires attention both to the fen itself and to surrounding land uses. Because some of the fen complexes (and their associated conservation zones) cross multiple privately-owned parcels, fen conservation also requires coordinating across property boundaries. Fens that are known to harbor the bog turtle, or may serve as potential habitat for the turtle, require special protective measures to safeguard wetland habitat quality and turtle travel corridors. The U.S. Fish and Wildlife Service recommends the following (adapted from Klemens 2001):

1. **Protect the wetland habitat**. The entire wetland, not just those portions that have been identified as, or appear to be, optimal for nesting, basking, or hibernating, should be protected from direct destruction and degradation. The following activities (not a comprehensive list) should be avoided within the wetland:
    - development of any kind;
    - wetland draining, ditching, tiling, filling, excavation, stream diversion, or construction of impoundments;
    - herbicide, pesticide, or fertilizer application (except as part of an approved bog turtle management plan);

- mowing or cutting of vegetation (except as part of an approved bog turtle management plan);
- delineation of lot lines for development, even if the proposed building or structure will not be in the wetland.

2. **Establish a 300 ft (90 m) buffer zone**. A protective "buffer" around known or potential bog turtle wetlands will help prevent or minimize the effects of human activities. Activities in this zone could indirectly destroy or degrade the fen habitat over the short or long term and should be thoroughly evaluated in consultation with the U.S. Fish and Wildlife Service and the NYS DEC. Activities in this zone that may adversely affect bog turtles and their habitats include but are not limited to:
    - construction of roads, residences, driveways, parking lots, sewer lines, utility lines, stormwater or sedimentation basins, or other structures;
    - mining;
    - herbicide, pesticide, or fertilizer application;
    - farming (with the exception of light to moderate grazing);
    - stream bank stabilization (e.g., rip-rapping).
3. **Assess potential impacts within at least 2,500 ft (750 m) of the fen**. Despite the distance, development activities occurring within the drainage basin of the fen or at least one-half mile from the boundary of the buffer zone may adversely affect bog turtles and their habitat. Development within this area may also sever important travel corridors between wetlands occupied or likely to be occupied by bog turtles, thereby isolating populations and increasing the likelihood of road mortality as turtles attempt to disperse.
    - Activities such as the construction of roads and other impervious surfaces, groundwater extraction (e.g., wells), septic/sewer facilities, and mining have a high potential to alter the hydrology and chemistry of the fen habitat.
    - Construction of new roads and bridges should be avoided within this area.
    - Existing roads with medium to high volume traffic may be ideal candidates for "turtle underpasses" that are intended to provide safer road crossings for this species.

WETLAND COMPLEXES

Target Areas

A wetland complex is any group of adjacent and nearby swamps, marshes, wet meadows, ponds, other wetland types, or streams. Characteristics that lend especially high biodiversity value to wetland complexes are large size, inclusion of a wide variety of wetland types, and intact upland habitat between wetlands. Large varied wetland complexes occur along Fishkill Creek (including large swamps and fens) and along Hynes Road (which also includes fens). Other large

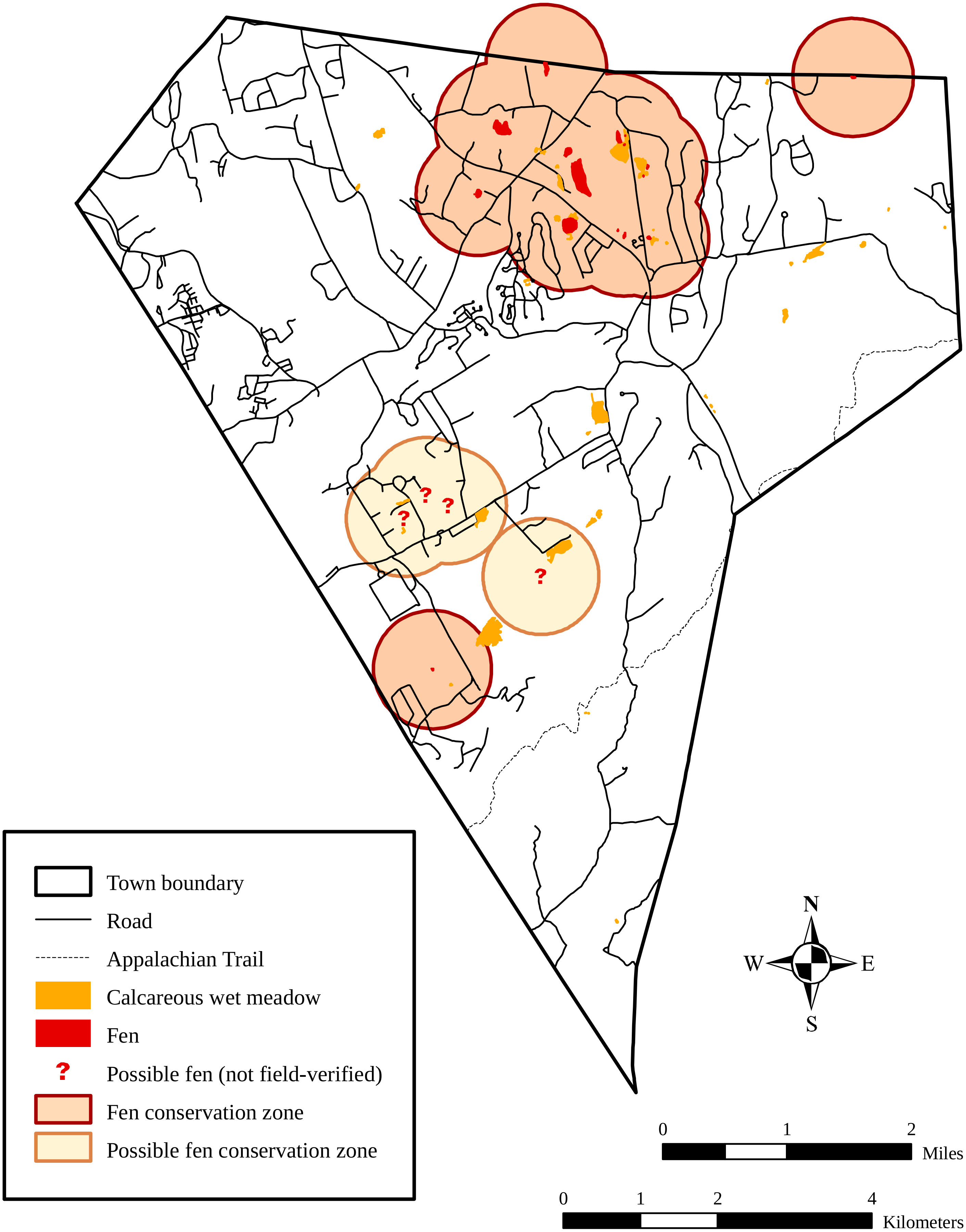


Figure 9. Calcareous wet meadows, fens, possible fens (not field-verified), and associated conservation zones in the Town of Beekman, Dutchess County, New York. Fen conservation zones extend 2,500 ft (750 m) from the fen edge. Hudsonia Ltd., 2009.

complexes were found in Frog Hollow on both sides of South Green Haven Road (including one fen), near the junction of Depot Hill and Grape Hollow roads (including the largest marshes in the town), and east of Pleasant Ridge Road on the north and south sides of Gardner Hollow Road (including the Prison Reservoir). The many small, often isolated wetlands (mostly swamps and intermittent woodland pools) in the eastern highlands exemplify wetland complexes with intact intervening upland habitats (Figure 10).

Conservation Issues

Many animals move among several types of wetland and upland habitats throughout the year. For instance, spotted turtle* (NYS Special Concern) is a highly mobile species that depends on a variety of habitats to survive and reproduce. It is known to use marsh, fen, wet meadow, hardwood and shrub swamp, shrub pool, intermittent woodland pool, and open water habitats within a single year (Fowle 2001). Furthermore, although it depends on a large number of wetlands, spotted turtle may spend up to three-quarters of its time during the active season in uplands. This species follows an annual pattern of activity (which likely varies by individual, population, and region): it usually overwinters in bottomland hardwood swamps or wet meadows, spends spring and early summer in one to several seasonal and permanent pools, travels up to 1,870 ft (570 m) to nest in open upland habitat, and spends late summer aestivating (quiescent) in upland forest. It can travel 3,300 ft (1,000 m) or more between wetlands. Because of this intricate annual pattern of habitat use, whole complexes of wetland and upland habitats are required to support spotted turtle populations, including seasonal wetlands such as intermittent woodland pools (Joyal et al. 2001, Milam and Melvin 2001). The spotted turtle exemplifies mobile wildlife species that depend on a mosaic of wetland and upland habitats and require safe travel routes between those habitats.

Recommendations

1. **Protect intermittent woodland pools, fens, kettle shrub/buttonbush pools, and their conservation zones** as described in previous sections of this report. These habitats are used by spotted turtle (and many other species).
2. **When the above habitats are located within 3,300 ft (1,000 m) of a swamp, marsh, or wet meadow (wintering habitat), protect the intervening upland habitats**. These

upland areas encompass spotted turtle travel corridors, and nesting, aestivation (summer dormancy), and basking sites.

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

Wet meadow

STREAMS AND RIPARIAN CORRIDORS

Target Areas

Fishkill Creek and its tributaries Frog Hollow Brook, Gardner Hollow Brook, Whortlekill Creek, and Whaley Lake Stream, are the largest perennial waterways in Beekman. There are also several smaller perennial streams and numerous intermittent streams throughout the town, which provide habitat for many plants and animals (both resident and transient), and are important to the ecology of the entire stream watersheds (Figure 11).

Conservation Issues

Low gradient, perennial streams can be essential core habitat for the wood turtle (NYS Special Concern). Wood turtles use streams with overhanging banks, muskrat burrows, submerged logs, or other underwater shelter for overwintering. In early spring, they use logs and stream banks for basking. In late spring and summer, wood turtles (especially females) move into and beyond the adjacent riparian zone to bask and forage in a variety of wetland and upland habitats, and females may travel long distances from their core stream habitat to find open, sparsely vegetated upland nesting sites.

Conserving wood turtle populations requires protecting not only their core habitat (the perennial stream), but also their riparian wetland and upland foraging habitats, upland nesting areas, and the migration corridors between these habitats. The wood turtle habitat complex can encompass the wetland and upland habitats within 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, and preserve other ecosystem processes (Saunders et al. 2002).

Recommendations

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

1. **Protect the integrity of stream habitats**.
    - Prohibit engineering practices that alter the physical structure of the stream channel such as stream channelization, artificial stream bank stabilization (e.g., rock rip-rap, concrete), construction of dams or artificial weirs, vehicle crossing (e.g., construction or logging equipment, ATVs), and the clearing of natural stream bank vegetation. 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.
2. **Protect riparian wetland and upland 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**. 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 wood turtle passage.
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 limit the reproductive success of the turtles over the long term. We recommend that large areas of potential nesting habitat within the 660 ft (200 m) stream conservation zone (e.g., upland meadows, upland shrublands, waste ground with exposed gravelly soils) be protected from development and other disturbance.

Small perennial stream

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. Blanding's turtles* (NYS Threatened) sometimes nest in lawns and gardens.

There are many landscape modifications and land use practices that can be applied to the developed parts of Beekman 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) as habitats in their own right due to our mapping protocols at a town-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. The town can take a leading role in educating the general public about such actions and encouraging landowner participation.

ENHANCING HABITAT CHARACTERISTICS

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

2. ***Replace lawn areas with multi-layered landscapes.*** Manicured lawns have little biodiversity value and their maintenance requires higher inputs of water and chemicals than other types of horticultural landscaping, such as native wildflower meadows, perennial gardens, or ornamental woodlands. Lawns are usually maintained with motorized lawn mowers, which contribute to air and noise pollution. Wildflower meadows will not only help to support native animals, but their maintenance requires less mowing, and thus produces fewer carbon emissions to the atmosphere. Use of native species ornamental plantings is important, as 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 ornamentals are invasive species. 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.

MINIMIZING DISTURBANCE TO RESIDENT AND MIGRATORY BIOTA

1. ***Minimize the impacts of roads on wildlife.*** One of the greatest immediate threats to wildlife in suburban areas is road mortality. A study to identify roadways with the highest incidence of wildlife mortality could be used to direct the following measures to the places where they will be most effective. The maps of conservation zones in this report could also inform such efforts (e.g., roads within conservation zones for intermittent woodland pools could be priorities for facilitating amphibian crossings).
    - Reduce speed limits and post wildlife crossing signs along 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 light in cities and in residential and commercial areas can be a deterrent to 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 lights) that minimize the attraction of flying insects, and prohibit the use of "bug-zappers."

3. ***Discourage human-sponsored predators, including domestic cats and dogs.*** Human-sponsored predators are species such as raccoon, opossum, and striped skunk, whose populations often burgeon in response to conditions created by humans. 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 indoors 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 or chain-link fences (excluding those designed to prevent access to pitfalls), and design or modify them to have spaces or openings to allow safe passage.
- Encourage building designs that minimize harm to wildlife. For example, consult New York City Audubon's publication "Bird-Safe Building Guidelines" (Brown and Caputo 2007) when planning building construction and renovation.

CONSERVATION AREAS IN BEEKMAN

The Town of Beekman has a great diversity of habitats distributed throughout the town. To synthesize the information presented above, and to facilitate discussion of conservation priorities, we have divided the town into five "conservation areas," each with a unique character and combination of priority habitats (Figure 12). We hope that this approach will help to illustrate the larger ecological context of particular locations, and will help to focus local conservation efforts on those measures most appropriate to each conservation area. For discussion of conservation issues and recommendations for each habitat type, refer to the preceding sections.

Eastern Highlands

Including the ridges and high hills in the town's easternmost section, this area encompasses more than one third of the town's total area. The Eastern Highlands include the Depot Hill and Grape Hollow areas (extending west to approximately the railroad tracks), the Nuclear Lake area (between Route 55 and Gardner Hollow Road, extending west to Pleasant Ridge Road), and the West Mountain area (the northeastern corner of the town, west to approximately Sterling Drive). The Appalachian National Scenic Trail traverses portions of the Depot Hill and Nuclear Lake areas. Much of the land in the Eastern Highlands is in federal and state ownership, including parcels adjacent to the Appalachian Trail and West Mountain State Forest. Most of this rugged, relatively undeveloped area is included in the New York State Department of Environmental Conservation's Highlands Significant Biodiversity Area, which is noted for its largely contiguous landscape of forests and wetlands linking the mid-Atlantic states to New England. In southeastern Dutchess County, the Highlands also serve as a link between the Dutchess County Wetlands and the Harlem Valley Calcareous Wetlands Significant Biodiversity Areas (Penhollow et al. 2006). The Eastern Highlands include the highest elevations in Beekman (exceeding 1,300 ft [395 m]), many areas of steep slopes, and the following conservation priorities:

- The four largest contiguous habitat areas in the Town of Beekman, the largest of which is west of Grape Hollow and Depot Hill roads and exceeds 1,850 ac (748 ha). These and other large habitat patches in the area are separated by relatively little development. The Eastern Highlands is by far the least developed part the town.

- The four largest contiguous forest areas in the town (the largest is approximately 1,725 ac [nearly 700 ha]). The forests in the Eastern Highlands varied greatly in species composition, but most areas were dominated by hardwoods. At higher elevations dry oak-hickory communities were prevalent, while lower elevations had a greater variety of hardwoods (e.g., maples, birches, American beech) and higher incidences of non-native shrubs and herbs in the understory. We noted the occasional occurrence of uncommon understory plants such as broad beech fern in upland forested areas, maidenhair fern in rich forests, and small purple fringed orchis* in one forested wetland. We also encountered area-sensitive breeding birds such as red-shouldered hawk,* scarlet tanager,* hermit thrush,* wood thrush,* and cerulean warbler* in these forested areas. The large, variable forested areas of the Eastern Highlands provide suitable habitat for a variety of wide-ranging reptiles and small and large mammals. The Nuclear Lake Management Site Clearance Subcommittee (1982) reported that bobcat and other forest birds of conservation concern—northern goshawk, ruffed grouse, black-throated-blue warbler, worm-eating warbler, and Canada warbler—have been observed near Nuclear Lake in the past.
- Eighty-three intermittent woodland pools and pool-like swamps, which are potential breeding pools for Jefferson,* blue-spotted,*and marbled salamanders,* and wood frog.* Along with intervening upland habitats, these typically small wetlands form complexes with each other and other types of wetlands in the Eastern Highlands, providing potential habitat for species such as spotted turtle.* We observed breeding wood frogs* and eastern ribbon snake* in association with vernal pools in the Eastern Highlands.
- At least ten small patches of oak-heath barren habitat. This is a rare habitat type in southeastern New York, occurring only in relatively high elevation areas with exposed bedrock or shallow soils, and droughty conditions. The Eastern Highlands are the only part of the town where this habitat occurs. Oak-heath barrens and other crest habitats may be of particular importance to snakes of conservation concern for basking and breeding.

- Extensive ledge and talus formations in steep terrain. Uncommon plant species such as shining clubmoss and red elderberry were found in association with acidic rocky habitats in the highlands.
- Several large water bodies and associated wetland complexes. Prison Reservoir, Nuclear Lake (which extends beyond the town's boundary), and Ludington Lake are among the largest open water bodies in the town. The three beaver ponds near the junction of Depot Hill and Grape Hollow roads represent the largest occurrences of marsh habitat in the town. Both vegetated (marsh) and unvegetated large water bodies provide habitat for many fish and waterfowl species. We observed a northern water snake, American black duck,* and great blue heron* in association with these water bodies.
- Several perennial streams and many intermittent streams. Some of the perennial streams, may provide suitable habitat for wood turtle.* Gardner Hollow Brook (along with its largest tributaries), designated by New York State as a Class A stream (i.e., used as a source of drinking water), flows into the Prison Reservoir. This stream is known to support wild-reproducing brook trout, and may also support slimy sculpin* (Kiviat 2007). We observed Louisiana waterthrush, a species associated with the healthy invertebrate communities of clean streams, feeding in both small perennial and large intermittent streams in the Highlands area. Many of the streams in the Highlands are fed in part by springs and seeps, and represent the headwaters of larger streams in other parts of Beekman and surrounding towns.

Pleasant Ridge

This area includes three north-south running ridges, and the hill south of Gardner Hollow Road (between Pleasant Ridge Road and Route 55). Due to much widely dispersed residential development, habitat patches in the Pleasant Ridge area are relatively small and isolated. Recommendations for enhancing the habitat characteristics of such settled landscapes are given above (see enhancement of developed areas section). Streams draining this area are vulnerable to high volumes of surface runoff from developed areas. Because these streams feed wetlands and larger streams in other parts of the town it is important that their water quality be protected. Priority habitat types in this part of Beekman include:

- The northwestern corner of the conservation area is part of a habitat patch of approximately 230 ac (90 ha). This mostly forested area has steep, rocky slopes including extensive ledges and talus, some of which is calcareous. Two areas east of Pleasant Ridge Road are part of the large (>1,100 ac [445 ha]), contiguous habitat patch in the northeastern corner of the town (including West Mountain State Forest lands).
- Two Class A perennial streams flow through the Pleasant Ridge conservation area. These are tributaries to Gardner Hollow Brook which feeds the Prison Reservoir.

Clove Valley Fen Complex

The northern portion of the Fishkill Creek valley, including areas around Route 55, Hynes Road, and Clove Valley Road, can be defined as a fen complex. This area (and the rest of the valley) is underlain by limestone and dolostone bedrock, supporting natural communities that are adapted to calcareous conditions, such as fens and calcareous wet meadows. Much of the area is fragmented by roads and buildings, but some of the undeveloped areas are underlain by Prime Farmland Soils or Farmland Soils of Statewide Importance, and some areas include the following priority habitat types:

- Numerous fens, calcareous wet meadows, and their associated wetlands. Fens and calcareous wetlands in this area varied in size and plant communities (e.g., some fens had high shrub cover), but in general appeared to be high quality habitats for rare plants and animals such as bog turtle.* We documented occurrences of swamp birch (NYS Threatened) in three of the fens in this area. The fens and calcareous wetlands were often adjacent to other types of wetlands (e.g., swamp, marsh, stream, pond), forming larger contiguous wetland areas. Along with intervening upland areas, these habitats form large wetland complexes that cover nearly the entire conservation area (see Figure 11).
- Fishkill Creek and several perennial and intermittent tributaries. Fishkill Creek is the largest perennial stream in the Town of Beekman. In the Clove Valley Fen Complex conservation area it flows out of Furnace Pond and southward through the town. Several perennial tributaries flow directly into Fishkill Creek in this area, and another flows south to join Whaley Lake Stream.
- One large meadow (ca. 43 ac [17 ha]).

- Limestone knolls and small outcrops (calcareous crest/ledge/talus), which can support rare plant species of calcium-rich environments.

Fishkill Creek Valley/ Frog Hollow

Encompassing the southern and central portions of the largest valley in the town, this lowland area is underlain by limestone and dolostone. The rich valley has attracted intensive human land uses (such as agriculture and residential development), but still supports habitats of conservation concern, including:

- Numerous large meadows, which are potential habitat for grassland breeding birds. The meadows in this area are the largest in the town, including all single meadows greater than 50 ac (20 ha) and all contiguous meadows (without regard to fences or hedgerows) greater than 100 ac (40 ha). Much of this area is underlain by Prime Farmland Soils or Farmland Soils of Statewide Importance.
- Several perennial streams: Fishkill Creek, Frog Hollow Brook, Flat Rock Brook, Whaley Lake Stream (lower portion), and various unnamed perennial tributaries. This network of perennial streams in a lowland area provides valuable habitat to species such as wood turtle.* The Fishkill Creek floodplain is broad in places (see Sullivan and Stevens 2005), and has large floodplain forests, meadows, and other habitats. Wetlands and wetland complexes in this area are mostly associated with perennial streams.
- A fen and several calcareous wet meadows. It is likely that other yet unidentified fens exist in this part of town. Calcareous wet meadows were relatively common in the Frog Hollow area (the southeastern portion of this conservation area). The Frog Hollow wetlands are adjacent to the Dutchess County Wetlands Significant Biodiversity Areas (Penhollow et al. 2006).

Western Hills/ Sylvan Lake

This area include all lands west of the Fishkill Creek valley in the Town of Beekman. The area is characterized by numerous low hills; the highest of these—Clapp Hill—reaches nearly 900 ft (270 m). Moderate to intensive development is distributed largely along the main roads throughout this area. Conservation priorities in this area include:

- Two large contiguous habitat areas: an area over 1,000 ac (400 ha) between Sylvan Lake and Martin Roads, and an area of approximately 630 ac (255 ha) between Route 55 and Clapp Hill Road/Baker Road. These areas are largely forested, and represent the largest contiguous forest patches east of the Fishkill Creek valley within the town. We noted some large trees as well as red-shouldered hawk,* scarlet tanager,* and yellow-billed cuckoo in these forests.
- Two potential Blanding's turtle* core wetlands, and the conservation zone of an additional core wetland in nearby Union Vale. Many potential nesting areas and associated wetlands (within the turtle's travel distance from its core wetlands) are also found in this area. Nearby wetlands include a small buttonbush pool, two small kettle shrub pools, and Sylvan Lake–the largest body of water in the town.
- Whortlekill Creek. This stream has its headwaters near Clapp Hill Road, and flows perennially for most of its length within the town. It has several intermittent tributaries and areas of seepy streambanks, and may provide habitat for wood turtle.* Another perennial stream near the town's northern boundary flows from around Route 55 westward in to Jackson Creek and then into Sprout Creek.
- Thirty intermittent woodland pools and small pool-like swamps. These form large wetland complexes with other wetlands and intervening uplands, most concentrated in the northern and southern portions of this conservation area.
- Several moderately sized meadow areas, as well as orchards which have some of the habitat characteristics of meadows. Some of the undeveloped portions of this conservation area are underlain by Prime Farmland Soils and Farmland Soils of Statewide Importance.

REVIEWING SITE-SPECIFIC LAND USE PROPOSALS

In addition to town-wide land use and conservation planning, the habitat map and report can be used for reviewing site-specific development 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.
3. Consult figures 4-11 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, fens, or other 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.
    - 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 Town of Beekman. 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. 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 “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, such as the location and extent of remaining unfragmented habitat blocks, areas where fens or other rare habitats occur, and the patterns of habitat fragmentation caused by roads and private residential development. This kind of general information can help the town consider where future development should be concentrated and where future conservation efforts should be targeted. An understanding of the significant ecological resources in the town will enable local decision makers to focus limited conservation resources where they will have the greatest impact.

At the site-specific scale, we hope the map will be used 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 town should consider refining and/or updating the habitat map over time.

After presenting the completed habitat map, database, and report to the Town of Beekman, 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 town, and devising ways to integrate this new information into land use planning and decision making.

Conservation of habitats is one of the best ways to protect biological resources. We hope that the information contained in the habitat map and in this report will help the Town of Beekman plan wisely for future development while taking steps to protect biological resources. Incorporating this approach into planning and decision making will help to minimize the adverse effects of human activities on the landscape, integrate the needs of the human community with those of natural communities, and protect the ecological patterns and processes that support us and the rest of the living world.

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APPENDICES

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

Buttonbush pools and kettle shrub pools. Both of these wetlands are fairly deep-flooding, isolated from perennial streams, and have a shrub-dominated flora with buttonbush normally the dominant plant. We define kettle shrub pool as a specific type of shrub pool that is located in a glacial kettle—a depression formed by the melting of a stranded block of glacial ice. Since kettles can be difficult to identify definitively, in the absence of information on a shrub pool's origin we classify those that have deep, mucky substrates and are found within 490 ft (150 m) of mapped glacial outwash soils as kettle shrub pools.

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 Faber (2002). 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. 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 bodies of open water in our region were probably created by damming or excavation, and were mapped as constructed ponds. Those that we mapped as "open water" habitats 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 Town of Beekman 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 large 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. Streams that were channelized or diverted by humans (i.e., ditches) were mapped when observed in the field or on aerial photos; we mapped ditches as "streams" because they function as such from a hydrological perspective.

Upland 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. Hardwood and coniferous trees are generally distinguishable in aerial photos taken in the spring, although 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 upland 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 town, 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. In the Fishkill Creek Corridor we mapped some of these ambiguous areas of floodplain forest as swamp, while in other parts of the town we mapped them as upland forest.

Map updates in Fishkill Creek corridor. In 2005 Hudsonia published a map and report on significant habitats in a 2000-meter-wide corridor along Fishkill Creek (Sullivan and Stevens 2005). In the current project we updated some aspects of the habitat map for this 3,900 ac (1,600 ha) section of the town, but conducted no new site visits. These changes were intended to provide consistency in mapping protocols at the boundaries between the two study areas (see other sections of this appendix), and to provide some coarse updates to the corridor map to improve the general accuracy of the town-wide map analysis. However, the map in the Fishkill Creek corridor area still largely reflects the habitat conditions during 2003-2005 (for instance, mapped red cedar woodlands may have since grown to become upland forests, and areas of forest may have been cleared to become meadows). Updates made to the entire corridor area were: 1) the inclusion (or line correction) of “new” developments that were visible on spring 2004 aerial photos (but not the spring 2000 aerial photos used during the original corridor mapping); 2) boundary corrections for expanded/altered large constructed ponds (as visible on 2004 aerial photos); 3) connection of stream lines through water bodies, wetlands, and short underground distances; 4) depicting streams >10 m in width as polygons; 5) division of forest areas by dirt or mowed roads, and meadow areas by fences, hedgerows, and tree lines; 6) re-naming of habitats according to current protocols (e.g., changing a water body labeled as constructed pond to open water); 7) and replacement of roads with newer, town-wide roads data. The main updates made along the boundaries of the two study areas were the removal of habitat patches less than 150 ft (<50 m) wide (and otherwise surrounded by developed areas), and other adjustment of developed area boundaries to match the current map’s boundaries.

Appendix B. Explanation of ranks of species of conservation concern listed in Appendix C. Explanations of New York State Ranks and New York Natural Heritage Program Ranks are from the New York Natural Heritage Program website, accessed in 2008 (http://www.dec.ny.gov/animals/29338.html).

NEW YORK STATE RANKS

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

ANIMALS

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

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

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

PLANTS

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

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

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

NEW YORK NATURAL HERITAGE PROGRAM RANKS – ANIMALS AND PLANTS

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

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

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

S4 Apparently secure in New York State.

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

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

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

Species that meet one or more of the following criteria (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 Town of Beekman. 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.)***
pinesap (RG)	Blanding's turtle (T, S2S3, SGCN)	cerulean warbler (SC, PIF1, SGCN)
silvery spleenwort (RG)	eastern racer (SGCN)	Canada warbler (PIF1, SGCN)
Back's sedge (T)	eastern rat snake (SGCN)	Kentucky warbler (S2, PIF1, SGCN)
American ginseng (RG)	northern goshawk (SC, S3N, SGCN)	black-and-white warbler (PIF2)
red baneberry (RG)	red-shouldered hawk (SC, SGCN)	black-throated blue warbler (SGCN)
poke milkweed (RG)	Cooper's hawk (SC, SGCN)	black-throated green warbler (RG)
lopseed (RG)	sharp-shinned hawk (SC, SGCN)	worm-eating warbler (SGCN)
leatherwood (RG)	broad-winged hawk (RG)	hooded warbler (RG)
hackberry (RG)	ruffed grouse (SGCN)	ovenbird (RG)
Vertebrates	American woodcock (PIF1, SGCN)	scarlet tanager (PIF2, SGCN)
wood frog (RG)	barred owl (RG)	southern bog lemming (RG)
spotted salamander (RG)	whip-poor-will (SC, PIF2, SGCN)	Indiana bat (E, S1, SGCN)
Jefferson salamander (SC, SGCN)	eastern wood-pewee (PIF2)	black bear (RG)
blue-spotted salamander (SC, SGCN)	Acadian flycatcher (S3)	bobcat (RG)
marbled salamander (SC, S3, SGCN)	wood thrush (PIF1, SGCN)	New England cottontail (SC, S1S2, SGCN)
eastern box turtle (SC, S3, SGCN)	hermit thrush (SGCN)	fisher (RG)

UPLAND CONIFER FOREST		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
pinesap (RG)	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)	pine siskin (RG)
Cooper's hawk (SC, SGCN)	barred owl (RG)	evening grosbeak (RG)
sharp-shinned hawk (SC, SGCN)	red-breasted nuthatch (RG)	purple finch (PIF2)

RED CEDAR WOODLAND		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
Carolina whitlow-grass (T, S2)	wood turtle (SC, S3, SGCN)	short-eared owl (E, S2, PIF1, SGCN)
yellow wild flax (T, S2)	Blanding's turtle (T, S2S3, 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)
Invertebrates	ruffed grouse (SGCN)	golden-winged warbler (SC, PIF1, SGCN)
olive hairstreak (butterfly) (RG)	black-billed cuckoo (SGCN)	blue-winged warbler (PIF1, SGCN)
Vertebrates	northern saw-whet owl (S3)	eastern towhee (PIF2)
spotted turtle (SC, S3, SGCN)	long-eared owl (S3, SGCN)	

NON-CALCAREOUS CREST/LEDGE/TALUS

Plants
mountain spleenwort (T, S2S3)
Bicknell's sedge (T, S3)
bronze sedge (RG)
clustered sedge (T, S2S3)
reflexed sedge (E, S2S3)
whorled milkweed (RG)
blunt-leaf milkweed (RG)
rock sandwort (RG)
goat's-rue (RG)
slender knotweed (R, S3)
dittany (RG)
Torrey's mountain-mint (E, S1)
Allegheny-vine (RG)
three-toothed cinquefoil (RG)
stiff-leaf aster (RG)

Invertebrates
Edward's hairstreak (butterfly) (S3S4)
striped hairstreak (butterfly) (RG)

Invertebrates (cont.)
brown elfin (butterfly) (RG)
olive hairstreak (butterfly) (RG)
northern hairstreak (butterfly) (S1S3, SGCN)
gray hairstreak (butterfly) (RG)
Horace's duskywing (butterfly) (RG)
swarthy skipper (butterfly) (RG)
Leonard's skipper (butterfly) (RG)
cobweb skipper (butterfly) (RG)
dusted skipper (butterfly) (S3)

Vertebrates
Fowler's toad (SGCN)
northern slimy salamander (RG)
marbled salamander (SC, S3, SGCN)
eastern box turtle (SC, S3, SGCN)
eastern rat snake (SGCN)
eastern racer (SGCN)
eastern hognose snake (SC, S3, SGCN)
eastern worm snake (SC, S2, SGCN)

Vertebrates (cont.)
copperhead (S3, SGCN)
timber rattlesnake (T, S3, SGCN)
turkey vulture (RG)
golden eagle (E, SHB, S1N, SGCN)
whip-poor-will (SC, PIF2, SGCN)
black vulture
common raven (RG)
winter wren (RG)
eastern bluebird (RG)
hermit thrush (RG)
Blackburnian warbler (PIF2)
cerulean warbler (SC, PIF1, SGCN)
worm-eating warbler (PIF1, SGCN)
small-footed bat (SC, S2, SGCN)
boreal redback vole (RG)
porcupine (RG)
fisher (RG)
bobcat (RG)

CALCAREOUS CREST/LEDGE/TALUS

Plants
purple cliffbrake (RG)
walking fern (RG)
smooth cliffbrake (T, S2)
wall-rue (RG)
side-oats grama (E, S1)
Emmons' sedge (S3)
Bicknell's sedge (T, S3)
yellow wild flax (T, S2)

Plants (cont.)
Carolina whitlow-grass (T, S2)
hairy rock-cress (RG)
yellow harlequin (S3)
Dutchman's breeches (RG)
pellitory (RG)
northern blazing-star (T, S2)
small-flowered crowfoot (T, S3)
roundleaf dogwood (RG)

Invertebrates
anise millipede (RG)
olive hairstreak (butterfly) (RG)

Vertebrates
eastern hognose snake (SC, S3, SGCN)
eastern racer (SGCN)
eastern rat snake (SGCN)
copperhead (S3, SGCN)

OAK-HEATH BARREN

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

Invertebrates
brown elfin (butterfly) (RG)
cobweb skipper (butterfly) (RG)

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

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

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

UPLAND SHRUBLAND

Plants
stiff-leaf goldenrod (RG)
shrubby St. Johnswort (T, S2)
butterflyweed (RG)

Invertebrates
Aphrodite fritillary (butterfly) (RG)
cobweb skipper (butterfly) (RG)
dusted skipper (butterfly) (S3)
Leonard's skipper (butterfly) (RG)

Vertebrates
wood frog (RG)
spotted turtle (SC, S3, SGCN)
eastern box turtle (SC, S3, SGCN)

Vertebrates (cont.)
wood turtle (SC, S3, SGCN)
Blanding's turtle (T, S2S3, SGCN)
northern harrier (T, S3B, S3N, SGCN)
ruffed grouse (SGCN)
black-billed cuckoo (SGCN)
short-eared owl (E, S2, PIF1, SGCN)
northern saw-whet owl (S3)
whip-poor-will (SC, PIF2, SGCN)
willow flycatcher (SGCN)
brown thrasher (PIF2, SGCN)
loggerhead shrike (E, S1B, SGCN)
white-eyed vireo (RG)

Vertebrates (cont.)
blue-winged warbler (PIF1, SGCN)
golden-winged warbler (SC, PIF1, SGCN)
prairie warbler (PIF1, SGCN)
yellow-breasted chat (SC, S3, SGCN)
clay-colored sparrow (S2)
vesper sparrow (SC, SGCN)
field sparrow (PIF2)
grasshopper sparrow (SC, PIF2, SGCN)
Henslow's sparrow (T, S3B, PIF1, SGCN)
eastern towhee (PIF2)
New England cottontail (SC, S1S2, SGCN)

UPLAND MEADOW		
Plants	***Invertebrates (cont.)***	***Vertebrates (cont.)***
small-flowered agrimony (S3)	swarthy skipper (butterfly) (RG)	sedge wren (T, S3B, PIF2, SGCN)
Bush's sedge (S3)	***Vertebrates***	eastern bluebird (RG)
Invertebrates	spotted turtle (SC, S3, SGCN)	savannah sparrow (RG)
Baltimore (butterfly) (RG)	eastern box turtle (SC, S3, SGCN)	vesper sparrow (SC, SGCN)
meadow fritillary (RG)	wood turtle (SC, S3, SGCN)	grasshopper sparrow (SC, PIF2, SGCN)
Aphrodite fritillary (butterfly) (RG)	Blanding's turtle (T, S2S3, SGCN)	Henslow's sparrow (T, S3B, PIF1, SGCN)
dusted skipper (butterfly) (S3)	northern harrier (T, S3B, S3N, SGCN)	bobolink (SGCN)
Leonard's skipper (butterfly) (RG)	upland sandpiper (T, S3B, PIF1, SGCN)	eastern meadowlark (SGCN)

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

SWAMP		
Plants	***Vertebrates (cont.)***	***Vertebrates (cont.)***
swamp cottonwood (T, S2)	four-toed salamander (SGCN)	American woodcock (PIF1, SGCN)
swamp lousewort (T, S2)	spotted turtle (SC, S3, SGCN)	red-shouldered hawk (SC, SGCN)
winged monkey-flower (R, S3)	wood turtle (SC, S3, SGCN)	barred owl (RG)
wood horsetail (RG)	eastern box turtle (SC, S3, SGCN)	willow flycatcher (SGCN)
false hop sedge (R, S2)	Blanding's turtle (T, S2S3, SGCN)	white-eyed vireo (RG)
Invertebrates	great blue heron (RG)	eastern bluebird (RG)
phantom cranefly (RG)	American bittern (SC, SGCN)	prothonotary warbler (S2, PIF1, SGCN)
Vertebrates	wood duck (PIF2)	Canada warbler (PIF1, SGCN)
blue-spotted salamander (SC, SGCN)	Virginia rail (RG)	northern waterthrush (RG)

BUTTONBUSH POOL/KETTLE SHRUB POOL		
Plants	***Vertebrates***	***Vertebrates (cont.)***
Helodium paludosum (moss) (RG)	wood frog (RG)	Blanding's turtle (T, S2S3, SGCN)
pale alkali-grass (RG)	blue-spotted salamander (SC, S3, SGCN)	spotted turtle (SC, S3, SGCN)
short-awn foxtail (RG)	Jefferson salamander (SC, S3, SGCN)	eastern ribbon snake (SGCN)
buttonbush dodder (E, S1)	marbled salamander (SC, S3, SGCN)	wood duck (PIF2)
spiny coontail (T, S3)	spotted salamander (RG)	American black duck (PIF1, SGCN)

MARSH		
Plants	***Vertebrates***	***Vertebrates (cont.)***
winged monkey-flower (R, S3)	northern cricket frog (E, S1, SGCN)	pied-billed grebe (T, S3B, S1N, SGCN)
buttonbush dodder (E, S1)	northern leopard frog (RG)	American black duck (PIF1, SGCN)
spiny coontail (T, S3)	spotted turtle (SC, S3, SGCN)	northern harrier (T, S3B, S3N, SGCN)
Invertebrates	Blanding's turtle (T, S2S3, SGCN)	king rail (T, S1B, PIF1, SGCN)
black dash (butterfly) (RG)	American bittern (SC, SGCN)	Virginia rail (RG)
bronze copper (butterfly) (RG)	least bittern (T, S3B, S1N, SGCN)	sora (RG)
mulberry wing (butterfly) (RG)	great blue heron (RG)	common moorhen (RG)
	wood duck (PIF2)	marsh wren (RG)

WET MEADOW

Invertebrates
Baltimore (butterfly) (RG)
mulberry wing (butterfly) (RG)
black dash (butterfly) (RG)
two-spotted skipper (butterfly) (RG)
meadow fritillary (butterfly) (RG)
bronze copper (butterfly) (RG)
eyed brown (butterfly) (RG)

Invertebrates (cont.)
Milbert's tortoiseshell (butterfly) (RG)
phantom cranefly (RG)

Vertebrates
eastern ribbonsnake (RG, SGCN)
spotted turtle (SC, S3, SGCN)
American bittern (SC, SGCN)

Vertebrates (cont.)
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)
twig-rush (RG)
Schweinitz's sedge (T, S2S3)
handsome sedge (T, S1)
Bush's sedge (S3)
ovate spikerush (E, S1S2)
slender lady's-tresses (RG)
rose pogonia (RG)
showy ladyslipper (RG)
spreading globeflower (R, S3)
scarlet Indian paintbrush (E, S1)
grass-of-Parnassus (RG)
Kalm's lobelia (RG)
bush aster (T, S2)

Plants (cont.)
fringed gentian (RG)
swamp lousewort (T, S2)
roundleaf sundew (RG)
small-flowered agrimony (S3)
bog valerian (E, S1S2)
buckbean (RG)
swamp birch (T, S2)
alder-leaf buckthorn (RG)

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
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)
featherfoil (T, S2)

Invertebrates
black dash (butterfly) (RG)
mulberry wing (butterfly) (RG)
springtime physa (snail) (RG)

Vertebrates
wood frog (RG)
Jefferson salamander (SC, SGCN)
marbled salamander (SC, S3, SGCN)
four-toed salamander
spotted salamander (RG)
spotted turtle (SC, S3, SGCN)

Vertebrates (cont.)
wood turtle (SC, S3, SGCN)
Blanding's turtle (T, S2S3, 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.)
Blanding's turtle (T, S2S3, SGCN)
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
Bush's sedge (S3)
devil's-bit (T, S1S2)

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

Vertebrates
northern dusky salamander (RG)

STREAM & RIPARIAN CORRIDOR

Plants
winged monkey-flower (R, S3)
riverweed (T, S2)
spiny coontail (T, S3)
goldenseal (T, S2)
cattail sedge (T, S1)
Davis' sedge (T, S2)
small-flowered agrimony (S3)
false-mermaid (RG)
swamp rose-mallow (RG)
may-apple (RG)

Invertebrates
Marstonia decepta (snail) (RG)
brook floater (mussel) (T, S1, SGCN)

Invertebrates (cont.)
Pisidium adamsi (fingernail clam) (RG)
Sphaerium fabale (fingernail clam) (RG)
arrowhead spiketail (dragonfly) (S2S3, SGCN)
mocha emerald (dragonfly) (S2S3, SGCN)
sable clubtail (dragonfly) (S1, SGCN)
ostrich fern borer (moth) (SGCN)

Vertebrates
creek chubsucker (fish) (RG)
bridle shiner (fish) (RG)
brook trout (fish) (SGCN)
slimy sculpin (fish) (RG)
northern leopard frog
northern dusky salamander (RG)

Vertebrates (cont.)
wood turtle (SC, S3, SGCN)
great blue heron (RG)
American black duck (PIF1, SGCN)
wood duck (PIF2)
red-shouldered hawk (SC, SGCN)
American woodcock (PIF1, SGCN)
bank swallow (RG)
winter wren (RG)
cerulean warbler (SC, PIF1, SGCN)
Louisiana waterthrush (SGCN)
river otter (SGCN)
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
agrimony, small-flowered	*Agrimonia parviflora*
alder	*Alnus*
alkali-grass, pale	*Puccinellia distans*
Allegheny-vine	*Adlumia fungosa*
arrowhead, broad-leaved	*Sagittaria latifolia*
arrowwood, northern	*Viburnum dentatum* v. *lucidum*
arum, arrow	*Peltandra virginica*
ash, green	*Fraxinus pennsylvanica*
ash, white	*Fraxinus americana*
aspen, quaking	*Populus tremuloides*
aster, bush	*Aster borealis*
aster, stiff-leaf	*Aster linariifolius*
azalea, swamp	*Rhododendron viscosum*
baneberry, red	*Actaea spicata* ssp. *rubra*
barberry, Japanese	*Berberis thunbergii*
basswood	*Tilia americana*
bergamot, wild	*Monarda fistulosa*
birch, black	*Betula lenta*
birch, gray	*Betula populifolia*
birch, swamp	*Betula pumila*
birch, yellow	*Betula alleghaniensis*
blackberry, northern	*Rubus allegheniensis*
blackgum	*Nyssa sylvatica*
bladdernut	*Staphylea trifolia*
blueberry, highbush	*Vaccinium corymbosum*
blueberry, late lowbush	*Vaccinium angustifolium*
bluegrass, Kentucky	*Poa pratensis*
bluejoint	*Calamagrostis canadensis*
bluestem, little	*Schizachyrium scoparium*
bracken	*Pteridium aquilinum*
breeches, Dutchman's	*Dicentra cucullaria*
buckbean	*Menyanthes trifoliata*
buckthorn, alder-leaf	*Rhamnus alnifolia*
butterflyweed	*Asclepias tuberosa*
butternut	*Juglans cinerea*
buttonbush	*Cephalanthus occidentalis*
cattail	*Typha*
cedar, eastern red	*Juniperus virginiana*
cherry, black	*Prunus serotina*
chokeberry	*Aronia*
cinquefoil, shrubby	*Potentilla fruticosa*
cinquefoil, three-toothed	*Potentilla tridentata*
cliffbrake, purple	*Pellaea atropurpurea*
cliffbrake, smooth	*Pellaea glabella*
clubmoss, shining	*Huperzia lucidula*
cohosh, blue	*Caulophyllum thalictroides*
columbine, wild	*Aquilegia canadensis*
coontail, spiny	*Ceratophyllum echinatum*
cottonwood, swamp	*Populus heterophylla*
crowfoot, small-flowered	*Ranunculus micranthus*
deerberry	*Vaccinium stamineum*
devil's-bit	*Chamaelirium luteum*
dittany	*Cunila origanoides*
dodder, buttonbush	*Cuscuta cephalanthi*
dodder, field	*Cuscuta campestris*
dogwood, gray	*Cornus foemina* ssp. *racemosa*
dogwood, red-osier	*Cornus sericea*
dogwood, roundleaf	*Cornus rugosa*
dogwood, silky	*Cornus amomum*
elderberry, red	*Sambucus racemosa*
elm, American	*Ulmus americana*
elm, slippery	*Ulmus rubra*
false-mermaid	*Floerkea proserpinacoides*
featherfoil	*Hottonia inflata*
fern, broad beech	*Thelypteris hexagonoptera*
fern, cinnamon	*Osmunda cinnamomea*
fern, fragile	*Cystopteris fragilis*
fern, maidenhair	*Adiantum pedatum*
fern, marsh	*Thelypteris palustris*
fern, ostrich	*Matteuccia struthiopteris*
fern, sensitive	*Onoclea sensibilis*
fern, Virginia chain	*Woodwardia virginica*
fern, walking	*Asplenium rhizophyllum*
flag, blue	*Iris versicolor*
flax, yellow wild	*Linum sulcatum*
foxtail, short-awn	*Alopecurus aequalis*
gentian, fringed	*Gentianopsis crinita*
ginseng, American	*Panax quinquefolius*
globeflower, spreading	*Trollius laxus*
goat's-rue	*Tephrosia virginiana*
goldenrod, bog	*Solidago uliginosa*
goldenrod, rough-leaf	*Solidago patula*
goldenrod, stiff-leaf	*Solidago rigida*
goldenseal	*Hydrastis canadensis*
grama, side-oats	*Bouteloua curtipendula*
grass-of-Parnassus	*Parnassia glauca*
grass, reed canary	*Phalaris arundinacea*
grass, Indian	*Sorghastrum nutans*
hackberry	*Celtis occidentalis*
hairgrass	*Deschampsia flexuosa*
hair-rush	*Bulbostylis capillaris*
harlequin, yellow	*Corydalis flavula*
hawthorn	*Crataegus*
hemlock, eastern	*Tsuga canadensis*
hickory, pignut	*Carya glabra*
hickory, shagbark	*Carya ovata*
holly, winterberry	*Ilex verticillata*
honeysuckle, Eurasian	*Lonicera* x *bella*
horsetail, wood	*Equisetum sylvaticum*
huckleberry, black	*Gaylussacia baccata*
ironweed, New York	*Vernonia noveboracensis*
knotweed, Japanese	*Fallopia japonica*
knotweed, slender	*Polygonum tenue*
lady's-tresses, slender	*Spiranthes lacera*
ladyslipper, showy	*Cypripedium reginae*
leatherwood	*Dirca palustris*
lobelia, Kalm's	*Lobelia kalmii*
locust, black	*Robinia pseudoacacia*
lopseed	*Phryma leptostachya*
loosestrife, purple	*Lythrum salicaria*

(CONTINUED)

Common Name	Scientific Name	Common Name	Scientific Name
lousewort, swamp	*Pedicularis lanceolata*	saxifrage, golden	*Chrysosplenium americanum*
mannagrass	*Glyceria*	sedge, Back's	*Carex backii*
maple, Norway	*Acer platanoides*	sedge, Bicknell's	*Carex bicknellii*
maple, red	*Acer rubrum*	sedge, bronze	*Carex aenea*
maple, sugar	*Acer saccharum*	sedge, Bush's	*Carex bushii*
may-apple	*Podophyllum peltatum*	sedge, cattail	*Carex typhina*
meadowsweet	*Spiraea alba* v. *latifolia*	sedge, clustered	*Carex cumulata*
milkweed, blunt-leaf	*Asclepias amplexicaulis*	sedge, Davis'	*Carex davisii*
milkweed, poke	*Asclepias exaltata*	sedge, Emmons'	*Carex albicans* v. *emmonsii*
milkwort, field	*Polygala sanguinea*	sedge, false hop	*Carex lupuliformis*
milkwort, whorled	*Polygala verticillata*	sedge, handsome	*Carex formosa*
monkey-flower, winged	*Mimulus alatus*	sedge, lakeside	*Carex lacustris*
(a moss)	*Helodium paludosum*	sedge, Pennsylvania	*Carex pensylvanica*
moss, peat	*Sphagnum*	sedge, porcupine	*Carex hystericina*
mountain-mint, blunt	*Pycnanthemum muticum*	sedge, reflexed	*Carex retroflexa*
mountain-mint, Torrey's	*Pycnanthemum torrei*	sedge, Schweinitz's	*Carex schweinitzii*
oak, black	*Quercus velutina*	sedge, sterile	*Carex sterilis*
oak, chestnut	*Quercus montana*	sedge, tussock	*Carex stricta*
oak, red	*Quercus rubra*	sedge, woolly-fruit	*Carex lasiocarpa*
oak, scarlet	*Quercus coccinea*	sedge, yellow	*Carex flava*
oak, scrub	*Quercus ilicifolia*	serviceberry	*Amelanchier*
oak, swamp white	*Quercus bicolor*	shadbush, dwarf	*Amelanchier stolonifera*
oak, white	*Quercus alba*	skunk-cabbage	*Symplocarpus foetidus*
orangeweed	*Hypericum gentianoides*	spicebush	*Lindera benzoin*
orchid, small purple fringed	*Platanthera psycodes*	spike-muhly	*Muhlenbergia glomerata*
paintbrush, scarlet Indian	*Castilleja coccinea*	spikerush, ovate	*Eleocharis obtusa* v. *ovata*
pellitory	*Parietaria pennsylvanica*	spleenwort, ebony	*Asplenium platyneuron*
pine, pitch	*Pinus rigida*	spleenwort, maidenhair	*Asplenium trichomanes*
pine, white	*Pinus strobus*	spleenwort, mountain	*Asplenium montanum*
pinesap	*Monotropa hypopithys*	spleenwort, silvery	*Deparia acrostichoides*
pinweed, slender	*Lechea tenuifolia*	St. Johnswort, shrubby	*Hypericum prolificum*
pogonia, rose	*Pogonia ophioglossoides*	sweetfern	*Comptonia peregrina*
polypody, rock	*Polypodium virginianum*	sweetflag	*Acorus*
pond-lily, yellow	*Nuphar advena*	sycamore	*Platanus occidentalis*
pond-lily, white	*Nymphaea odorata*	twig-rush	*Cladium mariscoides*
poverty-grass	*Danthonia spicata*	valerian, bog	*Valeriana uliginosa*
prickly-ash, American	*Zanthoxylum americanum*	vervain, blue	*Verbena hastata*
raspberry	*Rubus*	viburnum, maple-leaf	*Viburnum acerifolium*
rattlebox	*Crotalaria sagittalis*	violet	*Viola*
reed, common	*Phragmites australis*	wall-rue	*Asplenium ruta-muraria*
riverweed	*Podostemum ceratophyllum*	water-plantain	*Alisma triviale*
rock-cress, hairy	*Arabis hirsuta* v. *pycnocarpa*	water-shield	*Brasenia schreberi*
rose, multiflora	*Rosa multiflora*	whitlow-grass, Carolina	*Draba reptans*
rose-mallow, swamp	*Hibiscus moscheutos*	willow	*Salix*
rush, toad	*Juncus bufonius*	willow, autumn	*Salix serissima*
rush, soft	*Juncus effusus*	willow, sage-leaved	*Salix candida*
sandwort, rock	*Minuartia michauxii*	witch-hazel	*Hamamelis virginiana*
sarsaparilla, bristly	*Aralia hispida*	woolgrass	*Scirpus cyperinus*