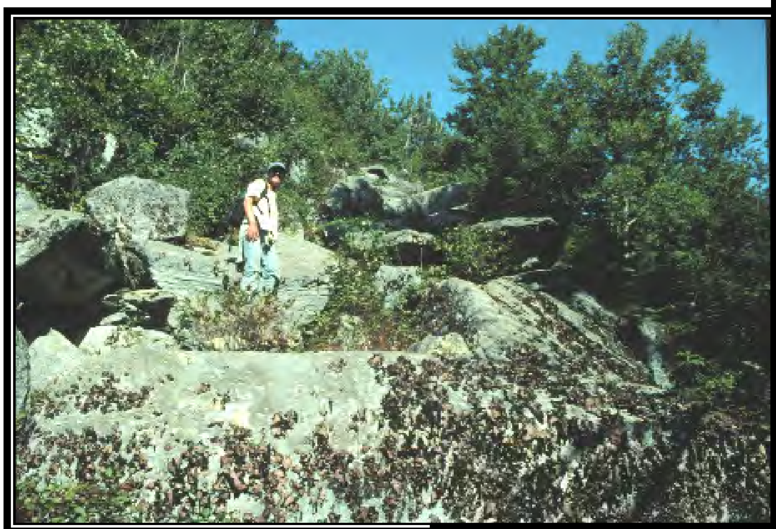
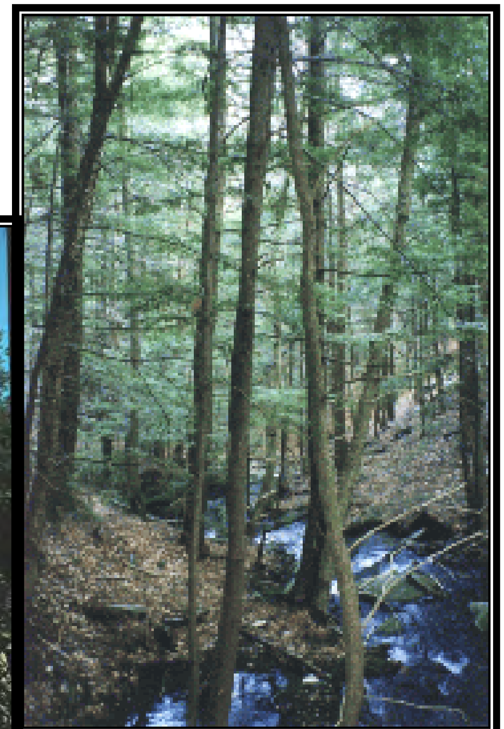
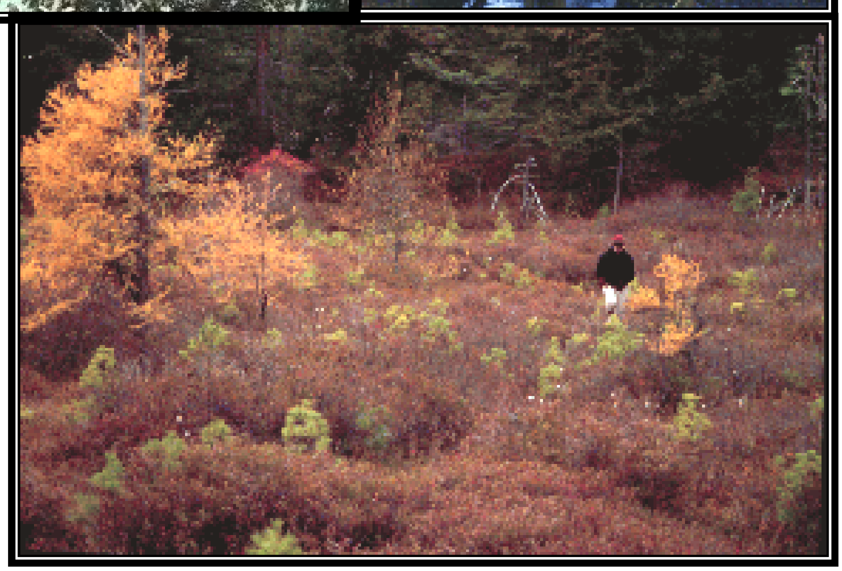
RARE, UNIQUE, AND EXEMPLARY NATURAL COMMUNITIES OF QUABBIN WATERSHED
Final Report







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PART 1: INTRODUCTION AND BACKGROUND

The purpose of this document is to identify, classify, and describe the rare, unique, and exemplary *natural communities* (hereafter referred to as simply rare natural communities) in the Quabbin watershed area of Massachusetts and to provide recommendations for their management on lands administered by the Metropolitan District Commission (MDC). Due to the under-representation of rare, unique, and exemplary natural communities, their loss may have a disproportionate effect on the biological diversity of the overall landscape. Thus, to conserve biodiversity, it is essential that these communities be identified and that management activities occur with an understanding of their potential impacts on these communities. This document is intended to help MDC identify, delineate, and manage these communities in a manner that preserves their ecological integrity while fulfilling their primary commitment to water quality.

WHAT ARE NATURAL COMMUNITIES?

Generally defined, a natural community is an assemblage of physical and biotic conditions that occur together to form a functionally distinct portion of the landscape. A site's physical environment (i.e., a combination of geologic, hydrologic, edaphic, and topographic conditions), disturbance regime (i.e., the size, distribution, timing, frequency, and magnitude of disturbances), and biotic interactions (e.g., competition, herbivory, etc.) will largely determine vegetation composition and structure, and these in turn will determine fauna present. In order to conserve these natural communities, the abiotic and biotic conditions must be recognized and preserved as systems rather than as separate elements. It is important to note that there is not widespread consensus on the appropriate criteria used to define natural communities. In some cases (e.g., The Nature Conservancy), communities have been defined and delineated on the basis of the dominant floristics, without explicit consideration of the abiotic environment. In other cases (e.g., U.S. Forest Service), communities have been defined and delineated on the basis of abiotic factors, without consideration, or with only secondary consideration, given to floristics. Here, we utilize a combination of abiotic and biotic features to classify natural communities. Specifically, we use abiotic characteristics to hierarchically organize and classify the landscape into ecological units and then use floristics, including a combination of dominant and rare species across all life forms, to classify sites into natural communities.

Natural communities vary considerably in their spatial extent and distribution. Some communities are quite common in occurrence and cosmopolitan in distribution, whereas others are rare, unique, or exemplary according to various criteria. Communities that feature individual species or species assemblages that are uncommon, restricted to specific site conditions, on the edge of their range, or relics of former climate conditions qualify for this latter designation. Communities may be rare regionally, statewide, or locally. Some communities are designated exemplary because they represent an archetype of a common, but declining community type. Conservation of rare, unique, and exemplary natural communities preserves assemblages of organisms and physical features that are not commonly found on the landscape. Conserving these communities ensures the persistence of system components and natural processes of undiscovered importance.

Myriad factors operating on different spatial and temporal scales control the development and distribution of natural communities in a landscape. Broad scale geological processes create and shape landforms and influence the development of hydrologic and edaphic variability across the landscape. These physical site conditions influence light, water, mineral and nutrient availability to plants. These physical environments affect and are affected by ecological processes (e.g., natural disturbances) to produce diverse environments for plants to establish, grow, and reproduce. Because most plant species are only able to successfully compete with other species over a narrow range of environmental conditions, the variability in environments results in many distinctive associations of plant species. Hence, the physical environment created over broad space and time scales provides a template for the development of distinctive natural communities.

In addition to broad scale geological and ecological processes, natural communities are influenced by human land use activities. In particular, activities that alter the physical characteristics of the site (e.g., moving earth, altering hydrological flow) have a long-lasting impact on the subsequent community, and alter the potential for certain communities to develop. Less intrusive activities that involve manipulation of vegetation (e.g., timber management) and animals (e.g., habitat engineers such as beaver, and herbivores such as deer) can have a long-lasting legacy on the composition and structure of the vegetative community as well. In some cases, these human activities may be beneficial, or even necessary, for the development and persistence of some natural communities. A good example is in the control of deer populations which, when overabundant, can have a dramatic effect on plant establishment and development. In other cases, human activities (e.g., silviculture, prescribed fire) may be used to restore natural communities to a more healthy and viable condition. A good example is in the use of silviculture and controlled fire to manage accumulated fuels and restore fire as an ecological process in *Pinus rigida-Quercus ilicifolia* communities.

Consideration of anthropogenic activities is of particular interest in our project area because of its land-use history (see below) and the important role that past human activities have had in shaping current "natural" communities. However, the focus of this report is not on describing the unique combination of forces (natural and anthropogenic) that acted upon a site to create the current community. Instead, here we are primarily interested in describing the current condition of rare natural communities, identifying and describing the distribution of individual rare natural communities, and suggesting ways to maintain or, in some cases, restore these rare natural communities in the study area.

PROJECT AREA

As described in the Quabbin Watershed: MDC Land Management Plan 1995-2004 (1995), the Quabbin watershed drains an area of roughly 39,000 ha (approximately 23,500 ha of which are owned by MDC) and is located on the west flank of the eastern upland physiographic province of south-central Massachusetts, an area characterized by extensive preglacial erosion and weathering followed by two major continental glaciations during the Pleistocene Epoch. The topography in the eastern part of the watershed is irregular with moderate slopes, while the western part is characterized by two well-defined, steeply sloped ranges oriented north and south through the length of the watershed. The hills have a general relief of 150 to 430 m above sea level and are characterized by undulating topography of north and northeast trending hills and relatively narrow valleys. The hills frequently expose bedrock on their summits and flanks. The bedrock consists of metasedimentary and metavolcanic gneisses, schists and granites of Paleozoic age overlain by thin till deposits on the uplands and deep level outwash deposits in the narrow valleys (Denney 1982; Heeley 1972). Specifically, surficial deposits of ablation till and basal till blanket the upland slopes with a thin veneer ranging from 0.3 to 15 m or more in thickness. The valley bottoms and lowlands are generally filled with stratified glacial outwash deposits consisting of varying amounts of silt, sand, and gravel. Glacial till is the most extensive deposit in the watershed. The till is overlain by a thin mantle of eolian silt and very fine sand. The climate is characterized as temperate. Precipitation is evenly distributed throughout the year, with a mean annual precipitation of 112 cm. Temperatures range from a mean low in January of -6 degrees Celsius to a mean high in July of 19 degrees Celsius.

The project area has undergone dramatic changes in land use and vegetation in the last 350 years as a result of both anthropogenic and natural disturbances (Williams 1982; Foster et al. 1998). The area was initially almost completely forested until European colonists transformed the landscape into an agrarian countryside dominated by tilled fields, pastures, and woodlots (Foster 1998). Beginning in the 1830's with the settlement of Ohio and accelerated around the time of the American Civil War, farm abandonment and reforestation led to the development of the modern largely forested landscape (Whitney 1994; Foster 1995). Extensive timber harvesting of old field pines around the turn of the century and subsequent secondary forest succession, coupled with catastrophic wind disturbance associated with the hurricane of 1938, the chestnut blight (and other diseases and damaging insects), excessive deer browsing, and the artificial planting of off-site *Pinus resinosa* and native *Pinus strobus*, have dramatically altered the current forests of the Quabbin watershed. Currently, the forests are classified as "transition hardwoods-white pine-hemlock" (Westveld 1956) and are dominated by a mixture of deciduous trees (primarily *Quercus*, *Acer*, *Betula*, *Fraxinus*, and *Carya*) and two important conifers (*Tsuga canadensis* and *Pinus strobus*). The dominant forest cover is *Quercus* with *Acer rubrum* occurring on the wetter sites and *Pinus strobus* dominating the drier sands and gravel. *Acer saccharum* and *Fraxinus americana* are generally limited to less acidic soils with moderately high moisture content. Some species (e.g., *Nyssa sylvatica*, *Fraxinus nigra*, *Pinus rigida*, among others) are restricted to uncommon environments and therefore have a very restricted distribution. Embedded within this forested matrix are numerous palustrine and aquatic communities, including 212 km of perennial streams and 920 ha of temporarily, seasonally, and permanently flooded wetlands and water bodies (excluding vernal pools).

The history of the Quabbin landscape highlights the dynamic nature of this ecological system. The combination of natural and anthropogenic disturbances has caused the landscape to undergo many changes. In particular, these forces have created and altered the occurrence and distribution of the natural communities we observe today, and they will continue to shape their occurrence and distribution in the future landscape. It is especially important to recognize the affects of anthropogenic activities on the occurrence and distribution of natural communities in this landscape, because in many cases the current natural community reflects the legacy of past land use practices and not the potential natural community based on the physical abiotic environment.

POTENTIAL THREATS

Conservation of rare communities requires that we first identify potential threats to their integrity and persistence prior to determining the best course of management. We identified several current and potential threats, both natural and anthropogenic, to the integrity and long-term viability of rare natural communities in the project area. It is important to note that these threats represent both current and potential threats, and that this list serves as a master list of threats of potential impact to the rare natural communities in the project area. The most significant threats to each community are described in the community descriptions below. Moreover, we collected little direct evidence of impacts of these threats within the study area; rather, these represent likely threats based on a general understanding of the ecology of these natural communities and the occurrence of particular physical, biological, and chemical disturbances within the project area. For purposes of presentation, we grouped threats into three broad categories: physical disturbance events, biological agents, and site contamination; each are described below.

Physical disturbance events

For our purposes, physical disturbances include all natural or anthropogenic events that substantially alter the physical structure and function of a natural community from its current state. Natural catastrophic disturbance events such as strong winds, ice storms, and flooding may result in localized or far-reaching effects on species composition, structure, and processes. Susceptibility to these threats is not necessarily specific to a community type, but is perhaps more related to exposure due to topographic position (slope, aspect), and stand characteristics (vegetation species and size) (Foster and Boose 1992). Natural fires are an uncommon event in southern New England, however, certain community types may be more susceptible, or somewhat dependent on fire for persistence (e.g., *Pinus rigida - Quercus ilicifolia* woodland) (Patterson and Sassaman 1988). While natural disturbance events of high intensity and severity (e.g., hurricanes) are among the most dramatic natural causes of forest change, the frequency of large-scale events in central Massachusetts is relatively low. It is certainly impossible and undesirable from a biodiversity standpoint, to prevent such events since they are an integral part of forest dynamics and succession in New England. Indeed, these disturbances are critical to the maintenance of vegetation dynamics. Hence, we do not view these natural physical disturbances as posing a threat to any natural community, even though a specific community may be impacted by these events in the short-term.

Anthropogenic disturbances that involve vegetation removal and disruption of the soil integrity may result in a suite of localized and far-reaching effects, such as soil compaction, erosion, and sedimentation. Specific disturbances and the types of rare natural communities potentially impacted are given below:

- Forestry practices that involve the removal of vegetation and the construction of roads and skid trails can disrupt and compact soil, increase sediment input to nearby streams, change characteristics of the micro environment such as light and humidity, and facilitate the penetration of invasive plants (Riley 1984 *in* Trobulak and Frissell, Seyedbagheri 1996 *in* Trombulak and Frissell 2000, Parendes and Jones 2000). All rare communities within proximity of forestry practices are potentially affected if best management practices (BMP's) are not carefully implemented.

- Human-imposed water levels associated with the Quabbin Reservoir may affect adjacent, hydrologically-associated wetlands if the natural range of variation is suppressed or exceeded. Stabilized water levels may affect plant community dynamics that are tied to temporal patterns of flooding and draw-down. The extent to which this actually impacts rare natural communities at Quabbin has not been investigated.

- Pedestrian foot traffic can cause soil compaction and erosion, and degradation of highly sensitive plant communities. This is particularly a threat to rocky outcrops, summits, and cliffs where soil development and shallow-rooted plant colonies are easily destroyed and slow to return (Parikesit et al. 1995).

- While natural fires are quite uncommon, accidental fires caused by Quabbin visitors have occurred in the past, and could pose a threat to all natural communities (O'Connor et al. 1995).

Biological agents

For our purposes, biological agents include all native and exotic organisms that have an adverse, disproportionate effect on the structure and function of a community. These agents may be plants (e.g., purple loosestrife, *Lythrum salicaria*), vertebrates (e.g., white-tail deer, *Odocoileus virginiana*), invertebrates (e.g., hemlock woolly adelgid, *Adelges tsugae*), pathogens (e.g., chestnut blight, *Cryphonectria parasitica*), or combinations of the above (e.g., beech bark disease fungus, *Nectria coccinea* and beech scale, *Cryptococcus fagisuga*). Effects may be relatively localized, endemic, or epidemic. Community susceptibility to this threat is dependent on the life history requirements and establishment mechanisms of the invasive organism. Invasive species may have specific physical or biological site requirements, as in the case of purple loosestrife, an exotic plant that mainly poses a threat to open wetland systems (Thomson et al. 1987). Other invasive species, such as the hemlock woolly adelgid, may be specific to hosts of a particular genus or species. Alternatively, invasive species may be more general in the community type invaded, but require an opportunity, such as the elimination of competitors, to become established. A common mechanism of invasive plants is to become established following a disturbance event and prior to the reestablishment of native species.

Many exotic species do not have natural control agents and therefore may effectively displace native species altogether. Particularly aggressive species may form monospecific communities that alter ecosystem functions and diminish the overall biological diversity of the site. In addition to the threat of exotic species, native species that are important biological components of the local ecosystem may, under certain circumstances, become invasive and pose a threat to natural communities. Unchecked deer populations, for example, may result in excessive herbivory, eliminating regenerating canopy species and palatable shrubs. This not only changes the composition and structure of the vegetation, but also can create an opening for invasive plant species like hayscented fern (*Dennstaedtia punctilobula)* and Japanese barberry (*Berberis thunbergii*) to become established.

The most apparent and relevant biological threats to rare natural communities in the project area are described below:

- The exotic and native invasive plants, Japanese barberry, purple loosestrife, common reed (*Phragmites australis*), hayscented fern, Asian bittersweet (*Celastrus orbiculatus*), and Japanese knotweed (Polygonum cuspidatum), have been observed at various sites throughout Quabbin, but a comprehensive distribution of these species is not known. Japanese barberry is an escaped ornamental of old Quabbin homesteads and seems to have usurped the niche of native shrubs during a period of heavy deer browse. It is a thorny shrub, unpalatable to deer, can form monotypic communities under various forest types (Ehrenfeld 1999). It is widespread throughout Quabbin and in several places, including the richer northern hardwood sites, has formed impenetrable thickets that are low in native plant diversity. Purple loosestrife, a tall herbaceous plant with a showy purple inflorescence, poses a threat to all palustrine wetlands with adequate light availability (Thomson et al. 1987). At Quabbin, it has been sited in portions of an acidic peatland. Common reed, a tall grass species of uncertain origin (Galatowitsch et al. 1999), forms monotypic stands in shallow, open palustrine areas. It has been sited in portions of the reservation, but its specific threat to rare communities at Quabbin is undetermined. Japanese knotweed is an agressive exotic shrub-like herbaceous perennial that poses a threat to a variety of community types due to its resistence to a harsh conditions (flooding, drought, shade, and high temperatures) and its ability to rapidly colonize disturbed sites or scoured flood plains (Remalely 1999). It has colonized several sites within Quabbin but its extent and threat to rare community types is not known. Asian bittersweet is a perennial vine that displaces native plant communities of open and forested sites by aggressively growing over and around them. Eventually the vine usurps available resources, resulting in degeneration and death of the native plant community (Bergmann and Swearingen 1999). The distribution of Asian bittersweet at Quabbin, and its threat to rare natural communities is unknown at this time.

- The invasive exotic insects, gypsy moth (*Lymantria dispar*) and hemlock woolly adelgid, both have potential to cause severe defoliation in the Quabbin area. A highly destructive exotic insect pest in former decades, the gypsy moth is currently in check in the Quabbin area due to released parasitoids, predators, and pathogens. Endemic gypsy moth outbreaks still occur in other areas of the state, however, and could resurface in high densities at Quabbin in the future (Boettner pers. comm.). This could be a relevant threat to Quabbin's forest communities, including *Tsuga canadensis* forest and *Pinus rigida - Quercus ilicifolia* woodland. Hemlock woolly adelgid is a destructive insect that effectively kills entire stands of hemlock, preventing reestablishment, and promoting stand conversion to hardwood types (Orwig and Foster 1998). It appears to be well-established throughout the study area.

- The native wildlife species, beaver, moose (*Alces alces*), and white-tail deer are important organisms in the Quabbin area, but can, in certain situations, threaten the integrity of natural communities. Beavers can flood open areas, wetlands, and forests by damming small streams. While this often creates valuable habitat for herons, waterfowl, moose, and other wildlife, adjacent peatlands and forested swamps can be effectively destroyed by the resulting sustained flooded conditions. Ungulates have the potential to over-browse if populations explode, preventing forest regeneration, and paving the way for unpalatable invasive plant invasions. Although historically over-abundant and destructive, white-tail deer are currently kept in check at Quabbin through a yearly hunt. Moose is a relatively recent addition to the Quabbin ecosystem. The population appears to be increasing and it has been observed locally to have a dramatic impact on vegetation.

Site contamination

For our purposes, site contamination includes the introduction of substances that change the chemical composition and function of a site. Inputs of point source and non-point source pollution can greatly disrupt ecological processes, animal and plant physiology, and pose a threat to water quality. Although we recognize that these concerns may not be relevant in the Quabbin area at present, given current watershed protection measures, we have outlined some possible threats to natural communities related to the input of contaminants.

- Sand, salt, and heavy metals are road-associated threats that mainly affect natural communities located adjacent to a road. If contaminants enter aquatic systems, however, agents can be transported much more effectively and impacts can be far-reaching. Increased salinity and suspended sediments in nearby streams, localized plant death, and erosion from loss of salt-intolerant vegetation are among the negative effects of salt and sand application (Molles 1980). Heavy metals can contaminate soil and reach plant tissues up to at least 200 m from roadsides; this threat increases with traffic level (Trombulak and Frissell 2000). Quabbin has an extensive network of roads, including major highways, that are adjacent to and cross over streams, wetlands, and open water systems. It is unclear to what degree road pollution is currently impacting natural communities in the Quabbin, but it should be considered a potential threat that warrants attention.

- Inputs of fertilizers, manure, and septic waste from local residents can flood natural communities with high levels of nitrogen, phosphorus, and bacteria, causing algal blooms and other disruptions of nutrient cycling. Communities threatened are likely to be connected hydrologically to a pollution source. As above, it is unclear to what degree agriculture and septic-related contamination is currently impacting natural communities in the Quabbin, but it remains a definite threat in the future.

- Herbicides and pesticides applied broadly pose a threat to non-target recipients. Herbicides are used along powerlines to control the growth and succession of flora. These chemicals could have a detrimental affect on natural communities if they traveled from the site of application, since they can kill algae, non-target plants, fish and other aquatic organisms (Yurich 1978, Mitchell 1998). Wind-carried mists and volatilization are possible mechanisms of transport (Mitchell 1988). Similarly, pesticides applied broadly to control mosquitoes and other pests may pose a threat to non-target fauna. Again, it is unclear to what degree herbicides and pesticides are currently impacting natural communities in the Quabbin.

- Truck spills and illegal dumping includes a whole suite of possible contaminants from toxic chemicals to waste from toilet-equipped vehicles. It is unclear whether these two threats, both difficult to anticipate and prevent, are a current threat to natural communities in the Quabbin.

- Airborne pollutants pose a widespread threat to all communities. Acid deposition, nitrogen loading, and increased levels of troposheric ozone are some examples of pollutants that can act as single or synergistic stresses on ecosystems around the globe (Taylor et al. 1994). There is evidence that air pollutants significantly alter physiology and growth on the single-plant level (Winner 1994), and therefore they are likely a relevant threat to the overall structure and function of ecosystems locally, regionally, and globally. Note, however, that there is little that MDC can do to counter these threats.

MANAGEMENT OPTIONS

The management of target rare communities should have the goal of maintaining the integrity of existing communities, enhancing communities that have been degraded, and maintaining connectivity among communities (e.g., through the use of corridors between communities, or by minimizing the occurrence of movement barriers) where needed to insure their integrity and viability. In attempting to achieve this goal, it is important to note that natural communities do not exist in isolation; they are open ecological systems that interact to varying degrees via the flow of energy and material with the surrounding landscape. In other words, each community maintains an intricate interdependency on the surrounding landscape. Therefore, management actions should consider not only the site itself, but also the surrounding landscape context. Hence, a two-level management approach involving both site- and landscape-level actions is warranted. Unfortunately, very little is known about the landscape-level needs of most rare communities. For example, we know very little about the movement of organisms from one community unit to another or the extent to which the intervening landscape structure affects these movement rates and patterns. Therefore, it is exceedingly difficult to specify reliable, scientifically supported, landscape-level management actions that will ensure the viability of designated rare natural communities. In addition, it is important to recognize that natural communities do not exist in a static state. The species composition and structure of a community is in constant flux due to changes in the environmental conditions caused by natural disturbances and plant succession. The goal of management is not to stop these processes, but to protect these areas from destructive anthropogenic disturbances, and to use applicable techniques to maintain and enhance communities.

The following is a list of site-level management options that could be used to achieve the goals stated above. These represent the range and types of management actions that could be applied to any specific community at the site level; specific and more detailed recommendations on the application of each technique are given on a case by case basis in the individual community descriptions below. For purposes of presentation, we grouped management options into two broad categories: active management, and restrictions.

Active Management

For our purposes, active management refers to the use of techniques that biologically, physically, or chemically manipulate a site. These are intrusive management activities that are generally reserved for communities that require active intervention to preserve or restore the integrity of the community. In most cases, these activities are in response to a clearly recognized and demonstrated threat to the viability of the community. Some examples are described below:

- Silviculture.--Silvicultural cuttings may be required in some communities in order to change species compositions or ecological conditions to those more conducive to the perpetuation of that community.

- Controlled burns.--Some communities contain one or more species that are adapted to periodic fires. Controlled burns may be required in these areas.

- Removal of undesirable plants.--Invasive plants (both exotic and native) are a problem throughout the Quabbin area. Removal of these plants, either mechanically or chemically, may be needed in order to reduce competition with plants endemic to some communities.

- Removal of undesirable animals.--Some animals, most noticeably deer and beaver, can impact plant communities. Removal or exclusion (by fencing) of these animals may be needed in some areas, although the costs may be prohibitive.

- Addition of plants or animals.--Some plants or animals not currently present, or present in low numbers, in some communities may be needed to ensure the perpetuation of these communities. In addition, some community types may provide habitats for rare, threatened or endangered species, and under special circumstances, reintroductions may be warranted.

Restrictions

For our purposes, restrictions involve limiting the use, spatial distribution, or timing of certain anthropogenic activities, such as forestry, development, or recreational activities, in order to prevent or slow degradation to sites. Logging is the most noticeable anthropogenic disturbance within the Quabbin area, but pollution and foot traffic can cause degradation in some community types as described above. Logging, hunting, fishing, or general access may need to be restricted within areas of some community types. These restrictions may need to be extended to buffer zones around communities, or corridors between communities. In addition, these restrictions may be permanent or seasonal. Many of these potential restrictions are already imposed under the current Quabbin management plan. For example, best management practices outlined in the plan comply with all the requirements of the Wetlands Protection Act (M.G.L. Ch. 131) and the Forest Cutting Practices Act (M.G.L. Ch. 132) for cutting in wetlands and within a 50 foot filter strip along streams, rivers, water bodies, and wetlands. Moreover, the plan’s best management practices greatly exceed many of these standards.

MANAGEMENT RECOMMENDATIONS

The focus of this report is on the classification, identification, and description of the rare natural communities on the Quabbin. Although a necessary first step, this effort should properly be viewed as only the first step towards achieving the conservation of these communities. In this section, we identify several subsequent steps (i.e., management recommendations) that could be taken to ensure the conservation of rare communities on the Quabbin. However, we recognize the severe and real practical constraints (i.e., money and labor) to implementing all of the recommendations. Thus, noncompliance with all recommendations should not be viewed as failure to achieve the goal of rare community conservation. Instead, these recommendations should be viewed as a strategic planning framework that outlines a series of actions that would improve the likelihood of achieving the goal of rare community conservation. A commitment to any of the following recommendations would demonstrate a commitment by the agency to rare community conservation. This applies equally to the community-specific recommendations given below.

- <u>Site-specific management plans</u>.--Based on the community-specific management recommendations given in the individual community descriptions below, we recommend that site-specific management plans be developed for each rare community site. These site plans should tailor the community-level recommendations given in this report into a plan of action for each individual site that takes into account the site-specific context. Site plans should provide spatially explicit information about the area to be managed, including a delineation of the target community and a variable-width buffer zone within which management action will be directed. In addition, site plans should provide a detailed schedule of management actions to be taken.

- <u>Comprehensive mapping of all rare natural communities</u>.--Through the collaborative efforts of UMass and MDC, we have begun the process of mapping rare communities on the Quabbin. However, the mapping done in conjunction with this initial investigation represents a cursory and somewhat arbitrary effort to map sites, and was done largely for the purpose of identifying reference sites for the field work associated with the description of each community type. Given the current classification and community descriptions and mapping criteria, the next step should be to systematically map all natural communities using a combination of aerial photo interpretation, terrain analysis, and field surveys, and fully integrate this information into the forest cover type mapping effort and GIS database.

- <u>Establish a special management designation for all areas identified as rare natural communities</u>.--This management zone would include the delineated target natural communities plus a buffer zone of variable width around each community. Within this management zone, the objective would be to maintain or enhance the integrity of the target natural communities. Such a designation may not seem necessary, since many of these areas are either already protected (e.g., wetlands) or occur in areas not subject to typical forest management activities due to site conditions (e.g., rock outcrops). However, this management designation would serve to elevate the recognized importance of rare communities and would demonstrate a commitment on the part of the agency to conserve these communities. Figure 1 illustrates what this management zone might look like geographically based on the current reference sites and all wetlands and steep slope areas. Note that many of the mapped steep slope areas do not contain target rare communities, but it provides an excellent map of the distribution of potential rare communities associated with exposed rock. This map would logically be developed in conjunction with the systematic mapping of all rare natural communities, as described above.

- Systematic monitoring of all rare natural communities.--The only way to track the condition of each community for the purpose of assessing ecological integrity is through systematic and periodic monitoring. For our purposes, monitoring means the periodic and systematic collection of data that allows for the quantitative and qualitative assessment of change in ecological conditions over time. Monitoring is an essential component of adaptive management and is especially critical here due to the paucity of information available on the current and future threats to rare communities on the Quabbin and the uncertainties associated with the impacts of various management activities intended to conserve these communities. Ideally, all communities should be monitored to ensure that management is effective. A monitoring program should be established that involves the assessment of the physical environment and the biological composition and structure of each community. Such a program should involve periodic resampling of each community, perhaps on a fixed-year cycle, and, for pragmatic reasons, should probably involve a rapid assessment of community composition, structure, and function. The appropriate physical and biological indicators should be selected on a community by community basis due to the underlying differences among communities. In addition, the data should be stored in a well-documented, standardized database that allows for summarization and reporting on an annual basis.

INFORMATION NEEDS

In completing this initial investigation, it became apparent that huge gaps exist in our knowledge base concerning the ecology of the rare communities on the Quabbin and, more importantly, the current and future threats to these communities and the likely impacts of alternative management actions. Yet this information is critical to the informed conservation of these communities. Obtaining this information will require a serious commitment on behalf of the management agency.

- Scientific investigation into the causes and consequences of rarity of Quabbin natural communities.--In the course of our investigation, it became painfully clear that we do not have a relevant reference framework for evaluating the current condition of each community. In particular, we do not have a good understanding of the historic range of variability in the extent, distribution, and compositional and structural makeup of each community. For example, the current blackgum swamp communities contain very few blackgum trees and do not closely resemble the archetype community described by the Natural Heritage Program. Is this the natural state of this community type in the Quabbin? Or does this largely reflect the legacy of past land use practices or the impacts of beaver? At at least one site on the Quabbin, beaver are known to be the cause of extensive blackgum mortality (Bruce Spencer, pers. Commun.). Was this community type more common historically? And if so, how common in terms of extent and distribution was it? The answer to these and related questions are needed before truly informed management decisions can be made. Unfortunately, there are limited options for conducting appropriate investigations on the historic range of variability in natural communities, and the inferences drawn from such investigations are usually weak. Nevertheless, having an appropriate reference framework clearly remains a critical aspect of rare community conservation and warrants further investigation.

- <u>Scientific investigation into the impacts of various threats (physical disturbances, biological agents, and contamination) on specific communities and the response to alternative management activities</u>.--It is indeed surprising how little we know about the impacts of various threats to the integrity of specific communities. Much of what is known stems from general knowledge derived from studies conducted elsewhere on different communities or from personal observations. Very little reliable knowledge gained from scientific experimentation exists that directly applies to the rare communities on the Quabbin. In addition, there is little scientific basis from which to judge how specific communities are likely to respond to various management activities. Yet, given the seriousness of some of the imposing threats described above, it behooves us to establish a strong scientific basis for proactive management. Perhaps one of the best examples of a case in need is the potential impacts of the hemlock wooly adelgid on hemlock-dominated forest communities and the uncertainties associated with various silvicultural activities designed to prevent, or minimize, adverse impacts. In addition, we have little understanding of whether community values can be maintained or restored by replacing extirpated species with suitable substitutes. For example, if native hemlock is lost from hemlock-dominated communities, can the community values be maintained if another species (native or non-native) with similar characteristics (e.g., Norway spruce, *Picea abies*) is used as a replacement.

- <u>Scientific investigation into the movement of organisms among patches of rare communities</u>.—It is quite apparent that we know very little about the movement of organisms among habitat patches and the affects of intervening landscape structure on those movement patterns. Without this information, it is exceedingly difficult to make informed recommendations for the management of lands between rare communities to insure connectivity for those organisms. Unfortunately, there are an almost unlimited number of relevant questions. For example, for species exclusively associated with a specific natural community (i.e., found in that community and no others), are populations effectively isolated and independent or do they function as metapopulations? If the latter, what is the mechanism for movement of individuals among local populations (e.g., juvenile dispersal)? When does movement among local populations occur? How do roads and other corridors in the intervening landscape affect movement rates, patterns, and success? How do various forest management activities that alter forest structure and environmental conditions affect movement rates, patterns, and success? Ideally, one or more species exclusively associated with each rare community should be identified and then an autecological study conducted. Given the magnitude of this task, it is perhaps more realistic to select a single community to focus on first.

PART 2: NATURAL COMMUNITY CLASSIFICATION AND DESCRIPTIONS

NATURAL COMMUNITY CLASSIFICATION

Through literature review, discussion with experts, and site examination, we first developed a comprehensive hierarchical classification system for all natural community types that are likely to occur within Quabbin (Table 1). We then developed detailed descriptions (based on current literature sources) for the communities that we feel deserve special recognition because of their rare, unique, or exemplary status. We primarily used lists of target communities provided by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) as a guideline for our choices. In some cases, however, we included communities that are not necessarily rare statewide, but that are especially vulnerable or unique within the Quabbin area. Finally, we chose a small set of reference sites to survey and evaluated how closely they resembled the descriptions we had initially developed. For all rare community types we discuss methods for finding, recognizing, and mapping individual sites.

We adopted a nested hierarchical approach for classifying natural communities based on physical abiotic factors and the dominant life form of the vegetation. Specifically, we used physical characteristics to stratify the landscape into ecological land units and then, in some cases, used dominant life form to further subdivide the ecological land units. The factors used to hierarchically organize communities varied among branches of the hierarchy (i.e. they were nested) to reflect the fact that different environmental variables regulate community structure in different ecological systems. Individual natural communities exist within the tertiary levels of the hierarchy and represent a unique combination of ecological land unit and plant association. However, in some cases, we were unable to identify discrete natural community types within the tertiary level of the hierarchy because of the variety of overlapping plant associations found within that ecological land unit type. In these cases, the tertiary strata define somewhat generalized natural community types that can vary considerably in plant composition among sites.

We identified natural communities distributed among three broad groups based on landscape position: (1) terrestrial communities, (2) riparian communities, and (3) palustrine communities (Table 1). Although we recognized the occurrence of aquatic natural communities (lentic and lotic systems), it was beyond the scope of this study to consider their classification.

Terrestrial Communities

Terrestrial communities include all communities where the soil is never inundated and where the vegetation is not influenced by hydric conditions. We identified 14 different terrestrial communities stratified into two categories based on soil depth: (1) communities on exposed rock or shallow soils, and (2) communities on deep soils.

Terrestrial communities on exposed rock and shallow soils include all plant communities where the depth of the soil to bedrock or talus inhibits full closure of the tree canopy, causes trees to be slow growing and stunted, or prevents any plant growth. We identified four different community types (three of which are rare) stratified into two categories based on surficial geology: (1) bedrock outcrops (including summits, ridgetops, and cliffs), and (2) talus slopes. Bedrock outcrops on summits and ridgetops are areas with exposed bedrock but little overall slope. Cliffs, in contrast, are areas of vertical, exposed rock. We combined these into a single ecological land unit class because of similarities in vegetation. Talus slopes at Quabbin are areas of large boulders below a cliff or ridge.

Terrestrial communities on deep soils include all forests and woodlands where the depth of soil to bedrock does not inhibit the growth of trees. In most cases, there will be a fully formed canopy and subcanopy. In some cases, such as *Pinus rigida-Quercus* lowland woodlands, soils are deep but trees can be stunted due to a lack of soil moisture. We identified ten different community types stratified into two categories based on soil moisture and drainage: (1) dry forests with well-drained soils, and (2) mesic forests with moderately well-drained soils. Each drainage type was further stratified by soil texture and fertility, largely differentiating the sandy soils from the loams and silt-loams.

Riparian Communities

Riparian communities include all communities occurring at the interface between lacustrine (lentic) and riverine (lotic) systems and the adjacent upland. Although these communities often feature hydrophytes, they usually do not occur on hydric soils and are different from ‘fringe’ type palustrine wetlands (see Palustrine Communities) that are closely associated with streams, rivers, ponds, and lakes. Riparian communities typically occur as a linear strip located between standing or flowing water, and the adjacent upland. As such, its species composition is heavily influenced by fluctuating water levels.

Riparian zones are ecotones: areas of gradual transition between two distinct environments. As a result, they take on characteristics of both adjoining communities. The physical environment is often a continuous gradient of change from the aquatic to terrestrial environment. Consequently, plant species composition often changes in a continuous fashion along the transriparian gradient. Moreover, these gradients may be very subtle in humid, temperate environments, such as western Massachusetts. Under these circumstances, it is exceedingly difficult to identify and delineate discrete riparian communities, making riparian community classification problematic. Despite these difficulties, it is widely acknowledged that riparian areas are keystone features in the landscape because of the major role they play in regulating many geomorphological and ecological processes. In addition, it is widely understood that riparian areas provide critical habitat for many wildlife species. For these and other reasons, we classified riparian areas into natural community types, even though we recognize that these communities often are not distinct and discrete units on the ground.

We stratified riparian areas into two categories based on geomorphic considerations: (1) streamside communities, and (2) pond- and lake-side communities.

Streamside communities include all riparian areas adjacent to lotic (flowing) aquatic systems (primarily small intermittent and perennial streams in the Quabbin). We characterized streamside communities as either high gradient or low gradient, depending on the gradient of the streams to which they were adjacent. High gradient streams feature constrained, narrow channels, and may have cascades and exposed bedrock. A floodplain is usually very narrow or absent. Low gradient streams are braided and have flat, wider channels. These streams may have a wider floodplain, and may have associated palustrine wetlands. Both high and low gradient reaches may occur at different locations along the same stream. In most cases, trees are the dominant life form of streamside communities with occasional codominance of shrubs, particularly along streams with wide channels, or that are associated with wetlands.

Pond-side and lake-side communities include all riparian areas associated with lacustrine systems. We characterized these communities as either abrupt shore bank or gentle sloping shore. Abrupt shore banks do not have to be high from water, but rather exhibit an abrupt, vertical transition from upland to lacustrine communities. In contrast, gently sloping shores are gradual transitions from upland to lacustrine communities and are beach-like. Both types may have muddy, sandy, or rocky substrate, and exhibit physical and floristic characteristics that reflect the fluctuation of water level. Pond- and lake-side communities may be dominated by forest, shrub, or herbaceous cover, although abrupt bank shores are most likely to be dominated by shrub or forest cover, whereas gentle sloping shores are more commonly dominated by herbaceous or shrub cover.

Palustrine Communities

Palustrine communities include all communities that are permanently flooded (i.e., not lacustrine or riverine systems) to saturated at least part of the year, and whose vegetation composition is influenced by hydric conditions (i.e., dominated by hydrophytes). We stratified palustrine communities into two categories based on general soil type: (1) wetlands on mineral or muck soils, and (2) wetlands on peat.

Wetlands on mineral or muck soils include palustrine communities not restricted to peatlands. Muck is a well-decomposed organic soil and often occurs over a mineral substrate. Hydric mineral soils are sands, silts, and clays, and often have thick organic top layers. We classified community types stratified into two categories based on hydro-geomorphology; specifically, the proximity and hydrological connection to other water bodies and wetlands: (1) basin and seepage wetlands, and (2) fringe wetlands. Basin wetlands are isolated hydrologically with the exception of intermittent streams. Seepage wetlands may be located at the base of a slope, near a groundwater discharge site, or along an ephemeral stream. Fringe wetlands are located along a lake, pond, perennial stream, or wetland. Many of the individual palustrine communities can occur in all three conditions, and are listed as such.

Wetlands on mineral or muck soils were further stratified on the basis of the water regime. We divided the suite of water regimes identified by Cowardin et al. (1979) into two broad groups: (1) temporarily flooded, and (2) permanently flooded. Temporarily flooded wetlands are seasonally or temporarily inundated and saturated most times of the year. Permanently flooded wetlands include sites that are semi-permanently to permanently inundated. The tertiary stratification of wetlands on mineral or muck soils was based on the dominant life form categories of forest, shrub, or herbaceous. Tree species that are less than six meters (20 feet) in height were classified as shrubs. Note: in some cases (e.g., shrub swamps, aquatic bed), we did not attempt to distinguish the numerous possible plant associations that occur in that general ecological land unit. In these cases we provide one or two example plant associations in parenthesis in Table 1.

Wetlands on peat include palustrine communities restricted to peatlands. Peat is a poorly decomposed organic substrate. It is comprised of fibrous, easily recognizable plant matter, and usually has an accumulation of a half-meter (1.5 feet) or more. We identified six different community types stratified into two categories based on hydro-geomorphology, as described above. Peatlands were further stratified on the basis of the dominant life form categories of forest, shrub, or herbaceous, as described above.

NATURAL COMMUNITY DESCRIPTIONS

What follows is a series of descriptions for rare natural communities that are likely to occur in the Quabbin Watershed area of Massachusetts. All community descriptions have a common format, as follows:

<u>Community Classification</u>.--Full natural community classification, as given in Table 1. The nomenclature for community descriptions follows Gleason and Cronquist (1991).

<u>Cross Reference</u>.--A cross-reference to NHESP target communities.

<u>Status</u>.--Refers to the Natural Community Ranks developed for the Natural Heritage system by The Nature Conservancy. The global rank (G) reflects the rarity of the community throughout the world and the state rank (S) reflects the rarity within Massachusetts, as follows:

G1 Critically imperiled throughout its range due to extreme rarity (5 or fewer occurrences, or very few remaining individuals, acres, or miles of stream) or extremely vulnerable to extinction due to biological factors.

G2 Imperiled throughout its range due to rarity (6 to 20 occurrences, or few remaining individuals, acres or miles of stream) or highly vulnerable to extinction due to biological factors.

G3 Either very rare throughout its range (21 to 100 occurrences), with a restricted range (but possibly locally abundant), or vulnerable to extinction due to biological factors.

G4 Apparently secure throughout its range (but possibly rare in parts of its range)

G5 Demonstrably secure throughout its range (however, it may be rare in certain areas).

GU Status unknown.

S1 Typically 5 or fewer occurrences, very few remaining individuals, acre, or miles of stream or especially vulnerable to extirpation in Massachusetts for other reasons.

S2	Typically 6 to 20 occurrences, few remaining individuals, acres, or miles of stream or very vulnerable to extirpation in Massachusetts for other reasons.

S3	Typically 21 to 100 occurrences, limited acreage, or miles of stream in Massachusetts.

S4	Apparently secure in Massachusetts.

S5	Demonstrably secure in Massachusetts.

SU	Status unknown in Massachusetts.

SH	Noted historically with no extant sites known in Massachusetts.

<u>Physical Characteristics</u>.--Comprehensive description of the physical environment (i.e., geologic, hydrologic, edaphic, and topographic conditions).

<u>Vegetation Composition</u>.--General description of the vegetation composition that is indicative of the community. A complete list of all plant species found in the rare communities of Quabbin is provided in appendix 1.

<u>Rare Plants and Vertebrates</u>.--Taxonomically organized list of uncommon plants and animals possibly associated with the community. The list includes state- and federally-listed endangered (E) and threatened (T) species, state-listed species of special concern (SC), and generally uncommon species (U). The symbol given under "MA Status" represents the species' status in the state of Massachusetts as give by NHESP. Note, the uncommon species designation (U) is not an official designation; these are species of interest because they are not commonly seen in the project area. The symbol given in parenthesis refers to the national status of the species as defined under the Endangered Species Act of 1973. A complete list of all vertebrate species associated with each rare community is provided in appendix 2. For each community, we included a list of rare plant species whose physical site requirements may be met in the given site type and wildlife species that may have a vital life history function (food, cover, breeding sites) provided for in the given site type. We constructed these lists to be consistent and thorough, however, several plant species and some animal species are highly unlikely to occur in these communities due to extreme rarity or local extirpation.

It is important to note that a shortcoming of the natural community classification system is that it weakly addresses the importance of the surrounding landscape in determining the suitability of the community as habitat for uncommon wildlife species. It must be recognized that wildlife and plant habitat quality is determined by a complex set of characteristics ranging from fine-scale microsite conditions, to the arrangement of community types on the landscape. A community that provides a vital function for a particular wildlife species is suitable habitat only if all vital functions are provided for within a reasonable proximity. It is not adequate to classify these communities as habitat without first considering the adjacent available resources.

Survey Summary.--Summary of field inventory of the Quabbin reference sites. These sites were inventoried in the field during the summer, 1999. The completed field data forms are included in appendix 3.

The following abbreviations are used in the Survey Summary charts:

Deg.:	Degree of Slope
Asp.:	Aspect of Slope
Dbh:	Diameter Breast Height (1.3 m)
C.V.:	Coefficient of Variation
Can:	Canopy
SCan:	Sub-Canopy
TShr:	Tall Shrub Layer
SShr:	Short Shrub Layer
Herb:	Herbacaceous Layer
NVas:	Non-Vascular Plants
NR:	Not Recorded
NA:	Not Applicable

Quabbin Reference Sites.--A list of reference sites on the Quabbin. A reference map is provided to show the general location of the reference sites. Note, a few communities do not have reference maps because they were not sampled in the field as part of this study. These communities were sampled as part of the study on avian communities associated with hemlock-dominated forests and maps will be generated upon completion of that study.

Mapping Criteria.--Guidelines for recognizing and delineating each community.

Threats.—Current and potential future threats, including natural and anthropogenic agents, to the viability of the community in the Quabbin watershed.

Management Recommendations.--Recommendations for the management of the community designed to improve the quality or ensure perpetuity (and viability) of the community in the Quabbin watershed.

Table 1. Classification of natural communities of the Quabbin watershed. Individual natural communities are marked with ✷. Rare communities described in detail in this report are given in bold with a page number reference for the detailed description. Tertiary categories without specified communities have an indiscriminant number of plant associations found on that ecological land unit.

TERRESTRIAL COMMUNITIES

- ♦ Terrestrial communities on exposed rock and shallow soils
    - Bedrock outcrops, summits, ridgetops and cliffs
        - ✷ ***Vaccinium* shrubland (Community 1; page 23-)**
        - ✷ ***Juniperus virginiana* shrubland (Community 2; page 27)**
        - ✷ *Quercus - Ericaceae* woodland
    - Talus slopes
        - ✷ **Talus slope community (Community 3; page 31)**
- ♦ Terrestrial communities on deep soils
    - Dry forests / well-drained soils
        - ▪ Sandy soils
            - ✷ ***Pinus rigida - Quercus ilicifolia* woodland (Community 4; page 35)**
            - ✷ *Pinus strobus* forest
        - ▪ Poor sandy-loams
            - ✷ *Quercus - Pinus strobus* forest
            - ✷ *Quercus - Pinus - Carya* forest
        - ▪ Rich sandy-loams to loams
            - ✷ *Carya - Quercus - Fraxinus* forest
            - ✷ *Acer – Betula* mixed hardwood forest
    - Mesic forests / moderately well-drained soils
        - ▪ Sandy-loams
            - ✷ *Quercus - Pinus - Carya* forest
            - ✷ *Acer – Betula* mixed hardwood forest
        - ▪ Sandy-loams to loams
            - ✷ ***Tsuga canadensis* -dominated forest (Community 5; page 40)**
            - ✷ *Acer saccharum - Betula - Fagus grandifolia* forest
            - ✷ *Acer – Betula* mixed hardwood forest
        - ▪ Loams to silt-loams
            - ✷ *Quercus - Acer saccharum* forest
            - ✷ *Acer – Betula* mixed hardwood forest
            - ✷ ***Acer saccharum - Fraxinus americana - Tilia americana* forest (Community 6; page 46)**

RIPARIAN COMMUNITIES

- ❖ Streamside communities
    - ♦ High-gradient stream communities
        - ✷ Mixed hardwood stream community (e.g., *Betula spp., Fraxinus americana*)
        - ✷ ***Tsuga canadensis*-dominated stream community (Community 7; page 50)**
    - ♦ Low-gradient stream communities
        - Shrub streamside communities
            - ✷ Shrub-dominated stream community (e.g., *Alnus spp*.)
        - Forest streamside communities
            - ✷ Mixed hardwood stream community (e.g., *Betula spp., Fraxinus americana*)
            - ✷ ***Tsuga canadensis*-dominated stream community (Community 7; page 50)**
- ❖ Pond and lake-side communities
    - ♦ Bank shores
        - ▪ Shrub bank shores (e.g. *Vaccinium corymbosum*)
        - ▪ Forested bank shores (e.g. *Acer rubrum, Nyssa sylvatica*)
    - ♦ Gentle sloping (beach-like) shores

- Herbaceous beach shores (e.g. *Gratiola aurea*)
- Shrub beach shores (e.g. *Alnus spp.*)

PALUSTRINE COMMUNITIES

- Wetlands on mineral or muck soils
  - Basin and seepage wetlands
    - Temporarily flooded wetlands
      - Non-vegetated wetlands
        - **Vernal/autumnal pool (Community 11; page 70)**
      - Wet meadows
        - Robust emergent meadow (e.g., *Typha latifolia*)
        - Graminoid meadow (e.g., *Carex stricta, Calamagrostis canadensis*)
      - Shrub swamps
        - **Kettlehole shrub swamp (Community 11; page 70)**
        - Non-kettlehole shrub swamp (e.g., *Vaccinium corymbosum, Ilex verticillata*)
      - Forested swamps
        - ***Nyssa sylvatica* swamp (Community 8; page 54)**
        - ***Fraxinus nigra* swamp (Community 9; page 60)**
        - *Acer rubrum* swamp
        - ***Picea mariana* swamp (Community 10; page 65)**
    - Permanently flooded wetlands
      - Marshes
        - Aquatic bed (e.g., *Nymphaea odorata*)
        - Emergent marsh (e.g., *Typha latifolia, Pontederia cordata*)
        - Shrub swamp (e.g., *Cephalanthus occidentalis*)
  - Fringe wetlands
    - Temporarily flooded wetlands
      - Wet meadows (e.g., *Carex stricta*)
      - Shrub swamps (e.g., *Alnus spp., Salix spp.*)
      - Forested swamps
        - ***Nyssa sylvatica* swamp (Community 8; page 54)**
        - ***Fraxinus nigra* swamp (Community 9; page 60)**
        - *Acer rubrum* swamp
        - ***Picea mariana* swamp (Community 10; page 65)**
    - Permanently flooded wetlands
      - Marshes
        - Aquatic bed (e.g., *Potamogeton spp., Myriophyllum spp.*)
        - Robust emergent marsh (e.g., *Typha latifolia*)
        - Graminoid – broadleaf emergent marsh (e.g., *Scirpus spp., Pontederia cordata*)
        - Shrub swamp (e.g., *Cephalanthus occidentalis*)
      - Beaver impoundments
- Wetlands on peat
  - Basin and seepage peatlands
      - Herbaceous peatlands
        - **Poor fen (Community 12; page 75)**
      - Shrub peatlands
        - **Bog/acidic fen (Community 12; page 75)**
      - Forested peatlands
        - **Bog transition forest (Community 12; page 75)**
  - Fringe peatlands
      - Herbaceous peatlands
        - **Poor fen (Community 12; page 75)**
      - Shrub peatlands
        - **Bog/acidic fen (Community 12; page 75)**
      - Forested peatlands
        - **Bog transition forest (Community 12; page 75)**

COMMUNITY 1
VACCINIUM SHRUBLAND

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Exposed Rock and Shallow Soils
Bedrock Outcrops, Summits, Ridgetops and Cliffs

Cross Reference
Similar to NHESP description of *Acidic Rocky Summit/Rock Outcrop Community*.

Status
G4 S4; Found in only small patches in the Quabbin area.

Physical Characteristics
This alliance occurs on acidic bedrock outcrops, summits, ledges, and cliffs of igneous or metamorphic rock. Soils are acidic, thin and sandy with shallow accumulations of organic matter on bedrock outcrops. *Vaccinium* shrubland communities are also sometimes found on upland glacial plains.

Vegetation Composition
Dominant woody species include *Vaccinium angustifolium* and *V. pallidum*. Other common woody species include *Aronia melanocarpa* and *Gaylussacia baccata*. Where sufficient soil has accumulated small, stunted trees or shrubs may be present, including *Betula papyrifera, Carya glabra, C. ovalis, Castanea dentata, P. strobus, Quercus alba, Q. coccinea, Q. ilicifolia, Q. prinoides, Q. prinus, Q. rubra, Q. velutina* and *Sassafras albidum*. *Pinus rigida* is present on some ridgetops. Though not obligate, it is an indicator species for this community. The canopy, where it

exists, is open. This type does not include an unbroken tree canopy.

In addition to ericaceous species, the herbaceous layer consists of *Carex pensylvanica, Corydalis sempervirens, Deschampsia flexuosa, Euthamia graminifolia, Lycopodium obscurum, L. digitatum, Oryzopsis pungens, Rubus hispidus,* and *Schizachyrium scoparium*. Mosses and lichens may also be present.

Sources: Vander Kloet 1988, Maillette 1988, Sneddon et al. 1994, Parikesit et al. 1995, Kelley and Larson 1997, Ruffner and Abrams 1998

Rare Vertebrates

Birds

Common Name	Scientific Name	MA Status
Bald Eagle	*Haliaeetus leucocephalis*	E (T)
Peregrine falcon	*Falco peregrinus*	E (T)

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Degraaf and Rappole 1995

Reptiles

Common Name	Scientific Name	MA Status
Black rat snake	*Elaphe obsoleta*	E
Northern copperhead	*Agkistridon contortrix*	E
Timber rattlesnake	*Crotalus horridus*	E

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

	Quabbin Reference Sites:	Compartment	Site Quality
1.	Bial's Hill	Prescott, Compartment 2	Marginally Representative
2.	Rattlesnake Hill	New Salem, Compartment 16	Representative
3.	Lighthouse Hill	Prescott, Compartment 13	Representative

Two circular plot 15 meters in diameter were sampled at each of the above sites. All plots are located in areas of relatively high elevation with a sparse or non-existent tree canopy. At all sites the shrubland area is surrounded by low canopy forest, except at Lighthouse Hill where a cliff forms the border on the west side. Ericaceous shrubs are common to all sites.

Species found in our survey that are not listed above include *Amelanchier spicata, Comandra umbellata, Danthonia spicata,* and *Panicum depauperatum.* The mean soil pH of sites surveyed is 4.3; the mean basal area is 10 m^2/ha (43 $ft.^2$/ac); the mean dbh is 16.2 cm (6.4 in.).

Due to the presence of *Pinus rigida*, Rattlesnake Hill and Lighthouse Hill are considered better examples of this community than Bial's Hill. Rattlesnake Hill has a high density of *Quercus prinus*, which forms a low canopy on parts of the ridgetop. It should be considered unusual in this respect. All three sites are representative of the community description in terms of soil pH and drainage. Differences in soil texture from the community description may be due to the high variability of soils within these sites.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Bial's Hill	1	High level	0 / NA	5	Silt loam	A: 3.9 B: 4.3	Well drained
Rattlesnake Hill (N.S.)	1	High slope	9 / 200	3	Clay loam	A: 3.6 E: 3.5 B: 4.9	Rapidly drained
Lighthouse Hill	1	Ridgetop	20 / 140	<20	Sandy loam	A1: 4.6 A2: 4.9	Well drained

Site Name	No. of plots	Mean Dbh cm (in.)	C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	SCan	TShr	SShr	Herb	NVas	Height (m) Can	SCan
Bial's Hill	1	11.6 (4.6)	0.19	5.7 (25)	15	0	15-20	10-15	1-5	0	12	NA
Rattlesnake Hill (N.S.)	1	18.8 (7.4)	0.15	18.3 (80)	25-30	0	<1	10-15	<1	50	11	NA
Lighthouse Hill	1	15.1 (5.9)	0.36	5.7 (25)	25	0	0	25-50	5	5-10	11	NA

Mapping Criteria

Information Sources

- Aerial photography can be used to identify areas of sparse canopy cover, stunted trees and exposed bedrock.
- Topographic maps can be used to identify ridgelines, summits and cliffs.
- Soils maps can be used to identify areas of extremely well drained, thin soils.

Indicators

Topography

- *Vaccinium* Shrubland occurs on ridges and summits or occasionally on areas of bedrock outcrops with thin and extremely well drained soil on mid or lower slopes.
- This community may be associated with exposed rock at the top of cliffs.

Substrate

- Sites occur on thin, dry, acidic soils with areas of exposed bedrock.

Species

- *Vaccinium* species less than one meter in height are the dominant plants. Occasional stunted trees and larger shrubs may be present.
- The presence of *Pinus rigida* is a strong indicator of this community type.

Minimum Mapping Unit and Boundaries

- The minimum mapping unit is 0.05 hectare (.11 acre). Whole cliffs, ridge tops or bedrock outcrops should be considered as one unit. The boundary of the community type should be drawn to include all areas of exposed rock. On ridges, the edge of the community should be considered as the point at which the slope of the surrounding hill exceeds 60%.

Threats

Current Threats

- Due to the dry and shallow nature of the soil, excessive foot traffic may damage shrubland plants and cause erosion. *Vaccinium* Shrubland in areas currently open to the public may be at risk.

Potential Threats

- Although we are not aware of any invasive exotic speices that currently pose a threat to this community, there is always the potential threat of future invasions.

Management Recommendations

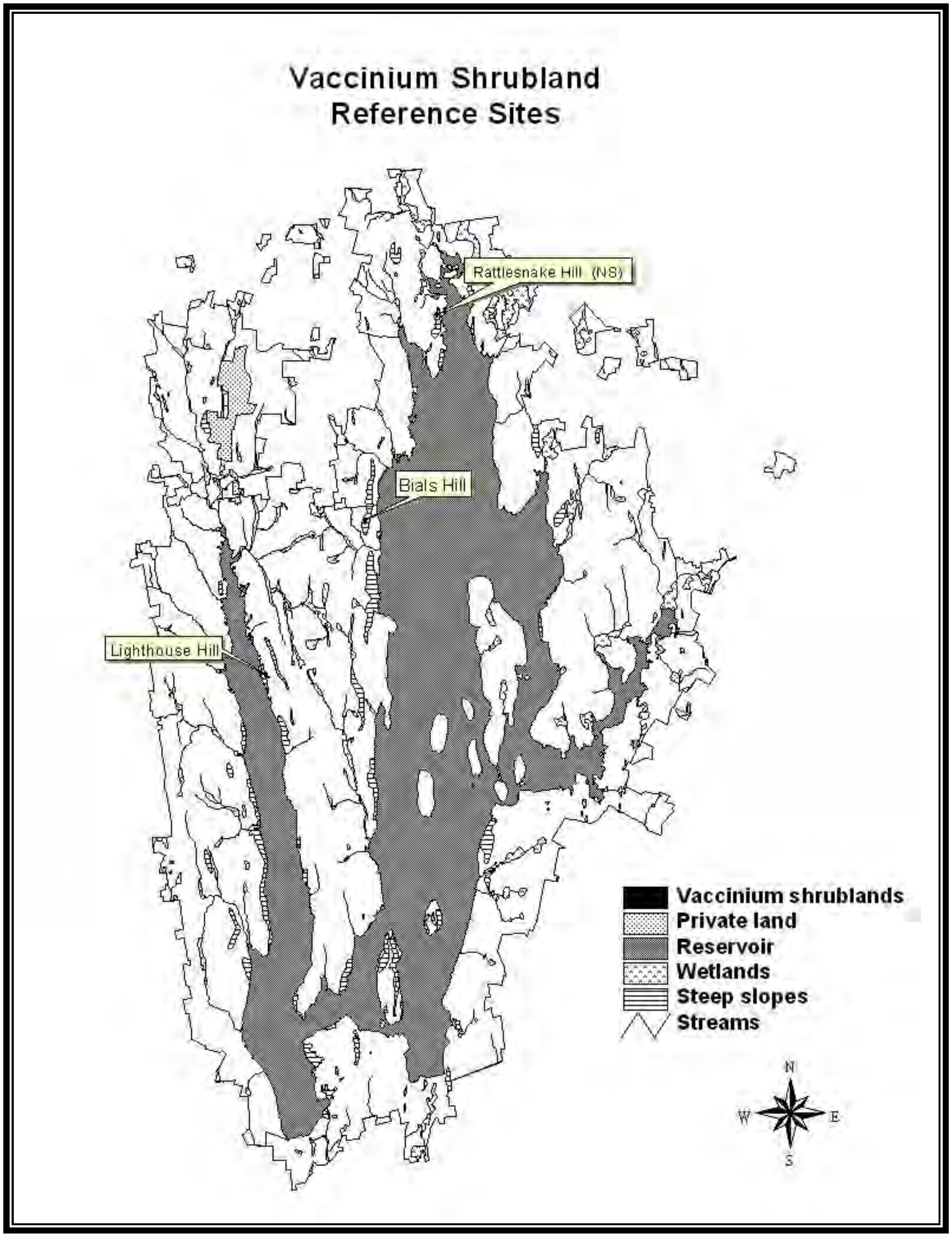
Restrictions

- Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) in and within a 50 ft. buffer zone surrounding this community should be curtailed.
- Where rock out crop communities (including *Vaccinium* Shrubland, *Juniperus virginiana* Shrubland, and Talus Slope Communities) are clustered in an area (e.g., along a ridgetop), forested corridors should remain between these areas in order to facilitate wildlife movement.

- In public access areas where foot traffic is causing a problem, completely restricting access may not be an option. In these cases, posting to inform the public that they are entering a sensitive area and instructing them to avoid trampling vegetation may be advisable.

Monitoring

- Monitoring of shrubland communities should take particular note of invasive plant species, damage to shrubs due to foot traffic, and soil erosion.



COMMUNITY 2
JUNIPERUS VIRGINIANA SHRUBLAND

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Exposed Rock and Shallow Soils
Bedrock Outcrops, Summits, Ridgetops and Cliffs

Cross Reference
Similar to NHESP description of *Circumneutral Rocky Summit/Rock Outcrop Community*.

Status
G4 S2 (S3); This type is rare regionally.

Physical Characteristics
This community is found on ridgetops, bedrock outcrops and cliffs. Soils typically originate from circumneutral bedrock outcrops such as syenite, basalt, diorite, shale, or some types of gneiss. The bedrock types do not include limestone or marble. The presence of rocks or a rock layer often either prohibits trees from growing or significantly inhibits their development. Shrubs and small trees are dominant.

Vegetation Composition
The tree canopy, where it exists, is sparse. Shrubs and herbaceous plants are the dominant life forms. Tree species found in these areas include *Acer saccharum*, *Betula papyrifera, Carya glabra*, *C. ovalis, Fraxinus americana, Quercus rubra* and possibly *Tilia americana*. Other woody species include *Celtis occidentalis* and *Ostrya virginiana. Juniperus virginiana* is a strong indicator of this community type.

Understory species include *Arabis drummondii Asclepias verticillata, Geranium robertianum, Hepatica americana, Lespedeza spp., Ranunculus fascicularis, Rosa carolina, Saxifraga virginiensis, Senecio obovatus, S. pauperculus, Sorghastrum nutans, Staphylea trifolia, Viola palmata, V. sagittata, Woodsia obtusa,* and *W. ilvensis*.

Sources: Sneddon et al. 1994, Parikesit et al. 1995, Kelley and Larson 1997

Rare Plants

Common Name	Scientific Name	MA Status
Green rock-cress	*Arabis missouriensis*	T
Linear-leafed milkweed	*Asclepias verticillata*	T
Narrow-leafed vervain	*Verbena simplex*	E
New England blazing star	*Liatris scariosa var. novae-angliae*	SC
Michaux's sandwort	*Arenaria stricta*	SC

Sources: National Audubon Society 1980, NHESP 1985, Sorrie 1987, Gleason and Cronquist 1991, Brumback and Mehroff 1996, Petersen and McKenny 1996, Massachusetts NHESP 1998

Rare Vertebrates

Birds

Common Name	Scientific Name	MA Status
Bald Eagle	*Haliaeetus leucocephalis*	E (T)
Peregrine falcon	*Falco peregrinus*	E (T)

Sources: Bent 1937, Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Veit and Petersen 1993, Degraaf and Rappole 1995

Reptiles

Common Name	Scientific Name	MA Status
Black rat snake	*Elaphe obsoleta*	E
Northern copperhead	*Agkistridon contortrix*	E
Timber rattlesnake	*Crotalus horridus*	E

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Rattlesnake Hill	Petersham, Compartment 8	Marginally Representative
2.	Soapstone Hill	Petersham, Compartment 12	Marginally Representative
3.	Fairview Hill, Gate 31	New Salem, Compartment	Marginally Representative

One or two circular plots 15 meters in diameter were sampled at each of the above sites. All plots are located in areas of sparse or non-existent tree canopy and relatively high elevation. A few *Juniperus virginiana* were present near each of the plots, but the species was not abundant in any. All sites featured plant species indicative of circumneutral summit communities, but no sites exhibited a classic example.

Species found in our survey that are not listed above include *Agrostis perennans, Antennaria plantaginifolia, Aronia melanocarpa, Cardamine parvifolia, Carex laxiflora, C. pensylvanica, Comandra umbellata, Corydalis sempervirens, Danthonia spicata, Digitaria sanguinalis, Erechtites hieraciifolia, Euthamia graminifolia, Helianthemum canadense, Hieracium venosom, Leersia spp., Lysimachia quadrifolia, Krigia virginica, Parthenocissus quinquefolia, Poa compressa, Polytrichum commune, Potentilla simplex, Pteridium aquilinum,* *Quercus prinoides, Rumex acetosella, Schizachyrium scoparium, Silene antirrhina, Solidago bicolor, S. nemoralis, Vaccinium angustifolium, V. pallidum* and *Vulpia octoflora.* The mean soil pH of sites surveyed is 4.5. The mean basal area is 8 m^2/ha (35 $ft.^2$/ac); the mean dbh is 16.5 cm (6.5 in.).

Juniperus virginiana Shrubland is usually associated with circumneutral soils, though all survey sites at Quabbin have soils with a pH of 4.9 or less. The average soil pH of the *Juniperus virginiana* Shrubland sites is only slightly less acidic than the average soil pH of the *Vaccinium* Shrubland sites, though the only later type is associated with acidic soils. All three sites are representative of the community description in terms of soil texture and drainage. Though the sites surveyed at Quabbin are marginally representative of the type described by NHESP in terms of vegetation, they do have some of the species associated with circumneutral ridgetops. Because of the general lack of circumneutral substrate and associated vegetation in the Quabbin watershed, these areas deserve recognition and protection.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Rattlesnake Hill (Pet.)	1	Ridgetop	20 / 140	0 to 4	Sandy loam	A: 4.3 B: 4.2	Well drained
Soapstone Hill	1	Ridgetop	25 / 190	0 to 6	Sandy loam	A: 4.1 B: 4.6	Well drained
Fairview Hill	2	Ridgetop	12 / 200, 250	5 to 7	Loam	A: 4.3 B: 4.9	Well drained

Site Name	No. of plots	Mean Dbh		Basal area	Percent Cover						Height (m)	
		cm (in.)	C.V.	m^2/ha (ft^2/ac)	Can	SCan	TShr	SShr	Herb	NVas	Can	SCan
Rattlesnake Hill (Pet.)	1	15.0 (5.9)	0.13	6.9 (30)	35	0	5	25	15	0	14	NA
Soapstone Hill	1	18.8 (7.4)	NA	4.6 (20)	5-10	0	20	10	25-30	0	9	NA
Fairview Hill	2	17.6 (6.9)	0.20	6.3 (28)	0-20	0	0-10	10-25	10-20	1-20	17	NA

Mapping Criteria

Information Sources

- Aerial photography can be used to identify areas of sparse canopy cover, stunted trees and exposed bedrock.
- Topographic maps can be used to identify ridgelines, summits, and cliffs.
- Soils maps can be used to identify areas of extremely well drained, thin soils.

Indicators

Topography

- *Juniperus virginiana* Shrubland occurs on ridges and summits or occasionally on areas of bedrock outcrops with thin and extremely well drained soil on mid or lower slopes.

Substrate

- Sites occur on thin, dry soils with areas of exposed bedrock.

Species

- *Juniperus virginia, Fraxinus americana* and *Tilia americana* are indicator species.

Minimum Mapping Unit and Boundaries

- The minimum mapping unit is 0.05 hectare (.11 acre). Whole ridge tops or bedrock outcrops should be considered as one unit. The boundary of the community type should be drawn to include all areas of exposed rock. On ridges, the edge of the community should be considered as the point at which the slope of the surrounding hill exceeds 60%.

Threats

Current Threats

- Due to the dry and shallow nature of the soil, excessive foot traffic may damage shrubland plants and cause erosion. *Juniperus virginiana* Shrubland in areas currently open to the public may be at risk.

Potential Threats

- Although we are not aware of any invasive exotic speices that currently pose a threat to this community, there is always the potential threat of future invasions.

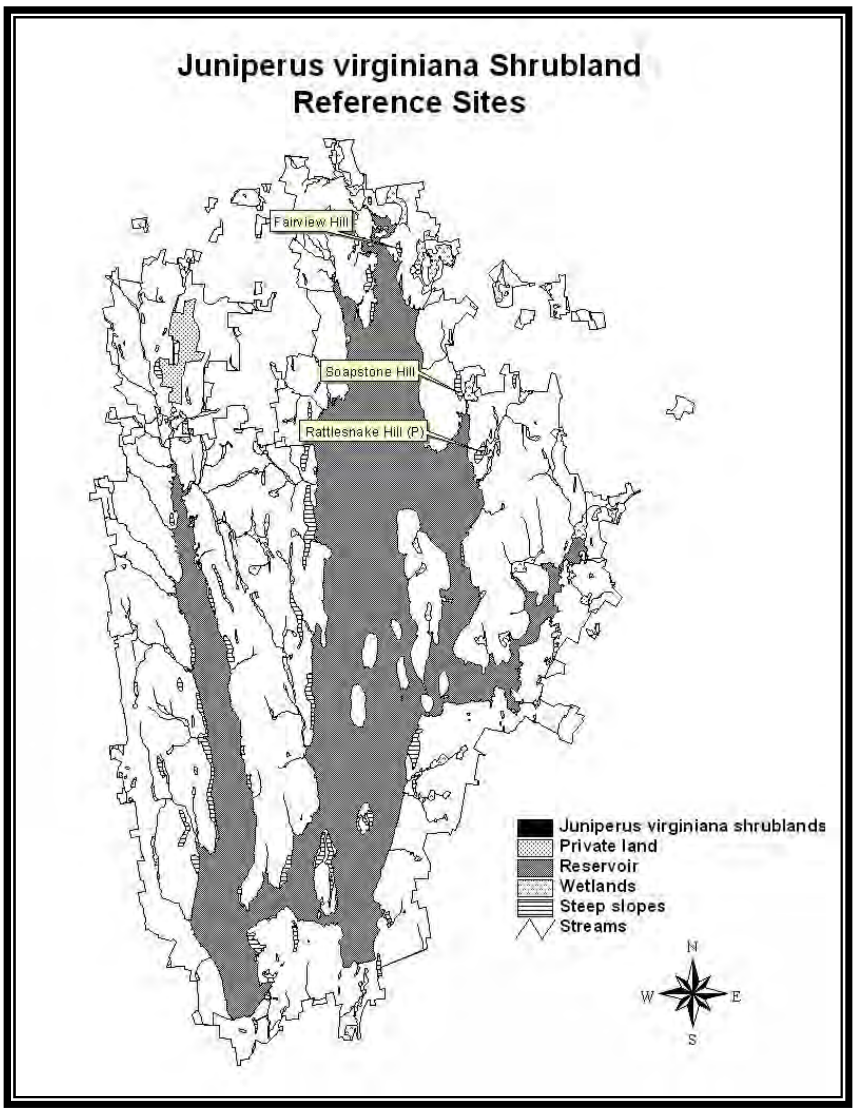
Management Recommendations

Restrictions

- Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) in and within a 50 ft. buffer zone surrounding this community should be curtailed.
- Where rock out crop communities (including *Vaccinium* Shrubland, *Juniperus virginiana* Shrubland, and Talus Slope Communities) are clustered in an area, forested corridors should remain between these areas in order facilitate wildlife movement.
- In public access areas where foot traffic is causing a problem, completely restricting access may not be an option. In these cases, posting to inform the public that they are entering a sensitive area and instructing them to avoid trampling vegetation may be advisable.

Monitoring

- Monitoring of shrubland communities should take particular note of invasive plant species, damage to shrubs due to foot traffic, and soil erosion.



COMMUNITY 3
TALUS SLOPE COMMUNITY

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Exposed Rock and Shallow Soils
Talus Slopes

Cross Reference
Similar to NHESP descriptions ***Acidic Talus Forest / Woodland Community*** and ***Circumneutral Talus Forest / Woodland Community***.

Status
Talus slopes are generally uncommon within the Quabbin area.

Physical Characteristics
Soils are shallow and can be acidic to circumneutral. Large boulders are present. The presence of rocks or a rock layer either prohibits trees from growing or significantly inhibits their development, resulting in an open canopy. Although acidic and circumneutral talus slopes are sometimes considered separate communities, they are combined here because known sites in the Quabbin area have characteristics of both and cannot be easily categorized.

Vegetation Composition
A variety of tree species may be present, including ***Acer rubrum, A. saccharum, Betula lenta, B. alleghaniensis, Carya glabra, C. ovalis, C. ovata, Fraxinus americana, Prunus serotina, P. virginiana, Quercus spp.*** and others.

The shrub layer is usually sparse and may include young or stunted specimens of the canopy species*.* *Cornus rugosa* and *Sambucus racemosa* var. *pubens* are usually common. It may also include *Acer spicatum, Amelanchier spp*., *Hamamelis virginiana, Kalmia latifolia, Rhus typhina,* and *Toxicodendron radicans*.

The herbaceous layer may include *Aralia nudicaulis, Aster acuminatus, Dryopteris marginalis, Maianthemum canadense, Parthenocissus quinquefolia*, *Polypodium virginianum,* and *Pteridium aquilinum*. Ericaceous shrubs may be common. Vines and twining herbs are frequently present in quantity.

Source: Sneddon et al. 1994, Swain and Kearsley 1999

Rare Plants

Common Name	Scientific Name	MA Status
Climbing fumitory	*Adlumia fungosa*	T
Purple clematis	*Clematis occidentalis*	SC
Shining wedge grass	*Sphenopholis nitida*	?

Sources: National Audubon Society 1980, Sorrie 1989, Gleason and Cronquist 1991, Brumback and Mehroff 1996, Petersen and McKenny 1996, Massachusetts NHESP 1998

Rare Vertebrates

Birds

Common Name	Scientific Name	MA Status
Bald Eagle	*Haliaeetus leucocephalis*	E (T)
Cooper's hawk	*Accipiter cooperii*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Bent 1937, Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Veit and Petersen 1993, Degraaf and Rappole 1995

Reptiles

Common Name	Scientific Name	MA Status
Black rat snake	*Elaphe obsoleta*	E
Northern Copperhead	*Agkistridon contortrix*	E
Timber rattlesnake	*Crotalus horridus*	E

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Soapstone Hill	Petersham, Compartment 12	Representative*
2.	Rattlesnake Hill	New Salem, Compartment 16	Representative*
3.	Rattlesnake Hill	Petersham, Compartment 8	Representative*

*All sites are more representative of acidic talus communities, but have some characteristics of circumneutral communities.

One circular plot 15 meters in diameter was sampled at each of the above sites. All plots were located on slopes between 25 and 40 degrees, with many large boulders present and an open or non-existent tree canopy. Some literature sources specify that *Quercus* and *Carya* species dominate talus slopes. Though these species were not found on the sample sites, the sites were similar in shrub composition and landscape position.

Species found in our survey that are not listed above include *Agrostis perennans, Aquilegia canadensis, Arisaema triphyllum, Aster macrophyllus, Carex argyrantha, C. cephalophora, C. laxiflora, Chenopodium album, C. simplex* (a watchlist species), *Corydalis sempervirens, Danthonia compressa, D. intermedia, D. spicata, Diervilla lonicera, Galium spp., Muhlenbergia mexicana, Rubus occidentalis, Smilacina racemosa, Solanum dulcamara, S. nigrum, Solidago caesia, S. rugosa,* and *Triodanis perfoliata.* Soils were generally too shallow to take a meaningful soil sample, usually existing as scattered pockets of organic matter on boulders. The mean basal area is 11 m^2/ha (47 ft.^{2}/ac); the mean dbh is 34.8 cm (13.7 in.). Only the plot on Rattlesnake Hill, New Salem contained canopy trees; all measurements of dbh are from that plot.

Though the vegetation composition of these sites differs in some repects from the described community, they are very good examples in terms of substrate, slope, and topographic position. The most unique characteristic of these sites is the boulder strewn slopes themselves, and therefore they areas deserve recognition and protection.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Soapstone Hill	1	Mid slope	40 / 120	0 to 9	Sandy loam	A: 4.0	Rapidly drained
Rattlesnake Hill (N.S.)	1	Mid slope	26 / 150	NR	NR	NR	Rapidly drained
Rattlesnake Hill (Pet.)	1	Low slope	30 / 150	0 to 3	Sandy loam	NR	Rapidly drained

Site Name	No. of plots	Mean Dbh cm (in.)	C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	SCan	TShr	SShr	Herb	NVas	Height (m) Can	SCan
Soapstone Hill	1	0	NA	0	0	0	15-20	10	20-25	NR	NA	NA
Rattlesnake Hill (N.S.)	1	34.7 (13.6)	0.18	16.1 (70)	30-40	15	0	10-15	15-25	15-25	23	NR
Rattlesnake Hill (Pet.)	1	43.3 (17.0)	NA	18.3 (80)	40	10	15	0	25-30	0	27	NR

Mapping Criteria

Information Sources
- Topographic maps can be used to find areas of steep slope (30% or more).
- Aerial photography may show areas of talus and large boulders, which cause an open tree canopy.

Indicators

Topography
- Talus communities occur on steep slopes.

Substrate
- Large boulders are present.

Species
- Canopy can have variable composition; Defining species are *Cornus rugosa* and *Sambucus racemosa.*

Minimum Mapping Unit and Boundaries
- The minimum mapping unit is 0.05 hectare (0.11 acres). Boundaries should be drawn to include all areas of talus with an open or non-existent tree canopy.

Threats

Potential Threats
- Disturbances to areas above talus slopes may change hydrologic regimes, and increase sedimentation and woody debris on the slopes.

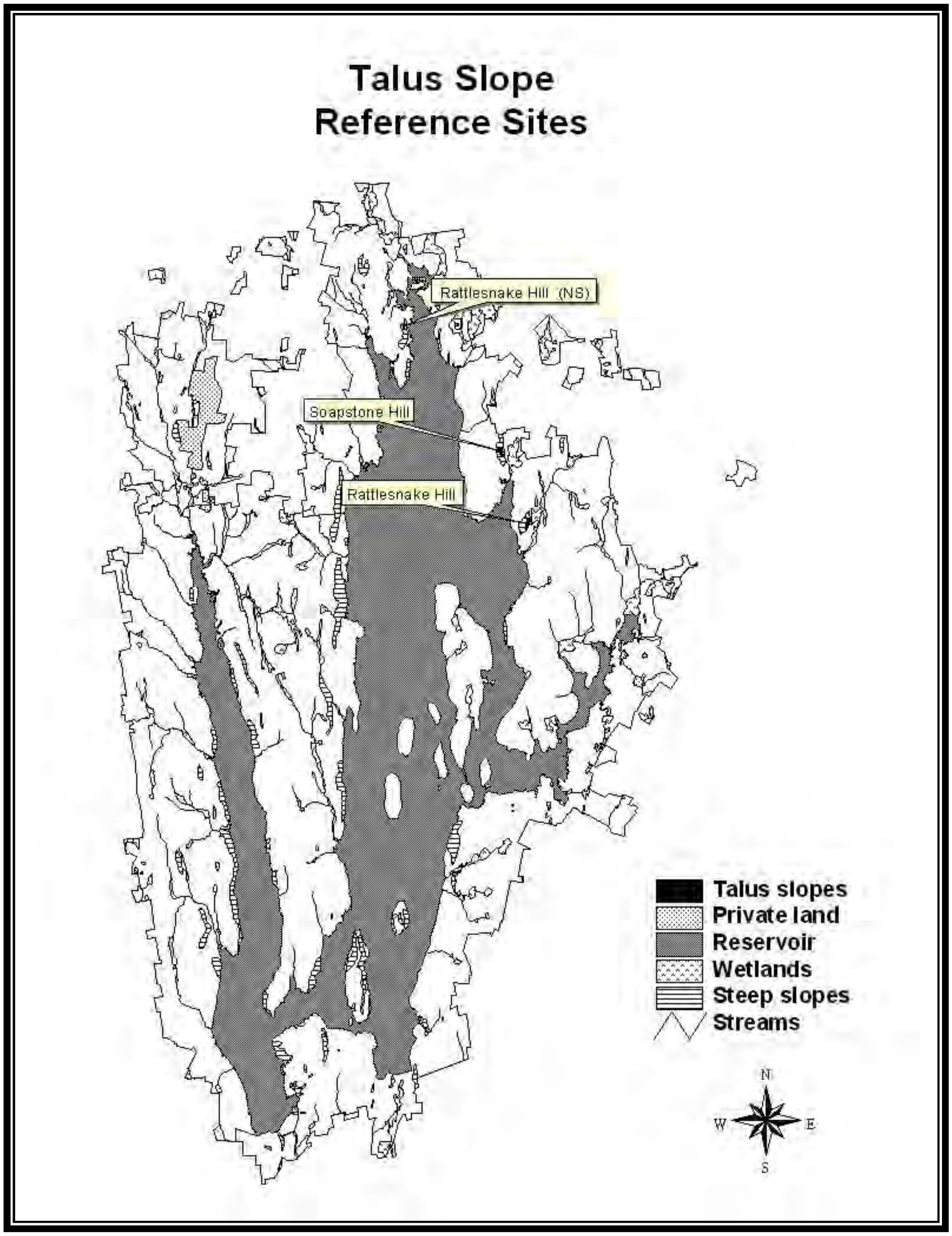
Management Recommendations

Restrictions

- Physical disturbances (e.g., timber harvesting) that alter microclimate (e.g., light) conditions and/or hillslope processes should be curtailed in a 50 ft. buffer zone above talus slopes.
- Where rock out crop communities (including *Vaccinium* shrubland, *Juniperus virginiana* shrubland, and Talus Slope communities) are clustered in an area forested corridors should remain between these areas.
- Though talus slopes are not usually prone to high levels of foot traffic, the plant communities of these areas are often delicate due to thin and droughty soils. In public access areas where foot traffic is causing a problem, completely restricting access may not be an option. In these cases, posting to inform the public that they are entering a sensitive area and instructing them to avoid trampling vegetation may be advisable.

Monitoring

- Monitoring of talus slope communities should take particular note of invasive plant species, damage to shrubs due to foot traffic, soil erosion and sedimentation.



COMMUNITY 4
PINUS RIGIDA – QUERCUS ILICIFOLIA WOODLAND

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Deep Soils
Dry Forests / Well-Drained Soils
Sandy Soils

Cross Reference
Similar to NHESP description of *Pitch pine – Oak Forest.*

Status
G2 S2; This community is both rare regionally and in the Quabbin area. It is often maintained by controlled burns.

Physical Characteristics
These communities occur on well drained, acidic, sandy, nutrient poor soils. The continuance of the forest type may be dependent on fire disturbance. Woodlands of this type include Pitch pine / Scrub Oak barrens and associated transitional woodlands.

Vegetation Composition
Dominant canopy species are *Pinus strobus*, *Quercus alba, Q. coccinea, Q. rubra* and *Q. velutina. Pinus rigida* is an indicator species; though it is always present it may not be plentiful. Less commonly, *Betula populifolia* may occur. *Quercus ilicifolia* often occurs in the understory.

Understory Species include *Aronia melanocarpa, Comptonia peregrina, Cypripedium acaule, Danthonia spicata, Gaultheria procumbens, Gaylussacia baccata, Kalmia angustifolia, Pteridium aquilinum, Quercus prinoides, Schizachyrium scoparium, Vaccinium angustifolium* and *V. pallidum.* Mosses and lichens are also common.

Sources: Zampella and Good 1992, Sneddon et al. 1994, Waterman et al. 1995, Motzkin et al. 1996, Seischab 1996 a and b, Massachusetts NHESP fact sheets

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Cooper’s hawk	*Accipiter cooperii*	SC
Long-eared owl	*Asio otus*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Bent 1937, Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Veit and Petersen 1993, Degraaf and Rappole 1995

Amphibians

Common Name	Scientific Name	MA Status
Eastern spadefoot **	*Scaphiopus holbrookii*	T

**This species is found in this forest type only if it is located near a wetland or open water resource.

Sources: Degraaf and Rudis 1981, 1983, 1987

Reptiles

Common Name	Scientific Name	MA Status
Eastern worm snake	*Carphosis amoenus*	T

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Fairview, near gate 31	New Salem, Compartment 20	Marginally Representative
2.	Belchertown Road powerline	Hardwick, Compartment 1	Marginally Representative

3. Observatory Hill Hardwick, Compartment 2 Marginally Representative

One or two circular plots 15 meters in diameter were sampled at each of the above sites. Of the sites sampled, only Observatory Hill had been burned recently. All sites are dominated by an overstory of pines and oaks in the canopy and ericaceous shrubs in the herbaceous layer.

Species found in our survey that are not listed above include *Amelanchier spp., Corylus americana, Lycopodium tristachyum,* other *Lycopodium spp., Trientalis borealis* and *Viburnum dentatum.* The mean soil pH of sites surveyed is 4.1; the mean basal area is 27 m^2/ha (117 $ft.^2$/ac); the mean dbh is 23.3 cm (9.2 in.).

Though these sites are only marginally representative of the described community type, they represent the best examples in the Quabbin area and deserve recognition and protection. Due to the suppression of fires and possibly the removal of pitch pine, this community type may have been more widespread in the past. The use of controlled burns may increase the density and distribution of *Pinus rigida* and cause these areas to more closely resemble the described type.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Fairview (Gate 31)	1	Low level	0 / NA	5.5	Sandy loam	A: 3.4 E: 3.7 B: 4.5	Well drained
Powerline (Bel.)	1	High slope	NR / 210	3.5	Clay loam	A: 3.5 B: 4.3	Well drained
Observatory Hill	2	High level	5 / 10, 320	5 to 6	Clay loam	A: 4.0 B: 4.6	Well drained

Site Name	No. of plots	Mean Dbh cm (in.)	C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	SCan	TShr	SShr	Herb	NVas	Height (m) Can	SCan
Fairview (Gate 31)	1	22.1 (8.7)	0.41	29.9 (130)	25-50	10-15	10-15	5-10	NR	0	21	7.5
Powerline (Bel.)	1	27.0 (10.6)	0.33	33.3 (145)	25-50	15	25-50	25-50	<5	0	18-20	10-11
Observatory Hill	2	22.8 (9.0)	0.44	21.3 (93)	15-50	0-5	15-25	75	5-10	0	17	0-10

Mapping Criteria

Information Sources

- Maps of soil types can be used to find areas of excessively drained soils.
- Aerial Photography can be used to find areas of mixed conifers and hardwoods with small, stunted trees.
- Some Pitch pine areas have been mapped and are currently being managed with controlled burns.

Indicators

Topography

- ***Pinus rigida – Quercus*** Woodlands usually occur in flat areas, but may exist on dry slopes.

Substrate

- ***Pinus rigida – Quercus*** Woodlands occur on excessively drained sandy soils.

Species

- ***Quercus*** species are the dominant canopy tree. The existence of a small proportion (5%) of Pitch pine in the canopy indicates a ***Pinus rigida – Quercus*** Woodland.

Minimum Mapping Unit and Boundaries

- The minimum mapping unit is 0.25 hectare (0.51 acre). The community boundaries should include any *Pinus rigida* and any areas within 17 meters (50 feet) with excessively drained soils.

Threats

Current Threats

- ***Pinus rigida – Quercus ilicifolia*** Woodlands are often maintained as part of the landscape by periodic fires. *Pinus rigida* may not be able to compete with other canopy species in areas where fires are suppressed.

Management Recommendations

Active Management Options
We suggest a management regime that focuses first on site restoration, then on maintenance. The specific management actions will need to be tailored to the site and will primarily be dependent on the level of hardwood invasion to the site. Sites are expected to fall into two general categories that are common variants of this community type:

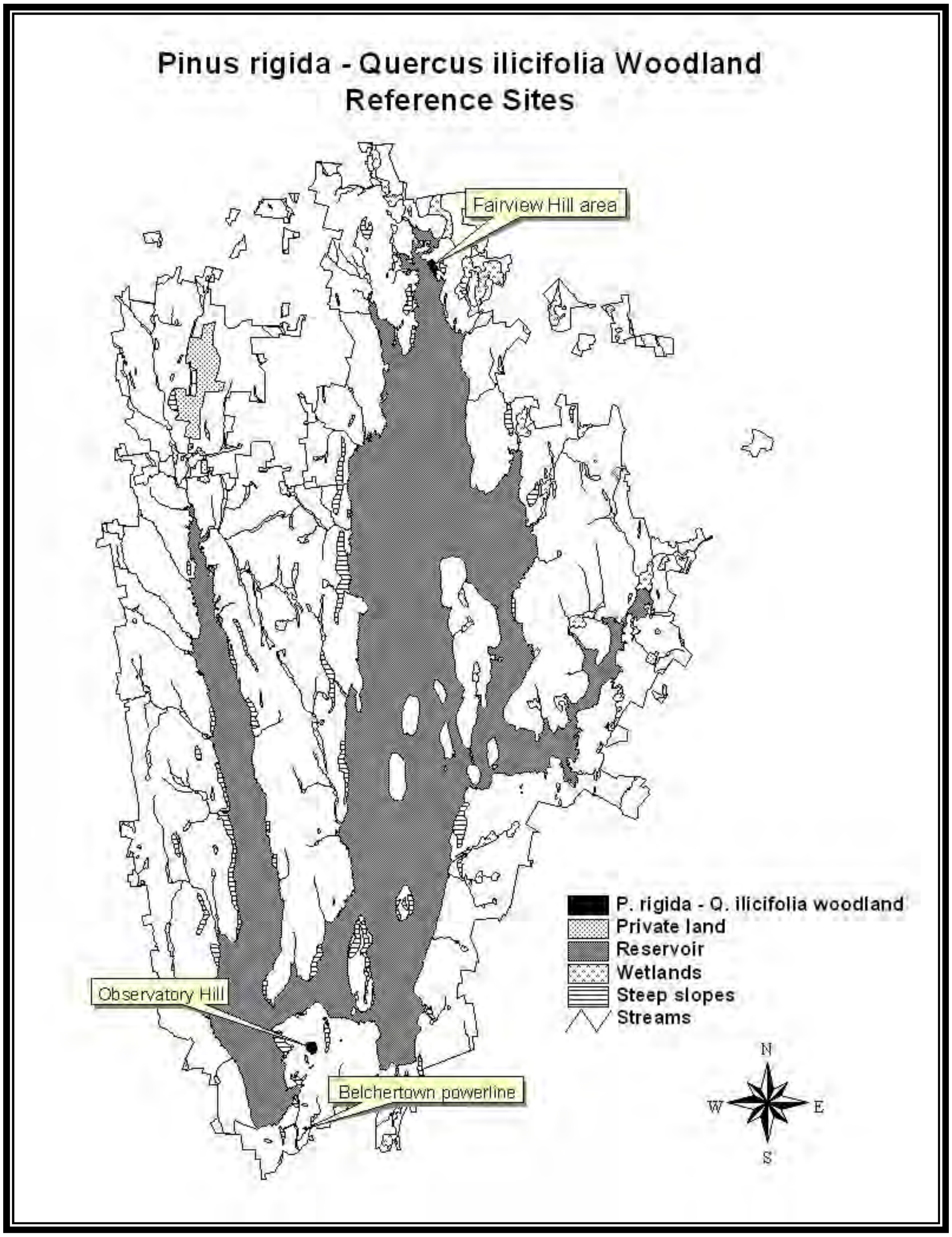
- Sites that area more scrub shrub dominated (scrub barrens) typically have an open canopy and a sparse or non-existent hardwood component. *Pinus rigida* will be present but sparse; *Quercus ilicifolia* and various ericaceous shrub species will be abundant. Management at these sites should focus on maintaining *Quercus ilicifolia* as primarily short, small-stemmed shrubs to better control the fire intensity. To attain this structure (restoration) the site may initially require frequent burning to kill off large -stemmed *Quercus ilicifolia.* Fire may be used in a cycle of 10 to 15 years to maintain this structure and composition. Plant development at each site should be monitored in order to attain the most effective regime.

- Sites that have a well-developed canopy (pitch pine woodland) and a large hardwood component will require more intense management for restoration and management. The desired result is a woodland, dominated by *Pinus rigida* with a minimal competing hardwood component (which will overtop and shade out desired species). At mature sites with abundant hardwoods, it is recommended that selective logging during the summer take place prior to implementing a fire regime. During the growing season, rapid-growing species such as *Betula populifolia* will have less root reserves available to fuel effective stump sprouts. Thus, selective cutting during this time will result in less aggressive stump sprounting. Frequent dormant season burns (5 to 10 year cycle) can then follow up to keep hardwood invasion at a minimum. Mechanical treatment (soil scarification) is recommended between burns to expose mineral soil, thereby encouraging *Pinus rigida* regeneration and discouraging hardwood invasion. Plant development at each site should be monitored in order to attain the most effective regime.

If firebreak construction is necessary, logging within and surrounding the site should be allowed.

Restrictions
- Logging within *Pinus rigida - Quercus ilicifolia* Woodlands should be limited to treatments designed to facilitate regeneration of the desired tree species and aid in the restoration of fire as the dominant disturbance process in this community.

Monitoring
- Monitoring of *Pinus rigida - Quercus ilicifolia* Woodlands should take place to assure that controlled burns are having the desired effect and that invasive plants have not been introduced.


Pinus rigida - Quercus ilicifolia Woodland
Reference Sites
Fairview Hill area
Observatory Hill
Belchertown powerline
P. rigida - Q. ilicifolia woodland
Private land
Reservoir
Wetlands
Steep slopes
Streams
N
W
E
S

COMMUNITY 5
TSUGA CANADENSIS-DOMINATED FOREST

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Deep Soils
Mesic Forests / Moderately Well-Drained Soils
Sandy-loams to Loams

Cross Reference
Similar to NHESP description of *Oak-Hemlock-White Pine Community*

Status
G? S5; Though patches of *Tsuga canadensis*-dominated forest are not rare, at Quabbin they are generally confined to discrete patches within the primarily hardwood watershed. We have chosen to include this community because its persistence is threatened due to the northward advancement of the hemlock woolly adelgid (*Adelges tsugae*). This community deserves special recognition because its characteristics (vertical structure, cool microclimate, open understory, and short-needled foliage) are unique in central Massachusetts; its loss would change Quabbin significantly in terms of available wildlife habitat and landscape diversity.

Physical Characteristic

Soils are acidic and nutrient poor, moderately well-drained sandy-loams and loams derived from granites and schists.

Vegetation Composition

Tsuga canadensis is dominant, with *Acer rubrum, A. saccharum, Betula alleghaniensis, B. lenta, Fagus grandifolia, Pinus strobus,* and *Quercus spp.* as common associates. Some *Tsuga* dominated stands are the result of the removal of *Pinus* from a mixed *Pinus / Tsuga* stands.

The understory is characteristically sparse and often absent. Where a shrub layer is present *Acer pensylvanicum, Hamamelis virginiana,* and *Kalmia latifolia* can occur.

The herbaceous layer may include *Clintonia borealis, Epigaea repens, Gaultheria procumbens, Lycopodium spp., Maianthemum canadense, Medeola virginiana, Mitchella repens, Monotropa uniflora, Oxalis acetosella, Streptopus roseus,* and *Trientalis borealis.*

Sources: Charney 1980, Brown et al. 1982, Mladenoff 1990, Godman and Lancaster 1991, Foster et al. 1992, Foster and Zebryk 1993, Sneddon et al. 1994, Swain and Kearsley 1999

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Cooper's hawk	*Accipiter cooperii*	SC
Long-eared owl	*Asio otus*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Bent 1937, Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Degraaf and Rappole 1995

Survey Summary

	Quabbin Reference Sites	Compartment	Site Quality
1.	Atherton Brook area	Shutesbury, compartment 14	Representative
2.	Jucket Hill	Pelham, compartment 2	Representative*
3.	Gate 40	Petersham, compartment 6	Representative
4.	Pelham Hollow	Pelham, compartment 9	Representative*
5.	Egypt Brook area	Prescott, compartment 12	Representative*

*Hemlock woolly adelgid has been noted at these sites.

Circular plots 15 meters in diameter were established at each site listed above. Data has been summarized for three of the above sites. Data for most soil characteristics are not available. All sites are characterized by abundant *Tsuga canadensis* and associates *Acer rubrum, Betula alleghaniensis, B. lenta, Fraxinus americana, Pinus strobus,* and

Quercus rubra. Understory is sparse except where canopy openings are present. *Aralia nudicaulis, Maianthemum canadense*, *Mitchella repens*, and *Trientalis borealis* are common to all sites.

Species found in our survey that are not listed above include *Cypripedium acaule, Dennstaedtia punctilobula, Monotropa uniflora, Uvularia sessilifolia, and Viola sp.*

All of the sites listed above are representative of the *Tsuga canadensis*-dominated upland forest community type in structure, composition, and physical character. The Jucket Hill, Pelham Hollow, and Egypt Brook area stands are located on steep slopes, while the Atherton Brook area and Gate 40 sites occur on relatively flat terrain. Sites with evidence o HWA infestation include Jucket Hill, Pelham Hollow, and Egypt Brook area. Examples of this stand type are not uncommon at Quabbin, but are threatened by the HWA. All stands of this type should be identified, mapped, and managed in a manner that promotes their perpetuity.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Atherton Brook area	2	Low level	0 / 0	NR	NR	NR	Well drained
Jucket Hill area	2	Mid slope	10, 12 / 30, 34	NR	NR	NR	Well drained
Egypt Brook area	2	Mid slope	16, 22 / 112	NR	NR	NR	Well drained

Site Name	No. of plots	Mean Dbh cm (in.)	Mean Dbh C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	SCan	TShr	SShr	Herb	Nvas	Height (m) Can	SCan
Atherton Brook area	2	37.6 (14.8)	0.38	39.8 (173)	65-80	0-5	1-20	5-20	3	0	26	18
Jucket Hill area	2	29 (11.4)	0.48	45.3 (197)	60-85	5	0	0	1-15	0	24.5	12
Egypt Brook area	2	27.8 (11)	0.38	34 (147.5)	70	0-15	0	0-1	1-15	0-1	28.5	16

Mapping Criteria

Information Sources

- Aerial photography can be used to find areas with dense stands of hemlock.

Indicators

Topography

- *Tsuga canadensis*-dominated Forests can be found in a variety of areas. They are more common on mid slopes and on north facing slopes. *Tsuga canadensis* dominated areas on steep slopes adjacent to streams should be considered High-gradient *Tsuga canadensis*-dominated Riparian Zones rather than *Tsuga canadensis*-dominated Forests.

Substrate

- Soils are usually deep, moist, acidic and nutrient poor loams.

Species

- Hemlocks comprise 80% of the canopy cover. The understory is sparse.

Minimum Mapping Unit and Boundaries

- The minimum mapping unit is 0.48 hectare (1 acre). The community boundaries should include all areas of continuous hemlock canopy.

Threats

Values of Hemlock-dominated Forest

Given the recent attention on hemlock due to the hemlock wooly adelgid (HWA) and the contention over future management actions, it is important to distinguish the unique ecological values of this community type in the Quabbin watershed

- Eastern hemlock represents one of only two abundant, native conifer cover types within the primarily hardwood dominated matrix of central Massachusetts. It represents a unique, distinct and functional natural community type on the landscape.

- The unique vegetation structure, deep shade, cool microclimate, and dense, well-distributed foliage characteristic of hemlock stands are not replicated in the other common conifer type, white pine.

- Though no wildlife species are considered obligates to hemlock, the black-throated green warbler is strongly associated with hemlock and other short-needled conifers through most of its range (Benzinger 1994 and references therein, Parrish 1995, Mitchell 1999). Therefore, the lack of other abundant short-needled conifer cover types in central Massachusetts probably makes it preferential habitat for black-throated green warblers and other similarly associated species (e.g., blackburnian warbler, magnolia warbler, solitary vireo, and hermit thrush) (Benzinger and references therein, Mitchell 1999). Hemlock ravines in the Quabbin area have been observed to be the primary breeding habitat in Massachusetts for the Acadian flycatcher, a southern species that has been expanding its range northward (Blodget pers. comm). The dense foliage may provide winter cover for ungulates and other wildlife (Forbes and Theberge 1993, Pauley et al. 1993, Griesemer et al. 1998).

- Hemlock at Quabbin not only provides a unique habitat component to the landscape, but several extant stands also provide extensive patches of uninterrupted conifer habitat. The value of interior forest habitat is becoming increasingly of interest, as large forest patches are becoming fragmented and converted to other cover types. There is evidence that an increase in forest edge may increase or retain overall species richness (through a change in species composition to include more generalist species), but may decrease the occurrence of more specializing interior species (Kroodsma 1984, Derleth et al. 1989, Germaine et al. 1997)

- For most taxa, there is lack of published scientific research that investigates the role of hemlock as a key habitat component. Therefore, value of hemlock is still largely unknown, particularly to invertebrates and other traditionally under-studied taxa.

- From a biodiversity conservation stand point, the elimination of any natural community type from the landscape represents a significant loss with potential consequences.

Current Threats
The hemlock woolly adelgid (HWA) can potentially defoliate entire stands of hemlock. In Connecticut, it was observed that a rapid understory response, primarily of black birch, can occur as adequate light penetrates the damaged canopy to the forest floor (Orwig and Foster 1998). Under these conditions, complete cover type conversion may result with hemlock reinitiation unlikely. The forest structure and microclimate will differ markedly from its initial condition. Invasive species such as hayscented fern may begin to grow due to increased light availability. If HWA defoliation becomes widespread throughout central Massachusetts, it could signify a major change in forest composition, structure, and function.

Based on the continuing work of Orwig and Foster (1998), HWA appear to be indiscriminant in its attack on hemlock. All life stages of both healthy and weakened trees appear to be susceptible to HWA. Moreover, these investigators have not found reliable relationships between site conditions and rates of HWA infestation and hemlock mortality. On the other hand, even within the region of heaviest infestation, some stands appear to escape infestation. Thus, clearly there exists an incomplete understanding of the complex factors involved in HWA-hemlock relationships. As HWA moves northward into new environmental regimes (e.g., climate), it is inappropriate to assume that all, or even most, hemlock stands will suffer high levels of mortality following infestation. Currently, HWA is widely distributed throughout Quabbin, although many stands are still not infested. With much still unknown about the insect's outbreak behavior in New England, it is difficult to predict the actual intensity and pattern with which the HWA will strike the Quabbin. It is possible that resulting defoliation will be patchy, leaving several stands or groups of trees intact, therefore retaining a viable seed source.

Other damaging insect pests include the elongate hemlock scale (***Fiorinia externa***), the circular hemlock scale (***Nuculaspis tsugae),*** hemlock looper (***Lambdina fiscella fiscella***), and hemlock borer (***Melanophila fulvoguttata***), . The two scale species, introduced from Japan, cause yellowing of the foliage, needle loss, and death within a decade (Douglas and Cowles 2000). The hemlock looper is a native defoliating caterpillar that, like HWA, has the potential to cause over 80% mortality in a stand (Heyd 1996). The hemlock borer is a beetle that attacks stressed, weakened trees (Heyd 1996); once established, it could severely complicate other current hemlock problems like HWA. The actual status of each of these insects at the Quabbin is unknown.

Potential Threats

Due to the uncertain future of hemlock stand dynamics in the face of HWA, a possible threat we perceive is the broad application of any one management strategy. The implementation of a single strategy across Quabbin designed to achieve regeneration of other tree species in hemlock-dominated stands may threaten the future of hemlock stands as a represented community type in this landscape. In particular, forestry practices that involve removal of large portions of hemlock overstory to encourage regeneration of other species, essentially break up contiguous patches of hemlock. While the implementation of theses practices may be deemed consistent with management goals for water quality, it should be recognized that if all hemlock stands throughout Quabbin are excessively opened up and infiltrated by other cover types, the unique character of interior, dark, cool, and sparsely-vegetated hemlock stands may be eliminated from the landscape or irrevocably altered for the foreseeable future. Under this scenario, hemlock patches would likely decrease in overall size and reside as minor inclusions throughout the hardwood forest matrix, reducing the representation of hemlock as a community type on the landscape. Accordingly, interior hemlock forest habitat may be greatly reduced for certain species and the increased light may change microhabitat conditions and encourage establishment of invasive plants.

In addition, it has been suggested for consideration that other native and non-native conifer tree species be planted to replace dead and dying hemlock stands. The exotic ***Picea abies***, for example, has been successfully planted throughout the Quabbin and has proven to grow quite well on sites similar to those dominated by hemlock. The overall character (e.g., structure and microclimate) of these exotic spruce stands appear to be similar to hemlock stands. Thus, it seems likely that at least some of the ecological values associated with hemlock-dominated stands could be maintained in spruce-dominated stands. However, it is unknown whether spruce stands function similarly as habitat for wildlife, or whether energy and material fluxes are quantitatively and qualitatively similar. Moreover, it is a philosophical issue as to whether any exotic species should be used to replace a native community, especially when the overriding goal of the management of this community is to conserve native biodiversity.

Management Recommendations

Active Management Options

The potential large-scale impact of HWA on hemlock stands and the Quabbin landscape as a whole must be factored into the overall forest management plan. To address the goals of obtaining complex forest structure for water quality protection, encouraging the persistence of hemlock on the landscape, and addressing HWA disturbance in the context of both of these goals, we suggest an approach that makes use of a suite of techniques. Given the uncertainty associated with possible HWA impacts and responses to various management activities, we recommend using techniques that span a gradient of management intensity and methodology. In this manner, the risk of experimental management is dispersed among treatments, rather than concentrated under one unproven strategy. These recommendations were developed in close consultation with several faculty in the Department of Natural Resources Conservation at Umass (see inside cover for list of names). In addition, we drew from the following publications (Becker et al. 1996, Brogger 1996, Crow 1996, Lorimar 1996, Pubanz 1996, Tubbs 1996, Goerlich and Nyland 2000, and Kelty 2000).

Although there is no consensus regarding the single best methodology for achieving hemlock regeneration, we have summarized common themes below. It should be noted that MDC has extensive experience in regenerating hemlock and has experimented with a variety of approaches. We believe that the following guidelines are consistent with and, in part, based on those experiences:

- Hemlock regenerates and succeeds in small, scattered gap openings (1/10th acre), and competition with rapidly growing hardwoods increases as gap size increases. The creation of small gap openings in and immediately surrounding hemlock stands (i.e., where there is a hemlock seed source) to encourage hemlock regeneration could enlarge existing hemlock stands and promote multi-aged stand development.
- Retention of 70 to 80% canopy cover discourages competition from shade-intolerant species and helps maintain cool ground temperature (i.e., retaining cool microsite conditions that favor hemlock regeneration).

- Two-cut and three-cut shelterwood methods using light selection thinning, slows release of other species and maintains shade to prevent shade-intolerant species from invading, thereby favoring the establishment and growth of hemlock.
- Soil scarification that results in exposure of mineral soil increases hemlock regeneration potential and is highly recommended for most cuts.
- Strategically placing cuts adjacent to a seed-producing mature hemlock will help provide adequate seeding of the site.

Below, we describe management scenarios that could be applied at different sites throughout Quabbin. A detailed replicated design to maximize scientific analysis potential should be worked out prior to implementation.

1. Unmanaged sites (i.e., no treatment); no clearing or thinning would occur in any portion of the stand. These sites can serve as a reference condition and would include both infested and non-infested sites. In keeping with water quality protocol, these sites could potentially be ones deemed least exposed to catastrophic winds, although this may introduce confounding variables and complicate future analysis.

2. Thinned sites, consistent with methods outlined in the MDC Land Management Plan under "Intermediate Cuts" (p. 88), would receive light treatment and mimic single tree gap openings. If possible, this scenario would include both infested and non-infested sites.

3. Small group cuts, similar to those discussed in the "Release of Regeneration" section of the MDC Land Management Plan (p. 87), would be applied to several sites. Each may vary in size, dispersion, and soil scarification treatment. We recommend small $1/10^{th}$ acre cuts dispersed at different densities throughout the stand. Soil scarification, with use of a rock rake (Becker et al. 1995) or another proven method, should be applied as a treatment to some stands. This method may also be used to enlarge stands. If possible, this scenario would include both infested and non-infested sites.

4. Two-cut (first cut leaves 50% canopy cover or 110 ft^2 evenly dispersed) or three-cut (first cut leave 70-80% canopy cover, second cut leave 50% with 10 years between cuts) shelterwood techniques would be applied. Soil scarification, using a rock rake (Becker et al. 1996), or another proven method should be applied as a treatment to some stands. If possible, this scenario would include both infested and non-infested sites.

With the application of experimental management scenarios, we may be able to investigate some or all of the following questions:

- How do various management scenarios affect the survival and regeneration of hemlock in stands that are currently infested with HWA versus stands not infested?
- How do various management scenarios affect the likelihood of stands becoming infested with HWA in the future? In addition, what are the physical and biological characteristics that affect the likelihood of a stand becoming infested under various management scenarios?
- How does the level of damage and mortality differ among infested sites under each treatment over time?
- Which management scenarios create higher risks to invasive plant establishment? Also, does HWA infestation and subsequent damage and mortality affect invasive plant establishment?

Restrictions

- Forestry activities that take place in hemlock stands should be focussed toward regeneration of hemlock and stand perpetuity, rather than species replacement.
- As indicated in the 1995 MDC Land Management Plan, coarse woody debris should not be removed. Specifically, the overall microtopography including mounds, logs and other dead and downed debris should be retained for the benefit of ground and stream dwelling organisms and nutrient cycling contributions.

Monitoring

- The occurrence, distribution, and density of invasive insects, particularly HWA, should be tracked at Quabbin so that informed decisions on hemlock management are possible.

COMMUNITY 6
ACER SACCHARUM - FRAXINUS AMERICANA - TILIA AMERICANA FOREST

Classification
TERRESTRIAL COMMUNITIES
Terrestrial Communities on Deep Soils
Loams to Silt-loams

Cross Reference
Similar to NHEP description of *Rich, Mesic Forest Community*.

Status
G4 S3; This type is more common in other parts of the state. Due to the lack of calcareous bedrock In the Quabbin area, this community is uncommon and restricted to circumneutral, mesic soils.

Physical Characteristics
Includes forests on rich soils, possibly with calcareous substrate. Soils are rich in humus, high in nutrients, and moist but not saturated. The high nutrient content is due weathering of calcareous bedrock or to high nutrient leaf litter (from *Tilia americana, Acer saccharum,* etc.). Soil pH is relatively high compared to other local forest types. Occurs more frequently on middle and lower slopes, facing north or east.

Vegetation Composition
Dominant Canopy Species include *Acer saccharum, Fraxinus americana* and *Tilia americana*. *Acer saccharum* can occur to the exclusion of other species. *Tilia americana* may not be present. Associated species include *Betula alleghaniensis, B. lenta, Carya glabra, C. ovalis, Fagus grandifolia* and *Quercus rubra*. Rich Mesic forests may occur adjacent to Oak / Pine forests.

Immature trees of the canopy species occur in the understory as they are all shade tolerant, though the subcanopy may be sparse. *Carpinus caroliniana, Cornus alternifolia, Dirca palustris* and *Ostrya virginiana* may also be present.

The herbaceous layer is made up of *Actea alba, Adiantum pendatum, Allium tricoccum, Asarum canadense, Cardamine diphylla, Caulophyllum thalictroides, Claytonia caroliniana, Dicentra canadensis, D. cucullaria, Erythronium americanum, Hepatica americana, Medeola virginiana, Osmorhiza claytonii, Polystichum acrostichoides, Sanguinaria canadensis, Solidago flexicaulis, Trillium erectum* and *Viburnum lentago*.

Sources: Sneddon et al. 1994, Swain and Kearsley 1999, Massachusetts NHESP fact sheets

Rare Plants

Common Name	Scientific Name	MA Status
American ginseng	*Panax quinquefolius*	SC
Autumn coralroot	*Corallorrhiza odontorhiza*	SC
Barren strawberry	*Waldsteinia fragarioides*	SC
Black cohosh	*Cimicifuga racemosa*	E
Black maple	*Acer nigrum*	SC
Bristly black currant	*Ribes lacustre*	SC
Broad waterleaf	*Hydrophyllum canadense*	E
Canadian sanicle	*Sanicula canadensis*	T
Downy agrimony	*Agrimonia pubescens*	T
Glade-fern	*Athyrium pycnocarpon*	Watch list
Golden seal	*Hydrastis canadensis*	E
Hairy wood-mint	*Blephilia hirsuta*	E
Handsome sedge	*Carex formosa*	T
Hitchcock's sedge	*Carex hitchcockiana*	SC
Long-styled sanicle	*Sanicula gregaria*	T
Narrow-leaved spring beauty	*Claytonia virginica*	T
Putty-root	*Aplectrum hyemale*	E
Red mulberry	*Morus rubra*	E
Long-spurred violet	*Viola rostata*	T
Woodland millet	*Milium effusum*	T

Sources: National Audubon Society 1980, Sorrie 1987, Gleason and Cronquist 1991, Brumback and Mehrhoff 1996, Petersen and McKenny 1996, Massachusetts NHESP 1998

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Bald Eagle	*Haliaeetus leucocephalis*	E (T)
Cerulean warbler	*Dendroica cerulea*	U
Cooper's hawk	*Accipiter cooperii*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Degraaf and Rappole 1995

Survey Summary

Several candidate sites were investigated but none were found to have the vegetation characteristics of this type. These sites would most likely be classified as *Quecus-Acer saccharum* Forests (Red oak-Sugar maple Transition

Forest in the NHESP classification). ***Acer saccharum*** **-** ***Fraxinus americana*** **-** ***Tilia americana*** Forests may exist in other areas at Quabbin.

<u>Mapping Criteria</u>

<u>Information Sources</u>
- Soils maps can be used to find moderately drained, rich soil types, such as the Rippowam series.

<u>Indicators</u>

Topography
- *Acer saccharum* **-** *Fraxinus americana* **-** *Tilia americana* Forests occur on mid and lower slopes usually facing north or east.

Substrate
- Forests of this type have deep, rich, mesic soils.

Species
- The *Acer saccharum* **-** *Fraxinus americana* **-** *Tilia americana* Forest community is best identified by the presence of spring ephemerals and other rich-site herbs such as *Asarum canadense, Erythronium americanum, Hepatica americana,* and *Trillium erectum*. The less rich northern hardwood forest that occurs at Quabbin may feature some of these species, but will be less diverse.
- *Tilia americana* is an uncommon species in the Quabbin area. The presence of a small amount of mature *Tilia* (5% of canopy cover) indicates the presence of this community type, or possibly a *Tilia americana* **-** *Fraxinus americana* Woodland. If *Tilia* is not present, a canopy comprised of *Acer saccharum* and *Fraxinus americana* (80% of the canopy for the two species combined) indicates this community type.

<u>Minimum Mapping Unit and Boundaries</u>
- The minimum mapping unit is 0.48 hectare (1 acre). The boundaries of this community will be hard to define due to the presence of *Acer saccharum* and *Fraxinus americana* in the general forest and the lack of any prominent topographic feature as an indicator.

<u>Threats</u>

Current Threats
- *Acer saccharum* **-** *Fraxinus americana* **-** *Tilia americana* Forests are susceptible to invasive plants, particularly Japanese barberry and hayscented fern. Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) in and surrounding this community should be considered carefully.

<u>Management Recommendations</u>

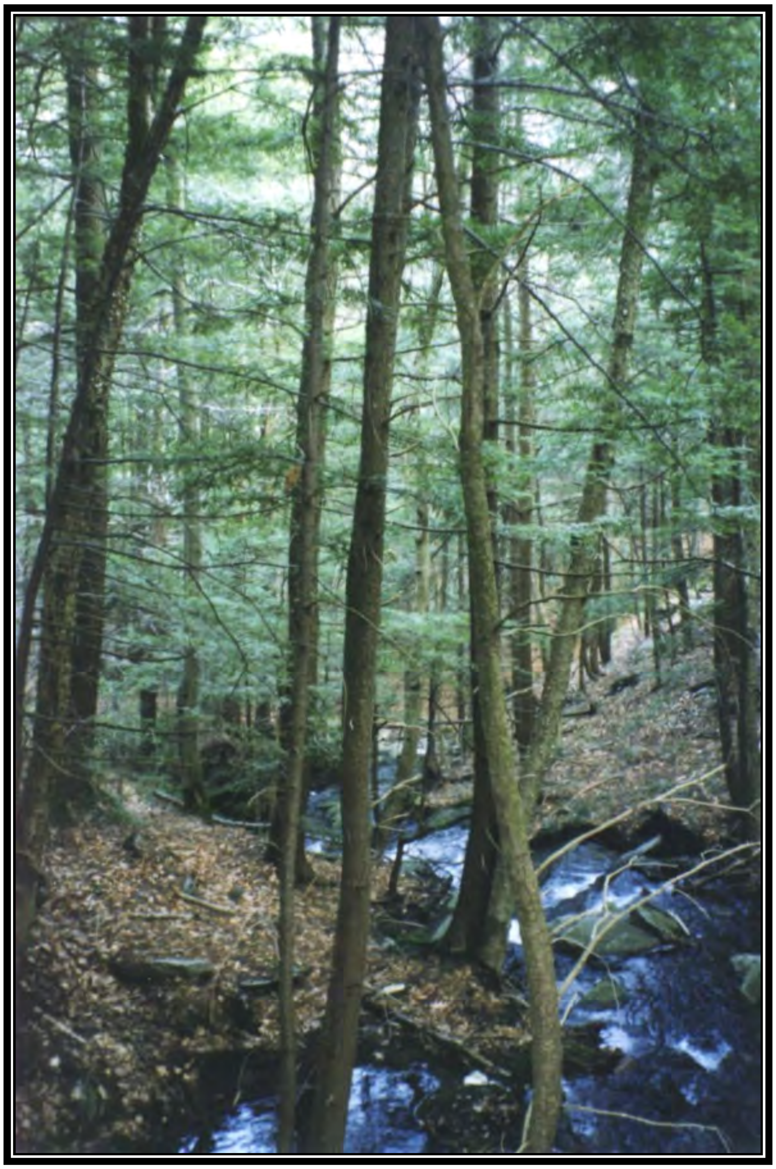
Active Management Options
- Where plant invasions are not yet extensive and physical removal of the plants is feasible, invasive plants should be eradicated.

Restrictions
- Given the widespread threat of invasives and the ability of this community to sustain itself through natural gap-phase regeneration processes, physical disturbances (e.g., timber harvesting) that alter microclimate (especially light conditions) should be curtailed within the community and in a 50 ft. buffer zone around designated communities. Timber harvests may be deemed necessary to facilitate regeneration of desired shade-tolerant species in sites where past land use practices encouraged encroachment by other species not associated with this community. However, the use of timber harvest should be weighed carefully against the threat of invasives on a site by site basis.

Monitoring

- Monitoring of *Acer saccharum - Fraxinus americana - Tilia americana* Forests should take particular note of invasive plant species.

COMMUNITY 7
HIGH AND LOW GRADIENT *TSUGA CANADENSIS* STREAM COMMUNITIES



Classification
RIPARIAN COMMUNITIES
Steamside Communities
High-gradient and Low-gradient Stream Communities
Forest Streamside Communities

Cross Reference
Similar to NHESP description of *Hemlock Ravine Community*.

Status
G? S5; Though patches of *Tsuga canadensis*-dominated forest are not rare, at Quabbin they are generally confined to discrete patches within the primarily hardwood watershed. We have chosen to include this community because its persistence is threatened due to the northward advancement of the hemlock woolly adelgid (*Adelges tsugae*). This community deserves special recognition because its characteristics (vertical structure, cool microclimate, open understory, and short-needled foliage) are unique in central Massachusetts; its loss would change Quabbin significantly in terms of available wildlife habitat and landscape diversity.

Physical Characteristics
High-gradient streams often have cascades and exposed rock within a constrained channel. In the Quabbin area, this condition is relatively uncommon and confined to small reaches along otherwise lower gradient channels. Where present, steep sloping banks may have rocky outcrops and thin soils. *Tsuga* tends to out-compete other tree species on steep slopes, thin, acidic soils, and within cool, low light microhabitats; therefore this community can in occur along short stream sections that feature these conditions within otherwise hardwood dominated forest stands. Low-gradient streams may be more braided, have wider channels, and lack the steep slopes of ravines. Slope and soil conditions may be less exclusive to other species; in addition, unconstrained, wider channels may allow more light to reach the forest floor, resulting in higher flora diversity. Both high-gradient and low-gradient conditions can occur at different sites along the same stream.

Vegetation Composition
Tsuga canadensis is the dominant canopy tree, with common associates *Acer rubrum, Betula alleghaniensis, B. lenta, Fagus grandifolia,* and *Pinus strobus.* Also present may be *Acer saccharum, Betula papyrifera,* and *Quercus rubra.*

The dense shade and cool microclimate of hemlock communities limits the development of shrub and herbaceous vegetation. Vegetation is sparse with the ground cover dominated by litter. Understory may be slightly more developed in low-gradient stream communities. Where a shrub layer is present *Hamamelis virginiana, Kalmia latifolia, Vaccinium corymbosum* and regenerating canopy species are the most common.

Common herbaceous plants include *Aralia nudicaulis, Chimaphila maculata, Coptis trifolia, Epigaea repens, Gaultheria procumbens, Maianthemum canadense, Mitchella repens, Trientalis borealis,* and *Polystichum acrostichoides.* Along the stream channel *Galium spp., Lobelia cardinalis,* and *Viola rotundifolia* may be present.

Sources: Jorgensen 1978,Charney 1980, Brown et al. 1982, Corbett and Lynch 1985, Mladenoff 1990, Godman and Lancaster 1991, Foster et al. 1992, Foster and Zebryk 1993, Sneddon et al. 1994, Hedman et al. 1996, Swain and Kearsley 1999

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Silver-haired bat	*Lasionycteris noctivagans*	U
Red bat	*Lasiuris borealis*	U
Water shrew	*Sorex palustris*	SC

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Acadian flycatcher	*Empidonax virescens*	U
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC
Cooper's hawk	*Accipiter cooperii*	SC

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Degraaf and Rappole 1995, Lyons and Livingston 1997

Amphibians

Common Name	Scientific Name	MA Status
Spring salamander	*Gyrinophilus porphyriticus*	SC

Sources: Degraaf and Rudis 1981, 1983, 1987, Jarman 1993

Reptiles

Common Name	Scientific Name	MA Status
Wood turtle	*Clemmys insculpta*	SC

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Gulf Brook	Pelham, compartment 9	Representative

2.	Atherton Brook	Shutesbury, compartment 14	Representative
3.	Cobb Brook	Shutesbury, compartment 14	Representative
4.	Unnamed Brook at gate 46	Hardwick, compartment 8,9	Representative*
5.	Egypt Brook	Prescott, compartment 12	Representative*

* Hemlock woolly adelgid has been noted at these sites.

Circular plots 15 meters in diameter were established at each site listed above. Data has been summarized for three of the five reference sites listed above. Data for most soil characteristics are not available. All sites are characterized by abundant *Tsuga canadensis* and associates *Acer rubrum, Betula alleghaniensis, B. lenta, Fraxinus americana, Pinus strobus,* and *Quercus rubra*. Understory is sparse except where canopy openings are present. *Aralia nudicaulis, Maianthemum canadense, Mitchella repens,* and *Trientalis borealis* are common to all sites. Atherton Brook, Gulf Brook, and Unnamed Brook have steep sloping sides and areas of exposed rock along and within the channel.

Species found in our survey that are not listed above include *Dennstaedtia punctilobula, Osmunda cinnamomea Monotropa uniflora, Uvularia sessilifolia, and Viola sp.*

All sites are representative examples of *Tsuga canadensis* stream communities. All sites feature reaches with steep sloping sides. Gulf Brook and Atherton Brook are the best examples of this community because they are embedded within an extensive hemlock stand. Gulf Brook and Unnamed Brook have the highest gradient in the reaches surveyed. Acadian flycatchers (*Empidonax virescens*), a relatively recent addition to the migratory breeding bird population of Massachusetts (and suspected hemlock ravine obligate), have been observed singing in 1999 and 2000 at Gulf and Atherton Brooks. Evidence of HWA infestation has been observed at Unnamed and Egypt Brooks. Although hemlock stream communities like those listed above are not rare, they are threatened by HWA all such sites should be identified, mapped, and managed in a manner that promotes their perpetuity.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Atherton Brook	2	Channel wall	26, 36 / 60, 246	NR	NR	NR	Well drained
Cobb Brook	2	Low level	0, 8 / 0, 272	NR	NR	NR	Well drained
Egypt Brook	2	Low level	5, 18 / 60, 234	NR	NR	NR	Well drained

Site Name	No. of plots	Mean Dbh		Basal area	Percent Cover						Height (m)	
		cm (in.)	C.V.	m^2/ha (ft^2/ac)	Can	SCan	TShr	SShr	Herb	NVas	Can	SCan
Atherton Brook	2	19.6 (7.7)	0.32	49.5 (215)	60-70	10-15	0-3	0-3	1-10	10	26	14.5
Cobb Brook	2	22.8 (9)	0.39	47.8 (208)	70-80	25-30	0-5	0	0	0	24.5	15
Egypt Brook	2	28.2 (11.1)	0.39	32.8 (142.7)	60-80	15-20	0	0-15	15-20	5-10	25	13

Mapping Criteria

Information Sources

- Topographic maps can be used to find steams with steep gradient banks
- Aerial photography can be used to find area of dense hemlock canopy.

Indicators

Topography

- High-gradient Riparian Zones include streams whose banks have at least a 30% slope.

Substrate

- Soil acidity may vary. Soils are moist and can be deep in some places. High-gradient Riparian Zones may have areas of exposed bedrock.

Species

- Hemlock is at least 60% of the canopy cover.

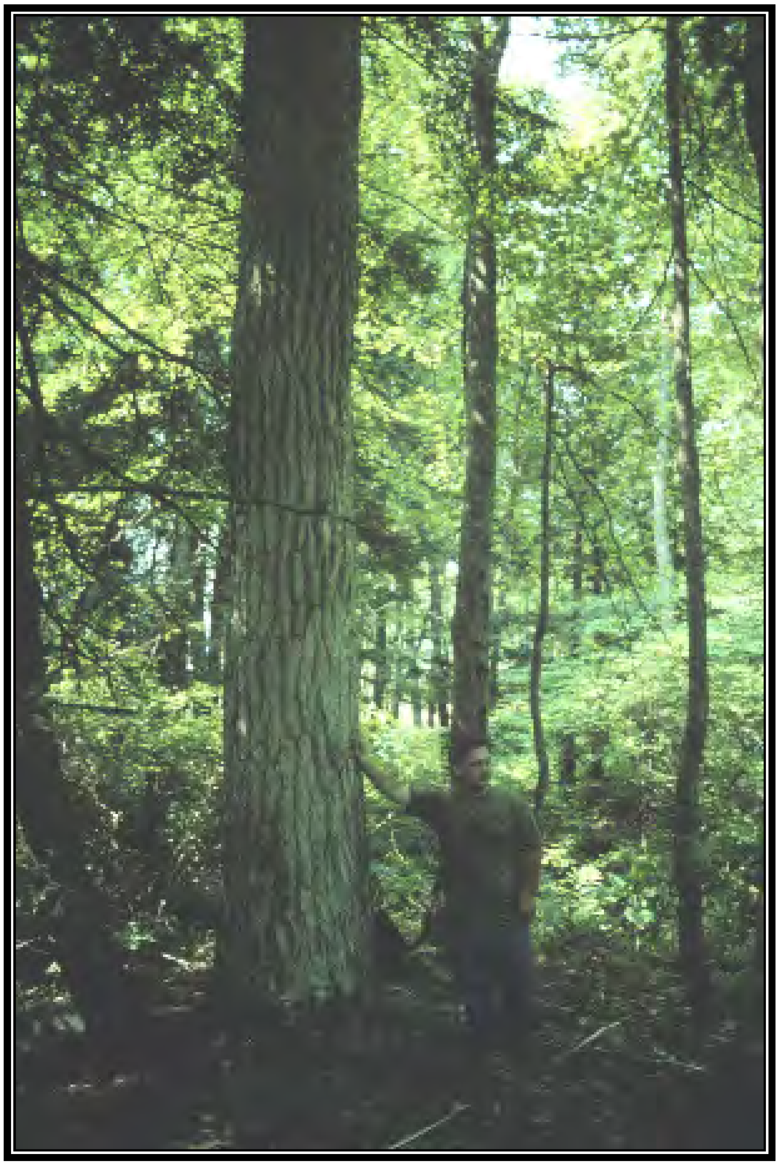
Minimum Mapping Unit and Boundaries

Hemlock stream reaches that are at least 0.48 hectare (1 acre) in area should be included. It is difficult to define the border of most riparian communities because of a constant transriparian gradient. Hemlock stream communities present a particular problem because the presence of the stream certainly changes the value of a hemlock stand (e.g., wildlife such as Acadian flycatchers may choose hemlock ravines over upland hemlock stands and other habitats), but it is difficult to pin-point where the stream community ends and the upland community begins. At many sites within Quabbin, the hemlock stream communities are discrete reaches within steeper or cooler areas of the drainage, or on the north-facing sides of channels; many sites abruptly transition into the more common hardwood types upslope. In these cases, we suggest putting the border along the edge of transition. For other situations, such as Atherton Brook, where the stream occurs within an extensive hemlock forest community, we suggest adopting the best management guidelines for timber harvest. Borders of this community type would be defined according to where hypothetical timber harvest would be legal. This border should vary with slope, and adjacent steep slopes and areas of exposed rock should always be included.

Threats and Management Recommendations

- Threats and management recommendations outlined for the *Tsuga canadensis*-dominated upland forest community apply to the *Tsuga canadensis*-dominated stream community as well.

COMMUNITY 8
NYSSA SYLVATICA SWAMP



Classification
PALUSTRINE COMMUNITIES
Wetlands on Mineral or Muck Soils
Basin and Seepage Wetlands and Fringe Wetlands
Temporarily Flooded Wetlands
Forested Swamps

Cross Reference
Similar to NHESP description of *Acidic Seepage Swamp/Black Gum Swamp*

Status
G3 S2; Swamps with abundant *Nyssa sylvatica* are uncommon or non-existent in the Quabbin area.

Physical Characteristics
Swamps featuring *Nyssa sylvatica* occur on mineral, shallow muck, or peat soils, and are seasonally flooded to saturated. Basin swamps occur in topographic depressions and have no inlet or outlet with the exception of ephemeral streams that run vernally, autumnally, or following rain events. Seepage swamps occur on a slope, at the base of a slope, or near a groundwater discharge site. The vegetation composition is influenced by overland and groundwater flow into the swamp. Fringe *Nyssa sylvatica* swamps may occur on the edge of a pond, lake, perennial stream, or wetland. In all types, microtopography is characterized by hummocks and hollows; the hummocks often support communities of more upland species.

Vegetation Composition
In Quabbin, *Acer rubrum* or *Tsuga canadensis* are usually the dominant canopy species and may be accompanied by *Betula alleghaniensis, B. lenta, Fraxinus nigra, F. americana, Nyssa sylvatica, Pinus strobus, Picea mariana, Quercus bicolor* and *Ulmus americana.*

Common shrubs associated with this community type include *Cephalanthus occidentalis, Ilex verticillata, Lyonia ligustrina, Nemopanthus mucronatus, Vaccinium corymbosum,* and *Viburnum dentatum.* In seepage areas the shrub layer may include *Lindera benzoin, Rhamnus alnifolia*, and *Toxicodendron vernix* as associates. On drier areas (edges, mounds and hummocks) of the site *Acer pensylvanicum, Hamamelis virginiana, Kalmia latifolia,* and *Viburnum alnifolium* may occur.

Typically the herbaceous layer is highly diverse (particularly in seepage swamps) and may be dominated by *Carex stricta*, and *Symplocarpus foetidus*. Associates may include *Aralia nudicaulis, Arisaema triphyllum, Caltha palustris, Carex spp., Coptis trifolia, Galium spp., Impatiens capensis, Iris versicolor, Lycopus uniflora,* *Maianthemum canadense, Medeola virginiana, Osmunda cinnamomea, O. regalis, Onoclea sensibilis, Rubus hispidus, Scirpus spp., Sphagnum spp., Thelypteris palustris, T. simulata, Trientalis borealis,* and *Viola spp.*

Sources: Frosburg and Blunt 1970, Messier 1980, Rawinski 1984, Zebryk 1991, Golet et al. 1993, Sneddon et al. 1994, Massachusetts NHESP fact sheets

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U
Southern bog lemming	*Synaptomys cooperi*	SC
Water shrew	*Sorex palustris*	SC

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987, Golet et al. 1993

Birds

Common Name	Scientific Name	MA Status
Cooper's hawk	*Accipiter cooperii*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, Sumpter 1990, National Geographic Society 1992, Degraaf and Rappole 1995

Amphibians

Common Name	Scientific Name	MA Status
Blue-spotted salamander	*Ambystoma laterale*	SC
Four-toed salamander	*Hemidactylum scutatum*	SC
Jefferson salamander	*Ambystoma jeffersonianum*	SC
Marbled salamander	*Ambystoma opacum*	T

Sources: Degraaf and Rudis 1980, 1983, 1987, Golet et al. 1993, Jarman 1995

Reptiles

Common Name	Scientific Name	MA Status
Spotted turtle	*Clemmys guttata*	SC
Wood turtle	*Clemmys insculpta*	SC

Sources: Degraaf and Rudis 1980, 1983, 1987, Golet et al. 1993

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Prescott Peninsula	Prescott, compartment 9	Marginally Representative*
2.	Blackington Swamp	New Salem, compartment 24	Marginally Representative*
3.	Dugway Road at gate 39	Petersham, compartment 6	Marginally Representative*

*Although the low abundance of *Nyssa sylvatica* limits the quality of these sites, they are otherwise representative in terms of plant associates and physical structure.

Two circular plots 15 meters in diameter were sampled at each of the above sites. At all sites *Nyssa sylvatica* occurs in isolated pockets rather than as an abundant canopy species. *Nyssa* trees representing all age classes are present, including abundant seedlings at the Dugway Road site, and a very large (82.5 cm, 32.5 in. dbh) tree on the edge of the Prescott Peninsula site. *Acer rubrum, Betula alleghaniensis, B. lenta,* and *Tsuga canadensis* are the most common dominants. The shrub cover varied from nearly non-existent to very dense, with *Vaccinium corymbosum* common to all sites. In most cases diverse herbaceous cover was present, and all sites featured significant cover of *Sphagnum spp.*

Species not listed in the above description that were found in the surveys are: ***Aster divaricatus, Carex atlantica, C. brunnescens, C. bullata, C. folliculata, C. intumescens, C. lupulina, C. stricta, C. trisperma, Glyceria striata, Habenaria clavellata, H. lacera, Monotropa uniflora, Picea mariana, Scirpus expansus, Sorbus americana, Symplocarpus foetidus, Vaccinium angustifolium,*** and ***Viburnum nudum var. cassinoides.*** The mean soil pH of all *Nyssa sylvatica* swamp sites is 4.2. The mean dbh of all species located within sample plots (includes trees only over 10 cm, 4 in. dbh) is 22.1 cm (8.7 in.). The mean dbh of *Nyssa sylvatica* trees located within the sample plots is 17.4 cm (6.9 in.). Mean total basal area for the above sites is 24 m^2/ha (106 ft^2/ac). Mean basal area of *Nyssa sylvatica* for the above sites is 6 m^2/ha (26 ft^2/ac).

Although the low abundance of *Nyssa sylvatica* limits the quality of these sites, they are otherwise representative in terms of plant associates and physical structure. The substrate type varies from muck to sandy loam. The hummock dominated microtopography of the Prescott Peninsula site allowed more upland species to occur elevated from normal flooded condition. The swamps located on the Prescott Peninsula and at Dugway appeared to be basin swamps, and therefore hydrologically isolated. The topographic position and hydrology of the plots at Blackington swamp are less clear. It seems that we sampled on the edge (and more nutrient rich area) of an acidic peat swamp. The sites represent a diversity in species composition and structure; they range in understory from tall shrub thickets (Prescott Peninsula site, Blackington Swamp), to a more open, short shrub dominated (Blackington Swamp) or herbaceous dominated communities (Dugway Rd. site). Although these sites may lack abundance of black gum, and therefore are marginal examples of this community type, they represent a unique forested swamp type within Quabbin and deserve recognition and protection. All such swamps at Quabbin should be located, mapped, monitored, and protected.

Site Name	**No. of plots**	**Topographic Position**	**Slope Deg. / Asp.**	**A Horizon Depth (cm)**	**Average Soil Texture**	**Mean Soil pH by Horizon**	**Hydrologic Regime**
Prescott	2	Basin floor	0 / NA	>20	Clay / Muck	A: 4.3	temporarily flooded
Blackington Swamp	2	Basin floor	0 / NA	5 to 16	Clay lo./Sand lo.	A: 4.2 B: 4.8	temporarily flooded
Dugway Rd. (Gate 39)	2	Basin floor	0 / NA	> 60	Muck	A: 3.7	temporarily flooded

Site Name	**No. of**	**Mean Dbh**		**Basal area**	**Percent Cover**						**Height (m)**	
	plots	**cm (in.)**	**C.V.**	**m^2/ha (ft^2/ac)**	**Can**	**SCan**	**TShr**	**SShr**	**Herb**	**NVas**	**Can**	**SCan**
Prescott *	2	21.2 (8.4)	0.67	17.2 (75)	75-80	NR	20	0	0-40	NR	18-24	NR
Blackington Swamp	2	20.6 (8.1)	0.57	36.8 (160)	15-75	15-30	50-60	NR	10-75	NR	20-33	15
Dugway Rd. (Gate 39)	2	17.7 (7.0)	0.38	27.6 (120)	60-80	1-15	0-10	NR	60-95	NR	18-27	10-12

* Basal area was not measured in one plot at the Prescott site.

Mapping Criteria

Information Sources

- Some *Nyssa sylvatica* sites are already known by MDC personnel.
- GIS data layers depicting forested wetlands or hydrography may aid in locating forested wetlands that can be examined for species composition. Sites may be hydrologically isolated, connected to an intermittent or ephemeral stream, or adjacent to a wetland or water body.
- Aerial photos may show forested wetlands depending on the season and canopy cover at the time the photos were taken. Features that may indicate the presence of a forested wetland and that can be recognized from an

aerial photo are: hardwood or mixed hardwood conifer canopy, standing water (not required), and hydrologic connection or isolation to a stream or water body .

- Many sites are mapped in the National Wetlands Inventory.

Indicators

Hydrology

- The swamp will be in an isolated depression (basin swamp), at the base of a slope (seepage), along an ephemeral stream, or adjacent to another wetland or water body. A basin swamp will have no inlet or outlet besides an intermittent stream. A seepage swamp may have water running though it by way of groundwater discharge or an ephemeral stream. Swamps may also be connected or adjacent to another wetland type or water body. Typically these forested wetlands are seasonally to temporarily flooded, and are saturated most of the year. It may be difficult to determine the hydrology in the field, therefore examining the site for seepage indicator plants (listed below) may be helpful. Riparian *Nyssa sylvatica* on non-hydric soils will not be mapped in this category.

Substrate

- Sites often occur on shallow muck over mineral soils. Microtopography of the swamps is often characterized by *Sphagnum spp.* hummocks. Some *Nyssa sylvatica* swamps occur on peat.

Species

- A *Nyssa sylvatica* swamp typically will have *Acer rubrum* or *Tsuga canadensis* as the dominant canopy species. The amount of *Nyssa sylvatica* trees present will vary. See community description for other species present. Refer to abbreviated list from Rawinski (1984) below for seepage indicator species. This is an abbreviated version that excludes calcicoles. The species marked with * are seepage indicator species and all others have a high occurrence in seeps.

Common Name	Scientific Name
False hellebore	*Veratrum viride**
Jack-in-the-pulpit	*Arisaema sp.*
Larger blue flag	*Iris versicolor*
Marsh marigold	*Caltha palustris* *
Orange touch-me-not	*Impatiens capensis*
Poison sumac	*Toxicodendron vernix*
Purple avens	*Geum rivale*
Red maple	*Acer rubrum*
Skunk cabbage	*Symplocarpus foetidus*
Spice bush	*Lindera benzoin* *

Minimum Mapping Unit and Boundaries

- Depending on the method used for mapping, a *Nyssa sylvatica* of at least 0.05 ha (.11 acres) should be mapped. This number is taken from an inventory by Golet and Davis (*in* Stone 1991), who were able to use this as their minimum mapping unit using 1:12,000 scale black and white photography. The use of remote methods may require larger mapping units and therefore, the smallest area that can be mapped accurately should be used. NWI maps use 0.48 ha (1 acre) as their smallest mapping unit where aerial photos are used, but this may be too large to incorporate some important sites. Adjacent wetlands of different types should be mapped as separate communities.

Sources: Rawinski 1984, Tiner 1991, Stone 1992

Threats

Current Threats

- Habitation by beaver is the primary threat to this community type, since excessive, sustained flooding would change the natural hydrology of the site, and make it inhospitable for many species.

Potential Threats

- Physical disturbances (e.g., timber harvesting, road construction) adjacent to swamps that disturb the soil and introduce light to this closed canopy community type may increase the threat of exotic species introduction and change the microclimate. In addition, because this community is defined by its hydrological regime, physical disturbances within the local catchment area that alter this regime could affect the integrity of the community.

Management Recommendations

Active Management Options

- To address beaver damage throughout Quabbin, we suggest developing a contingency plan in advance. By obtaining proper permits in advance to remove individuals that pose a specific threat to sensitive communities, water quality, or property of interest, immediate and effective action can take place. In addition to permit acquisition, we suggest the construction of a document that outlines the specific circumstances required for beaver removal, and a clear, comprehensive protocol for implementing such action. We also suggest the investigation of installing water level regulation devices for beaver damage mitigation.

- Although *Nyssa sylvatica* is not expected to dominate this community, it is a generally uncommon species at Quabbin; therefore, if suppressed individuals occur in the subcanopy and understory, it may be desirable to facilitate regeneration and growth through release. This species has been shown to develop slowly under shade in the subcanopy until a release event occurs (Orwig and Abrams 1994). Release could be accomplished through single tree thinning of the dominant species (typically red maple and hemlock). It is important to use this method sparingly so that the closed canopy condition is retained.

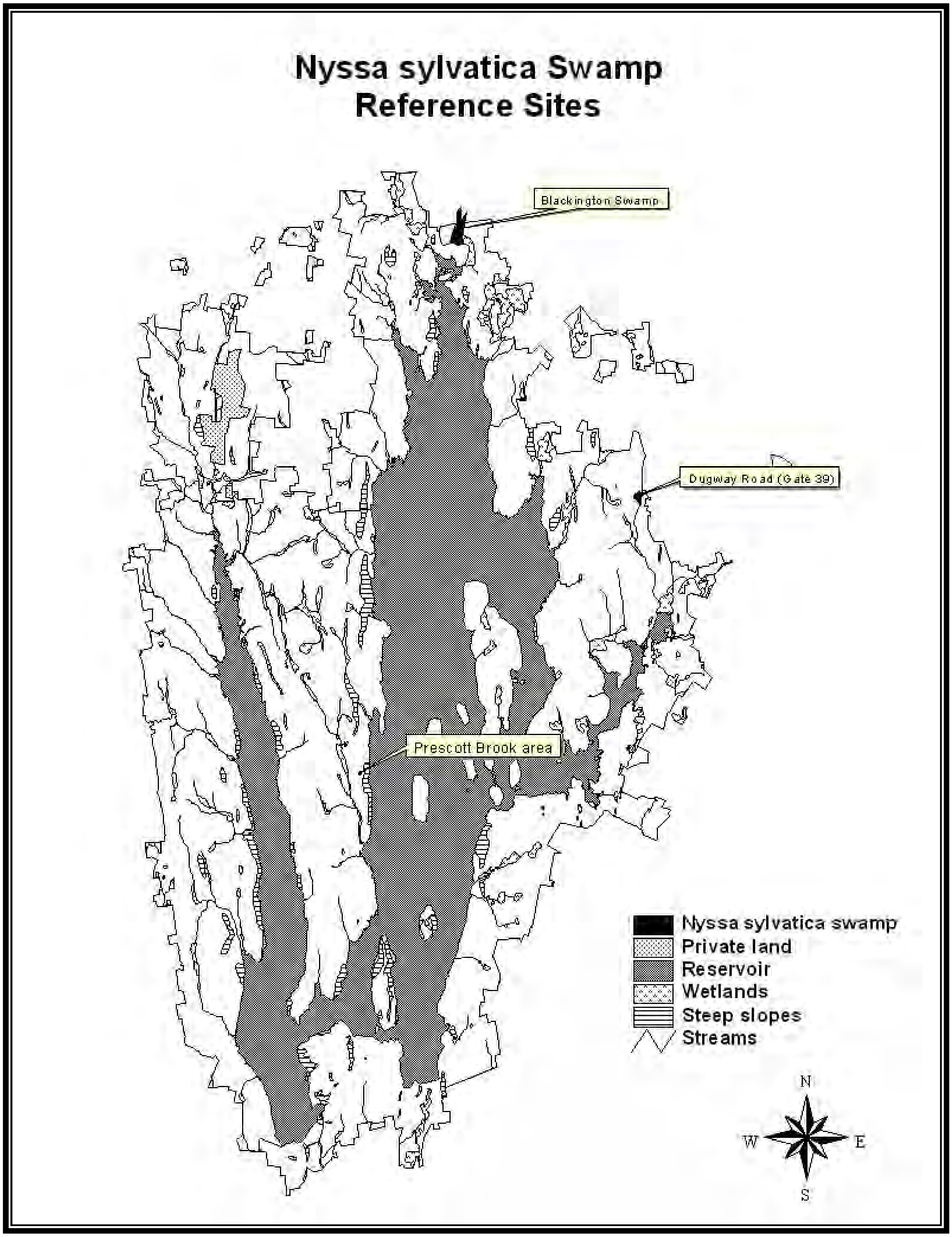
- The historical abundance of this community and the prevalence of *Nyssa sylvatica* in particular at Quabbin is unclear due to the poorly documented loss of swamps to agriculture and development and the uncertain characterization of these swamps under historic conditions. Therefore, we suggest an inquiry into whether the current state of this swamp type represents a major decline, or if it is within the range of natural variation.

Restrictions

- Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) within a 50 ft. buffer zone surrounding this community should be curtailed.
- Avoid any activities within the local catchment basin that may result in excessive or prolonged flooding or draw-down of the swamp.

Monitoring

- As part of the annual monitoring of beaver activity, identify new inhabitation at sites that may threaten this community type.


Nyssa sylvatica Swamp
Reference Sites
Blackington Swamp
Dugway Road (Gate 39)
Prescott Brook area
Nyssa sylvatica swamp
Private land
Reservoir
Wetlands
Steep slopes
Streams
N
W
E
S

COMMUNITY 9
FRAXINUS NIGRA BASIN AND SEEPAGE SWAMP

Classification
PALUSTRINE COMMUNITIES
Wetlands on Mineral or Muck Soils
Basin and Seepage Wetlands and Fringe Wetlands
Temporarily Flooded Wetlands
Forested Swamps

Cross Reference
Similar to NHESP description of *Acidic Seepage Swamp/Black Ash Swamp*.

Status
G3 S2; This community is uncommon in central Massachusetts.

Physical Characteristics
Fraxinus nigra may occur within an isolated basin (without associated perennial water flow), within a seepage area, or along the edge of a pond, perennial stream, or wetland.

Vegetation Composition
Fraxinus nigra may be a dominant canopy species, but at Quabbin is more likely to occur in scattered pockets. This type is often dominated or codominated by *Acer rubrum* and accompanied by *Betula alleghaniensis.* Associated tree species include *Carpinus caroliniana, Fraxinus americana, Pinus strobus,* and *Ulmus americana*

Common associated shrub species include *Hamamelis virginiana, Ilex verticillata, Lindera benzoin, Toxicodendron vernix,* and *Viburnum dentatum. Arisaema triphyllum, Impatiens capensis, Onoclea sensibilis, Osmunda cinnamomea,* and *Symplocarpus foetidus* are common within the herbaceous layer of this community. Other herbaceous plants include *Carex grayi, C. folliculata, C. stricta, Dryopteris cristata, Galium spp., Maianthemum canadense, Thelypteris palustris, Trientalis borealis,* and *Viola spp.*

Sources: Lynn and Karlin 1985, Lugo et al. 1990, Metzler and Barrett 1992, Hickler et al. 1999

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U
Southern bog lemming	*Synaptomys cooperi*	SC
Water shrew	*Sorex palustris*	SC

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Cooper's hawk	*Accipiter cooperii*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, Sumpter 1990, National Geographic Society 1992, Degraaf and Rappole 1995

Amphibians

Common Name	Scientific Name	MA Status
Blue-spotted salamander	*Ambystoma laterale*	SC
Four-toed salamander	*Hemidactylum scutatum*	SC
Jefferson salamander	*Ambystoma jeffersonianum*	SC
Marbled salamander	*Ambystoma opacum*	T

Sources: Degraaf and Rudis 1980, 1983, 1987, Jarman 1995

Reptiles

Common Name	Scientific Name	MA Status
Spotted turtle	*Clemmys guttata*	SC
Wood turtle	*Clemmys insculpta*	SC

Sources: Degraaf and Rudis 1980, 1983, 1987

Survey Summary

Quabbin Reference Sites:	Compartment	Site Quality
1. New Salem center	New Salem, compartment 15	Marginally Representative
2. Belchertown Road	Hardwick, compartment 1	Marginally Representative
3. Dugway Road at gate 39	Petersham, compartment 6	Marginally Representative

In each of the above listed sites, two 15-meter diameter sample plots were established. *Fraxinus nigra*, in all surveyed sites, occurs in pockets within stands dominated by other species. The most common canopy species, present at all sites is *Acer rubrum.* Other abundant canopy species include *Betula alleghaniensis* and *Tsuga canadensis*. At the Belchertown Road site, *Tilia americana* is at least as common as *Fraxinus nigra*, as both species occur in scattered pockets throughout the stand. The shrub cover at surveyed sites varies from nearly absent to dense, with *Ilex verticillata* the only species common to all sites. All sites have extensive and diverse herbaceous cover with *Osmunda cinnamomea* dominant in most surveys..

An abbreviated list of species observed in the surveys that are not listed in the above description, includes: *Berberis thunbergii, Carex crinita, C. folliculata, C. leptalea, C. radiata, C. stipata, C. trisperma, Chrysosplenium americanum, Cinna sp., Circaea alpina, Dryopteris intermedia, Equisetum arvense, E. sylvaticum, Galium asprellum, G. trifidum, Glyceria striata, Habenaria psycodes, Hydrocotyle americana, Myosotis scorpioides, Polygonum arifolium, P. sagittatum, Saxifraga pensylvanica, Scutellaria lateriflora, Senecio aurea, Solidago gigantea, Sorbus americana, Tilia americana, Trillium cernuum,* and *Uvularia sessilifolia.* Mean soil pH for all sites is 5.3. Mean dbh for all species (over 10 cm, 4 in. dbh) within the *Fraxinus nigra* survey plots is 19.4 cm (7.6 in.). Mean dbh for all *Fraxinus nigra* within the study plots is 16.1 cm (6.3 in.).

Although the low abundance of *Fraxinus nigra* limits the quality of these sites, they are otherwise representative in terms of plant associates and physical structure. The substrate type varies from muck to clay. All swamps appear to occur on basin floors; the exact hydrology, however (presence of seeps) is unknown. All sites have a diverse herbaceous species composition. The invasive shrub, *Berberis thunbergii* was found at the New Salem Center site. Although these sites lack abundant *Fraxinus nigra*, and therefore are marginal examples of this community type, they represent a unique forested swamp type within Quabbin and deserve recognition and protection. All such swamps at Quabbin should be located, mapped, monitored, and protected.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Soil Drainage
Belchertown Road	2	Basin Floor	0 / NA	30 to 100+	Peat / Muck	A: 5.3 B: 5.5	temporarily flooded
Dugway Rd. (Gate 39)	2	Basin Floor	0 / NA	>60	Muck	A: 3.7	temporarily flooded
New Salem Center	2	Channel Bed	0 / NA	>50	Muck / Clay	A: 5.2	temporarily flooded

Site Name	No. of plots	Mean Dbh		Basal area	Percent Cover						Height (m)	
		cm (in.)	C.V.	m^2/ha (ft^2/ac)	Can	SCan	TShr	SShr	Herb	NVas	Can	SCan
Belchertown Road	2	19.8 (7.8)	0.50	NR	15-20	50	25	10	25-50	0	20-25	15
Dugway Rd. (Gate 39)	2	17.7 (7.0)	0.38	27.6 (120)	60-80	1-15	0-10	NR	60-95	NR	18-27	10-12
New Salem Center	2	20.4 (8.0)	0.78	NR	30-50	0	25-35	5-20	90	NR	27	NA

Mapping Criteria

Information Sources

- Some sites may be already be known by MDC personnel.
- GIS data layers portraying forested wetlands and other hydrologic features may aid in locating *Fraxinus nigra* swamps. These sites maybe isolated hydrologically except for small streams or groundwater discharge, or may be connected or adjacent to another wetland or water body.
- Aerial photos may indicate forested wetland sites depending on the season and canopy cover at the time the photograph was taken. Features that may indicate the presence of a forested wetland and that can be recognized from a photo are: hardwood or mixed hardwood conifer canopy, standing water (not required), and hydrologic connection to a stream or water body (not required).
- Many sites are mapped in the National Wetlands Inventory.

Indicators

Hydrology

- This community may occur as an isolated basin swamp, or a seepage swamp. Seepage swamps will occur at the base of a slope, along an ephemeral stream, or near a groundwater discharge site. It may be difficult to determine the hydrology in the field. Seepage indicator plants may be helpful (see list adapted from Rawinksi 1984, page 54).

Substrate

- More information is needed.

Species

- Fraxinus nigra will be present. For seepage swamp indicator species, see page 54.

Minimum Mapping Unit and Boundaries

- Depending on the method used for mapping, a ***Fraxinus nigra*** swamp of at least 0.05 ha (.11 acres) should be mapped. This number is taken from an inventory by Golet and Davis (***in*** Stone 1991), who were able to use this as their minimum mapping unit using 1:12,000 scale black and white photography. The use of remote methods may require larger mapping units and therefore, the smallest area that can be mapped accurately should be used. NWI maps use 0.48 ha (1 acre) as their smallest mapping unit where aerial photos are used, but this may be too large to incorporate some important sites. Adjacent wetlands of different types should be mapped as separate communities.

  Sources: Rawinski 1984, Stone 1992, Tiner 1991

Threats

Current Threats

- Inhabitation by beaver is the primary threat to this community type, since excessive, sustained flooding would change the natural hydrology of the site, and make it inhospitable for many species.

Potential Threats

- Physical disturbances (e.g., timber harvesting, road construction) adjacent to swamps that disturb the soil and introduce light to this closed canopy community type may increase the threat of exotic species introduction and change the microclimate. In addition, because this community is defined by its hydrological regime, physical disturbances within the local catchment area that alter this regime could affect the integrity of the community.

Management Recommendations

Active Management Options

- To address beaver damage throughout Quabbin, we suggest developing a contingency plan in advance. By obtaining proper permits in advance to remove individuals that pose a specific threat to sensitive communities, water quality, or property of interest, immediate and effective action can take place. In addition to permit acquisition, we suggest the construction of a document that outlines the specific circumstances required for beaver removal, and a clear, comprehensive protocol for implementing such action. We also suggest the investigation of installing water level regulation devices for beaver damage mitigation

- At all Quabbin sites, ***Fraxinus nigra*** is sparsely represented. The historical abundance of this community and the prevalence of ***Fraxinus nigra*** in particular at Quabbin is unclear due to the poorly documented loss of swamps to agriculture and development and the uncertain characterization of these swamps under historic conditions. However, it is likely that ***Fraxinus nigra*** was once much more abundant and widely distributed since it was a target tree for basket makers. Therefore, we suggest an inquiry into whether the current state of this swamp type represents a major decline, or if it is within the range of natural variation. Depending on these findings, the use of silvicultural techniques to increase black ash abundance may later be planned and implemented.

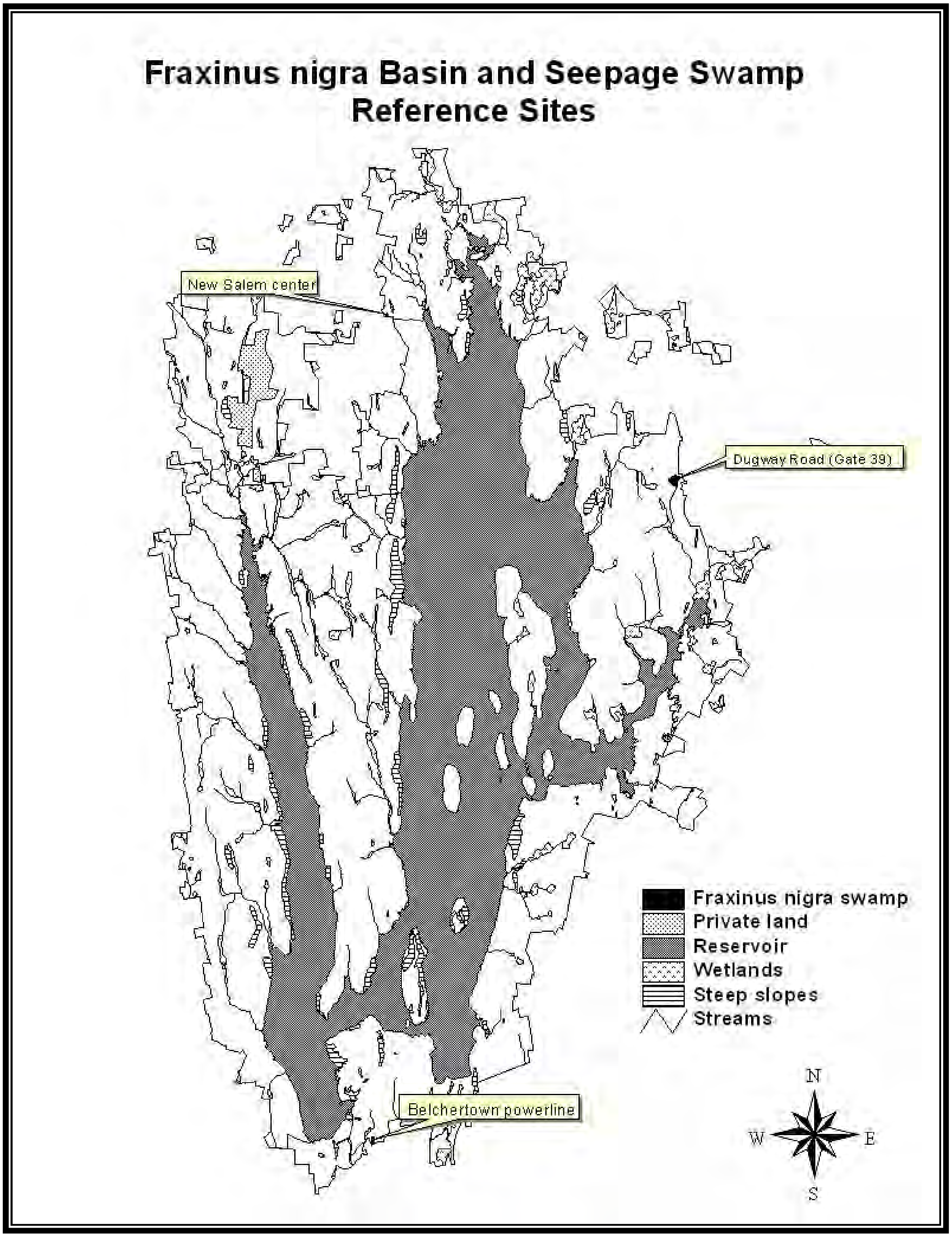
Restrictions

- Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) within a 50 ft. buffer zone surrounding this community should be curtailed.

- Avoid any activities within the local catchment basin that may result in excessive or prolonged flooding or draw-down of the swamp.

Monitoring

- As part of the annual monitoring of beaver activity, identify new inhabitation at sites that may threaten this community type.



COMMUNITY 10
PICEA MARIANA SWAMP

Classification
PALUSTRINE COMMUNITIES
Wetlands on Mineral or Muck Soils
Basin and Seepage Wetlands and Fringe Wetlands
Temporarily Flooded Wetlands
Forested Swamps

Cross-reference
None described by NHESP

Status
The occurrence and distribution of this community is unknown, but it is probably uncommon.

Physical Characteristics
This community occurs on mineral or muck soils. It may occur in a basin, in a seepage area, or along a pond or stream. More information on the physical characteristics of this community is needed. A similar community type, described on page 73 occurs on peat.

Vegetation Composition
Canopy is dominated by *Picea mariana*. Associated canopy species may include *Acer rubrum, Betula lenta, B. alleghaniensis, Larix laricina, Nyssa sylvatica, Pinus strobus, Tsuga canadensis.* Associated shrubs may include *Chamaedaphne calyculata, Ilex verticillata, Kalmia angustifo*lia, *K. latifolia, Nemopanthus mucronatus,* and *Vaccinium corymbosum*. Herbaceous species may include various *Carex spp.* and *Osmunda cinnamomea.* More information is needed on the floristic composition of this community type.

Source: Sneddon et al. 1994

Rare Plants

Common Name	Scientific Name	MA Status
Dwarf mistletoe	*Arceuthobium pusillum*	SC
Great laurel	*Rhododendron maximum*	T

Sources: Sorrie 1987, Gleason and Cronquist 1991, Brumback and Mehroff 1996, Petersen and McKenny 1996, Massachusetts NHESP 1998

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U
Southern bog lemming	*Synaptomys cooperi*	SC
Water shrew	*Sorex palustris*	SC

Sources: Degraaf et al.1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
Cooper's hawk	*Accipiter cooperii*	SC
Long-eared owl	*Asio otus*	SC
Northern goshawk	*Accipiter gentilis*	U
Sharp-shinned hawk	*Accipiter striatus*	SC

Sources: Degraaf et al. 1980, Degraaf and Rudis 1987, National Geographic Society 1992, Degraaf and Rappole 1995

Amphibians

Common Name	Scientific Name	MA Status
Blue-spotted salamander	*Ambystoma laterale*	SC
Four-toed salamander	*Hemidactylium scutatum*	SC
Jefferson's salamander	*Ambystoma jeffersonianum*	SC
Marbled salamander	*Ambystoma opacum*	T

Sources: Degraaf and Rudis 1981, 1983, 1987, Jarman 1995

Reptiles

Common Name	Scientific Name	MA Status
Spotted turtle	*Clemmys guttata*	SC
Wood turtle	*Clemmys insculpta*	SC

Sources: Degraaf and Rudis 1981, 1983, 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Blackington Swamp	New Salem, compartment 24	Not Representative*

**Picea mariana* is very scattered within the sampled plots; other portions of Blackington Swamp may be better examples of this type.

Picea mariana occurs in scattered clumps on the edge of a tall shrub swamp. Each of the two 15-meter diameter plots that were sampled have different tree composition. *Pinus strobus* and *Acer rubrum* dominate plot one, while *Picea mariana, Tsuga canadensis*, and *Nyssa sylvatica* dominate plot two. Both plots feature dense high shrub cover with *Hamamelis virginiana, Nemopanthus mucronatus,* and *Vaccinium corymbosum* occurring in both sites. Herbaceous plant cover is not extensive or diverse, however in one plot, four species of *Carex* are among the only 10 herbaceous species observed. The only herbaceous plants common to both plots are *Acer rubrum* seedlings and *Osmunda cinnamomea*.

Species observed in the surveys not listed in the above description include: ***Aralia nudicaulis, Carex atlantica, C. bullata, C. brunnescens, C. trisperma, Coptis trifolia, Dalibarda repens, Mitchella repens, Rubus hispidus, Toxicodendron vernix, Trientalis borealis, Viburnum alnifolium,*** and ***V. nudum*** var. ***cassinoides***. The mean soil pH of the two plots is 4.5. The mean dbh of all species (over 10 cm, 4 in. dbh) within the plots is 23.5 cm (9.3 in.). The mean dbh of all *Picea mariana* within the plots is 18.9 cm (7.4 in.). The mean total basal area of both plots is 28 m^2/ha (123 ft^2/ac). The mean basal area of *Picea mariana* in both plots is 5 m^2/ha (22 ft^2/ac).

Due to the paucity of *Picea mariana*, we determined that the plots surveyed at Blackington Swamp were not representative of a *Picea mariana* swamp community. Since we did not search the entire swamp, representative examples of this type may occur at Blackington Swamp or in other areas of Quabbin.

Site Name	**No. of plots**	**Topographic Position**	**Slope Deg. / Asp.**	**A Horizon Depth (cm)**	**Average Soil Texture**	**Mean Soil pH by Horizon**	**Soil Drainage**
Blackington Swamp	2	Basin floor	0 / NA	5 to 16	Clay lo./Sand lo.	A: 4.2 B: 4.8	temporarily flooded

Site Name	**No. of plots**	**Mean Dbh**		**Basal area**	**Percent Cover**						**Height (m)**	
		cm (in.)	**C.V.**	**m^2/ha (ft^2/ac)**	**Can**	**SCan**	**TShr**	**SShr**	**Herb**	**NVas**	**Can**	**SCan**
Blackington Swamp	2	20.6 (8.1)	0.57	36.8 (160)	15-75	15-30	50-60	NR	10-75	NR	20-33	15

Mapping Criteria

Information Sources

- Some sites may be already be known by MDC personnel
- GIS data layers portraying forested wetlands and other hydrologic features may aid in locating *Picea mariana* swamps. This wetland type maybe isolated hydrologically except for small streams or groundwater discharge sites, or may be connected or adjacent to another wetland or water body.
- Aerial photos may indicate forested wetland sites depending on the season and canopy cover at the time the photograph was taken. Features that may indicate the presence of a forested wetland and that can be recognized from a photo are: conifer canopy, standing water (not required), and hydrologic connection to a stream or water body (not required).
- Many sites are mapped in the National Wetlands Inventory.

Indicators

Hydrology

- More information is needed.

Substrate

- More information is needed.

Species

- *Picea mariana* is the dominant tree species.

Minimum Mapping Unit and Boundaries

- Depending on the method used for mapping, a *Picea mariana* swamp of at least 0.05 ha (.11 acres) should be mapped. This number is taken from an inventory by Golet and Davis (*in* Stone 1991), who were able to use this as their minimum mapping unit using 1:12,000 scale black and white photography. The use of remote methods may require larger mapping units and therefore, the smallest area that can be mapped accurately should be used. NWI maps use 0.48 ha (1 acre) as their smallest mapping unit where aerial photos are used, but this may be too large to incorporate some important sites. Adjacent wetlands of different types should be mapped as separate communities.

  Sources: Tiner 1991, Stone 1992, Sneddon et al. 1994

Threats

Current Threats

- Inhabitation by beaver is the primary threat to this community type, since excessive, sustained flooding would change the natural hydrology of the site, and make it inhospitable for many species.

Potential Threats

- Physical disturbances (e.g., timber harvesting, road construction) adjacent to swamps that disturb the soil and introduce light to this closed canopy community type may increase the threat of exotic species introduction and change the microclimate. In addition, because this community is defined by its hydrological regime, physical disturbances within the local catchment area that alter this regime could affect the integrity of the community.

Management Recommendations

Active Management Options

- To address beaver damage throughout Quabbin, we suggest developing a contingency plan in advance. By obtaining proper permits in advance to remove individuals that pose a specific threat to sensitive communities, water quality, or property of interest, immediate and effective action can take place. In addition to permit acquisition, we suggest the construction of a document that outlines the specific circumstances required for beaver removal, and a clear, comprehensive protocol for implementing such action. We also suggest the investigation of installing water level regulation devices for beaver damage mitigation

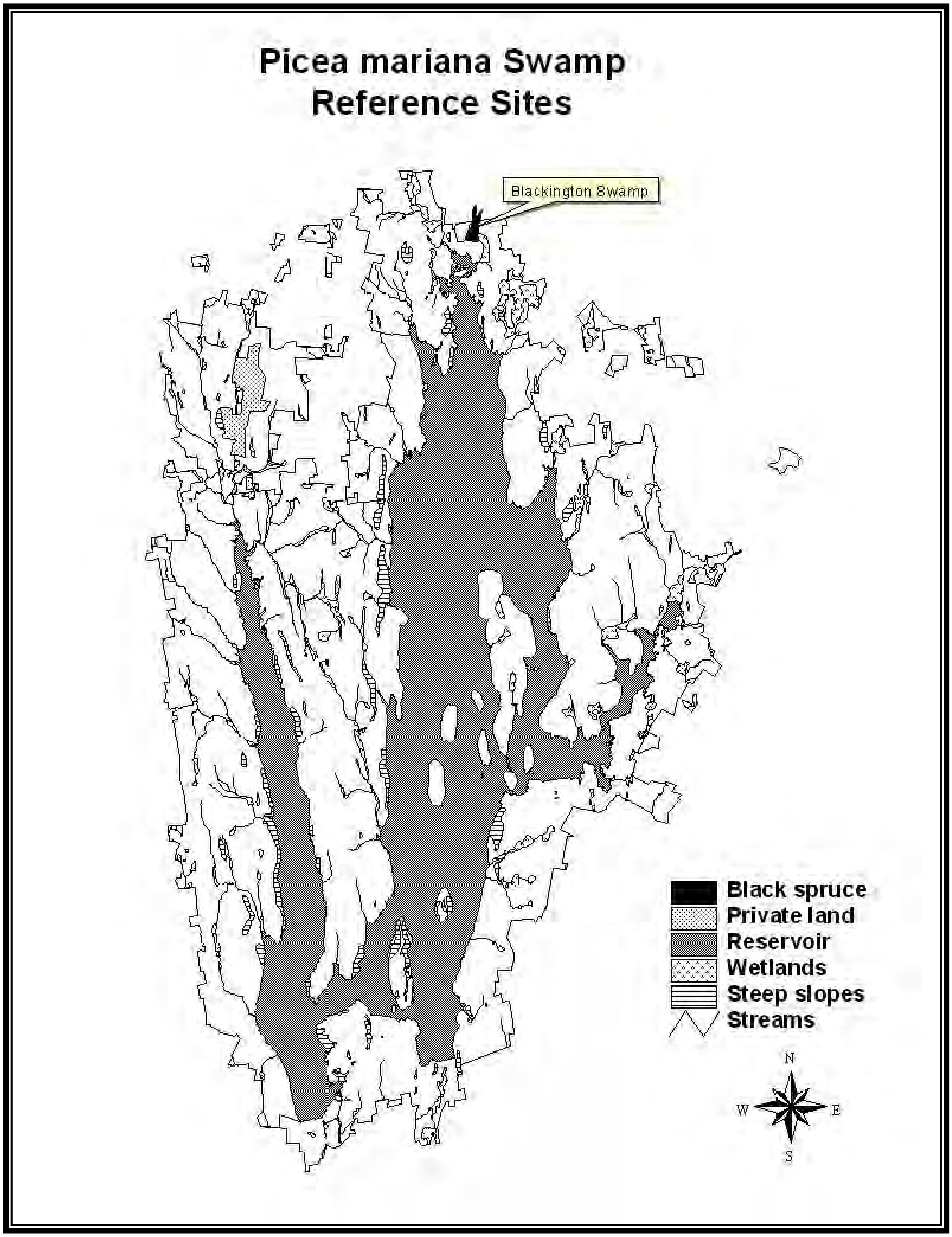
- More information is needed on the occurrence, location, and quality of this community type within Quabbin before more detailed recommendations and information needs can be identified.

Restrictions

- Because most invasive exotic plants respond favorably to disturbances that alter microclimate (e.g., light) conditions, physical disturbances (e.g., timber harvesting) within a 50 ft. buffer zone surrounding this community should be curtailed.
- Avoid any activities within the local catchment basin that may result in excessive or prolonged flooding or draw-down of the swamp.

Monitoring

- As part of the annual monitoring of beaver activity, identify new inhabitation at sites that may threaten this community type.


Picea mariana Swamp
Reference Sites
Blackington Swamp
Black spruce
Private land
Reservoir
Wetlands
Steep slopes
Streams
N
W
E
S

COMMUNITY 11
TEMPORARY PONDS: KETTLEHOLE SHRUB SWAMP, VERNAL/AUTUMNAL POOL

Classification
PALUSTRINE COMMUNITIES
Wetlands on Mineral or Muck soils
Basin and Seepage Wetlands
Temporarily Flooded Wetlands
Non-vegetated Wetlands and Shrub Swamps

Cross Reference
Similar to NHESP description of *Kettlehole Wet Meadow* (formerly *Inland Basin Marsh*).

Status
The kettlehole swamp community type described by NHESP (referred to as kettlehole wet meadow) has an unknown distribution and abundance. Other temporary ponds that do not meet NHESP criteria for a kettlehole swamp, (referred to generally as vernal pools) are not rare but often support a large faunal diversity (vertebrates and invertebrates) that rely on these sites for egg and larval development in the absence of fish. All sites have the potential to support state listed amphibian species and require conservation attention.

Physical Characteristics
As described by NHESP, kettlehole wetlands communities are restricted specifically to glacial kettle hole depressions in sandy outwash soils. Kettlehole swamps and other temporary ponds are commonly referred to as vernal pools. Both types exist in small, isolated depressions within upland forests. Typically the depressions are filled during wet periods of the year (spring, autumn, and sometimes following summer rain events), hold standing water for at least two consecutive months, and dry up completely by late summer in the absence of a large rain event. There are no permanent inlets, outlets, wetlands, or ponds adjacent to or bordering these pools. All pools that match the above description , regardless of vegetation characteristics, qualify as physical vernal pools and should be examined more closely to determine biological activity.

Vegetation Composition
Kettlehole swamps generally have vegetation that varies according to water level fluctuation. As described by NHESP, the kettlehole swamp (kettlehole wet meadow) sites consist of concentric rings of different plant life forms and species, with trees and shrubs occurring on the outer edge and herbaceous plants dominating the moister center. Bordering tree and shrub species include *Acer rubrum, Alnus incana, Aronia melanocarpa, Betula lenta, Cephalanthus occidentalis, Chamaedaphne calyculata, Decodon verticillatus, Ilex verticillata, Lyonia ligustrina, Nemopanthus mucronatus, Nyssa sylvatica, Pinus strobus, Spiraea alba var. latifolia,* and *Vaccinium corymbosum.* Herbaceous species may include *Bidens cernua, Leersia oryzoides, Lycopus uniflorus, Osmunda cinnamomea,*

Triadenum virginicum, Thelypteris palustris, various sedges (*Carex spp.* and *Scirpus spp.*), and rushes (*Juncus spp.*) on the water edge, and emergent and floating aquatic species (*Nymphaea odorata*, *Pontederia cordata*, *Proserpinaca spp., Sagittaria latifolia, Sparganium androcladum*) if standing water exists.

There is no particular plant community that defines other, non-kettlehole vernal pools, and therefore it is difficult to characterize these according to flora. Some have characteristic wetland vegetation, while others are simply small depressions in the forest with little or no vegetation at all. Stone (1992), in a study of 106 vernal pools in Amherst, MA, found that vegetation cover varies from less than 10% to 100%, and may be dominated either by deciduous shrubs or herbaceous vegetation. Within these pools, dominant species often were *Acer rubrum, Cephalanthus occidentalis, Vaccinium corymbosum*, and *Carex spp*. Often vernal pools are characterized according to use by aquatic and amphibian fauna (see indicator species below).

Sources: Reschke 1990, Stone 1992, Swain and Kearsley 1999, Massachusetts NHESP fact sheets

Rare Vertebrates

Amphibians

Common Name	Scientific Name	MA Status
Blue-spotted salamander	*Ambystoma laterale*	SC
Eastern spadefoot	*Scaphiopus holbrookii*	T
Four-toed salamander	*Hemidactylium scutatum*	SC
Jefferson's salamander	*Ambystoma jeffersonianum*	SC
Marbled salamander	*Ambystoma opacum*	T

Sources: Degraaf and Rudis 1981, 1983, 1987, Stone 1992, Jarman 1995

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	Pond at Gate 25	New Salem	Not Representative
2.	Pond at Gate 22	New Salem	Not Representative
3.	Brooks Pond, Gate 17	Prescott	Not Representative

Fifteen-meter diameter circular plots were set up at each of the ponds at gates 25 and 22. Brooks pond was surveyed using a belt transect method to better represent the vegetation composition in the survey. This was done by recording the species composition and percent cover in each 2m x 2m section along a straight transect across the pond. Species common to all sites include *Acer rubrum, Pinus strobus, Cephalanthus occidentalis, Ilex verticillata* and *Thelypteris palustris.*

Species observed in the surveys not listed in the above description include: *Betula populifolia, Carex radiata, C. vesicaria, C. vestita, Galium trifidum, Glyceria grandis, Maianthemum canadense, Mitchella repens, Rubus hispidus, Quercus rubra, Trientalis borealis, Tsuga canadensis,* and *Sium suave.*

There are many depression shrub swamps in the Quabbin area, however the three surveyed do not have the diverse herbaceous species composition, and obvious glacial kettlehole physical attributes associated with the kettlehole wetland community described by NHESP. This community may occur at Quabbin within some of the numerous temporary ponds located there. Due to their physical and hydrologic characteristics, however, all of the above sites qualify as physical vernal pools and therefore have the potential to support vernal pool-dependent breeders. For this reason, all such sites should be protected.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Hydrologic Regime
Gate 25	1	Basin floor	0 / NA	>60	Muck	A: 3.9	temporarily flooded
Gate 22	1	Basin floor	0 / NA	20	Clay loam	A: 4.3 B: 4.9	temporarily flooded
Brooks Pond (Gate 17)	1	Basin floor	0 / NA	>40	Muck	A: 4.8	temporarily flooded

Site Name	No. of plots	Mean Dbh cm (in.)	C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	SCan	TShr	SShr	Herb	NVas	Height (m) Can	SCan
Gate 25	1	0	NA	0	<10	0	75	NR	25-50	80	15	NA
Gate 22	1	0	NA	0	15-25	10	75	25	10	0	NR	NR
Brooks Pond (Gate 17)	1	0	NA	0	0	0	NR	NR	NR	NR	NA	NA

Mapping Criteria

Information Sources
- Map of vernal pools of Quabbin
- Aerial photography is a widely used method for locating vernal pool. During leaf-off pools can often be recognized in aerial photographs. Pools will not be connected hydrologically except for a possible intermittent stream.
- National Wetlands Inventory maps may not be helpful if wetlands under one acre are not included.

Indicators

Hydrology
- Vernal pools must be hydrologically isolated and hold standing water for at least two consecutive months of the year. No inlets or outlets besides intermittent streams are associated with this wetland type. Typically the pools are flooded in the spring and fall and are dry in late summer. If these criteria are met, the site is considered a physical vernal pool. See below for biological vernal pool status.

Indicator substrate
- Kettlehole swamps occur on sandy outwash within glacial kettle holes. Other temporary ponds are highly variable.

Indicator species
- Kettlehole swamps are characterized by wetland shrub species on the outer edge and herbaceous species within the wetter center. Non-kettlehole pool communities, unlike the others, are more defined by characteristic fauna, than flora. The presence of one or more obligate vernal pool fauna species (especially if breeding) serves as an indicator of this community (see Natural Heritage list below). There are many other species that use vernal pools facultatively. Some common plant species are *Acer rubrum* (red maple), *Cephalanthus occidentalis* (button bush) , *Vaccinium corymbosum* (highbush blueberry), and *Carex spp.* (sedges).

Natural Heritage and Endangered Species Program list of vernal pool obligate species

Amphibians

Common Name	Scientific Name
Blue-spotted salamander	*Ambystoma laterale*
Jefferson salamander	*Ambystoma jeffersonianum*
Marbled salamander	*Ambystoma opacum*
Spotted salamander	*Ambystoma maculatum*
Wood frog	*Rana sylvatica*

Invertebrate

Common Name	Scientific Name
Fairy shrimp	*Eubranchipus spp.*

Source: Stone 1992

Minimum Mapping Unit and Boundaries
- The vernal pools in the Quabbin Watershed have been mapped quite extensively. Since their size ranges so greatly and very small pools can be significant biologically, there should be no minimum size if the pool meets

the physical requirements. It should be noted that the upland sites surrounding biological vernal pools should be protected as well since the breeders spend most of their time in these areas. It is difficult to know what distance is sufficient.

Source: Stone 1992

Threats

Current Threats

Extensive surveys and careful forestry activities at Quabbin have ensured the protection of individual temporary ponds; therefore, the primary threat is to the adjacent upland habitat where many pond-breeding amphibians (e.g., mole salamanders) spend much of their life (Semlitsch 1998), and to the connectivity of small wetland clusters. To clarify, we define a cluster as a group of temporary ponds in which all ponds are within travelling distance of the target species (up to 600 m for some mole salamanders, but averaging 150 to 250m) from at least one other pond. There is evidence that temporary pond clusters support metapopulations of mole salamanders and that the pond clusters provide habitat for juvenile dispersal (McGarigal et al., unpubl. data). Forest clearing, road construction, and other activities that involve the removal of canopy cover and the introduction of a harsh microclimate, or physical barrier, may impede movement of pool-dependent fauna. Forestry operations may take place well beyond conservative buffer distances of pools, but since the distance pool-dependent breeders travel from underground dwellings and the extent to which they travel between pools is largely unknown, it is difficult to predict what will have an impact.

Management Recommendations

Active Management Options

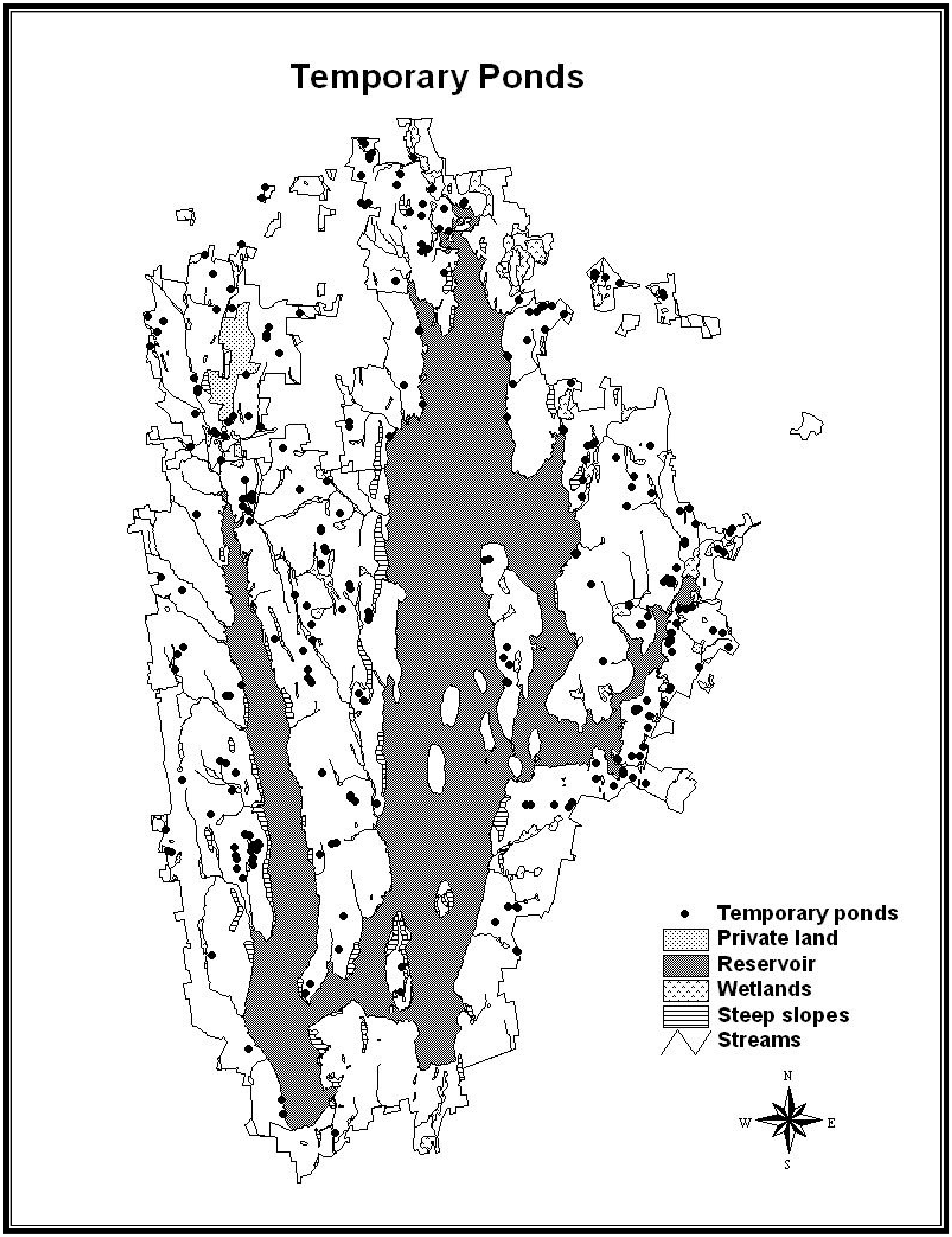
- To increase the connectivity of temporary ponds within a cluster, we suggest that intervening roads that are not well-used be abandoned.

Restrictions

- Always leave a minimum of 50 feet of forested buffer around the perimeter of a temporary pond to minimize changes in microclimate (light, temperature).
- Whenever possible, avoid activities that functionally disconnect pools from others in a cluster.
- Activities that may result in a barrier include the clearing of large forest patches and road construction that involves removal of most vegetation.
- When engaging in forestry activities near a temporary pond, retain ground moisture, shade, and cover (particularly coarse woody debris), to facilitate movement.
- When constructing a road near a temporary pond, retain canopy cover and any dense vegetation along the roadside to minimize changes in microclimate.

Monitoring

- Vernal pools at Quabbin have been intensely surveyed and have been periodically monitored for use by Massachusetts SC and T species. We support a regular inspection of pool use by mole salamanders, particularly those with Massachusetts protection status, during appropriate times of the year when adults and/or larvae can be observed easily. This is the subject of an ongoing study on the Quabbin.


Temporary Ponds
Temporary ponds
Private land
Reservoir
Wetlands
Steep slopes
Streams
N
W
E
S

COMMUNITY 12
WETLANDS ON PEAT: BOG, FEN, SWAMP, & ACIDIC POND SHORE

Classification
PALUSTRINE COMMUNITIES
Wetlands on Peat
Basin or Seepage Peatlands and Fringe Peatlands
Herbaceous, Shrub, and Forested Peatlands

Cross Reference
Similar to NHESP descriptions of *Level Bog* and *Acidic Basin Fen*.

Status
Bog, G3 S3, Acidic Fen, G4 S3; Highly nutrient-deficient peatlands that feature boreal species are uncommon in Massachusetts. Fens in central Massachusetts are likely to be acidic.

Physical Characteristics
The hydrologic characteristics that differentiate bogs from poor fens are often difficult to see in the field, and the vegetation compositions are often similar. Bogs will have low species diversity (typically dwarf ericaceous shrubs dominate) and will lack plant species that are intolerant to low nutrient availability. Species diversity may increase in zones of increasing nutrient availability. Fens in central Massachusetts are typically acidic and the vegetation composition often closely resembles bog communities. Fens in this system are determined by higher species diversity (especially in sedge species) throughout the peatland and are accompanied or codominated by ericaceous shrubs. It may be most practical to classify these communities as acidic shrub peatlands if the hydrology is unknown.

Many bogs occur in kettle hole depressions formed by melting ice that remained after the glaciers receded. The resulting oligotrophic ponds inhibit rapid decomposition, and accumulate organic matter (peat) over time. Often the peat begins at the shoreline and gradually encroaches upon the standing water, eventually forming a floating mat of peat. The vegetation is typically perched preventing contact with the groundwater. Therefore, this community type derives most nutrients from precipitation with very little groundwater or overland water flow influence. Bogs are usually formed on acid bedrock or glacial till derived from granite.

Fens are similar to bogs but exhibit somewhat increased nutrient availability (and slightly more diverse vegetation) due to an inlet, groundwater discharge, or overland water flow into the system. Poor fens are difficult to discern from bogs, and the two are often lumped together.

Acidic swamps that feature *Picea mariana* and other boreal species typically occur in basin depressions. Often this forest type occurs in transition zones between bogs and more nutrient rich areas.

Vegetation Composition

Open, oligotrophic peatlands are commonly dominated by *Chamaedaphne calyculata* and *Kalmia angustifolia,* with these species stunted in the most nutrient poor sections of the mat. *Drosera rotundifolia, D. intermedia, Eriophorum virginicum, Sarracenia purpurea, Vaccinium macrocarpon, V. oxycoccos,* and *Utricularia spp.* are characteristic peatland herbaceous plants. In cooler areas *Andromeda glaucophylla, Kalmia polifolia,* and *Ledum groenlandicum* will be present.. Fens are often codominated by sedge species. *Acer rubrum* saplings, *Aronia melanocarpa, Clethra alnifolia, Decodon verticillatus, Ilex verticillata, Larix laricina, Lyonia ligustrina, Myrica gale, Nemopanthus mucronatus, Picea mariana,* and *Vaccinium corymbosum,* may occur along the edges and transition areas where more nutrients are available.

Acidic forests that occur on peat are often dominated by *Picea mariana*. The understory may consist of *Chamaedaphne calyculata, Kalmia angustifolia, Vaccinium corymbosum,* and *Rhododendron canadense* Characteristic peatland herbaceous plants may be present on the forest floor. Other associates may include *Acer rubrum, Betula populifolia, Larix laricina, Ilex verticillata,* and *Nemopanthus mucronatus.*

Acidic pond shores are dominated by typical peat mat species such as various *Carex spp., Chamaedaphne calyculata, Drosera spp., Eriophorum viginicum, Kalmia angustifolia, Rhynchospora alba, Sarracenia purpurea, Vaccinium macrocarpon,* and *V. oxycoccos.* In areas where more nutrients are available, *Acer rubrum, Alnus incana, Cephalanthus occidentalis, Decodon verticillatus, Dulichium arundinaceum, Larix laricina, Peltandra virginica, Picea mariana, Pinus strobus, Spiraea alba var. latifolia, S. tomentosa, Triadenum virginicum, Tsuga canadensis, Vaccinium corymbosum,* may occur.

Sources: Messier 1980, Johnson 1985, Lynn and Karlin 1985, Damman and French 1987, Reschke 1990, Sneddon et al. 1994, Thomson 1996, Massachusetts NHESP fact sheets

Rare Plants

Common Name	Scientific Name	MA Status
Dwarf mistletoe	*Arceuthobium pusillum*	SC
Few flowered sedge	*Carex pauciflora*	E
Pod-grass	*Scheuchzeria palustris*	T
Thread rush	*Juncus filiformis*	T
Wiegand's sedge	*Carex wiegandii*	E

Sources: Sorrie 1987, Gleason and Cronquist 1991, Brumback and Mehroff 1996, Petersen and McKenny 1996, Massachusetts NHESP 1998

Rare Vertebrates

Mammals

Common Name	Scientific Name	MA Status
Eastern pipistrelle	*Pipistrellus subflavus*	U
Hoary bat	*Lasiuris cinereus*	U
Red bat	*Lasiuris borealis*	U
Silver-haired bat	*Lasionycteris noctivagans*	U
Southern bog lemming	*Synaptomys cooperi*	SC
Water shrew	*Sorex palustris*	SC

Sources: Degraaf et al. 1981, Degraaf and Rudis 1987

Birds

Common Name	Scientific Name	MA Status
American bittern	*Botaurus lentiginosus*	E
Northern harrier	*Circus cyaneus*	T
Pied-billed grebe	*Podilymbus podiceps*	E

Sources: Brewer 1967, Larson 1982, Degraaf et al. 1989, Degraaf and Rudis 1987, Reschke 1990, Sumpter 1990, National Geographic Society 1992

Amphibians

Common Name	Scientific Name	MA Status
Blue spotted salamander	*Ambystoma laterale*	SC
Four-toed salamander	*Hemidactylum scutatum*	SC
Jefferson salamander	*Ambystoma jeffersonianum*	SC
Northern spring salamander	*Gyrinophilis porphyriticus*	SC

Sources: Blanchard 1923, Degraaf and Rudis 1981, 1983, 1987, Larson 1982, Johnson 1985, Reschke 1990, Jarman 1995

Reptiles

Common Name	Scientific Name	MA Status
Spotted turtle	*Clemmys guttata*	SC
Wood turtle	*Clemmys insculpta*	SC

Sources: Degraaf and Rudis 1981, 1983, 1987, Damman and French 1987

Survey Summary

Quabbin Reference Sites:		Compartment	Site Quality
1.	South Spectacle Pond	New Salem, compartment 21*	Representative
2.	Lily Pond	Prescott, compartment 14	Representative
3.	Pottopaug Pond at gate 41	Hardwick, compartment 13	Representative
4.	Pottopaug Pond at Dana Center	Petersham, compartment 2	Representative
5.	Basset Pond	New Salem, compartment 21	Representative

* This site was not surveyed; Access is limited due to the presence of a moat surrounding the mat.

One or two 15 m circular sample plots were established at all sites except for South Spectacle Pond*. Trees are uncommon at all sites and primarily restricted to the edges of the peat mat. All sites surveyed have significant shrub cover with *Chamaedaphne calyculata* and *Vaccinium corymbosum* common to all sites. Herbaceous plants common to all sites include *Dulichium arundinaceum, Eriophorum virginicum*, and *Vaccinium macrocarpon.* Sites vary in structure ranging from the more herbaceous dominated site at Dana Center to the tall scrub thicket at the Bassett Pond site. The other three sites are primarily dwarf scrub shrub dominated.

Species not listed above that were observed in the surveys include: ***Amelanchier sp., Carex canescens, C. stricta, C. trisperma, C. utriculata, Iris versicolor, Galium trifidum, Gaylussacia baccata, Juncus effusus, Lysimachia terrestris, Nymphaea odorata, Osmunda cinnamomea, Rhododendron viscosum, Sagittaria latifolia, Tsuga canadensis, Typha latifolia,*** and ***Utricularia vulgaris.*** The lily pond site was the only one to have trees (over 10 cm, 4 in. dbh) located within the survey plot. Mean dbh of *Acer rubrum* at this site is 24.5 cm (9.6 in.).

All sites surveyed are representative of acidic peat wetlands, though they vary in structure, composition, and likely hydrology. All sites occur on peat of varying depths; Basset pond has a more shallow peat layer with a highly decomposed organic layer (muck) below. All sites occur either in a basin that is thoroughly carpeted with peat (e.g., Basset) or on a peat mat along the perimeter of a pond (e.g., Lily Pond). Sites vary in vegetation composition and include a herbaceous species-dominated site at Dana Center, two dwarf scrub shrub- dominated sites at Pautopaug and Lily Pond, and the tall shrub thicket at the Bassett Pond site. These sites all feature plants that are restricted to the specific hydrologic and nutrient-deficient conditions that occur there. These and all similar sites at Quabbin are worthy of protection.

Site Name	No. of plots	Topographic Position	Slope Deg. / Asp.	A Horizon Depth (cm)	Average Soil Texture	Mean Soil pH by Horizon	Hydrologic Regime
Dana Center	2	Bog	0 / NA	approx. 100	Peat	NR	Permanently flooded
Pautapaug	2	Bog	0 / NA	NR	Peat	NR	Permanently flooded
Lily Pond	1	Bog	0 / NA	NR	Peat	NR	Permanently flooded
Bassett Pond	1	Basin floor	0 / NA	>100	Peat / Muck	NR	Permanently flooded

Site Name	No. of plots	Mean Dbh cm (in.)	Mean Dbh C.V.	Basal area m^2/ha (ft^2/ac)	Percent Cover Can	Percent Cover SCan	Percent Cover TShr	Percent Cover SShr	Percent Cover Herb	Percent Cover Nvas`	Height (m) Can	Height (m) SCan
Dana Center	2	0	NA	0	0	0	0	25-50	NR	75	NA	NA
Pautapaug	2	0	NA	0	0	0	0-10	80	NR	50	NA	NA
Lily Pond	1	24.5 (9.6)	NA	4.6 (20)	10	0	15	50	90	80	12	NA
Bassett Pond	1	12.0 (4.7)	NA	0	10	0	75	NR	25	95	12	NA

Mapping Criteria

Information Sources

- Many sites are already known by MDC personnel.
- GIS data layers depicting open and shrub wetlands may aid in locating acidic peatlands. Sites are isolated hydrologically or located on the edge of a pond or lake.
- Aerial photographs may be used to identify and map peatlands. Open herbaceous and shrub wetlands can be seen on aerial photographs. Forested peatlands are more difficult to see on photos since they are often dominated by conifers.
- Many sites are mapped in the National Wetlands Inventory.

Indicators

Hydrology

- Although the hydrology of peatlands is the fundamental component that defines these communities, it is often difficult to discern bogs from acidic fens since the vegetation communities are so similar (see community description). It is likely that the acidic peatlands that will be encountered at the Quabbin Watershed will be oligotrophic, but not completely ombrotrophic (technically a bog is hydrologically isolated and receives nutrients from precipitation only). These sites, based on the vegetation communities, are often characterized, and widely accepted as bogs despite their hydrology. For the purposes of this system, we can classify these communities according to their dominant vegetation life form(i.e. acidic shrub peatland). Forested peatlands, will be saturated and may have water flowing through. Acidic pond shores are likely to not have an inlet nearby.

Substrate

- Acidic peatlands are easily identified by the presence of a peat mat. The mat may line the shore of an oligotrophic pond, or it may be large enough that no open water exists. It may have hummocks and hollows at woody sites. Acidic shores may not have a well developed peat mat, but will have an extensive ***Sphagnum spp.*** community on which characteristic acidic peatland plants will grow.

Species

- These communities will all have ***Sphagnum spp.*** communities. Acidic peatland vegetation is very distinct since it is well adapted, and often restricted to live in nutrient poor conditions. Fens that are nutrient poor will very closely resemble bogs in vegetation composition. ***Chamaedaphne calyculata*** is the dominant species. Other species, such as ***Drosera spp., Eriophorum spp., Kalmia angustifolia, K. polifolia, Ledum groenlandicum, Sarracenia purpurea*** and ***Vaccinium oxycoccos*** are strong acidic peatland indicator plants.

<u>Minimum Mapping Unit and Boundaries</u>

- Depending on the method used for mapping, a peatland of at least 0.05 ha (.11 acres) should be mapped. This number is taken from an inventory by Golet and Davis (***in*** Stone 1991), who were able to use this as their minimum mapping unit using 1:12,000 scale black and white photography. The use of remote methods may require larger mapping units and therefore, the smallest area that can be mapped accurately should be used. NWI maps use 0.48 ha (1 acre) as their smallest mapping unit where aerial photos are used. Adjacent wetlands of different types should be mapped as separate communities. Some peat communities occur as strips along the shoreline of a pond or lake, and these may be quite narrow.

  Sources: Tiner 1991, Stone 1992

<u>**Threats**</u>

Current Threats

- Peat communities are very susceptible to trampling and crushing. Heavy foot traffic and forestry activities that make use of bridges or corduroy, which come in direct contact with peat, can be harmful to peatland vegetation.

- The invasion of purple loosestrife is a current concern in some areas of Pottapaug Pond. Most acidic peatlands at Quabbin receive adequate light to support this plant. It is likely to establish well on the more nutrient rich edges of peatlands, but it is unclear whether it will infiltrate the more acidic portions.

- Since the unique communities of peatlands develop largely as a result of specific hydrological and chemical conditions, changes to these components will greatly threaten the persistence of associated flora at a site. Threats to the peatland hydrology at Quabbin are primarily associated with excessive and prolonged flooding above the level of peat due to beaver inhabitation. Rapid water level draw-down, a threat to peatlands in other areas, does not appear to be a threat at Quabbin.

Potential Threats

- The introduction of nutrients from roads and agricultural areas could greatly disturb the vegetation composition, since it would allow many species that are not adapted to acidic conditions to become established. It is not clear whether this is a current threat to acidic peatlands of Quabbin.

<u>**Management Recommendations**</u>

Active Management Options

- To address beaver damage throughout Quabbin, we suggest a contingency plan be put into place in advance. By obtaining proper permits in advance to remove individuals that pose a specific threat to sensitive communities, water quality, or property of interest, immediate and effective action can take place. In addition to permit acquisition, we suggest the construction of a document that outlines the specific circumstances required for beaver removal, and a clear, comprehensive protocol for implementing such action. We also suggest the investigation of installing water level regulation devices for beaver damage mitigation.

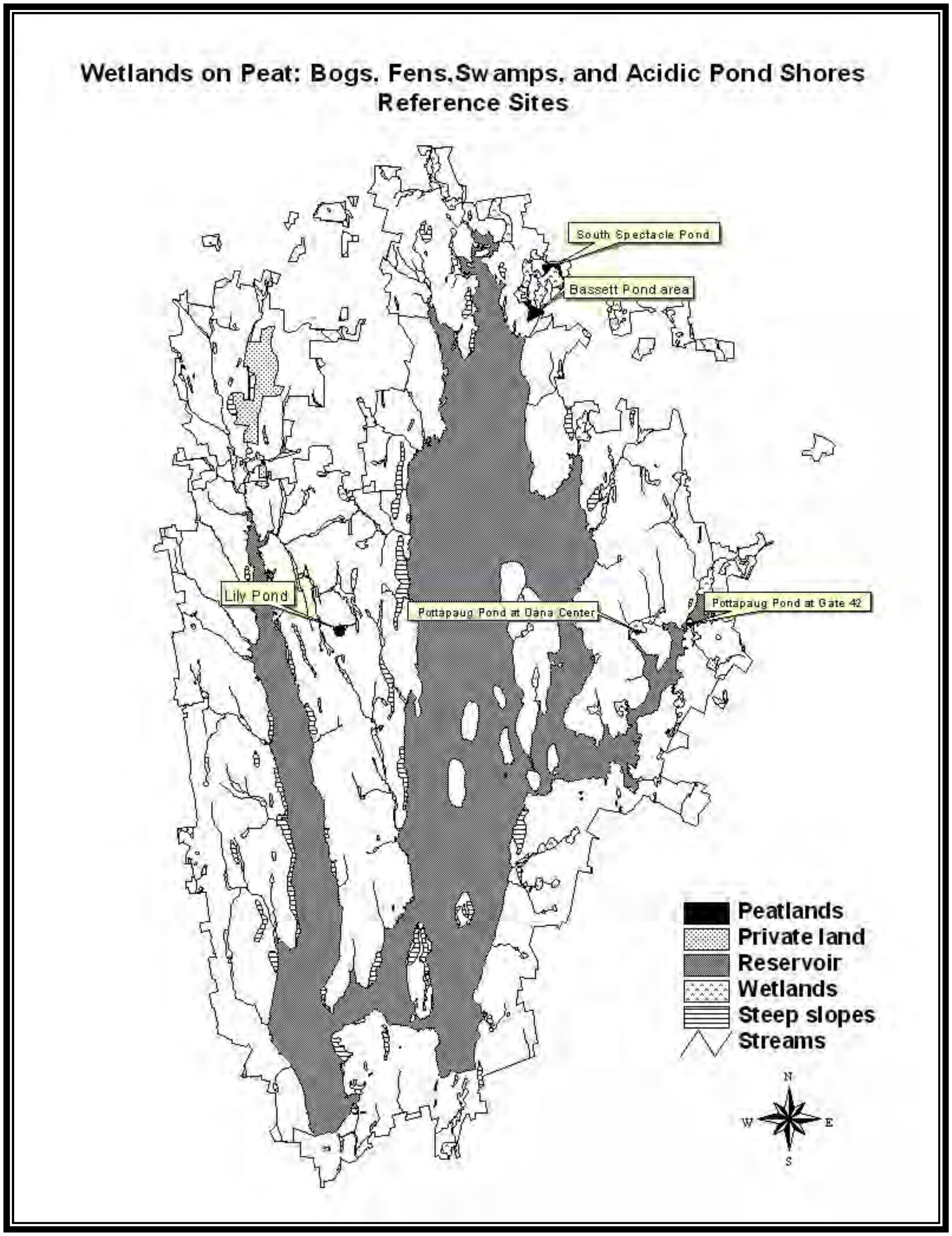
- To address purple loosestrife invasion, we suggest physical removal of plants younger than two years old. At this age, plants have fewer roots and are easier to remove effectively.

Restrictions

- Avoid crossing peat with equipment or devices that come in direct contact with peat.
- Avoid physical disturbance of soils adjacent to the peatland to help prevent invasive plant establishment.
- Avoid any activities that may result in excessive flooding or draw-down of the site.

Monitoring

- As part of the annual monitoring of beaver activity, identify new inhabitation at sites that may threaten to sustain flooding over the level of peat.



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Appendix 1

Master list of all plant species cited in this document, including both scientific and common names in alphabetical order by scientific name. All nomenclature follows Gleason and Cronquist 1991. Common names not found in Gleason and Cronquist are from the National Plant Data Center web page and other sources.

Sources: Gleason and Cronquist 1991, Peterson and McKenny 1996, Petrides 1988, USDA, NRCS 1999

Scientific name	Common name
Acer nigrum	Black maple
Acer pensylvanicum	Striped maple, Moosewood
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Acer spicatum	Mountain maple
Actea alba	White baneberry, Doll’s eyes
Adiantum pendatum	Maidenhair fern
Adlumia fungosa	Climbing fumitory
Agrimonia pubescens	Downy agrimony
Agrostis perennans	Upland bentgrass
Allium tricoccum	Wild leek
Alnus incana	Speckled alder
Amelanchier spp.	Shadbush, Serviceberry
Amelanchier spicata	Running seviceberry, Dwarf serviceberry
Andromeda glaucophylla	Bog rosemary
Antennaria plantaginifolia	Plantain-leaved pussytoes
Aplectrum hyemale	Putty-root
Aquilegia canadensis	Columbine
Arabis drummondii	Drummond’s rock-cress
Arabis missouriensis	Green rock-cress
Aralia nudicaulis	Wild sarsaparilla
Arceuthobium pusillum	Dwarf mistletoe
Arenaria stricta	Michaux's sandwort
Arisaema triphyllum	Swamp Jack-in-the-pulpit
Aronia melanocarpa	Black chokeberry
Asarum canadense	Wild ginger
Asclepias verticillata	Linear-leafed milkweed, Whorled milkweed
Aster acuminatus	Whorled wood aster
Aster divaricatus	White wood aster
Aster macrophyllus	Large-leaved aster
Athyrium pycnocarpon	Glade-fern
Berberis thunbergii	Japanese barberry
Betula alleghaniensis	Yellow birch
Betula lenta	Black birch, Sweet birch
Betula papyrifera	Paper birch
Betula populifolia	Gray birch
Bidens cernua	Bur-marigold
Blephilia hirsuta	Hairy wood-mint
Calamagrostis canadensis	Bluejoint
Caltha palustris	Marsh-marigold
Cardamine diphylla	Crinkleroot, Broad-leaved toothwort
Cardamine parvifolia	Sand bittercress

Carex argyrantha	Hay sedge
Carex atlantica	Prickly bog sedge
Carex brunnescens	Brownish sedge
Carex bullata	Button sedge
Carex canescens	Silvery sedge
Carex cephalophora	Oval-leaf sedge
Carex crinita	Fringed sedge
Carex folliculata	Northern long sedge
Carex formosa	Handsome sedge
Carex grayi	Gray’s sedge
Carex hitchcockiana	Hitchcock's sedge
Carex intumescens	Greater bladder sedge
Carex laxiflora	Broad looseflower sedge
Carex leptalea	Bristlystalked sedge
Carex lupulina	Hop sedge
Carex pauciflora	Few flowered sedge
Carex pensylvanica	Pennsylvania sedge
Carex radiata	Eastern star sedge
Carex stipata	Owlfruit sedge
Carex stricta	Upright sedge
Carex trisperma	Threeseeded sedge
Carex utriculata	Northwest Territory sedge
Carex vesicaria	Blister sedge
Carex vestita	Velvet sedge
Carex wiegandii	Wiegand's sedge
Carpinus caroliniana	Iron wood, Hornbeam
Carya glabra	Pignut hickory
Carya ovalis	(Sweet) Pignut hickory
Carya ovata	Shagbark hickory
Castanea dentata	American chestnut
Caulophyllum thalictroides	Blue cohosh
Celtis occidentalis	American hackberry, Northern hackberry
Cephalanthus occidentalis	Buttonbush
Chamaedaphne calyculata	Leatherleaf
Chenopodium album	Lamb’s quarters, Fat hen, Goosefoot
Chenopodium simplex	Mapleleaf goosefoot
Chimaphila maculata	Spotted wintergreen
Chrysosplenium americanum	Water mat
Cimicifuga racemosa	Black snakeroot, Black cohosh
Cinna spp.	Woodreed
Circaea alpina	Smaller enchanter’s nightshade
Claytonia caroliniana	Carolina spring-beauty
Claytonia virginica	Narrow-leaved spring beauty
Clematis occidentalis	Purple clematis
Clethra alnifolia	White alder, Sweet pepperbush
Clintonia borealis	Clintonia, Corn-lily
Comandra umbellata	Bastard toad-flax
Comptonia peregrina	Woodfern, Sweetfern
Coptis trifolia	Threeleaf goldenthread
Corallorrhiza odontorhiza	Autumn coralroot
Cornus alternifolia	Alternate-leaf dogwood, Pagoda dogwood
Cornus rugosa	Roundleaf dogwood
Corydalis sempervirens	Pale corydalis
Corylus americana	American hazelnut
Cypripedium acaule	Moccasin-flower
Dalibarda repens	Dewdrop

Danthonia compressa	Flattened oatgrass
Danthonia intermedia	Timber oatgrass
Danthonia spicata	Poverty oatgrass
Decodon verticillatus	Swamp loosestrife, Water-willow
Dennstaedtia punctilobula	Hayscented fern
Deschampsia flexuosa	Wavy hair grass
Dicentra canadensis	Squirrel-corn
Dicentra cucullaria	Dutchman's-breeches
Diervilla lonicera	Northern bush-honeysuckle
Digitaria sanguinalis	Hairy crabgrass, Northern crabgrass
Dirca palustris	Leatherwood
Drosera intermedia	Spatulate-leaved sundew
Drosera rotundifolia	Round-leaved sundew
Dryopteris cristata	Crested woodfern
Dryopteris intermedia	Intermediate woodfern, Fancy woodfern
Dryopteris marginalis	Marginal woodfern
Dulichium arundinaceum	Threeway sedge
Epigaea repens	Trailing arbutus
Equisetum arvense	Common horsetail, Field horsetail
Equisetum sylvaticum	Woodland horsetail
Erechtites hieraciifolia	Pilewort, Fireweed
Eriophorum virginicum	Tawny cottongrass
Erythronium americanum	Trout-lily, Adder's-tongue
Euthamia graminifolia	Flat-top goldenrod
Fagus grandifolia	American Beech
Fraxinus americana	White ash
Fraxinus nigra	Black ash
Galium asprellum	Rough bedstraw
Galium trifidum	Northern three-lober bedstraw
Gaultheria procumbens	Wintergreen, checkerberry
Gaylussacia baccata	Black huckleberry
Geranium robertianum	Herb-robert
Geum rivale	Purple avens, Water avens
Glyceria grandis	American mannagrass
Glyceria striata	Fowl mannagrass
Gratiola aurea	Yellow hedge-hyssop
Habenaria clavellata	Small woodland orchid, Club-spur orchid
Habenaria lacera	Ragged fringed orchid
Habenaria psycodes	Small purple fringed orchid
Hamamelis virginiana	Witch hazel
Helianthemum canadense	Frostweed
Hepatica americana	Round-lobed hepatica
Hieracium venosom	Rattlesnake-weed, Veiny hawkweed
Hydrastis canadensis	Golden seal
Hydrocotyle americana	Marsh-pennywort
Hydrophyllum canadense	Broad waterleaf, Maple-leaved waterleaf
Ilex verticillata	Common winterberry holly
Impatiens capensis	Orange touch-me-not, Jewelweed
Iris versicolor	Larger blue flag, Northern blue flag
Juncus effusus	Common rush, Soft rush
Juncus filiformis	Thread rush
Juniperus virginiana	Eastern red cedar
Kalmia angustifolia	Sheep laurel
Kalmia latifolia	Mountain laurel
Kalmia polifolia	Pale laurel, Swamp laurel
Krigia virginica	Virginia dwarf dandelion

Larix laricina	Larch
Ledum groenlandicum	Labrador-tea
Leersia oryzoides	Rice cutgrass
Lespedeza spp.	Lespedeza, Bush-clover
Liatris scariosa var. novae-angliae	New England blazing star
Lindera benzoin	Spice bush
Lobelia cardinalis	Cardinal-flower
Lycopodium digitatum	Southern ground-cedar, Fan clubmoss
Lycopodium obscurum	Princess pine, Tree groundpine
Lycopodium tristachyum	Wiry ground-cedar, Deeproot clubmoss
Lycopus uniflorus	Northern bugleweed, Northern water-horehound
Lyonia ligustrina	Male-berry
Lysimachia quadrifolia	Whorled loosestrife
Lysimachia terrestris	Yellow loosestrife, Swamp candles
Lythrum salicaria	Purple loosestrife
Maianthemum canadense	Canada mayflower
Medeola virginiana	Indian cucumber-root
Milium effusum	Woodland millet
Mitchella repens	Partridge-berry
Monotropa uniflora	Indian pipe
Morus rubra	Red mulberry
Muhlenbergia mexicana	Mexican muhly, Wirestem muhly
Myosotis scorpioides	True forget-me-not, Water scorpion-grass
Myrica gale	Sweetgale
Myriophyllum spp.	Water-milfoil
Nemopanthus mucronatus	Mountain-holly
Nymphaea odorata	Fragrant water-lily
Nyssa sylvatica	Blackgum, Tupelo
Onoclea sensibilis	Sensitive fern
Oryzopsis pungens	Mountain ricegrass
Osmorhiza claytonii	Sweet cicely
Osmunda cinnamomea	Cinnamon fern
Osmunda regalis	Royal fern
Ostrya virginiana	Hop-hornbeam, Ironwood
Oxalis acetosella	Common wood-sorrel, Northern wood-sorrel
Panax quinquefolius	American ginseng
Panicum depauperatum	Starved panicgrass
Parthenocissus quinquefolia	Virginia creeper
Peltandra virginica	Arrow arum, Tuckahoe
Phragmites australis	Common reed
Picea mariana	Black spruce
Pinus rigida	Pitch pine
Pinus resinosa	Red pine
Pinus strobus	White pine
Poa compressa	Canada bluegrass
Polygonum arifolium	Halberd-leaved tearthumb
Polygonum sagittatum	Arrow-leaved tearthumb
Polypodium virginianum	Rock polypody, Common polypody
Polystichum acrostichoides	Christmas fern
Polytrichum commune	Polytrichum moss, Common hair cap moss
Pontederia cordata	Pickerelweed
Potamogeton spp.	Pondweed
Potentilla simplex	Common cinquefoil, Old-field five-fingers
Proserpinaca spp.	Mermaid-weed
Prunus serotina	Black cherry
Prunus virginiana	Choke cherry

Pteridium aquilinum	Bracken, Eagle fern
Quercus alba	White oak
Quercus bicolor	Swamp white oak
Quercus coccinea	Scarlet oak
Quercus ilicifolia	Scrub oak
Quercus prinoides	Dwarf chinkapin oak
Quercus prinus	Chestnut oak
Quercus rubra	Northern red oak
Quercus velutina	Black oak
Ranunculus fascicularis	Early buttercup, Thick-root buttercup
Rhamnus alnifolia	Alderleaf buckthorn
Rhododendron canadense	Rhodora
Rhododendron maximum	Great laurel, White laurel
Rhododendron viscosum	Swamp honeysuckle, Swamp azalea
Rhus typhina	Staghorn sumac
Rhynchospora alba	White beaksedge
Ribes lacustre	Bristly black currant, Spiny swamp currant
Rosa carolina	Carolina rose, Pasture rose
Rubus hispidus	Bristly dewberry, Swamp dewberry
Rubus occidentalis	Black raspberry
Rumex acetosella	Common sorrel, Red sorrel
Sagittaria latifolia	Broad-leaved arrowhead
Salix spp.	Willow
Sambucus racemosa	Red elderberry
Sambucus racemosa var. *pubens*	Red elderberry
Sanguinaria canadensis	Bloodroot
Sanicula canadensis	Canadian sanicle
Sanicula gregaria	Cluster sanicle, Long-styled sanicle
Sarracenia purpurea	Pitcher-plant
Sassafras albidum	Sassafras
Saxifraga pensylvanica	Swamp saxifrage
Saxifraga virginiensis	Early saxifrage
Scheuchzeria palustris	Pod-grass
Schizachyrium scoparium	Little blue stem
Scirpus spp.	Bulrush
Scirpus expansus	Woodland bulrush
Scutellaria lateriflora	Mad-dog skullcap
Senecio aureus	Golden ragwort, Heart-leaved groundsel
Senecio obovatus	Roundleaf ragwort, Running groundsel
Senecio pauperculus	Balsam ragwort, Northern meadow groundsel
Silene antirrhina	Sleepy catchfly
Sium suave	Water-parsnip
Smilacina racemosa	False Solomon’s-seal
Solanum dulcamara	Nightshade, Bittersweet
Solanum nigrum	Common nightshade, Black nightshade
Solidago bicolor	Silver-rod
Solidago caesia	Blue-stemmed goldenrod
Solidago flexicaulis	Broad-leaved goldenrod
Solidago gigantea	Late goldenrod, Smooth goldenrod
Solidago nemoralis	Gray goldenrod
Solidago rugosa	Wrinkle-leaved goldenrod
Sorbus americana	American mountain ash
Sorghastrum nutans	Indian grass, Wood grass
Sparganium androcladum	Bur-reed
Sphagnum spp.	Sphagnum moss
Sphenopholis nitida	Shining wedge grass

Spiraea alba var. latifolia	Meadowsweet
Spiraea tomentosa	Steeplebush, Hardhack
Staphylea trifolia	Bladdernut
Streptopus roseus	Rose mandarin, Twisted stalk
Symplocarpus foetidus	Skunk cabbage
Thelypteris palustris	Marsh fern, Meadow fern
Thelypteris simulata	Bog fern
Tilia americana	American basswood
Toxicodendron radicans	Eastern poison ivy
Toxicodendron vernix	Poison sumac
Triadenum virginicum	Virginia marsh St. John’s-wort
Trientalis borealis	Starflower
Trillium cernuum	Nodding trillium
Trillium erectum	Purple trillium, Wake-robin
Triodanis perfoliata	Clasping Venus’ looking-glass
Tsuga canadensis	Eastern hemlock
Typha latifolia	Cat tail, Bullrush
Ulmus americana	American elm, White elm
Utricularia vulgaris	Greater bladderwort, Common bladderwort
Uvularia sessilifolia	Wild oats, Sessile bellwort, Merrybells
Vaccinium angustifolium	Late low blueberry, Common lowbush blueberry
Vaccinium corymbosum	Common highbush blueberry
Vaccinium macrocarpon	Large cranberry
Vaccinium oxycoccos	Small cranberry
Vaccinium pallidum	Southern low blueberry, Hillside blueberry
Veratrum viride	False hellebore, Indian poke
Verbena simplex	Narrow-leafed vervain
Viburnum alnifolium	Hobblebush
Viburnum dentatum	Southern arrowwood
Viburnum lentago	Sheepberry, Nannyberry
Viburnum nudum var. cassinoides	Wild-raisin
Viola palmata	Early blue, Wood violet
Viola rostrata	Long-spurred violet
Viola rotundifolia	Round-leaved yellow violet
Viola sagittata	Arrow-leaved violet
Vulpia octoflora	Sixweeks fescue
Waldsteinia fragarioides	Barren strawberry
Woodsia ilvensis	Rusty woodsia, Rusty cliff-fern
Woodsia obtusa	Blunt-lobed cliff-fern, Common woodsia

Appendix 2

The following wildlife habitat matrix is intended to provide a coarse overview of the Quabbin wildlife species that may use the rare natural communities addressed in this document. In the text, we provided lists of endangered, threatened, special concern, and uncommon species that may use the rare communities; here, we have included all mammal, bird, amphibian, and reptile species expected to occur in the Quabbin area. Wildlife species are listed according to taxonomic group (Class). Communities are divided broadly into categories based on landscape position (terrestrial, riparian, and palustrine). Each rare community type addressed in the document is located beneath the appropriate landscape position category. We indicated with an ‘X’, all community types that could provide some important life history function for each wildlife species. In the bird matrix, we included species that winter at Quabbin (designated with a W), or that are commonly observed during migration. We indicated with an * if a given wildlife species was not expected to benefit from any rare community type. We have also provided a short list of habitat requirements for each species.

Sources: Blanchard 1923, Bent 1938, Bent 1939, Bent 1953, Brewer 1967, Degraaf et al.1980, DeGraaf and Rudis 1981, DeGraaf et al 1981, Degraaf and Rudis 1983, Damman and French 1987, Degraaf and Rudis 1987, Sumpter 1990, National Geographic Society 1992, Degraaf and Rappole 1995, Jarman 1995, Lyons and Livingston 1997.

Appendix 3

Completed Natural Heritage Program quantitative community characterization data forms for all reference sites inventoried during 1999 in association with this project. The raw data recorded on these forms was summarized for each rare community and described under “survey summary” in the individual community descriptions.