BATES WOODS PARK

New London, Connecticut

FOREST MANAGEMENT PLAN

Prepared for Bates Friends Forever in Spring 2026 by:

Sweet Birch Consulting, LLC

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TITLE & SIGNATURE PAGE

Property Steward: **Plan Date: Spring 2026**

Bates Friends Forever
c/o Riverside Park Conservancy
P.O. Box 1082
New London, CT 06320-1082

Contact: Frida Berrigan
Phone: (860) 389-8566
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Property Information:

City: New London Plat: 95 Lot: C113-18-19

Total Assessor Acres: 75.43 Total GIS Acres: 76.55. Plan Acres (GIS): 54.2
Excluded Acres: 22.4 (non-forested developed area in northwest corner of park & solar array on former landfill site)

Property Location: USGS Topographic Quads: New London and Niantic

The section of Bates Woods Park within New London is located south of Chester Street and Jefferson Avenue (immediately south of the New London Multi-Magnet High School campus and the housing development on Ledge Road, Boulder Drive, and Buchanan Road); north of the Boston Post Road (U.S. Route 1); east of Clark Lane and the Clark Lane Middle School; and west of U.S. Route 1/State Highway 639; at the western edge of the City of New London, New London County, Connecticut

TSP Certification:
As a Technical Service Provider, I certify that I have prepared the Forest Management Plan (FMP). The plan complies with all Federal, State, Tribal, and local laws and requirements, meets applicable program requirements and recommended plan practices based on NRCS conservation practice standards and specifications, is consistent with the conservation program goals and objectives for which the program contract was entered into by the client, and incorporates alternatives that are both cost effective and appropriate to address the resource issues, and that all information provided is accurate as current forestry methods allow.

______________________________ ______________
Plan Preparer Date

Property Steward Certification:
As a representative of Bates Friends Forever (BFF), its fiscal agent, the Riverside Park Conservancy, and the City of New London (the landowner), I have been involved in the planning process and agree that the content of the FMP is accurate. I certify that I have reviewed this plan document and agree to the objectives described. I understand that BFF and/or the City of New London are responsible for keeping all necessary records associated with the implementation of this FMP. To maintain eligibility for NRCS programs, BFF understands that it must follow the management recommendations and schedule described for a period of ten years, or until a revised plan is submitted to the USDA Natural Resources Conservation Service and approved.

______________________________ ______________
Property Steward (BFF) Representative Date

Reviewer Certification:
As a USDA Natural Resources Conservation Service employee, I certify that I have administratively reviewed this Forest Management Plan and it meets all the Plan Development criteria for Conservation Plan Activity 106.

______________________________ ______________
USDA Natural Resources Conservation Service Representative Date

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Appendix 3: Oak Resiliency Assessment Report for Bates Woods Park

1. FOREST MANAGEMENT PLAN PURPOSE

This Forest Management Plan is intended as an overall blueprint to guide forest and land management activities in the undeveloped, mostly forested area of Bates Woods Park lying within the City of New London (not including a smaller adjacent section of the park located in the Town of Waterford). For simplicity, this land unit is usually referred to as “Bates Woods Park” and the wooded area as “Bates Woods” in this plan. The plan is a tool to help articulate steps towards achieving management goals and through specific management actions. In advance of implementing recommended conservation practices, Bates Friends Forever and its partners can work with USDA Natural Resources Conservation Service staff and/or a registered NRCS Technical Service Provider (TSP) to complete the required application and planning processes to access technical and potential financial assistance. The Forest Management Plan is a working document and may be revised when strategic or necessary (for example, when a severe weather event or pest outbreak changes conditions). This plan is written to serve as a guiding reference for no longer than ten years.

2. LANDOWNER’S MANAGEMENT GOALS

Bates Woods Park is a public park owned by the City of New London. Bates Friends Forever (BFF) is self-described “group of neighbors advocating for the stewardship of Bates Woods, an awesome park and open space.” BFF and its fiscal agent, a local 501(c)(3) nonprofit organization called the Riverside Park Conservancy, have a formal agreement to work in partnership with the City of New London and its Department of Public Works to care for the undeveloped areas of Bates Woods Park. Seeking to advance broader recognition that Bates Woods has rich educational, recreational, and scientific history and unlimited potential, BFF is committed to “efforts to encourage connection, foster stewardship, and increase access to Bates Woods.

Management goals for Bates Woods are to:

- Conserve open space and provide a natural forest reserve within the City of New London
- Provide opportunities for low-impact recreation, retreat, exercise, and education
- Maintain or enhance forest productivity and health
- Provide, maintain, and enhance wildlife habitat
- Consider forest climate resiliency and forest carbon storage & sequestration
- Protect and, where possible, restore cultural resource features
- Manage risks and address potential hazards

3. REGIONAL CONTEXT AND SIGNIFICANCE

Bates Woods Park is located at the western edge of New London, about one mile west of downtown and the Thames River's west bank and one mile south of the Interstate 95 corridor that cuts across the city in a roughly east-west direction. The park is situated in an-out-of-the-way area of the city characterized by relatively light population density, although the densely-settled Jefferson neighborhood is located immediately to the east. The census districts near the park are characterized by lower income than most of the surrounding region. While most of the park (75 acres) is in New London, a small section (about 10 acres) lies in Waterford, the adjacent town to the west. Two school complexes (the New London High School's Multi-Magnet Campus and Waterford's Clark Lane Middle School) are close to the park on its north and southwest sides. Another significant neighbor to the park is a large housing complex located immediately to the north (east of the high school).

The park lies at the headwaters of the watershed of Fenger Brook, a large stream that flows south-southeast through Waterford (near the boundary with New London) for about three miles before entering Alewife Cove, a tidal basin. Alewife Cove has a tidal river outlet that flows for another 1/3 mile south before entering Long Island Sound at the southernmost part of the city.


Small pond and woods south of main park road

Although it is not well known beyond the local area, Bates Woods Park is New London's largest public park and one of the two most significant tracts of natural forest remaining in the city, along with non-landscaped sections of the Connecticut College Arboretum (private, but open to the public) north of Interstate 95. Considering its urban location, Bates Woods Park has a significant amount of nearby green space on three sides, including New London's Cedar Grove Cemetery to the north, undeveloped land (largely forested wetlands) along the municipal boundary to the south, and Waterford's Stenger Farm park to the west and still-undeveloped forestland to the northwest.

At a larger scale, Bates Woods Park is an important link in a larger green corridor just west of heavily developed New London that extends north and inland from Long Island Sound. Two of the most important values that Bates Woods provides are a relatively large patch of forest habitat for wildlife and accessible open space for the many human residents who live nearby.

4. PROPERTY OVERVIEW

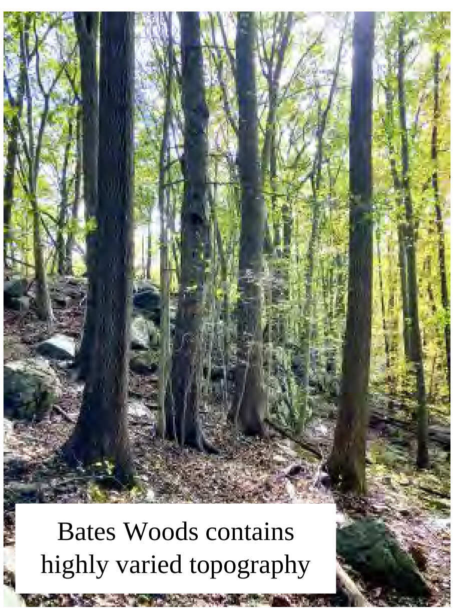
Bates Woods Park stands out as the most recognizeable component of a large forested buffer between densely developed, long-settled neighborhoods of New London and a newer, lower-density residential area of Waterford to the west. Much of area located along the muncipal boundary immediately southeast of the park is forested wetlands that are relatively inaccessible to humans.

The irregularly-shaped New London park parcel is roughly shaped like a “V” or backwards check mark. The southwestern boundary line is long and straight, while each of the other boundaries has several changes in direction.


Chester Street entrance gate to the developed area of the park.

Only the relatively flat 15-acre northwestern section of the park with frontage on Chester Street is developed. Here, a large stone gate from this main throughfare leads to a parking lot, playground, full-sized baseball and softball fields, a Little League baseall field, several storage sheds, and the New London Animal Control Department’s kennel facility. The City Department of Public Works maintains the developed area of the park.

A paved road from the parking lot off Chester Street extends through a mostly wooded landscape to another gate (providing access from Ashcraft Road) at the northeast corner, dividing the woods into northern and southern sections. South of this road, a public water utility aqueduct pipeline that transports water from reservoirs west of the city to the main urban service area also passes through the park. A standout feature of the undeveloped section of the park is the large variation in topography within a relatively small area. The elevation in the park ranges from approximately 150 feet above sea level in the northwest corner to 50 feet in the wetlands near the southern edge. Several rocky ridges and knobs with a general north-south orientation contrast with small valleys that include two small ponds and two wetlands that drain into ephemeral streams in the low-lying areas. Overall, the terrain on the north side of the road is higher in elevation, rockier, and more undulating than that on the south side. The southern portion of the park includes forested wetlands at the northern edges of the larger wetland complex extending to the southeast. Off the property, these wetlands drain into Fenger Brook.


Bates Woods contains highly varied topography

The 46-acre “Bates Woods” forest that gives the park its name is dominated by mature oak-hardwood forest with old trees. Soils and distance to bedock influence vegetation: most of the largest trees are in the valleys and on lower slopes, while the canopy has a lower height and is slightly more open on ridges and near ledges. The dominant canopy species are Northern red, black, and white oak, with significant secondary components of red maple and black birch (also known as sweet birch), while a fairly wide range of other species are present. Interspersed at irregular intervals are occasional older legacy trees, almost certainly more than 150 years old, with spreading crowns indicating that they grew in open canopy conditions. Most of these older trees show signs of decay and damage due to their advanced age. Primarily because of their location, these woodlands have high conservation value but known land use history rules out the presence of old-growth forest. All of the forest appears to have been altered and shaped by past land uses.


Butt of a 30+” DBH old oak

A prominent feature of the east-central portion of the park on the south side of the road is the site of the former New London Sanitary Landfill, surrounded by the woods. A major source of water pollution for decades, the landfill was capped in 1991 after being closed in 1988. The landfill permanently changed the topography in this section of the park and although the ground has been flattened, some of the slopes of the landfill are still evident. A fenced solar array was constructed at the south end of the former landfill site in 2025.

With its land use history, its is not surprisng that invasive plants known for colonizing disturbed areas are widespread in Bates Woods Park. Some of the most prevalent exotic invasives include Asiatic bittersweet vines, shrubby Japanese knotweed and Japanese barberry, and *Ailanthus* and Norway maple teees, along with *Phragmites* reeds in wetland areas. Greenbrier, a native species that is also invasive, is found throughout the woods.

The New London portion of Bates Woods Park is comprised of a single land parcel approximately 75 acres in size (there is a discrepancy of slightly more than 1 acre between the City Assessor and Southeast Connecticut Council of Governments GIS databases). Although it is often considered public conservation land since it is owned by the City of New London, the park is not permanently protected with a conservation easement preventing development or conversion to other land uses.

5. PROPERTY BOUNDARIES

The forest inventory did not include a comprehensive assessment of the condition of property boundaries. A stone marker observed at the corner immediately adjacent to east gate suggests that at least some of the parcel corners are surveyed and monumented. The interior boundary lines adjacent to the wooded areas of the park are not marked in a consistent manner. No discernable markers were observed in the vicinity of the property boundaries in several locations.

Sections of the southeastern and southwestern boundary lines, especially near the southern corner, pass through forested wetlands where thick vegetation and standing water can make passage difficult for humans. Portions of the southwestern line that also serves as the municipal boundary between New London and Waterford are marked by a waist-high stone wall.

The boundary at the far northwest corner of the park stands out from the others. Here, the northern edge of the developed section of the park is easy to recognize because it is marked by a large, mortared stone wall constructed along the south side of Chester Street.

Marking interior boundary lines using a consistent method (signs, paint blazes, etc.) will facilitate the location of property boundaries, promote better understanding of the physical extent of Bates Woods Park, and may help limit the use of unauthorized "herd paths" (from the housing development to the north, for example) accessing the park in an unplanned manner.

6. PAST LAND USE AND MANAGEMENT HISTORY

Information on the history of the park and past land use is from several sources:

- BFF representative Frida Berrigan
- 1977 Bates Woods Park Master Plan
- 1979 Environmental Review Team Report for Bates Woods Park
- 2025 Bates Woods management assessment report developed by Clayton Potter
- Wikipedia entry for Bates Woods Park

The online Native Land Digital atlas shows the land west of the Thames River where New London is now located as territory of the indigenous Mohegan and Western Nehantick (or Niantic) Tribes. The river may have served as a border between tribal territories, as the east side of the river is shown as territory of the Mohegan and also the Pequot Tribe. Members of all three groups continue to live in present-day Connecticut.

English settlers founded the settlement that became New London in 1646, early in the regional colonial era. For many years, the wetlands extending south of this area were known as the Cedar Swamp, although few, if any, cedars are now present within the boundary of the current park. In the uplands, settlers likely cleared areas with suitable soils for agriculture (animal pasture or possibly row crops) beginning in the 1700s, while unsuitable rocky and wetland areas remained forested. These farmlands had the benefit of being located close to the growing urban center of New London, which experienced early prosperity from its status as a port city. During the late 19^{th} and early 20^{th} Centuries, many forested acres in Connecticut were cleared and burned to create charcoal, but it is not known if this took place in parts of Bates Woods. Before being acquired by the City, the property was a farm and woodland owned by the Bates family for a significant period.

The City of New London purchased the property comprising Bates Woods in 1912 with the intention of turning it into a public park. As early as 1917, the *New London Day* newspaper included articles, editorials, and letters in which residents, high schoolers, Boy Scouts, and local

Stone fireplace and table built by WPA crews

clubs advocated for the City to make plans and improvements to the park so that it could be fully enjoyed by the community. The City made an impactful decision to construct a paved road through the middle of the park from one end to the other during the 1930s. In 1929, the local Chamber of Commerce encouraged the City to hire unemployed men to clean the park for public use. During the 1930s, crews of Works Progress Administration workers constructed the stone wall along Chester Street at the west entrance to the park and the stone gateposts at the east entrance from Ashcraft Road in addition to several "campsites" with stone fireplaces and concrete tables and benches. Near the southeast corner, WPA crews also dammed an ephemeral stream to create a shallow pond for ice skating during the winter and constructed a stone "skate house" between the pond and the main road.

In the 1950s, community members were still calling for more investment in Bates Woods Park. The Herbert F. Moran Nature Center, known to some the New London Zoo, was established on several acres in the non-forested northwestern section of the park. A *New York Times* article reports that "for many years [the zoo] had more than 100 animals, including African lions, ocelots, bobcats, skunks, raccoons, bears, mountain lions, beavers and monkeys."

During the mid-20th Century, the City also used the wooded, out-of-sight interior of the park as a solution help resolve the issue of how dispose of the waste produced by city residents and businesses. The New London Sanitary Landfill was established during the 1940s and accepted many tons of garbage each day during its peak years of use until finally being closed in 1988. At the time it was established, landfills like these were a standard waste disposal practice across much of the United States. Unfortunately, the landfill was located on wetlands at the headquarters of Fenger Brook. Waste dumped at the site contaminated the surroundings and polluted the downstream waters of Fenger Brook. After the landfill was closed, it was capped during a 1990-91 remediation project, but the lower slopes of the landfill are still apparent, and the extent of legacy impacts to soil and groundwater is uncertain.

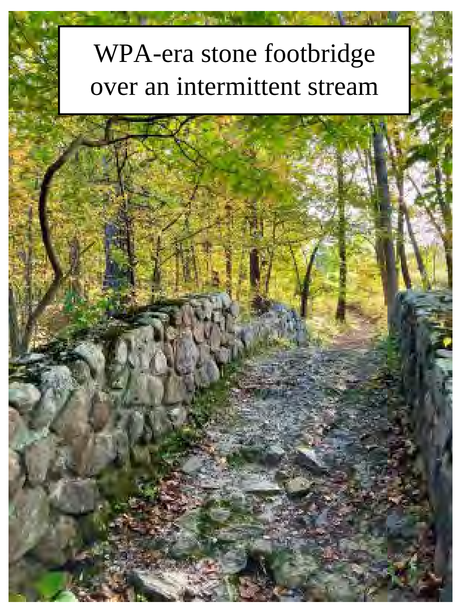
A 1977 Master Plan commissioned by the City proposed different concepts for reinvesting in the park and developing additional recreational use facilities, but these plans would have required complex collaboration and a large amount of funding that was never secured. Like many similar parks in urban areas of the country, Bates Woods Park experienced a decline in maintenance and use in later decades of the 20th century due to complex combination of socioeconomic factors. The zoo closed in the 1980s and some park facilities fell into disrepair or were vandalized when City services were curtailed as result of budget limitations and other factors. In part because of the easy access provided by the paved main road and the woods providing cover, the park attracted illegal dumping and other clandestine activities.

While the developed recreational facilities at the northwestern corner of the park continued to be popular, Bates Woods received relatively little attention for several decades. Local residents, especially neighbors, continued to use the woods and grassroots community groups such as the Friends of Bates Woods organized periodic cleanups, marked trails, and advocated for more resources being devoted to the park. Over the past decade or so, they observed the former landfill area being used as an unofficial storage area by the City Department of Public Works and others, with supplies and equipment sometimes blocking trails.

In response, a group of concerned citizens and neighbors with a strong interest in the park established Bates Friends Forever (BFF) and developed a formal agreement with the City to monitor and perform environmental stewardship work in Bates Woods. Concerns about the future of Bates Woods were heightened when the City received approval, with limited public input, to work with a solar energy developer to construct a 4-acre solar array on a portion of the former landfill site. The solar array, a surrounding fence, and an access road from the main park road were constructed over the course of 2025-26.

BFF volunteers worked to bring renewed attention to the park by jump-starting forest stewardship activities and organizing a community forum on this topic in 2025. One member participated in the Connecticut Master Woodland Manager Program organized by the Connecticut Forest & Park Association and the University of Connecticut. BFF applied for and was awarded a Connecticut Department of Energy & Environmental Protection grant to develop a forest management plan and perform invasive plant control work in Bates Woods. This forest management plan is the first formal one that has been prepared to guide management of the woodlands of Bates Woods Park.

7. CULTURAL RESOURCES AND LEGACIES


WPA-era stone footbridge over an intermittent stream

Bates Woods Park contains cultural resources and legacies that are remnants of its history and location in southeastern Connecticut's largest city. These features are ancillary to the focus of the forest management plan and more detailed information may be found in other reports and maps maintained by BFF and the City of New London. Below is incomplete list of cultural resources, many of which are still in use:

Park Entrances

- Masonry wall and gateway at the west park entrance on the south side of
- Masonry gateposts at the east park entrance at the west end of Ashcraft Road
- Paved main road through the park constructed during the 1930s

Northern Woods (Stand 1)

- West-central section: WPA crew-built “campsite” with massive stone fireplace and concrete table & benches located on the north side of the main road near a rack outcrop
- Small dam at wetland outlet
- Stone walls

Southern Woods (Stand 2)

- Eastern section:
  - Old recreation area on the south side of the road, where WPA crews constructed a stone footbridge leading from the road across a seasonal stream to two “campsites,” each with a massive stone fireplace and concrete table & benches
  - Foundation and walls of the old “skate house” at the northwest corner of the pond formerly used for ice skating in the southeastern section, just south of the road

- South of and roughly parallel to the road: active public water utility aqueduct pipeline transporting water from reservoirs to the city that was likely constructed early in the 20th Century Earthen and masonry sheathing for the pipe conduit can be observed along parts of the right-of-way.
- Unconfirmed, location unknown: There are reports of an old foundation in the woods, with speculation that the structure was used for storage of munitions during the Revolutionary War, keeping them away from Fort Trumbull on the New London waterfront
- Small dams at pond and wetland outlets
- Stone walls

Disturbed Area

- East-central section: former New London Sanitary Landfill site – another type cultural legacy that has required extensive mitigation
  - solar array constructed in 2025 is located on a portion of this site

The plan preparer was not informed of other specific cultural resources in the park.

Where stewardship activities or conservation practices are proposed for locations near cultural resources, they should be evaluated for consistency with BFF’s management goal of protecting and, where possible, restoring cultural resource features.

8. SOILS

Overall, soils are dominated by rocky upland complexes, with smaller pockets of wet soils, very stony glacial till soils, and urban/disturbed land. The park is an example of a classic southern New England upland landscape with strong topographic influence on soil distribution. The combination of soils shapes the ecological patterns, hydrology, and forest regeneration potential throughout the park.


Shallow-to-bedrock soils on rocky ridge

Bates Woods Park contains a diverse mix of soils shaped by glacial till, rocky uplands, and scattered wetland depressions. The dominant soils are the Charlton–Chatfield complexes, which together cover just over half of the park (52%) including much of the developed area in addition to the woods. These very rocky, well-drained upland soils occur on gentle to steep slopes and support the park's characteristic hardwood forests, especially oak and mixed upland species. Interspersed among these uplands are pockets of the Ridgebury, Leicester, and Whitman soil series, which are poorly drained and extremely stony, occupying low-lying areas and seasonal drainage areas. These wet soils, along with the very poorly drained Timakwa and Natchaug organic and mineral wetland soils, underlie 17% of the land area and form the park's swampy areas, seasonally flooded habitats, and hydrologically sensitive areas.


Wetland soils near intermittent stream

Moderately well-drained, very stony glacial till soils (Woodbridge and Sutton fine sandy loams) are found on gentler slopes in the central and western areas, mostly south of the road, and contribute to the park's productive upland forest matrix. Shallow, drought-prone areas occur where Hollis–Chatfield–Rock Outcrop complexes are present; these soils are thin over bedrock and support more scrubby vegetation. The soils reflect the significant areas of human disturbance and modification, with the former landfill and urban land soils in the developed park area amounting to 12% of the total acreage.

USDA Web Soil Survey data for forest soils in Connecticut is relatively coarse. Given that soil conditions can change rapidly across short distances, the soils data provides a useful assessment at the property level but rougher information at a finer scale.

Soil Resource Concerns


Bare ground susceptible to erosion within the disturbed area

Water & Wind Erosion

Erosion undoubtedly significantly impacted area around the landfill (referred to in this plan as the "disturbed area") when it was active. Many of these impacts were addressed during remediation work when the landfill was capped in 1990-91. There are areas of unstable soils on the slopes of the former landfill near the area that was cleared and graded for the solar array. Without information on prior conditions, it is impossible to determine how much soils were impacted by leveling and grading for the construction of the solar array, but it is apparent that the project left the area more vulnerable to erosion by disturbing vegetation and leaving bare soil.

Erosion of areas of bare ground and/or unstable soils can be prevented or mitigated by planting vegetation. Invasive plants appear to have colonized many areas that were previously disturbed. The same invasives are likely to spread and take hold in additional areas of bare or unstable soils unless a proactive management approach is undertaken to prevent this from happening. Native grasses and shrubs that are easy to establish and compete well in unproductive soils are good candidates for planting as part of a larger restoration project focused on the Disturbed Area.

Concentrated Erosion

Soil resource concerns related to erosion exist in a few locations where trails cross sensitive soils. On heavily used trails, foot and unauthorized mountain bike and ATV traffic can cause soil compaction leading to erosion. The most noticeable location where this is occurring is along the trail in the southern part of Stand 2 (Southern Woods) where it passes between the south slope of the former landfill and the forested wetlands of Stand 3. The wet soils in this area are more susceptible to disturbance than those in drier upland areas.

Soil compaction and erosion along this trail could be addressed by adding rock cribbing and/or planting new vegetation to stabilize soils. Additional or alternative measures could include employing access control measures (e.g., placing boulders in the trail) to deter mountain bikes and ATVs, relocating the trail elsewhere, or closing the trail with placement of brush piles and signs. Eligibility for NRCS technical and financial assistance can be determined through consultation with NRCS staff. Demonstration of a need to provide access for land management purposes, rather than just recreation, is usually required for NRCS to provide financial assistance to mitigate trail erosion.

9. FOREST HEALTH AND INVASIVE SPECIES

Forest health can be approached from a utilitarian or ecosystem perspective depending on management goals, which in the case of Bates Woods falls closer to the ecosystem end of the spectrum. BFF and the City of New London strive to maintain the ecological integrity of the forest, while also considering factors such as accessibility, aesthetics, and the safety of park visitors. In general, a healthy forest is a forest that possesses the ability to sustain the unique species composition and processes that exist within it.

Overall, the health of Bates Woods is fair compared to similar forests in southern Connecticut and Rhode Island. The fact that the park is a somewhat isolated woodland surrounded by an urban area has increased some forest health impacts, while limiting its exposure to other factors that afflict forests in suburban and rural parts of the state. The outbreak of the invasive spongy moth (*Lymantria dispar*, formerly known as the gypsy moth), that has led to widespread oak mortality in other parts of Connecticut over the past decade, appears to have had had little effect on this park. Nonetheless, the forest is negatively affected by some factors that are very common in southern New England and the Northeast in general (detailed in the discussion of Resource Concerns below).


Decaying old oak and stone wall

As noted previously, a significant number of old trees are scattered throughout the woodlands, some growing in clusters on slopes and in rock terrain while others are widely spaced and surrounded by younger trees in flatter, formerly farmed areas. Some of these old trees appear healthy, but others are affected by health and structural issues that are typical of advanced age. A moderately high percentage of the mature canopy trees show signs of some decay and damage such as cavities at the base and in crotches, dead tops and significant branches, and damage to crowns and branches.

Even with these older trees, the forest is still relatively homogeneous in terms of age as a result of past land use and mostly passive management, with few areas where younger trees are present and unevenly distributed understory regeneration. This relative lack of age class diversity makes the forest somewhat less resilient and more vulnerable to disturbances such as severe weather events or pest outbreaks that could disproportionately affect older trees.

An informal assessment of the forest understory noted patchy (generally poor to fair) tree regeneration conditions and development of understory herbs in different areas of the park. Seedlings and saplings of the dominant canopy species, especially oaks, and herbaceous species are irregularly distributed throughout Bates Woods and mostly found in areas where canopy gaps are present. Since oaks are moderately shade intolerant, the closed canopy in most of the woods limits the ability of oaks to regenerate. Dense greenbrier and exotic invasive plants inhibit regeneration of young trees in some areas. Regeneration conditions are also poor in the forested wetlands where there is dense understory vegetation.

Impacts on tree regeneration and understory vegetation resulting from white-tailed deer herbivory is a major forest health concern in many parts of Connecticut, but it appears that browse levels are modest in Bates Woods. It is reasonable to infer that these lower impacts are the result of lower deer population densities than suburban and rural areas, with the Park's location in the midst of an urbanized area providing less preferred habitat conditions for deer. Deer prefer to eat leafy native plant species they have evolved alongside and thus will often not touch exotic invasive plants. This dietary preference of deer can indirectly contribute to the spread of invasive plants. Since hunting is not a socially acceptable option in urban Bates Woods Park, options for managing deer browse are largely limited to protective shelters and vegetation fencing.


White oak regeneration

Additional evidence of the level of browse impacts from deer (and possibly other animals) on Bates Woods could be obtained by constructing a deer exclosure fence within the forest or in the disturbed area adjacent to the solar array. An exclosure allows for side-by-side comparison of regeneration and understory herb growth in fenced and unfenced areas. When combined with interpretive signage, exclosures can also have educational value if they are constructed where people can observe vegetation growth both inside and outside the fence.

The importance of considering subcanopy layers when assessing the health and sustainability of Bates Woods cannot be overstated. While seedlings, saplings, and poles are small and may be less apparent to some observers, these are the young trees that will grow into inevitable future gaps in the canopy. If these gaps are not filled by native trees and plants, they are more likely to become colonized by invasives. The understory is the layer of forest vegetation where less common and rare plants (shrubs, sedges, forbs, wildflowers, etc.) are most likely to be found. Some of these plants are delicate and vulnerable to disturbance. Furthermore, maintaining a variety of structural conditions in the understory, from abundant coarse woody debris to shrubby thickets, provides critical habitat for a wide variety of terrestrial wildlife.

Plant Resource Concern

Plant Productivity and Health – Negative Impacts

Invasive plant species area widespread in Bates Woods, especially in areas that have been heavily disturbed, at the edges of the woods, and in areas that have an open canopy. Efforts to combat invasive plants are a stewardship priority of BFF.

Japanese knotweed in fall (foreground)

Significant populations of shrub-like Japanese knotweed *(Fallopia japonica)* are found in disturbed areas along the south side of the paved road through the park, at the edge of the woods adjacent to the baseball fields, within the large disturbed area at the site of the former landfill, and in a few other locations. Japanese knotweed is a highly aggressive invader that is very hard to eradicate since it can reproduce vegetatively. In 2025, BFF volunteers cut and removed most of the knotweed growing along the south side of the park road through the woods, but it will return without follow-up treatment. Japanese barberry *(Berberis thunbergii)* is present in some forested wetland soils including those in the western part of Stand 2 and has the potential to become more widespread.

Asiatic bittersweet *(Celastrus orbiculatus)* and vines of the *Wisteria* genus are other exotic invasive plants that are very competitive at forest edges and openings where it has access to a significant amount of sunlight. These aggressive perennial vines can grow over and choke out other plants and climb and even gradually kill large trees, as evidenced by a number of overtaken trees near the road. Large vines trees can grow to several inches in diameter. Bittersweet is widespread on both sides of the road and in other locations where the canopy is open. Although its growth traits are similar, *Wisteria* has a more limited presence. BFF volunteers have targeted bittersweet and *Wisteria* growing into trees by cutting vines at the base, which kills the vines in the trees but leaves the rooted part of the plant on the ground still alive. Therefore, additional treatment is needed to control bittersweet in priority locations.

In addition to the invasive vines and shrubs are three species of trees now recognized as invasive species, at least two of which were widely planted in the 20th Century. A number of *Ailanthus* (Tree of Heaven) trees and Norway maples, some quite large, are growing in the woods and mostly found near the northern edges. These trees likely originated from seeds of trees growing in the developed areas adjacent to the park. Far away in southern part of the property, a few mature black locusts (a naturalized non-native species) were observed growing near the edges of the forested wetlands. Given the strong invasive tendencies of *Ailanthus* and Norway maple and their ability to produce seed, it is recommended that trees of these species be cut. The black locusts in the more remote location south of the former landfill area are a lower priority but may be candidates for cutting if a significant restoration project is undertaken at the disturbed former landfill site.

Mugwort (*Artemisia* spp.), which includes several species of flowering plants, is widespread in open areas, at forest edges, and along roads and trails where it has access to light. Multiflora *(Rosa multiflora)* is present in some areas where other where other invasive shrubs and vines are found and is known as an aggressive colonizer. Other exotic invasives that were not observed during the fall inventory are probably present.

The most widespread invasive species of all, however, happens to be a native species: greenbrier or bull briar *(Smiliax rotundiflora)*. This woody native vine with shiny rounded leaves and sharp thorns is found in almost all areas of the forest, although it is much more prevalent in some places than others. The fact that greenbrier can grow under a forest canopy and on both dry upland and somewhat hydric sites contributes to its abundance. Thick vines of native poison ivy are climbing into a number of trees and compromising their health. Wild grape, another native plant, can invade fields and open areas. All invasives are capable of colonizing disturbed areas. These native invasives most likely became established and spread around the property when most of the woods were farmland.

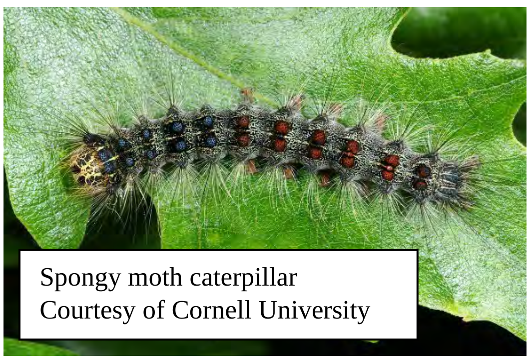
These invasive plants impact forest health by crowding out regeneration and impeding growth of native species and will likely continue to spread if left unchecked. Since eradication of invasive plant populations throughout the park is unrealistic, a more attainable goal is to focus on managing the most aggressive exotic species and focusing on high-priority focal areas such as trail roadsides, trail corridors, and other public use areas.

Cut invasive vines remaining in a tree

Successful control of invasive plants involves a commitment to treatment over multiple years and consistent monitoring. The most effective strategy for managing these plants typically involves the use of both mechanical and chemical methods. A combination of hand-pulling (for small plants) or mechanical cutting with judicious use of U.S. EPA-approved herbicides (cut stem or foliar mist application) usually has the greatest efficacy in reducing the size of invasive plant populations and minimizing their return. If BFF and the City prefer not to use herbicides, invasives can be managed through mechanical methods alone, but it must be recognized that this strategy usually requires much larger labor inputs (i.e., a work crew) and an annual, unceasing commitment to cutting back invasives in the priority areas and/or along the trails. If control is discontinued and invasive plants are still present, they will most likely grow back to their former extent. Following successful control efforts, some areas targeted for invasive plant management may be suitable for planting native vegetation to help prevent the invasives from returning or reduce their capacity to recolonize a given area.

In Connecticut as in other states, invasive plant management involving herbicide use is governed by specific pesticide regulations. In general, application of pesticides at a location other than one's own property must be performed by a licensed commercial pesticide applicator, who will follow product and site-specific use guidelines and reporting requirements. Some formulations of common herbicides are approved for use in wetlands and regularly used by well-known conservation organizations.

Along with invasive plants, several diseases affecting tree species found in the woodlands are important to note as they relate to forest health:


Spongy moth caterpillar
Courtesy of Cornell University

Among other species, oaks on the property are highly susceptible to damage from **spongy moth** and **winter moth**. The Entomological Society of America ceased using the former common name of gypsy moth for the first species in 2021. For both spongy moth and winter moth, heavy infestations occur on an irregular basis, and natural enemies play a key role in controlling moth populations during years of light infestations. Larval caterpillars cause damage to trees by feeding on their leaves and can completely defoliate areas of forest during the growing season. Repeated defoliations during successive growing seasons weaken trees and make them susceptible to insects such as the two-lined chestnut borer, a native beetle that is often the agent that actually kills the weakened trees. Healthy trees on soils not prone to drought are in the best position to survive repeated defoliations. Arboricultural treatments including horticultural oils and insecticides that may be appropriate for some urban or yard trees are not practical in a forest setting.

The following pests and pathogens affect different tree species that are only a minor component of the forest (each less than 2% of stocking), but are still worth noting:


Beech leaf disease (Courtesy of University of RI)

Beeches in the park are susceptible to two different diseases that together represent a significant threat: beech leaf disease and beech bark disease. **Beech leaf disease** is a relatively new condition that was first identified on American beech in Ohio in 2012 and initially observed in Connecticut in Fairfield County 2019. It has since spread throughout most of the state and is present in Bates Woods. The disease is caused by a foliar nematode, and the first signs are thickening and dark striping of the leaves, followed by the foliage withering, drying, yellowing, and leaf loss. After several years, the disease can be severe enough to cause tree decline and mortality. All ages and sizes of beeches are affected, although the rate of decline can vary based on tree size. In larger trees, disease progression is slower, beginning in the lower branches of the tree and moving upward. The disease also appears to spread faster between beech trees that are growing in clone clusters, as it can spread through their connected root systems. Most mortality occurs in saplings within 2-5 years. Where established, beech leaf disease mortality in sapling-sized trees can reach more than 90%. Research on treatments for landscape trees is underway, although these treatments are generally not practical for a large number of trees in a forest grove or stand.

Beech bark disease is a complex that involves both scale insects and fungi. First, scale insects (which appear as small white flecks on the bark) penetrate the bark by using their piercing and sucking mouth parts to extract fluids from the trunk and main branches. Trees of any size can be hosts, but larger diameter trees are more susceptible because of their size. Scale feeding wounds are then colonized by the *Neonectria* fungus (recognizable by its red, oval-shaped masses of fungal fruiting bodies at certain stages) which causes a bark wound or canker that slowly kills the infected tree. As bark is killed, trees take on a rough and cankered appearance that stands out in comparison to their normal, smooth-barked appearance. Boring insects are attracted to the weakened trees and their presence in turn attracts birds such as woodpeckers and sapsuckers. Trees suffering from beech bark disease are more sensitive to drought and freezing injury during the winter. Unfortunately, arboricultural treatments that may be appropriate for highly valued individual urban or yard trees are impractical in a forest setting.


Typical smooth-barked beech trunk (left) and one showing signs of beech bark disease (right)

Some birches may show signs of ***Nectria*** **canker**, a common and sometimes lethal disease that is caused by two species of fungi and affects many species of trees and shrubs. *Nectria* canker is characterized by the production of cankers that form on twigs, branches, and trunks where injuries occur. Cankers appear first as slightly sunken areas on the bark and can grow for years to become target-shaped or elongated. Small branches girdled by cankers can wilt, fail to leaf out, and die, while larger trees become more prone to breakage due to weakened wood. There is no cure for *Nectria* canker and pruning treatments that may be appropriate for some urban or yard trees are not practical in a forest setting.

Ash trees are susceptible to both a lethal disease and an exotic invasive insect pest. **Ash yellows** is a disease caused by bacterial parasites of the phloem tissue in ash trees that has become common in recent decades. These trees often exhibit slow branch and crown dieback before succumbing entirely. There is no remedy for ash yellows. More recently, populations of an exotic invasive beetle called the **emerald ash borer** have become established in Connecticut and neighboring states and this insect is increasingly considered endemic. This small green beetle is devastating to ash and control measures to date have not proven effective in containing its spread. For these reasons, many of the ash trees in the woods are dead or dying although some resistant lingering ash may persist.

10. CLIMATE CHANGE

In addition to longstanding forest health concerns, the changing climate is another factor that must be taken into account in forest management, especially as it occurs over long time horizons. The climate in Connecticut is more than two degrees warmer than it was in 1950. The growing season is becoming longer and bringing more extremely hot days. Precipitation patterns are changing with more heavy precipitation events interspersed with periods of dry weather. Additional changes are expected to occur in the coming decades.


Vernal pools are ecosystems sensitive to changes

While a detailed discussion of climate change impacts and climate-adaptive forest stewardship approaches and strategies is beyond the scope of this plan, the Oak Resiliency Assessment Report completed for Bates Woods (Appendix 3) includes an assessment of both forest vulnerability and adaptive capacity compared to other oak-dominated forests in the region. The summaries of issues of concern and discussion of different management pathways contain a great deal of information and references and links to additional resources.

The following are some general strategies that BFF and the City of New London can incorporate to promote a forest and park that is more resilient to the effects of climate change:

- Since heavy precipitation events are occurring with increased frequency, anticipate increased stormwater runoff and take action to address areas vulnerable to flooding and erosion. Given the topography, soils, and land use history, some parts of the park have relatively high susceptibility to this type of disturbance (e.g., slopes of the former landfill, disturbed areas with little vegetation, lowest sections of the park road, etc.)

- Maintain, restore, and construct roads and trails that can accommodate increased water runoff at times and resist erosion.
- Forest stands experiencing stress (drought, pests, mortality, etc.) will likely see additional stress as the climate changes, so actions to improve conditions will be beneficial.
- Since changing conditions are expected to favor the growth and expansion of invasive plant species populations, efforts to control invasives and minimize their spread will become increasingly important.
- Avoid creating or enlarging canopy openings in areas heavily impacted by invasive plants or having dense understory vegetation competing with desired species.
- Do not replace mature trees of species that that were commonly planted in the past but are now known to be invasive. In their place, promote or plant native tree species and/or those that are projected to be well adapted to future climate conditions in Connecticut.
- Consider in advance how the BFF and relevant City departments would want to respond in the event of a catastrophic weather event such as an ice storm, hurricane, or pest outbreak causing significant tree mortality.
- Follow land steward-oriented communications summarizing the latest research on climate change impacts on forests and evolving management strategies.

11. WILDLIFE HABITAT

The small ponds and wetlands have valuable habitat features

Near the core of a heavily developed and densely populated urban area, the park provides critical habitat for many species of wildlife. The proximity of the large forested wetland southeast of the park increases its habitat value beyond that of the woodlands alone, as it supports birds and animals that require other habitat types. Bates Woods comprises a medium-sized block of contiguous forest cover with some interior forest away from the edges that certain species require or prefer for their habitat needs. Although closed-canopy forest is the dominant land cover type, the park and its surroundings provide other habitats, including a large forest gap (the disturbed area) and mowed fields. Small ponds and wetlands, ephemeral streams, and a small portion of the large forested wetland near the southern edge of the park provide a modest range of hydrological features for birds, mammals, and amphibians that use these habitats.

The park provides important habitat for forest birds, both species that live in Connecticut year-round (such as turkeys, woodpeckers, and owls) and migratory songbirds that come north to New England for breeding and nesting in the late spring and summer. Downy and hairy woodpeckers may be attracted to the large decaying and dead trees. Hardwood forests are known for the wide range of insects they support that provide food for larger organisms. These woods offer good conditions for small mammals such as squirrels that thrive in closed-canopy areas and rabbits that prefer thicket-like patches of greenbrier and other invasive vines that offer protective cover. Many of these species benefit from the oak trees that provide acorns and hollow den cavities, standing dead trees (sometimes referred to as “snags”), and downed logs and coarse woody material on the ground. Where the forest surrounds the disturbed area, some of the tall hardwoods may provide good surveying perches for raptors. Rocky outcrops and ledges provide another type of habitat for animals including reptiles that favor these conditions.

Surrounded by woods, the disturbed area at the site of the former landfill acts as a large forest gap that may attract mammals such as white-tailed deer, coyotes, red fox and grassland songbirds including nuthatches, towhees, and several types of warblers. Many of the shrubs (both native and invasive) have berries that serve as a food source for birds and other wildlife. The presence of the solar array and heavily disturbed landscape that has suffered past pollution does degrade the current quality of the habitat, although it offers potential for restoration.

With its low vegetation characterized by shrubs and grasses, the disturbed area is also valuable for pollinators (bees, wasps, ants, butterflies, and some beetles) that face declining habitat. If there is interest in a larger restoration project, the disturbed area may be assessed by NRCS wildlife staff for potential pollinator habitat enhancement that could also provide aesthetic appeal in the form of seeded wildflowers.

Animal Resource Concern

Terrestrial Habitat for Fish and Wildlife – Habitat Degradation

Surrounded by forest, the disturbed area at the former landfill site offers potential habitat for birds that use shrublands and forest edges. Shelter for these birds, however, is limited by habitat degradation and there are few large remaining tree that offer branches and cavities for nesting and cover. Adding several bird boxes will provide habitat for species such as chickadees, nuthatches, woodpeckers, wrens, and barred owls and screech owls.

12. NATURAL HERITAGE AND ENDANGERED SPECIES

The database of State Natural Diversity Area maintained by the Connecticut Department of Energy and Environmental Protection (DEEP) has no records of rare, threatened, or endangered animals or plants on the property. The nearest terrestrial State Natural Diversity Area records are geographically associated with the upper Nevins Brook corridor in Waterford to the northwest and the Connecticut College Arboretum (on the other side of Interstate 95) to the north, with both locations about a mile from Bates Woods Park. The park may, however, support threatened or endangered species that should be protected. Further fieldwork by a qualified professional may result in the identification of these species. Connecticut DEEP specialists can provide more information on specific species that are associated with habitats found on the property.

Maintaining Bates Woods as a lightly managed forest reserve, as generally recommended in this plan, is consistent with protecting most rare species that might be found in the woodlands.

Although only very limited felling of live and dead trees is currently recommended to meet objectives, it must be noted that tree cutting practices funded or approved by NRCS are subject to federal rules regarding the Northern Long-Eared Bat and Tricolored Bat. Facing possible extinction from impacts from a deadly disease called white-nose syndrome, the Long-Eared Bat is listed as Endangered by the United State Fish and Wildlife Service and is protected under the Endangered Species Act (ESA). More recently, the Tricolored Bat has been proposed for Endangered listing for the same reason. Although there are no known long eared bat hibernacula on or near the property, tree cutting associated with NRCS conservation practices is restricted from taking place during the months of June and July.

13. RECREATION AND OTHER HUMAN USES

A trail sign in the woods

Bates Woods Park sees many human visitors. Most people currently only visit the area of the park at the northwest corner that is developed for recreational uses and includes grass fields, a playground, covered pavilions, and ballfields adjacent to the high school.

A smaller number of visitors venture into the larger part of the park that is occupied by Bates Woods. Since the park is not well known beyond the local area, most users are nearby residents who come to the woods from the nearby parts of New London or Waterford, driving or arriving on foot if they live close enough. Given the large, relatively secure parking lot inside the west entrance, most visitors follow the main road and enter the woods from this side. Most people probably stay close to the road, while those who are familiar use the network of trails and possibly the historic "campsites. Most visitors seek out the woods for low-impact recreation and retreat activities including walking, dog walking, trail running, birding, observing nature, picnicking, and relaxing.

Like other City parks, Bates Woods Park is officially closed at night. Hunting and camping are prohibited. BFF may request permission from the New London Recreation Department for permission to co-host a group camp out nights at a specific site in the park on designated nights.

Introducing people of different ages to Bates Woods and encouraging them to explore and help take care of it are ways that BFF draws people to its mission. With additional resources, BFF and the Recreation Department could build on the strength of their partnership to integrate more educational offerings into the range of recreational activities associated with Bates Woods. This could include building or strengthening partnerships with New London schools (both public and private). There is growing awareness of the benefits that forests provide to human health. Raising the profile of Bates Woods Park to a level like that of nearby Riverside Park could help boost civic appreciation of the park and the many benefits it offers to the community.

In November 2025, BFF hosted a community meeting on the forest management planning process that attracted about 40 participants and largely focused on public access and recreational use of the woods. Participants expressed strong interest in making more people (especially those living close to the park) aware of the park's natural resources, upgrading the park infrastructure that supports low-impact recreation, and addressing issues that may deter appropriate uses. Guided walks and activities can help introduce people to the park and offer an alternative to those who would rather explore with a group than on their own. Developing relationships with rock climbers' associations may afford ways to make the fine climbing and bouldering opportunities in the park accessible to more people in safe ways.

BFF and the City can enhance access for both recreation and land management activities by investing in maintaining and improving the trail system. Trails in areas where there is thick understory vegetation may become overgrown and inaccessible without periodic clearing. Some sections of trail on rocky slopes or close to the edges of wetlands may be susceptible to erosion following heavy precipitation or during extended periods of wet weather. Establishing trail signs and developing trail maps (both digital application-based and printable) will help more community members learn about and feel comfortable using the trail network. In addition, marking the trails with more frequent long-lasting blazes (paint or signs) will make them easier to follow.


Campsite fireplace

It is recommended that partners consider how the seven WPA-constructed "campsites" may be best adapted for contemporary use. While they serve as striking points of interest and indicators of park's history, the massive stone fireplaces and adjacent concrete tables with benches (some benches and tables are both missing) are outdated for current uses and may not often be used in the manner originally intended. Currently, these sites also serve as "attractive nuisances" that are a magnet for unwanted activities including graffiti and nighttime gatherings with fires that could easily spread into the woods. Any change to the campsites (restoring, adapting, or removing them) will require a committed investment.

Forest stewardship activities should take recreational uses into account. Conservation practices can be carried out with an eye towards improving or maintaining aesthetics and reducing visual impacts when possible. For example, downed wood from dead trees can be cleared from trails and used to construct brush piles for wildlife.

Although recreation management is not the focus of this plan, stewardship activities can enhance recreation and education and help minimize the impacts recreation has on Bates Woods. Most park users will support activities undertaken to improve the park if they understand the reasons. Visitors can be informed of resource concerns and policies through signage, websites, and other means.

Human uses that negatively affect Bates Woods include unauthorized access paths, impacts associated with unleashed dogs, public safety, and illegal dumping.

Frequent use of off-trail access routes creates “herd paths” that lead to trampling of understory vegetation and erosion on slopes. These paths are often redundant with the main trails and confusing to visitors. Following an assessment to inform decisions, unnecessary or undesired paths that are not already blocked can closed with downed wood and/or plantings at entry points to discourage people from using them.

Forest impacts from off-leash dogs include disturbance to wildlife and vegetation (not to mention other visitors) and animal waste in the woods. While some visitors who let their dogs run free are doubtless aware of the leash policy, posting signs at more trail entrances and providing dog waste bags at both entrances to the park may help reduce impacts.

Public safety is another issue thar deserves consideration in Bates Woods. While most of the park is surrounded by densely populated areas, many parts of the woods feel isolated and remote. Some unhoused individuals may live in tents in the woods from time to time. Evidence of dumping, graffiti, and litter is easy to find, reminding visitors that the woods can offer cover for those engaging in clandestine activities who do not wish to attract attention. For this reason, some people may feel uncomfortable visiting the woods or allowing family members such as children and teenagers to spend time there. More organized monitoring and patrols of the park, ideally involving the local police department, would help improve public safety (and, importantly, the perception of safety). Monitoring and/or periodic police patrols along the main park road through the woods also help deter dumping and other unwanted activities. BFF and the City may find it helpful to work with new or additional partners to address these issues.

14. WOOD AND CARBON

Although there has been little to no active silviculture in the woods in recent decades, biological growth has steadily increased the volume of wood and standing timber growing in the park. With the total timber volume estimated at 230,010 board feet of sawtimber and 424 cords of lower-quality wood, Bates Woods contain a significant timber resource composed almost entirely of hardwood species. The total wood volume can also be expressed as 4,216 tons of biomass, roughly half of which is stored forest carbon. Oak species collectively comprise 71% of the biomass volume, with red maple (16%) and black birch (6%) also representing significant amounts. Since it became a City park, growing and harvesting timber has never been a consideration since the priority goals are conserving open space and wildlife habitat and providing a place for human recreation and retreat.

Forest carbon storage

Carbon **sequestration** is the process through which atmospheric carbon is absorbed by plants through photosynthesis and then transferred to **storage** in plant biomass and soils. Most of the carbon in forest plants is in trees (trunks, branches, foliage, and roots), while soils also contain a large amount of carbon. Carbon is also stored in coarse woody debris (dead wood) and leaf litter on the forest floor. Since all plants are largely composed of carbon, active management can influence the natural cycles of carbon uptake and release in living and dead plant material. There are tradeoffs between maximizing carbon sequestration and storage, as it is often difficult to do both at the same time.

Sustainable forestry practices can sometimes increase the ability of plants to sequester and store carbon while enhancing other ecosystem services. In Bates Woods, however, mostly letting the trees grow, allowing natural processes to continue largely undisturbed, and protecting the soil from disturbance will continue to sequester carbon and most likely increase storage and stocking over the long term (a significant disturbance causing increased forest mortality, however, could lead to a reduction in carbon storage over the short-to-medium term). Managing invasive plants, which impede the growth of native tree species, will slightly enhance sequestration and storage in woody biomass, while controlling minor soil erosion will reduce soil carbon loss by a small amount. Therefore, management goals are consistent with increasing total carbon sequestration and storage in the woodlands.

15. POTENTIAL HAZARDS AND RISKS

Bates Woods sees higher levels of human use compared to other forests in Connecticut, but much less than the developed area of the park or other public parks in New London. Like other natural areas, there are risks associated with people using the park with a limited amount of monitoring and oversight. The New London Department of Public Works and Police Department are responsible for park maintenance and safety, respectively.

Periodic mortality of large trees along the main road, trails, and other higher-use areas presents a potential liability in that falling branches and limbs could strike visitors. Compared to the developed area and most other City parks, the risk of a falling tree in Bates Woods impacting a human target is low. Nonetheless, it is recommended that the BFF volunteers periodically monitor trees along the main road and trails and consider felling standing dead trees and those at risk of structural failure close to the trails and higher-use areas. BFF representatives will report noted potential hazard trees or limbs to the Department of Public Works.

Two large standing dead oaks that provide examples of risk trees are found midway along the main road, on the north side of the road opposite the section of the disturbed area that includes the small pond. These dead oaks are leaning towards the road and have large branches overhanging the road. These trees can be removed by professionals before they decay further and fall naturally (in sections or at once).

Risk trees overhanging main road

Conducting a documented Tree Risk Assessment of Bates Woods Park is beyond the scope of this plan, but the City may wish to work with BFF to have a Certified Arborist with this specific qualification conduct an assessment. It would be practical to include all higher-use areas of the park, including the developed area, the main road, and trail system, in a Tree Risk Assessment.

Fire is usually not a major risk in southern New England oak-hardwood forests due to high moisture levels at most times of the year, but dry forest sites including the Bates Woods uplands can be susceptible to fire during periods of low precipitation in the early spring (before leaf-out) and in the late fall. Visitors can use permanent cookout grills in the developed area of the park with a permit. Fires are now prohibited in Bates Woods, although the continued presence of the old stone WPA fireplaces and grills at some of the "campsites" encourages people to have them and occasional small wildfires resulting from human activity in the park have doubtless occurred. Limited monitoring of visitor use of the woods and the location of some of the drier areas of the forest adjacent to a large housing development do significantly increase the risk of fire from human ignition sources. In the event of a fire emergency, two New London Fire Department stations (the North Station on Broad Street and the downtown headquarters) are located less than a mile away. Limited vehicular access to interior areas of the woods could, however, limit the ability of a non-wildland fire crew to respond to fires far from city streets or the main park road.

16. FOREST INVENTORY

The purpose of a forest inventory is to develop a detailed estimate of a forest's composition for baseline documentation, management planning, and potential other purposes (such as scientific analysis or appraisal of economic value). The process is analogous to conducting a *census of the forest*. An inventory is typically preceded by dividing the land area of a given tract into distinct cover types and *stands*, or contiguous groups of trees which are sufficiently similar in species composition, size, age, and topographical position to be a distinguishable unit.

Since it is not realistic or practical to measure all the trees in the forest, quantitative data is collected at a number of sampling points in each stand and the measurements taken at these points are extrapolated to develop a statistically significant estimate of forest attributes including species composition, density of trees and stocking (basal area, trees per acre), size distribution, and volume of wood products. The number of sampling points in each stand and overall project is informed by how the data will be used and the level of detail and precision required. An inventory also includes qualitative information based on field observations of all the areas of the property that were visited or traversed, not just at data collected at the sampling plots.


Fall foliage along the main road

A sampling-based field inventory of the forested area of Bates Woods Park was conducted over two days in October and November 2025, following a preliminary visit in September. The complete dataset included 30 sampling plots with semi-random locations informed by use of digital aerial imagery, a grid for even plot distribution, and pacing. Covering 45.7 acres of the property, the inventory included 10 plots in Stand 1/Northern Woods (14.9 acres), 17 plots in Stand 2/Southern Woods (26.0 acres), and 3 plots in Stand 3/Forested Wetlands (4.8 acres). Non-forested areas including the developed area of the park and the disturbed area at the former landfill site (including the solar array) were excluded from the inventory.

At each sampling point, live trees greater than 4.5 inches in diameter were selected using variable-radius plots and a 10 basal area factor angle gauge. For each tree selected, the species, diameter at breast height (DBH: 4.5 feet) to the nearest inch, condition (healthy or unhealthy/damaged), and product classification (sawtimber, cordwood, cull) were recorded. Sawtimber volume was estimated by recording the number of 16-foot sawlogs, to the nearest half-log, in merchantable hardwood trees greater than 12 inches DBH and softwood trees greater than 10 inches DBH. Cordwood volume was estimated by recording the number of 16-foot logs, to the nearest half-log, in merchantable hardwoods 6 to 11 inches DBH, softwoods 6 to 9 inches DBH, and also in larger trees not of sawlog quality. Thus, different sections of a single merchantable tree could be assigned different product classifications.

In each stand, qualitative data was also noted for inclusion in the plan. At each plot, the relative abundance of regeneration (excellent, good, fair, poor, none) was recorded along with species of regeneration present. The presence of invasive plants was also recorded at each plot. Qualitative data also included notes on other trees present, understory vegetation, wildlife, cultural resources, topographic features, and management possibilities and limitations.

Inventory data was collected, stored, and processed using Forest Metrix PRO software. All forest inventory statistics and charts were calculated and produced using this software.

18. FOREST STAND OVERVIEW

Stand Number	Acres	Cover Type	Site Quality	Volume per Acre
1 (Northern Woods)	14.9	Oak-Hardwood	Varied	6.8 MBF / 10.5 cords
2 (Southern Woods)	26.0	Oak-Hardwood	Varied	4.8 MBF / 9.0 cords
3 (Forested Wetlands)	4.8	Red Maple Swamp	Poor	4.4 MBF / 8.4 cords

Visible at center in this photo is the public water supply aqueduct right-of-way that passes through the park to south of the main road.

19. PROPOSED MANAGEMENT PRACTICES AND TIMELINE

YEAR	AREA/STAND STAND(S)	ACRES	NRCS RESOURCE CONCERN	MANAGEMENT OBJECTIVE	ACTIVITY	NRCS PRACTICE	NRCS PRACTICE CODE
2026-2036	Perimeter of park	N/A	N/A	Clarify location of boundary lines and reduce risk of trespass issues and possible confusion over ownership	Mark boundary lines using a consistent method	N/A	N/A
2026-2036	Trail system	N/A	N/A	Improve and maintain access for land management and recreation	Improve and maintain trails; address erosion. Add blazes and create maps and add signage	N/A	N/A
2026-2036	Higher-use areas of park	N/A	N./A	Reduce risks associated with potential tree failure impacts on visitors, vehicles, etc.	Periodic monitoring for risk trees in developed area of park and along park road and trails	N/A	N/A
2026-2036	Strategic locations within Stands 1-2, including most problematic exotic invasive plant populations	approx. 5 acres total	Plant pest pressure	Reduce extent & spread of invasive plants and impacts on native plant populations, prioritizing efforts most likely to succeed	Invasive plant control: Mechanical and/or chemical treatment as appropriate Various species (see recommended management activities)	Brush Management	314
2026-2036	Locations of intensive invasive plant management efforts (Stands 1-2)	TBD	Plant pest pressure	Restore native plants and deter regrowth of invasive plants	Plant site-appropriate plants (shrubs and possibly ground cover and/or tree species)	Conservation Cover Tree/Shrub Establishment	327, 612

2026-2036	Northern and Southern Woods (Stands 1-2)	> 1 acre	Plant productivity and health	Improve resiliency by promoting regeneration of new age classes of a variety of native tree species	In canopy gaps, plant seedlings/saplings of native tree species adapted to projected future conditions. Use barriers to protect them from browse impacts	Tree/Shrub Establishment	612
2026-2036	Disturbed Area	up to 8.5 acres (entire area)	Erosion Plant pest pressure Terrestrial habitat for wildlife	Multi-stage restoration of heavily disturbed landscape	Stabilize erosion; manage invasive plants and restore native plants; improve wildlife habitat (pollinators)	Brush Management Conservation Cover Tree/Shrub Establishment Wildlife Habitat Planting	314, 327, 612, 420
2026-2036	Disturbed Area	Specific size TBD	Plant pest pressure	Assess and demonstrate impacts from deer (and other animals) on forest regeneration; Improve conditions for regeneration	Construct a demonstration deer exclosure fence	Tree/Shrub Establishment	612
2026-2036	Disturbed Area	N/A	Terrestrial habitat for wildlife	Provide shelter and nesting sites for desired species of birds	Erect bird boxes, specific number, size, and location TBD	Structures for Wildlife	649

STAND 1 (Northern Woods)

Acres: 14.9 Cover Type: Oak-Hardwood Canopy Height: 40-75 feet
Fully stocked @ 80% (Central Hardwoods chart) Snag Density: 12 ft²/ac

Site Quality	Site Index	Approx. Age	Stocking Density	Trees/ac	Average Diameter	Sawtimber volume/ac	Cordwood volume/ac
Varied	55 red maple 47-70 red oak	60-100+	100 ft²/ac	105	13.2”	6.8 MBF	10.5 cords


An area of the stand with productive soils and tall trees

This varied stand includes the woods north of the road running through the park, comprising a third (33%) of the wooded area. Long and narrow except at the west end, it extends from behind the baseball fields at the developed western end to the gate at the east end. This stand contains the park’s most dramatic topography, with a few rocky knobs and ridges creating abrupt changes in elevation over a short distance. A significant wetland that is partly open and partly forested is located in the far northeast corner just inside the gate and there are two smaller forested wetlands in the central and western sections of the stand (the former including an intermittent stream). Highly influenced by topography, soils are generally rocky and dominated by Charlton-Chatfield and Hollis-Chatfield-rock complexes. Growing site quality varies from mesic soils on lower slopes to rocky outcrops with very thin soil profiles.

Parts of the stand have been significantly impacted by human activity. While remnants from at least one low stone wall can be observed in the understory of the western portion of this stand, it can be presumed that the areas with significant slopes and/or ledges were not conducive to agriculture (pasture or row crops) and thus not farmed like nearby flatter areas. A long-abandoned rock quarry was established in an area near the center of the stand. Nearby, an area accessible from the paved road (across from the former dump site) has been used for “storing” curbstones and dumping unwanted items. A roadside “campsite” with a stone fireplace and concrete picnic table and benches constructed by WPA workers is located near the rock outcrop popular with climbers. A couple of unofficial trails lead off the park property to the housing complex to the north.

Tree species composition is influenced by the variations in topography and underlying soils. The canopy is dominated by oaks (73% of the total basal area), of which Northern red is the most common species (37%) followed by black (25%) and more modest amount of white (11%). Many oaks have large crowns with spreading branches, and a significant percentage of these trees are greater than 30” DBH, suggesting that parts of the woods have seen little disturbance for decades. The abundance of red oak indicates that mesic, productive growing sites are abundant where the terrain is not ledgy. Black birch and red maple are the most important secondary species, while each comprises only 8% of the basal area. Hickories and sassafras (2% each) and beech and white ash (1% each) are other minor native species that were sampled in inventory plots in drier areas. Invasive tree species including Norway maple and Tree of Heaven or *Ailanthus* (2% each) are mostly present around the edges of the stand and some of these trees are quite large.

In the understory, regeneration of tree species is patchy and variable throughout the stand. In the few locations where significant canopy gaps are found, oak regeneration is more abundant. Greenbrier is present throughout the stand and inhibits regeneration where its presence is heavy. Tall understory shrubs such as winterberry are mostly concentrated where soils are moist and wet, and invasive Japanese barberry is found in some of these areas as well. Some dense patches of Asiatic bittersweet are found where the canopy is open, especially in a few roadside locations where thick vines have grown into the treetops. A band of Japanese knotweed is growing along northwest edge of the woods behind the baseball fields and may be present in other areas as well.

The mature oak-hardwood forest provides excellent habitat for a range small mammals, birds, and insects, especially those that favor closed-canopy forest conditions and are not deterred by the understory greenbriar. The presence of oaks, hickories, and beeches provides hard mast for food, along with and cavities for dens and nests in different species of trees. With varying water levels, the wetland in the northeast corner appears to offer conditions similar to vernal pool, providing sheler for amphibious species, while the ephemeral stream in the low-lying central wetland offers a small area of bog-like habitat. Sunny perches on the exposed ledges and rocks found in a numer of areas may be favored by small reptiles.


A small canopy gap

Limited enrichment planting of native tree species projected to be well-adapted to changing conditions in canopy gaps may help slightly diversify the age class composition and boost the future resiliency of the stand. Planting of young tree seedlings can be spread over an extended period and occur in existing canopy gaps (mostly caused by dead or dying large ash, black birch, beech, and oaks), in future canopy openings that may result from additional mortality, and in gaps that may be created where invasive plants are treated. The shade tolerance of tree species to be planted can be matched to the size of the gap as less shade tolerant species will require larger gaps to survive and grow. Few of the gaps currently present are large enough for shade-intolerant species to persist and grow into the canopy. The number of seedlings planted in an individual gap can range from 1-3 depending on the opening size and desire for replacement of planted trees that do not survive, but there is no need to plant more as a gap may have enough growing space for only one mature tree. Species that are already present and appropriate for planting in uplands include black, red, and white oak, and hickories. Suitable areas in lowlands tend to be found on higher, drier microsites where oaks (especially red oak) and hickories may still be appropriate. If natural canopy tree mortality or invasive tree felling creates gaps in low-lying areas, black gum and red maple are both species adapted to future conditions that grow well in wet soils. Planted seedlings should be monitored and protected with fencing or tubing to deter browsing by deer and other animals. Tree planting to promote resilience has the potential to be an activity in which stewardship volunteers could participate.

Desired Future Condition for Stand 1 (Northern Woods)

The extent of this remnant mature forest remains intact and continues to provide habitat for many species of wildlife. Efforts to manage the *Ailanthus* and Norway maple trees, Asiatic bittersweet vines, Japanese barberry shrubs, and other exotic invasives prevent these species from spreading and becoming more difficult (or impossible) to control. Trees impacted by small disturbances (such as a windstorm or insect outbreak) are left in the woods unless they present safety risks or other concerns. Natural regeneration and/or planted trees gradually grow into canopy gaps. Marked, maintained trails provide safe access through a few parts of this stand to community members.

Alternatives for Achieving Desired Future Condition

No-Action Alternative: Exotic invasive populations spread and become very difficult or impossible to control. Trails become overgrown and eventually lost without maintenance. Forest growth and carbon sequestration and storage continue with possible disturbances due to pests, severe weather events, etc. Allowing graffiti at the picnic site and dumped items to remain encourages further dumping and unwanted human activities.

Alternative 1: Integrated invasive species management approach. Control of *Ailanthus*, Norway maple, Asiatic bittersweet, *Wisteria*, Japanese barberry and knotweed, and any other exotic invaders, including mechanical and appropriate herbicide application methods, followed by planting native shrubs and vegetation where practical. A limited amount of enrichment planting of tree seedlings protected from deer browse may be employed in canopy gaps. Trails are maintained, including mechanical control of greenbriar along trail corridors.

Alternative 2: No-herbicide invasive species management approach. Same as 1 (above) but without using herbicide application as a method for combatting targeted exotic invasives. Protection of natural regeneration in canopy gaps may be preferred to enrichment planting.

Public Recreation and Safety. Maintenance, blazing, and mapping of desired trails allows more members of the community to safely explore the woods of the north side of the park. Attention to the campsite and removal of dumped items promotes desired activities in the park and discourages unwanted ones. Periodic patrols deter illegal activities and help more people feel safe using the park.

Recommended Management Activities:

1. Both mechanical and herbicide application methods employed for controlling *Ailanthus*, Norway maple, Asiatic bittersweet, *Wisteria*, Japanese barberry and knotweed, and any other exotic invaders, followed by planting native shrubs and vegetation where practical. Appropriate herbicide methods will likely include cut-stem application of approved herbicide products. If successful elsewhere, invasives control may be extended to targeting greenbriar in priority areas such as along trails.

2. A limited amount of enrichment planting of tree seedlings protected from deer browse may be employed in canopy gaps. Alternatively, protection of natural regeneration in canopy gaps may be preferred to enrichment planting.

3. Maintenance, blazing, and mapping of desired trails allows more members of the community to safely explore the woods of the north side of the park. Restoration of the picnic area and removal of dumped items promotes desired activities in the park and discourages unwanted ones. Periodic patrols deter illegal activities and help more people feel safe using the park.

Northern Woods rock formations popular with climbers,
visible from the main road and located just uphill from the campsite

STAND 2 (Southern Woods)

Acres: 26.0 Cover Type: Oak-Hardwood Canopy Height: 40-85 feet
Fully stocked @ 90% (Central Hardwoods chart) Snag Density: 4.1 ft²/ac

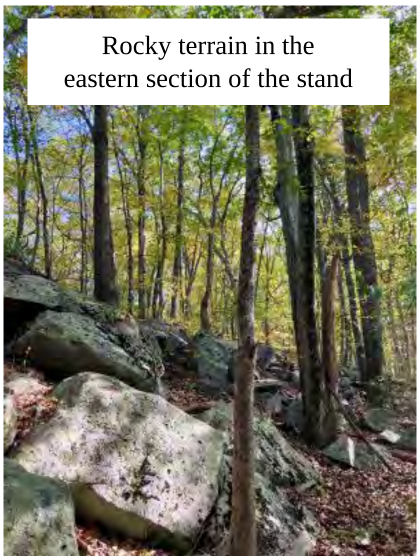
Site Quality	Site Index	Approx. Age	Stocking Density	Trees/ac	Average Diameter	Sawtimber volume/ac	Cordwood volume/ac
Varied	55 red maple 47-70 red oak	60-100+	94 ft²/ac	116	12.2”	4.8 MBF	9.0 cords

This stand is the largest of the three on the property (57% of the wooded area) and includes all of the intact upland woods south of the road running through the park. Roughly trapezoidal in shape with a “cutout” for the disturbed area and solar array (both also located south of the road), it extends from the edge of the developed park at the west end to the gate at the east end. The long, straight park boundary at the southwestern edge is also the municipal boundary with Waterford. These Southern Woods are varied in site character, while the overall topographic variation is not as heightened as in the northern stand. A ledgy hill in the west-central portion of the stand has a long and moderately steep northeast-facing slope. At the bottom of this slope, a narrow pond and ephemeral stream are located close to the road. An open wetland in the southeast corner is the largest in the park. A small amount wetland terrain is found along the western boundary but is mostly on the Waterford side. The southernmost portion of the stand includes the south slope of the former landfill. Rocky terrain is found along the eastern boundary. Soils include the Charlton-Chatfield and Hollis-Chatfield-rock complexes in the central and eastern portions, with productive Sutton and Woodridge fine sandy loams at the west end and some Timakwa and Natchaug soils in the south section.


Large old wolf tree in Stand 2

All parts of the stand have been significantly shaped by human activity. Before it was acquired by the City of New London, the flatter areas were farmed. Stone walls, an old unpaved road grade, and wolf trees (old trees with spreading crown that once grew in the open but are now surrounded by forest) provide evidence of agricultural use. After farm abandonment, much of the forest appears to have grown relatively undisturbed for decades. In the interior easter portion of the stand, CCC crews developed a concentrated area for recreational use, constructing a stone structure (now a ruin) and a stone footbridge leading from the road to two picnic sites with large stone fireplaces and tables. The creation and use of the landfill was a major disturbance that impacted its immediate surroundings. In addition, a public water utility aqueduct pipeline that transports water from reservoirs to the city service area passes through this stand roughly from west to east and comes close to the road near the pond. It was likely constructed early in the 20th Century; earthen and masonry sheathing for the pipe conduit can be observed along parts of the right-of-way. Unlike those north of the road, some of the trails in the Southern Woods are marked with occasional homemade signs (indicating whimsical names) and directional arrows. One section of trail in the southern part of the stand, located between the former landfill and forested wetland to the south, has become heavily eroded.

Tree species composition and growth is influenced by the topography, underlying soils, and level of past and current disturbance. The largest trees are found on the productive Sutton and Woodbridge soils in the western portion of the stand, while the ledges and rocks at the eastern edge limit tree growth. Woods have started to return to the edges of the former landfill, but the species composition and lower density reflect the degradation of habitat quality.


Rocky terrain in the eastern section of the stand

Although not quite as much as in the Northern Woods, oaks dominate the canopy (64% of total basal area). The relative abundance of each of the three oak species is similar in both stands. In the Southern Woods, Northern red is the most common (35%) followed by black (21%) and then white (8%). Oaks are well-suited to growing in all the soils except for those in the wettest areas. Probably because of the past agriculture and more recent disturbances, there are fewer oaks greater than 30” DBH than on the north side of the road – most of the trees of this size with large crowns and spreading branches are on the found productive growing sites at the west end of the stand or approaching the edges of the wetlands. Red maple is the most abundant of the secondary species (18%) and black birch is (7%) also found scattered throughout the stand. The inventory recorded 14 total species, indicating relative diversity, while nine of them are at 3% of basal area or less. As to conifers, hemlock and white pine have a very minor presence and there is a cluster of planted Norway spruce in the old recreation area. A few mature black locusts south of the landfill may also have been planted in the past. This naturalized species is now recognized as having invasive tendencies..

Understory conditions are variable in this stand, with young tree seedlings and saplings somewhat more abundant where the forest is less disturbed and compromised where disturbance is heavy. The mostly closed canopy conditions in less disturbed areas limit the development of oak regeneration. Sweet pepperbush and other tall shrubs are present in forested wetlands. One of the property’s most significant invasive plant infestations is found along the northern edge of the stand next to the road, where dense thickets of Japanese knotweed are found in several places between the developed area of the park and the pond. Knotweed is also found around the edges of the disturbed area, including the south slope of the former landfill, and it a few other locations. Greenbrier is present almost everywhere although generally not as dense as it is north of the road. A significant amount of Asiatic bittersweet is found in open-canopy along the road and in disturbed areas. Although not observed during the inventory, other exotic invasives such as Japanese barberry are doubtless present as well.

The mature oak-hardwood forest provides excellent habitat for a range small mammals, birds, and insects, especially those that are not deterred by the understory greenbriar. The presence of oaks, along with a few hickories and beeches provides hard mast for food, along with and cavities for dens and nests in different species of trees. The small pond, eastern open wetland, and adjacency to larger, mostly forested wetlands to the south provides added value to wildlife species that use these habitats, especially birds and amphibians. The proxmity to the disturbed area with the solar array significantly increases the amount of forest edge habitat. This will likely favor edge-loving wildlife such as deer, while detracting from habitat quality for species that prefer larger areas of interior forest.

Limited enrichment planting of native tree species projected to be well-adapted to changing conditions in canopy gaps may help slightly diversify the age class composition and boost the future resiliency of the stand. Planting of young tree seedlings can be spread over an extended period and occur in existing canopy gaps (mostly caused by dead or dying large ash, black birch, beech, and oaks), in future canopy openings that may result from additional mortality, and in gaps that may be created where invasive plants are treated. The shade tolerance of tree species to be planted can be matched to the size of the gap as less shade tolerant species will require larger gaps to survive and grow. Few of the gaps currently present are large enough for shade-intolerant species to persist and grow into the canopy. The number of seedlings planted in an individual gap can range from 1-3 depending on the opening size and desire for replacement of planted trees that do not survive, but there is no need to plant more as a gap may have enough growing space for only one mature tree. Species that are already present and appropriate for planting in uplands include black, red, and white oak, and hickories. Suitable areas in lowlands tend to be found on higher, drier microsites where oaks (especially red oak) and hickories may still be appropriate. If natural canopy tree mortality or invasive tree felling creates gaps in low-lying areas, black gum and red maple are both species adapted to future conditions that grow well in wet soils. Planted seedlings should be monitored and protected with fencing or tubing to deter browsing by deer and other animals. Tree planting to promote the resilience of Bates Woods has the potential to be an activity in which stewardship volunteers could participate.

Desired Future Condition for Stand 1 (Northern Woods)

The extent of the remnant mature forest is not encroached upon any further and continues to provide habitat for many species of wildlife. Efforts to manage the Asiatic bittersweet vines, shrub-like Japanese knotweed, and potentially black locust, along with other exotic invasives, deter or limit the spread of these and prevent them from becoming more difficult (or impossible) to control. Trees impacted by small disturbances (such as a windstorm or insect outbreak) are left in the woods unless they present safety risks or other concerns. Natural regeneration and/or planted trees gradually grow into canopy gaps. Marked, maintained trails provide safe access through a few parts of this stand to community members. The old recreation area is restored and items dumped in the woods are removed.

Alternatives for Achieving Desired Future Condition

No-Action Alternative: Exotic invasive populations spread and become very difficult or impossible to control. Trails become overgrown and eventually lost without maintenance. Forest growth and carbon sequestration and storage continue with possible disturbances due to pests, severe weather events, etc. Allowing dumped items and graffiti to remain at the old recreation site encourages further dumping and unwanted human activities.

Alternative 1: Integrated invasive species management approach. Control of Asiatic bittersweet, Japanese knotweed, *Wisteria*, possibly black locust, and any other exotic invaders, including mechanical and appropriate herbicide application methods, followed by planting native shrubs and vegetation where practical. A limited amount of enrichment planting of tree seedlings protected from deer browse may be employed in canopy gaps Trails are maintained, including mechanical control of greenbriar along trail corridors.

Alternative 2: No-herbicide invasive species management approach. Same as 1 (above) but without using herbicide application as a method for combatting targeted exotic invasives. Protection of natural regeneration in canopy gaps may be preferred to enrichment planting.

Public Recreation and Safety. Higher-level maintenance, blazing, and mapping of desired trails allows more members of the community to safely explore the woods of the south side of the park. The eroded section of trial between the former landfill and forested wetland is repaired. Updating the infrastructure at the old recreation site and removing dumped items promotes desired activities in the park and discourages unwanted ones. Periodic patrols deter illegal activities and help more people feel safe using the park.

Recommended Management Activities:

1. Both mechanical and herbicide application methods employed for controlling bittersweet, Japanese knotweed, *Wisteria*, and any other exotic invaders, followed by planting native shrubs and vegetation where practical. Although they spread more slowly and are located far from the road, consider control of black locusts as well. Appropriate herbicide methods will likely include cut-stem application of approved herbicide products. If successful elsewhere, invasives control may be extended to targeting greenbriar in priority areas such as along trails.

2. A limited amount of enrichment planting of tree seedlings protected from deer browse may be employed in canopy gaps. Alternatively, protection of natural regeneration in canopy gaps may be preferred to enrichment planting.

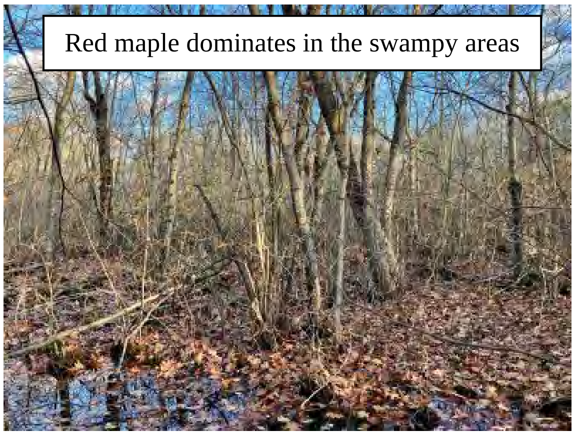
3. Higher-level maintenance, blazing, and mapping of desired trails allow more members of the community to safely explore the woods of the south side of the park. The eroded section of trail between the former landfill and forested wetland is repaired. Attention to the infrastructure at the old recreation site and removal of dumped items promotes desired activities in the park and discourages unwanted ones. Periodic patrols deter illegal activities and help more people feel safe using the park.

Open wetland surrounded by forest near the southestern corner of the Southern Woods

STAND 3 (Forested Wetlands)

Acres: 4.8 Cover Type: Red Maple Swamp Canopy Height: 30-45 feet
Variable stocking density (higher at wetland edges) Snag Density: 0 ft²/ac (but snags observed)

Site Quality	Site Index	Approx. Age	Stocking Density	Trees/ac	Average Diameter	Sawtimber volume/ac	Cordwood volume/ac
Poor	55-62 red maple 66 red oak	60-100+	73 ft²/ac	154	9.3"	0.9 MBF	7.1 cords


Red maple dominates in the swampy areas

The smallest of the three stands (11% of the wooded area), Stand 3 is very different from other parts of the park woodlands as it comprises the forested wetlands that occupy the southern corner of the Bates Woods Park. Despite the presence of a trail passing close to their edge, the forested wetlands are very difficult for humans to pass through and seldom, if ever, explored by visitors. From a landscape context, these wetlands encompass a significant area southeast of the park and only a small percentage of their total acreage is located on the park parcel. The wetlands themselves are essentially flat, while there is some rocky terrain along the edge shared with the upland Southern Woods (Stand 2) and a small rocky promontory surrounded by wetland. Stony Ridgebury Leicester, and Whitman soils typical of forested wetlands are found here, along with organic and mineral Timakwa and Natchaug wetland soils in the eastern portion.

The presence of wetlands inhospitable to agriculture or development suggests that small section of the park has experienced less vegetation disturbance than uplands that make up most of the park. This area may, however, have been affected by runoff and leaching from former landfill (with its edge located less than 250 feet away).

Due to the saturated soil and pools of standing water levels, forest inventory plots were located near the edges of stand and may not fully capture the lower stocking density in the wettest areas of the stand. The inventory recorded only four tree species. The high density (86% basal area) of red maple characterizes the stand as a red maple swamp and there is a minor presence of black gum and green ash (5% each), two other common wetland trees. A small amount of Northern red oak (5%) is found around the edges and growing on microsites that are not saturated. Snags observed in wetter areas of the stand suggest that water levels have contributed to canopy mortality.

The understory within the forested wetland is dense with tall vegetation and shrub composition varies with the amount of canopy cover and level of soil saturation. Exotic invasive *Phragmites* or common reed is a notable understory species, present in the wettest areas where the canopy is more open. Native understory species include sweet pepperbush, spicebush, winterberry, and probably swamp cabbage in small openings. *Phragmites* has taken over the understory of the larger wetland extending beyond the park boundary and controlling it is unrealistic without massive inputs of resources and labor.

Although these forested wetlands are inhospitable to humans, they provide good habitat for certain wildlife species, especially birds (including herons, wood ducks, warblers, and woodpeckers), amphibians (spring peepers and wood frogs can likely be heard here in the early spring), and reptiles. Small mammals such as beavers, otters, and muskrats also make use of this habitat, along with many species of invertebrates. The density of the vegetation makes it less attractive for larger mammals such as white-tailed deer. The ubiquitous *Phragmites* does reduce the quality of the habitat that the wetlands provide as this aggressive invader has pushed out native species such as cattails that also provide food for wildlife.

Desired Future Condition for Stand 3 (Forested Wetlands):

The forested wetlands remain intact and are managed as a reserve providing refuge for wildlife and absorbing and filtering stormwater. *Phragmites* reeds will probably remain an unavoidable component of the understory vegetation. Recreational trails do not enter or pass through this stand. Trees impacted by disturbances (such as windstorms or forest pest outbreaks) are left in the woods unless they pose specific concerns. Natural regeneration gradually grows into canopy gaps. Any early-stage populations of exotic invasive species that are discovered should be targeted for control

Alternatives for Achieving Desired Future Condition

No-Action Alternative: The forested wetlands are passively managed as a reserve where natural processes take place with minimal human intervention. Forest growth and carbon sequestration and storage continue with possible disturbances due to pests, severe weather events, etc. The wetland may slowly become more open over time if higher water levels due to flooding and storm events lead to additional canopy mortality.

Alternative 1: Partners pursue an aggressive invasive plant control approach with the goal of reducing the population of *Phragmites* reeds. This could entail use of mechanical and appropriate herbicide application methods suitable for use in wetland areas, followed by planting native wetland shrubs and vegetation if practical. The extent of the *Phragmites* population beyond the park parcel, however, means that preventing its return would be extremely difficult. This project would also likely be expensive and challenging to implement with volunteers.

Trails. Periodic monitoring ensures that recreational trails do not enter or pass through this stand. Any “herd paths” that are observed are blocked. Signs may be placed to encourage visitors to stay on the trail in Stand 2 that passes the edge of the wetland.

Recommended Management Activities:

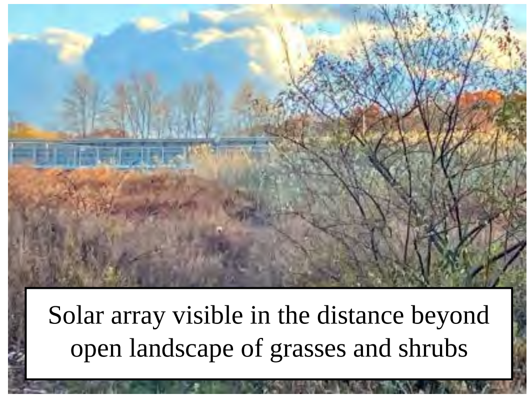
1. The forested wetlands are passively managed as a reserve where natural processes take place with minimal human intervention. Forest growth and carbon sequestration and storage continue with possible disturbances due to pests, severe weather events, etc. The wetland may slowly become more open over time if higher water levels due to flooding and storm events lead to additional canopy mortality. Any early-stage populations of exotic invasive species that are discovered should be targeted for control.

2. Periodic monitoring ensures that recreational trails do not enter or pass through this stand. Any "herd paths" that are observed are blocked. Signs may be placed to encourage visitors to stay on the trail in Stand 2 that passes the edge of the wetland.

Phragmites reeds and saturated soils in an area of the forested wetlands with a relatively open canopy, near the park boundary.

DISTURBED AREA

Acres: 8.5 (surrounding 4.4-acre fenced solar array)
Cover Type: Shrubs, vines, grasses, and bare ground with scattered trees in northern section



Solar array visible in the distance beyond open landscape of grasses and shrubs

This area is the located in the east-central portion of the parcel and on the south side of the road running through the park. It was not included in the sampling-based forest inventory since most of the area is not forested. While the majority of the land is now upland, the northwestern portion located relatively close to the road is a wetland with a small pond at the center. Possibly due to the flatter terrrain compared to many parts of the surrounding area, this section of the park has been a focus of human land uses (and abuses) for a long time. The terrain may have provided some of the land suited to agriculure when the property was a farm. Later, it provided and out-of-sight location for the New London Sanitary Landfill that was used from the 1940s through 1988 and significantly altered the terrain, filling in a small natural wetland and creating an artificial mound. The landfill site, a major source of water pollution for years, was remediated and capped in 1990-91 after being closed for more than a decade. After a few decades of relative inactivity, the City of New London constructed a 4.4-acre fenced solar array on the site of the former landfill in 2025, a project that required terrain leveling and grading. Although most of the acreage is located north of the solar array, the area mapped as the "Disturbed Area" includes a 50-foot buffer around the perimeter fence but excludes the area within the fence.

Knotweed is thick under the few trees

The disturbed area includes a hodgepodge of ground conditions and vegetation that appears to have developed haphazardly and with little planning over the past few decades. Some widely-spaced tall oaks and trees of other species are present north of the landfill site close to the road, but the rest of the area has few trees as a result of past land uses. Exotic invasive plants thrive on disturbed ground, and aggressive, opportunistic Japanese knotweed has colonized a significant area that was presumably once bare groud. Asaiatic bittersweet, mugwort, and autumn olive have a siginificant presence, and other exotic invasives are doubtless present also with native greenbrier and grape vines. Although the wetland surrounding the pond may be the area that has experienced the least recent disturbance, it has been colonized by *Phragmites* like the other wetlands. Recently, the former landfill acess road across the northeastern part of the area was repurposed as an access road to the solar array site. Now occupied by grasses and bare ground, the roadsides were heavily disturbed by using these areas as an equipment storage and staging area during construction.

Despite its land use history over the past several decades, the disturbed area does offer some habitat value to wildlife. Surrounded by woodlands, it is a large gap in the forest canopy offering meadow and early-successional forest conditions that are required or preferred by a suite of species, especially birds and edge-loving species. The shrubs provide cover to small mammals such as rabbits and the open areas may be favored by larger mammals at dusk and dawn. The wetland and pond add beneficial habitat variety, while the fenced solar array detracts from it.

Desired future condition for Disturbed Area:

Remaining unstable areas around the edges of the former landfill are mitigated so that erosion is no longer a potential concern. Exotic invasive plant populations are reduced to a manageable level with continued monitoring and periodic treatment. Native shrubs, grasses, and a limited number of trees are planted to take back and hold most of the growing space previously occupied by invasives. Thoughtful consideration of plantings provides beneficial habitat for pollinators along with attractive seasonal wildflowers. Trees should not be planted in the area where the underground cap was installed during remediation of the former landfill site because their roots may damage or penetrate the cap. Bird boxes on trees or on poles in areas with low vegetation provide habitat for migratory and/or permanent resident bird species. Since this open area near forest edges provides good deer habitat, it offers a good location to construct a deer exclosure fence. Placing the exclosure in a location visible from the main road would help more people see the extent to which herbivory by deer (and possibly other terrestrial animals) is impacting the regeneration of trees, shrubs, and other plants. Interpretive signs provide information and context on how the solar array provides renewable energy and is an asset to the City of New London.

Alternatives for Achieving Desired Future Condition

No-Action Alternative:

Where unstable soils are present in certain areas around the edge of the former landfill, erosion may continue occur during severe weather events. Without intervention, invasive plant populations will become more firmly established, colonize additional disturbed areas, and become more difficult or impossible to control. The unmanaged site provides limited habitat value for birds, pollinators, and wildlife. The appearance of the disturbed area remains unattractive and continues to be used for dumping and other undesirable activities. With little apparent security beyond the perimeter fence, the solar array could also potentially attract unwanted activity.

Alternative 1:

While maintaining the access road to the solar array, parts of the disturbed area around it offer a potentially promising candidate site for significant restoration project if there is cooperation and agreement among multiple partners (e.g., Bates Friends Forever, the City of New London, Connecticut DEEP, NRCS, etc.). Unless other resources are available, NRCS financial and technical assistance could be critical for planning and implementing such a project.

Consider collaborating with partners on a restoration project that could include the following elements:

- Mitigate erosion and stabilize soils
- Manage or reduce the spread of invasive plant populations
- Plant native shrubs, grasses, and (away from the cap) trees in place of invasive plants
- Enhance pollinator habitat (planting grasses and wildflowers)
- Add bird boxes in strategic locations around area with low vegetation
- Construct a deer exclosure fence to assess and demonstrate browse impacts on vegetation

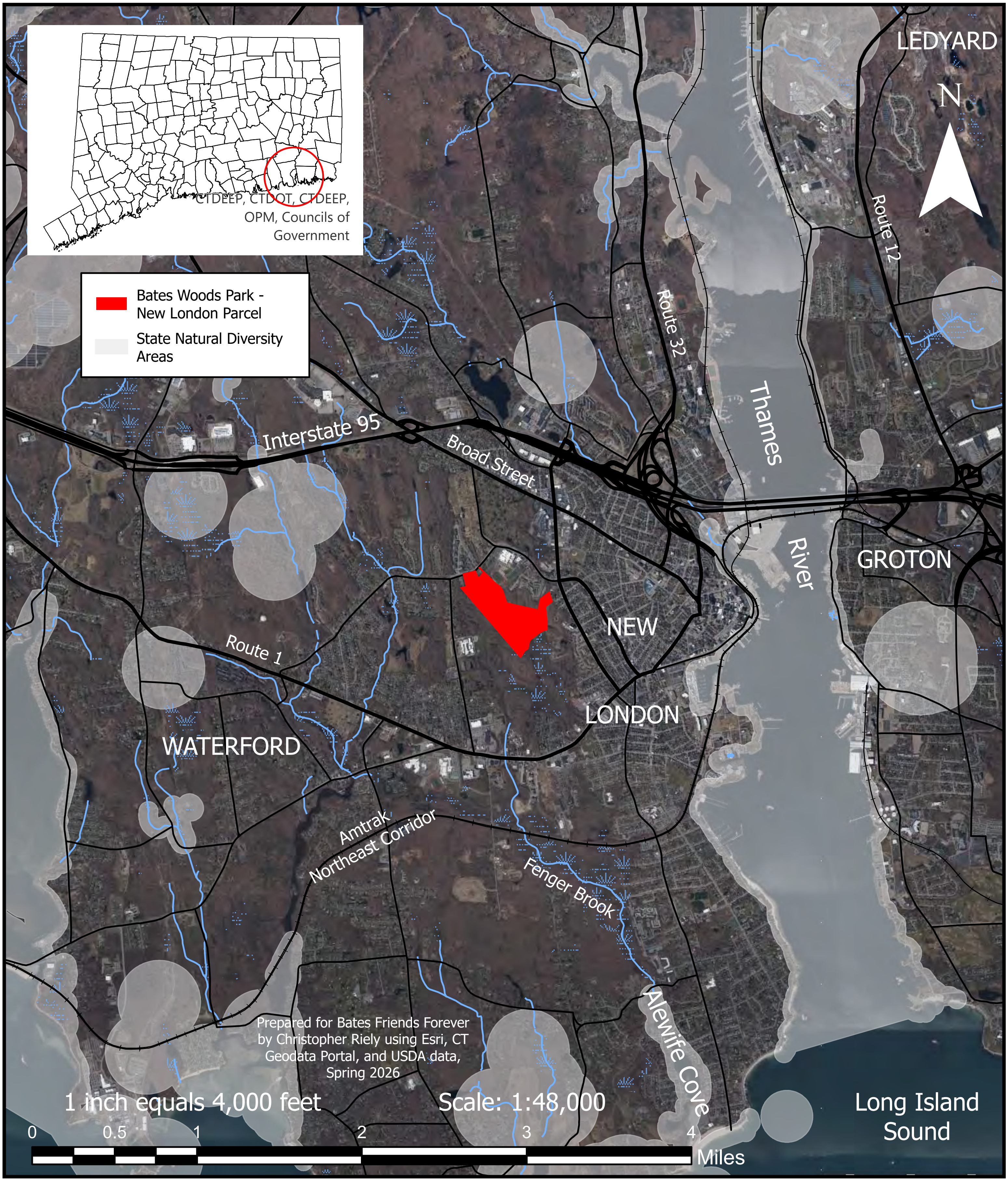
Recommended Management Activities:

Consider collaborating with partners on a restoration project that could include the following elements:

- Mitigate erosion and stabilize soils
- Manage or reduce the spread of invasive plant populations
- Plant native shrubs, grasses, and (away from the cap) trees in place of invasive plants
- Enhance pollinator habitat (planting grasses and wildflowers)
- Add bird boxes in strategic locations around area with low vegetation
- Construct a deer exclosure fence to assess and demonstrate browse impacts on vegetation

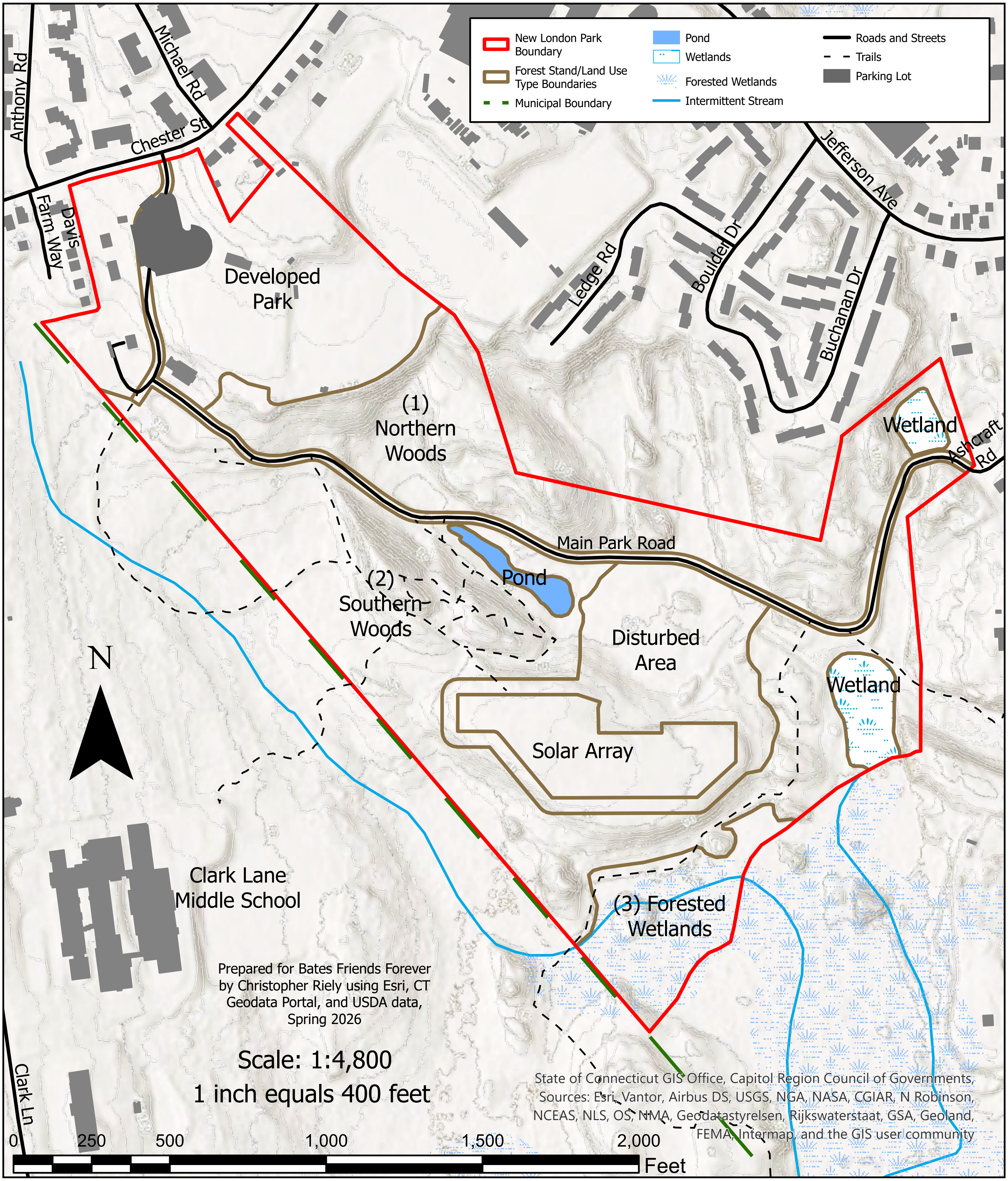
Dense Japanese knotweed and (in the distance) Asiatic bittersweet on the remaining slope of the former landfill adjacent to the solar array, looking west

BATES WOODS PARK
New London, CT
Locus Map with State Natural Diversity Areas



BATES WOODS PARK
New London, CT
Aerial Photo and Forest Stands Map

BATES WOODS PARK
New London, CT
Topographic & Hydrological Map



Soil Map—State of Connecticut, Eastern Part
(Bates Woods Park)

72° 7' 54" W
72° 6' 43" W
41° 21' 33" N
41° 21' 33" N

41° 20' 58" N
41° 20' 58" N
72° 7' 54" W
72° 6' 43" W

Map Scale: 1:7,600 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0, 100, 200, 400, 600

Feet: 0, 350, 700, 1400, 2100

Map projection: Web Mercator Corner coordinates: WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: State of Connecticut, Eastern Part
Survey Area Data: Version 6, Sep 16, 2025

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jun 14, 2022—Oct 6, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
3	Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony	6.1	8.0%
17	Timakwa and Natchaug soils, 0 to 2 percent slopes	6.6	8.6%
46B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	5.3	6.9%
51B	Sutton fine sandy loam, 0 to 8 percent slopes, very stony	6.0	7.8%
73C	Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky	28.4	37.1%
73E	Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky	11.2	14.7%
75C	Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes	1.5	2.0%
75E	Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes	1.5	2.0%
84B	Paxton and Montauk fine sandy loams, 3 to 8 percent slopes	0.0	0.0%
302	Dumps	6.3	8.3%
306	Udorthents-Urban land complex	2.5	3.3%
W	Water	1.0	1.3%
Totals for Area of Interest		**76.6**	**100.0%**

Forestland Productivity

This table is designed to assist forestland owners or managers in planning the use of soils for wood crops. It provides the potential productivity of the soils for wood crops.

Potential productivity of merchantable or *common trees* on a soil is expressed as a site index and as a volume growth rate number. The *site index* is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. *Common trees* are those that forestland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability. More detailed information regarding site index is available in the "National Forestry Manual," which is available in local offices of the Natural Resources Conservation Service or on the Internet.

The *Base Age* is the age of trees in years on which the site index is based. "TA" indicates total age. "BH" indicates breast height age. "N/A" indicates that base age is not applicable.

The *Site Index Curve Number* is listed in the National Register of Site Index Curves. It identifies the site index curve used to determine the site index.

The *Volume Growth Rate* is the maximum wood volume annual growth rate likely to be produced by the tree species. This number, expressed as cubic feet per acre per year, is calculated at the age of culmination of the mean annual increment (CMAI). It indicates the maximum volume of wood fiber produced per year in a fully stocked, even-aged, unmanaged stand.

Reference:
United States Department of Agriculture, Natural Resources Conservation Service, National Forestry Manual.

Report—Forestland Productivity

Forestland Productivity–State of Connecticut, Eastern Part				
Map unit symbol and soil name	Potential productivity			Trees to manage
	Common trees	Site Index	Volume of wood fiber	
			Cu ft/ac/yr	
3—Ridgebury, Leicester, and Whitman soils, 0 to 8 percent slopes, extremely stony				
Ridgebury, extremely stony	Eastern white pine	63	114.00	American elm, Blackgum, Green ash, Pin oak, Red maple, Swamp white oak, Yellow birch
	Northern red oak	66	43.00	
	Red maple	62	—	
	Sugar maple	56	29.00	
	White ash	60	—	
Leicester, extremely stony	Eastern white pine	69	129.00	Green ash, Red maple, Tuliptree
	Northern red oak	56	43.00	
	Red maple	70	43.00	
	Yellow birch	—	—	
Whitman, extremely stony	Blackgum	52	—	—
	Eastern white pine	56	100.00	
	Northern red oak	70	—	
	Red maple	60	29.00	
	Red spruce	44	86.00	
	White oak	57	—	
17—Timakwa and Natchaug soils, 0 to 2 percent slopes				
Timakwa	Atlantic white cedar	—	0.00	—
	Eastern hemlock	—	—	
	Eastern white pine	—	—	
	Red maple	55	29.00	
	Silver maple	80	29.00	
	Tamarack	61	57.00	
Natchaug	Atlantic white cedar	—	0.00	—
	Eastern hemlock	—	—	
	Eastern white pine	—	—	
	Red maple	55	29.00	
	Silver maple	80	29.00	
	Tamarack	61	57.00	

Forestland Productivity–State of Connecticut, Eastern Part				
Map unit symbol and soil name	Potential productivity			Trees to manage
	Common trees	Site Index	Volume of wood fiber	
			Cu ft/ac/yr	
46B—Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony				
Woodbridge, very stony	Black oak	77	—	Ash, Northern red oak, Sugar maple, Tuliptree, White oak
	Eastern white pine	67	114.00	
	Northern red oak	72	57.00	
	Red pine	65	114.00	
	Red spruce	50	114.00	
	Sugar maple	65	43.00	
	Yellow poplar	84	—	
51B—Sutton fine sandy loam, 0 to 8 percent slopes, very stony				
Sutton, very stony	Black cherry	72	43.00	Eastern white pine, European larch, Northern red oak, Norway spruce, White oak, White spruce
	Eastern white pine	62	114.00	
	Northern red oak	62	43.00	
	Red spruce	50	114.00	
	Sugar maple	54	29.00	
	White oak	—	—	
73C—Charlton-Chatfield complex, 0 to 15 percent slopes, very rocky				
Charlton, very stony	Eastern hemlock	—	—	Eastern white pine, European larch, Northern red oak, Norway spruce, Red pine, Scarlet oak, Sugar maple, Tuliptree, White ash, White oak
	Eastern white pine	65	114.00	
	Northern red oak	65	43.00	
	Red maple	55	29.00	
	Red pine	70	129.00	
	Red spruce	50	114.00	
	Shagbark hickory	—	0.00	
	Sugar maple	55	29.00	
	White oak	—	—	
Chatfield, very stony	Eastern hemlock	—	—	Eastern hemlock, Eastern white pine, European larch, Northern red oak, Norway spruce, Red pine, White oak
	Northern red oak	70	57.00	
	Sugar maple	65	43.00	
	White ash	75	43.00	
	White oak	—	—	

Forestland Productivity–State of Connecticut, Eastern Part				
Map unit symbol and soil name	Potential productivity			Trees to manage
	Common trees	Site Index	Volume of wood fiber	
			Cu ft/ac/yr	
73E—Charlton-Chatfield complex, 15 to 45 percent slopes, very rocky				
Charlton	Eastern hemlock	—	—	Eastern hemlock, Eastern white pine, Northern red oak, White oak
	Eastern white pine	65	114.00	
	Northern red oak	65	43.00	
	Red maple	55	29.00	
	Shagbark hickory	—	0.00	
	Sugar maple	55	29.00	
	White oak	—	—	
Chatfield	Eastern hemlock	—	—	Eastern hemlock, Eastern white pine, Northern red oak, White oak
	Northern red oak	70	57.00	
	Sugar maple	65	43.00	
	White ash	75	43.00	
	White oak	—	—	
75C—Hollis-Chatfield-Rock outcrop complex, 3 to 15 percent slopes				
Hollis	Chestnut oak	—	—	Chestnut oak, Eastern white pine
	Eastern hemlock	—	—	
	Eastern white pine	55	86.00	
	Northern red oak	47	29.00	
	Sugar maple	56	29.00	
Chatfield	Eastern hemlock	—	—	Eastern hemlock, Eastern white pine, Northern red oak, White oak
	Northern red oak	70	57.00	
	Sugar maple	65	43.00	
	White ash	75	43.00	
	White oak	—	—	
Rock outcrop	—	—	—	—

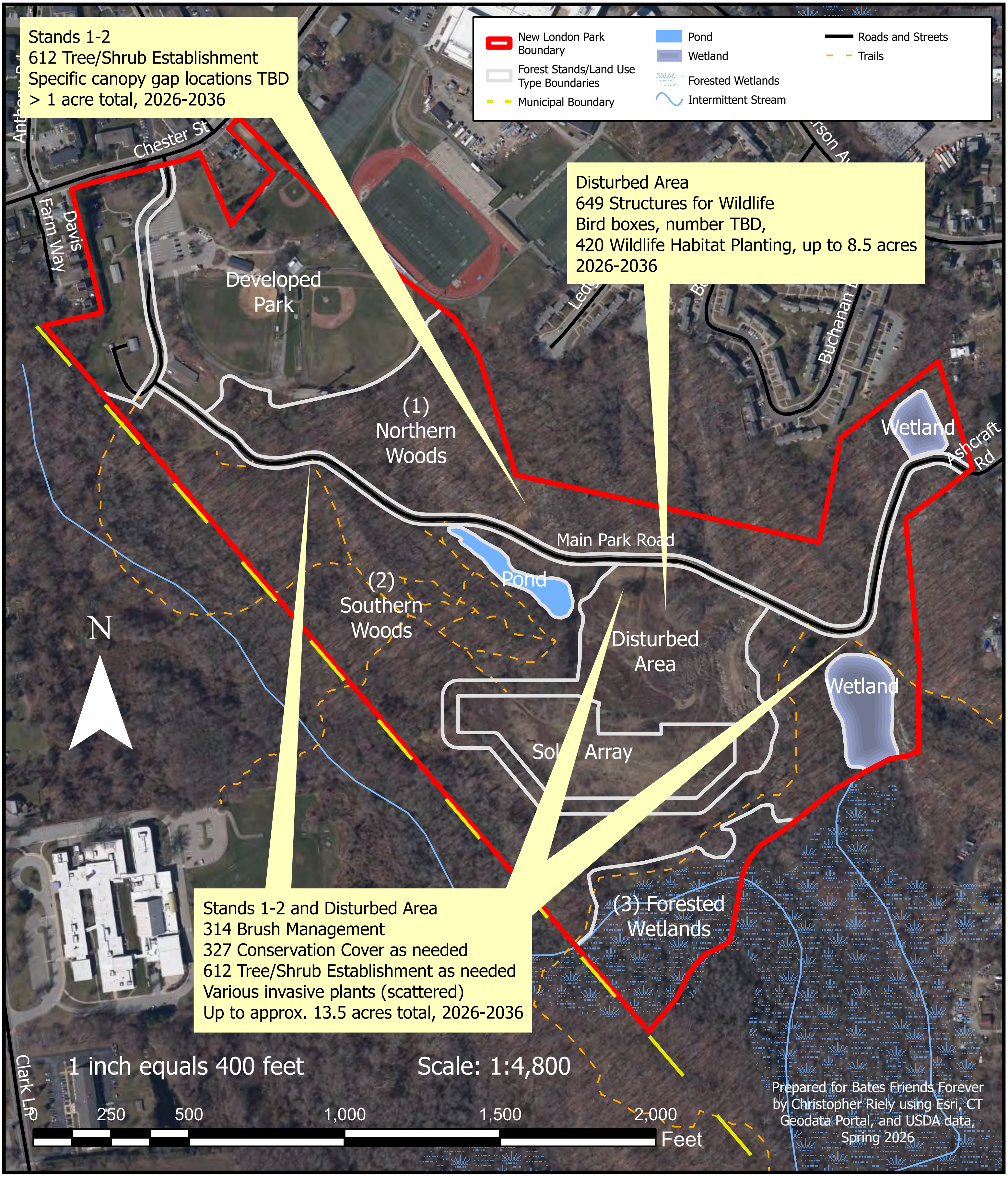
Forestland Productivity–State of Connecticut, Eastern Part				
Map unit symbol and soil name	Potential productivity			Trees to manage
	Common trees	Site Index	Volume of wood fiber	
			Cu ft/ac/yr	
75E—Hollis-Chatfield-Rock outcrop complex, 15 to 45 percent slopes				
Hollis	Chestnut oak	—	—	Chestnut oak, Eastern white pine
	Eastern hemlock	—	—	
	Eastern white pine	55	86.00	
	Northern red oak	47	29.00	
	Sugar maple	56	29.00	
Chatfield	Eastern hemlock	—	—	Eastern hemlock, Eastern white pine, Northern red oak, White oak
	Northern red oak	70	57.00	
	Sugar maple	65	43.00	
	White ash	75	43.00	
	White oak	—	—	
Rock outcrop	—	—	—	—
84B—Paxton and Montauk fine sandy loams, 3 to 8 percent slopes				
Paxton	Black oak	67	—	Eastern white pine, European larch, Northern red oak, Norway spruce, Red pine, Scarlet oak, Sugar maple, Tuliptree, White ash, White oak
	Eastern white pine	72	114.00	
	European larch	80	—	
	Northern red oak	68	43.00	
	Red pine	70	—	
	Scarlet oak	67	—	
	Sugar maple	75	43.00	
	White ash	89	—	
	White oak	60	—	
Montauk	Eastern white pine	75	143.00	Ash, Northern red oak, Sugar maple, Tuliptree, White oak
	Northern red oak	70	57.00	
	Sugar maple	65	43.00	
	White oak	—	—	
302—Dumps				
Dumps	—	—	—	—
306—Udorthents-Urban land complex				
Udorthents	—	—	—	—
Urban land	—	—	—	—

Forestland Productivity–State of Connecticut, Eastern Part				
Map unit symbol and soil name	Potential productivity			Trees to manage
	Common trees	Site Index	Volume of wood fiber	
			Cu ft/ac/yr	
W—Water				
Water	—	—	—	—

Data Source Information

Soil Survey Area: State of Connecticut, Eastern Part
Survey Area Data: Version 6, Sep 16, 2025

BATES WOODS PARK
New London, CT
Conservation Plan & Practices Map



Bates Woods Park

New London, CT

TRACT SUMMARY

Spring 2026

TRACT INFO

3 STANDS

ACRES 45.7

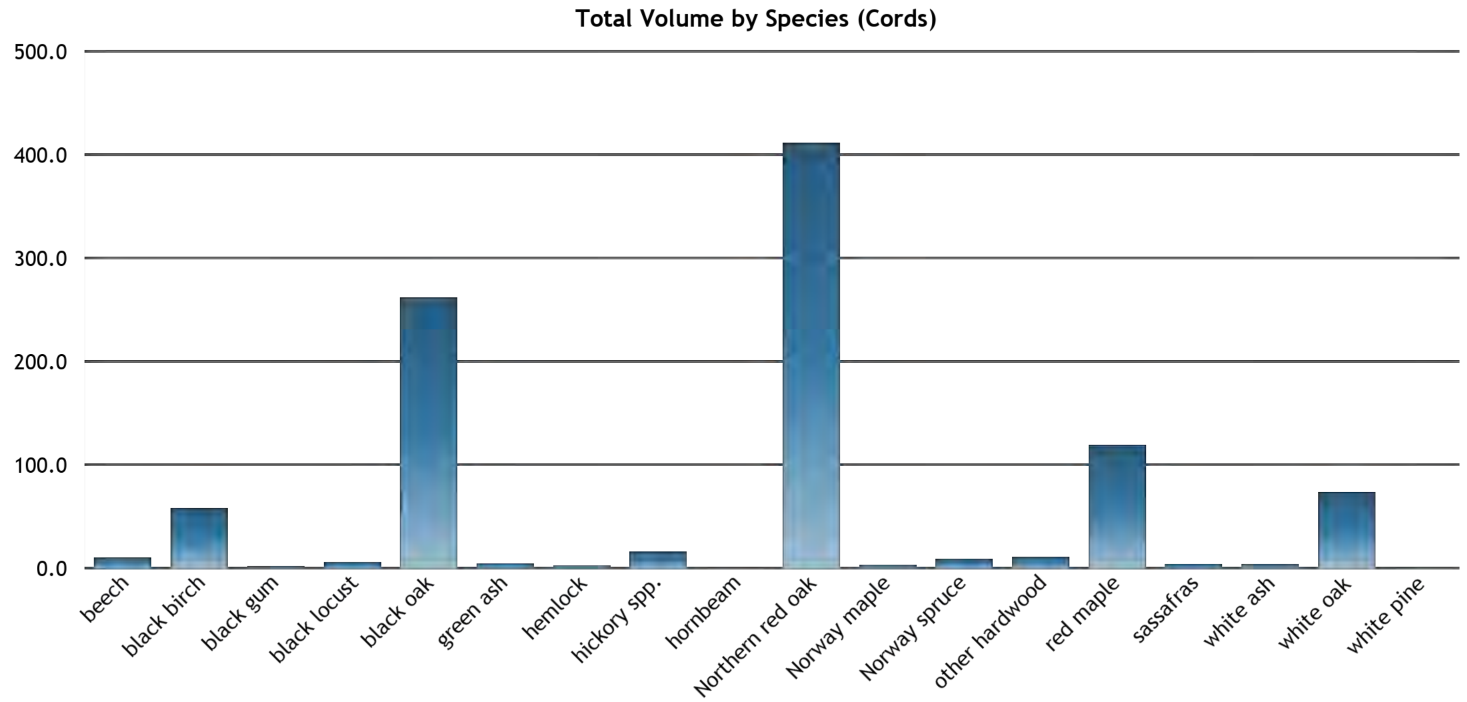
30 PTS

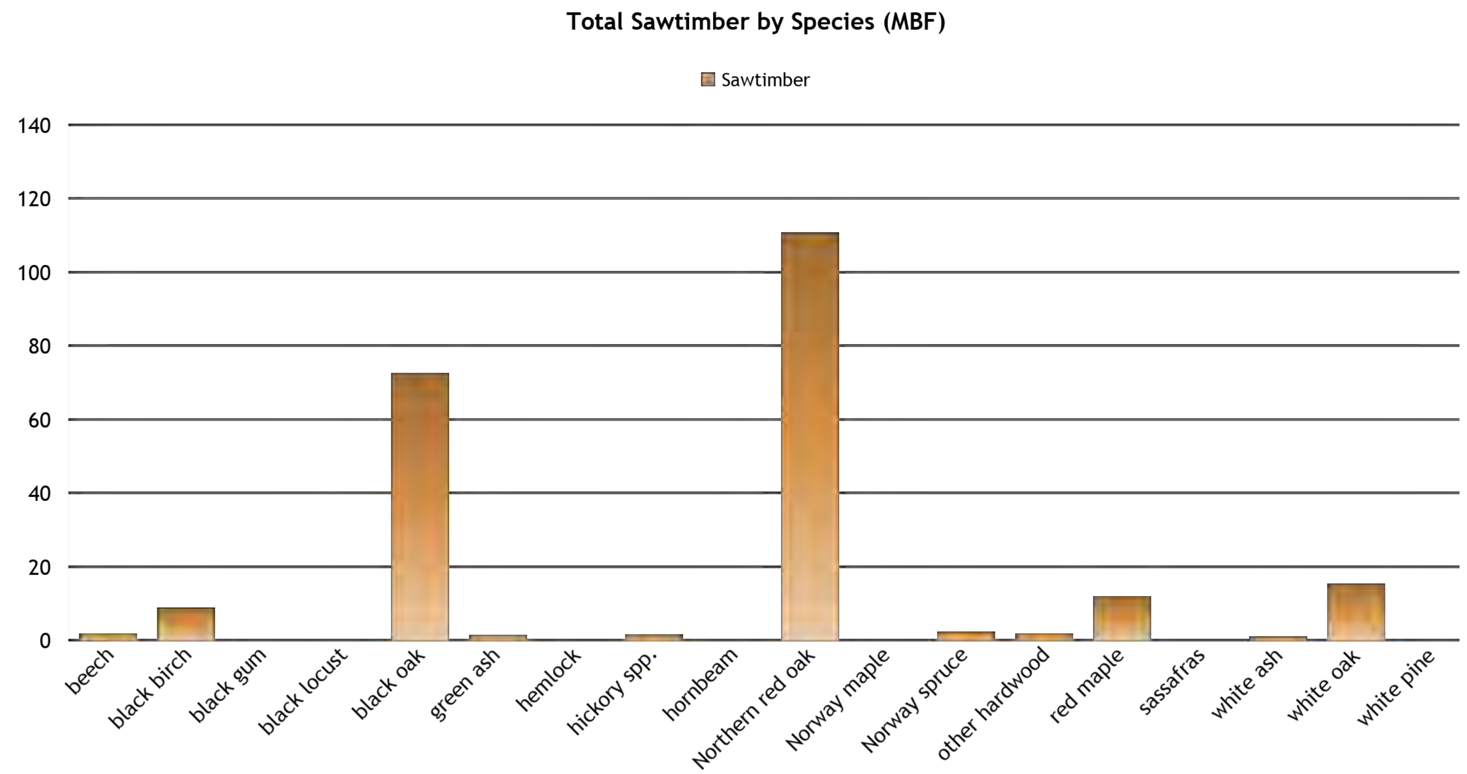
STATISTICAL ANALYSIS

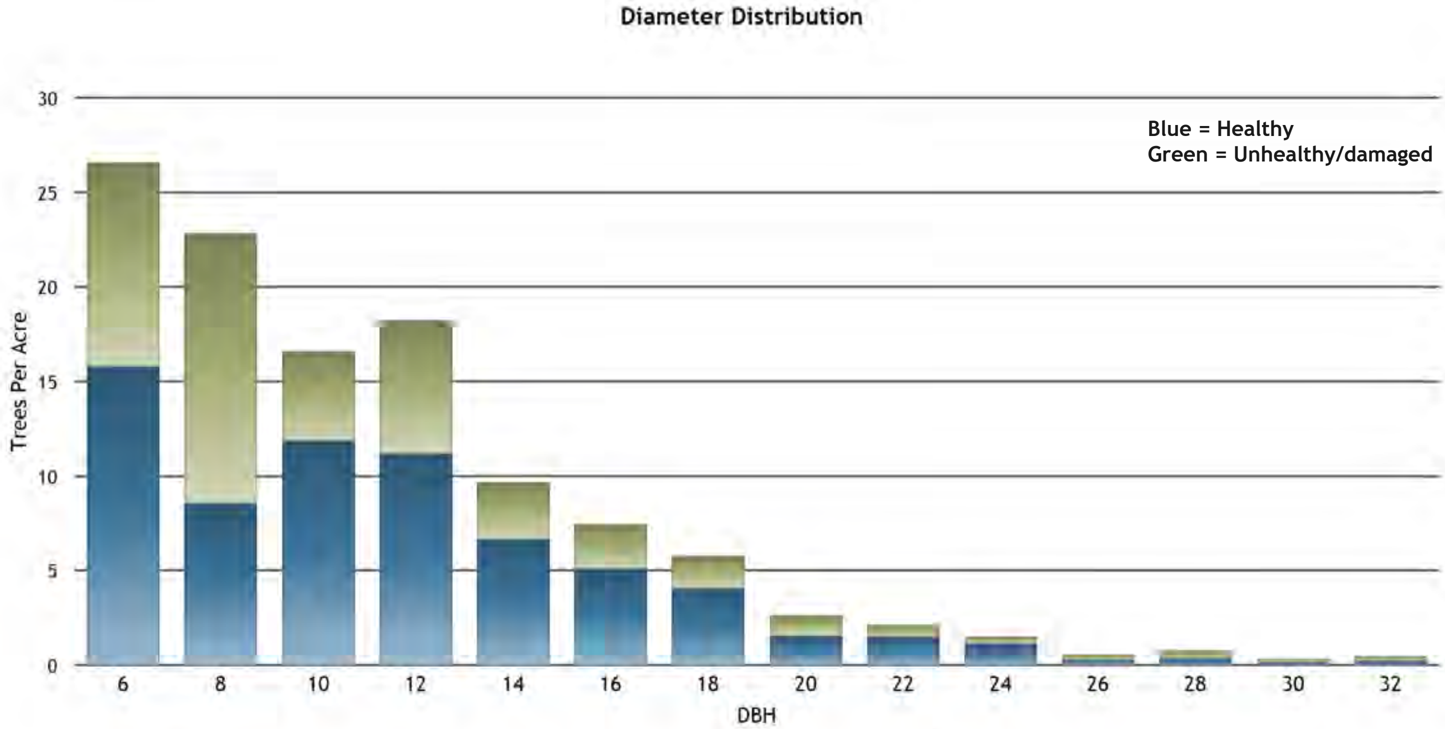
Confidence Interval 80%	BA	TPA	DBH	MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS
Average	93.7	116.2	12.2	24.8	5.03	9.28
Sampling Error	10.0%	15.2%			16.8%	12.3%
Probable Lower Limit	84.3	98.5			4.19	8.09
Probable Upper Limit	103.1	133.8			5.88	10.47

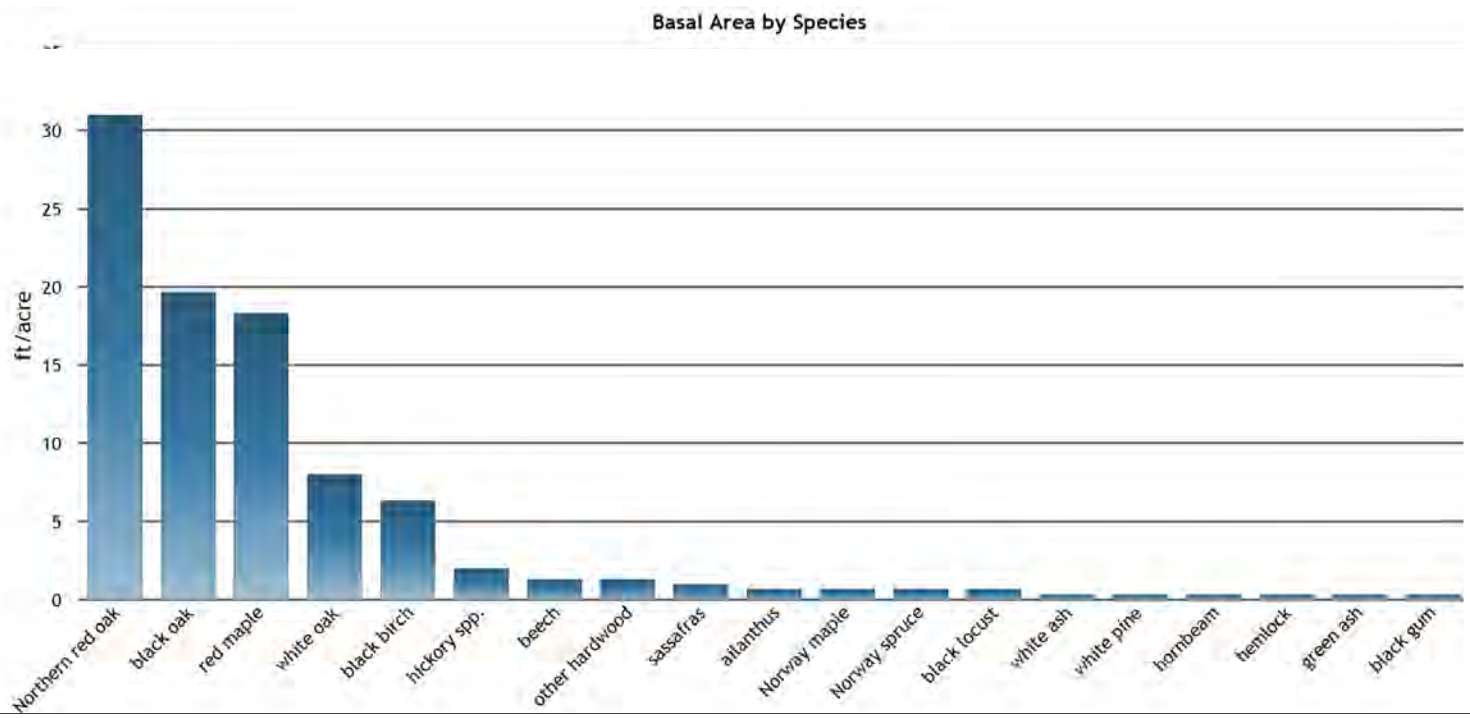
SPECIES COMPOSITION

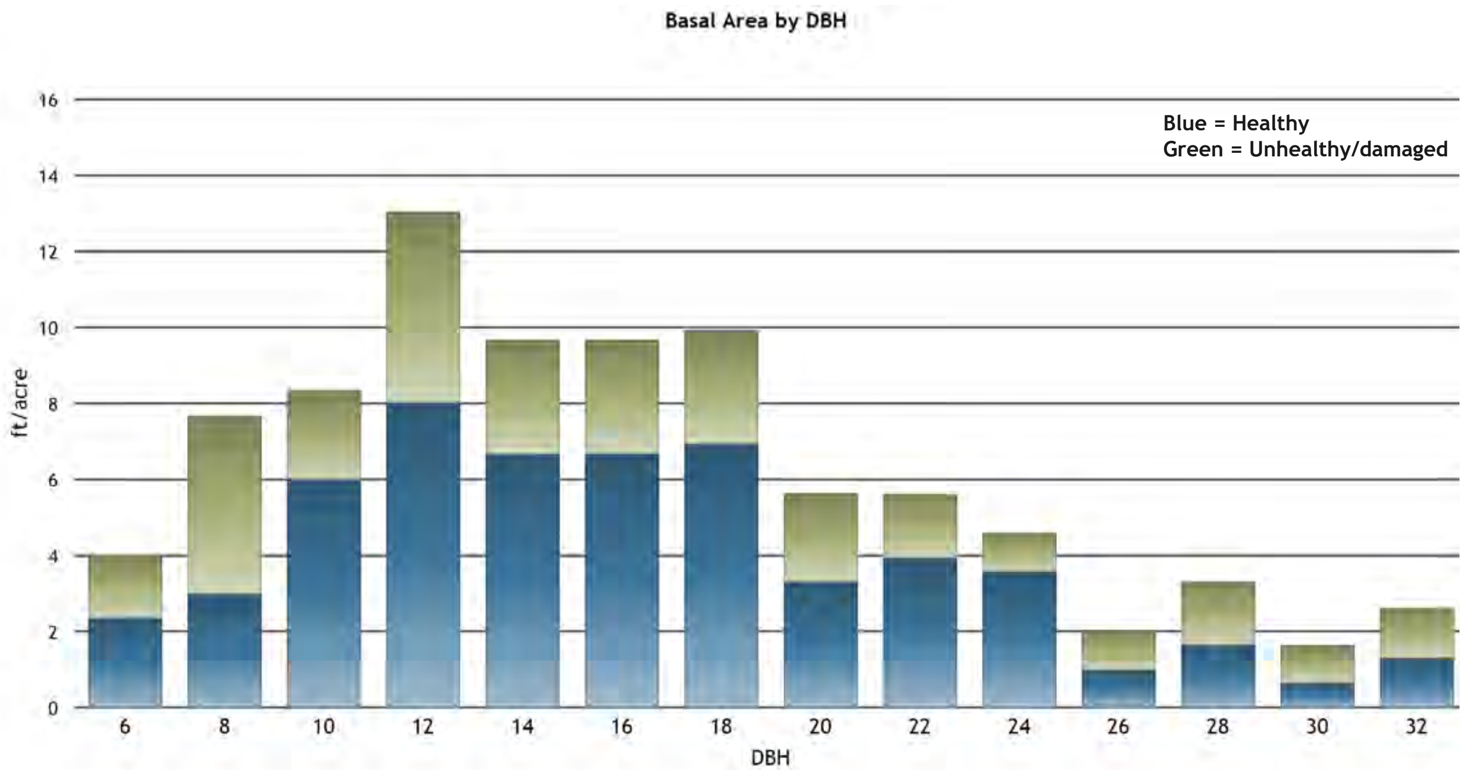
	BA		TPA		AVG MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS	TOTAL TRACT VOLUME MBF	TOTAL TRACT VOLUME CORDS
	93.7		116.2		24.8	5.03	9.28	230.01	424.12
Northern red oak	31.0	33.1%	24.9	21.4%	34.9	2.42	2.95	110.81	134.59
black oak	19.7	21.0%	11.8	10.2%	34.6	1.59	1.76	72.67	80.56
red maple	18.3	19.6%	38.0	32.7%	18.5	0.26	1.95	11.97	89.15
white oak	8.0	8.5%	8.2	7.1%	23.7	0.34	0.76	15.44	34.88
black birch	6.3	6.8%	10.8	9.3%	28.2	0.20	0.78	8.96	35.79
hickory spp.	2.0	2.1%	5.8	5.0%	25.3	0.04	0.26	1.66	11.72
beech	1.3	1.4%	4.0	3.5%	22.0	0.04	0.12	1.81	5.58
other hardwood	1.3	1.4%	0.9	0.8%	22.0	0.04	0.15	1.73	6.64
sassafras	1.0	1.1%	3.4	2.9%	13.3		0.09		4.09
ailanthus	0.7	0.7%	2.6	2.3%	0.0				
Norway maple	0.7	0.7%	0.2	0.2%	16.0		0.07		3.41
Norway spruce	0.7	0.7%	0.4	0.4%	36.0	0.05	0.07	2.33	3.18
black locust	0.7	0.7%	0.4	0.3%	32.0		0.13		6.09
white ash	0.3	0.4%	0.3	0.3%	32.0	0.02	0.03	1.10	1.22
white pine	0.3	0.4%	1.0	0.8%	8.0		0.03		1.16
hornbeam	0.3	0.4%	1.7	1.5%	8.0		0.03		1.16
hemlock	0.3	0.4%	0.6	0.5%	24.0		0.05		2.45
green ash	0.3	0.4%	0.4	0.4%	32.0	0.03	0.01	1.52	0.64
black gum	0.3	0.4%	0.6	0.5%	16.0		0.04		1.83


Total Volume by Species (Cords)
500.0
400.0
300.0
200.0
100.0
0.0
beech
black birch
black gum
black locust
black oak
green ash
hemlock
hickory spp.
hornbeam
Northern red oak
Norway maple
Norway spruce
other hardwood
red maple
sassafras
white ash
white oak
white pine


Total Sawtimber by Species (MBF)
Sawtimber
140
120
100
80
60
40
20
0
beech
black birch
black gum
black locust
black oak
green ash
hemlock
hickory spp.
hornbeam
Northern red oak
Norway maple
Norway spruce
other hardwood
red maple
sassafras
white ash
white oak
white pine


Diameter Distribution
Blue = Healthy
Green = Unhealthy/damaged
Trees Per Acre
30
25
20
15
10
5
0
6
8
10
12
14
16
18
20
22
24
26
28
30
32
DBH


Basal Area by Species
ft /acre
30
25
20
15
10
5
0
Northern red oak
black oak
red maple
white oak
black birch
hickory spp.
beech
other hardwood
sassafras
ailanthus
Norway maple
Norway spruce
black locust
white ash
white pine
hornbeam
hemlock
green ash
black gum


Basal Area by DBH
Blue = Healthy
Green = Unhealthy/damaged
ft/acre
16
14
12
10
8
6
4
2
0
6
8
10
12
14
16
18
20
22
24
26
28
30
32
DBH

TRACT BIOMASS

	TONS PER ACRE				TOTAL TONS			
	Roots	Bole	Other	Total	Roots	Bole	Other	Total
Healthy	9.4	38.3	11.4	59.0	427.5	1,748.2	522.0	2,697.8
Northern red oak	4.2	17.5	5.0	26.7	192.9	798.1	228.7	1,219.7
black oak	1.9	8.2	2.1	12.2	88.2	373.0	98.0	559.3
red maple	1.3	5.2	1.8	8.3	60.6	235.4	84.3	380.3
white oak	0.9	3.6	0.9	5.4	39.1	165.6	43.2	248.0
black birch	0.3	1.3	0.5	2.1	15.0	57.7	21.4	94.2
hickory spp.	0.3	1.0	0.4	1.7	12.1	45.0	18.4	75.5
beech	0.2	0.7	0.3	1.1	8.3	31.0	12.3	51.5
ailanthus	0.1	0.2	0.1	0.4	3.0	11.4	4.5	18.9
sassafras	0.1	0.2	0.1	0.4	2.8	10.0	4.4	17.1
other hardwood	0.0	0.2	0.0	0.3	2.2	8.2	2.1	12.5
green ash	0.0	0.1	0.1	0.2	1.7	6.8	2.3	10.8
black gum	0.0	0.1	0.1	0.2	1.6	6.0	2.3	9.9
Unhealthy	5.3	21.5	6.4	33.2	241.9	981.9	294.4	1,518.2
black oak	1.7	7.0	1.8	10.5	75.9	321.0	84.0	480.9
Northern red oak	1.1	4.7	1.2	7.0	50.7	214.3	56.3	321.2
red maple	1.0	3.7	1.4	6.1	44.7	169.0	65.9	279.5
white oak	0.5	2.1	0.7	3.3	23.8	95.2	30.7	149.6
black birch	0.5	1.9	0.6	3.0	21.8	86.5	28.9	137.1
Norway maple	0.1	0.5	0.1	0.7	4.9	21.0	5.1	31.0
other hardwood	0.1	0.4	0.1	0.7	5.4	19.7	5.7	30.8
black locust	0.1	0.4	0.1	0.5	3.9	16.3	4.6	24.8
Norway spruce	0.1	0.3	0.1	0.5	3.7	13.6	3.8	21.1
white ash	0.0	0.2	0.0	0.2	1.7	6.9	2.2	10.9
hemlock	0.0	0.1	0.0	0.2	1.6	5.7	1.8	9.1
hornbeam	0.0	0.1	0.0	0.2	1.4	4.5	1.7	7.5

Method: FIA DB 4.0, Jenkins Allometric Equation of Biomass with Component Ratio Method. Results are not directly comparable to FIA data. Tons expressed as oven-dry mass.

Roots - all below ground biomass
Bole- merchantable stem and associated bark
Other- stump, topwood, twigs, foliage
Total- all below and above ground biomass

Spring 2026

TRACT BIOMASS

	TONS PER ACRE				TOTAL TONS			
	Roots	Bole	Other	Total	Roots	Bole	Other	Total
sassafras	0.0	0.1	0.0	0.2	1.2	4.0	2.3	7.4
white pine	0.0	0.1	0.0	0.2	1.3	4.4	1.5	7.1
TOTAL	14.6	59.7	17.9	92.3	669.4	2,730.1	816.4	4,216.0

Method: FIA DB 4.0, Jenkins Allometric Equation of Biomass with Component Ratio Method. Results are not directly comparable to FIA data. Tons expressed as oven-dry mass.

Roots - all below ground biomass
Bole- merchantable stem and associated bark
Other- stump, topwood, twigs, foliage
Total- all below and above ground biomass

Sweet Birch Consulting, LLC

STAND 1	Northern Woods	BA 100.0	TPA 105.0	Sampling Method: Variable Radius Plots
ACRES 14.9				Basal Area Factor: 10.00 10 PTS

STATISTICAL ANALYSIS

Confidence Interval: 80	BA	TPA	DBH	MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS
Average	100.0	105.0	13.2	28.9	6.76	10.49
Sampling Error	13.2%	12.0%			23.0%	16.8%
Probable Lower Limit	86.8	92.4			5.21	8.73
Probable Upper Limit	113.2	117.6			8.32	12.25

SPECIES COMPOSITION

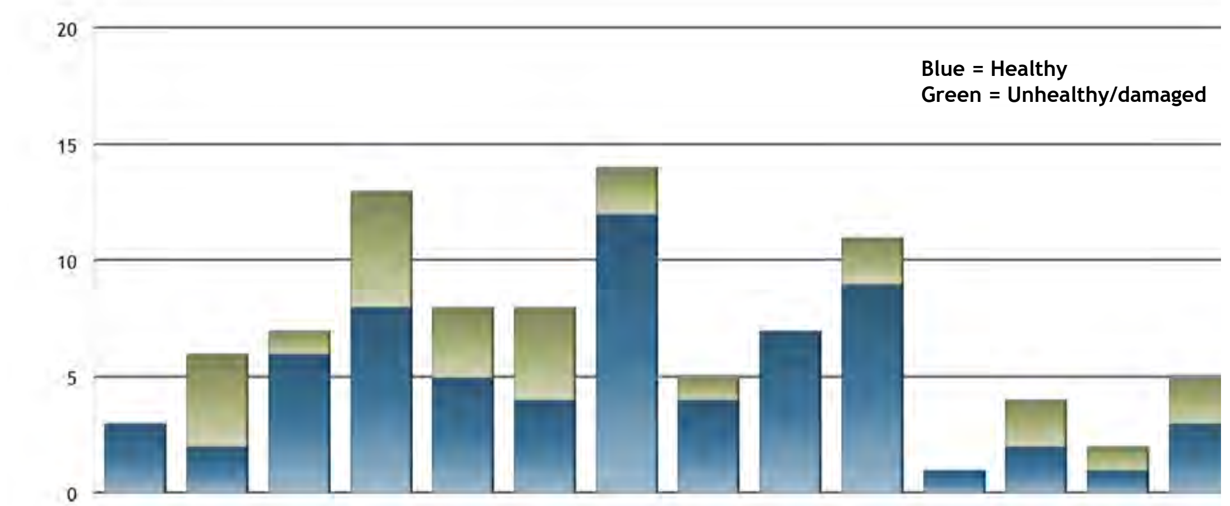
	BA		TPA		AVG MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS	TOTAL STAND VOLUME MBF	TOTAL STAND VOLUME CORDS
	100.0		105.0		28.9	6.76	10.49	100.79	156.30
Northern red oak	37.0	37.0%	28.3	27.0%	38.1	3.21	3.74	47.84	55.75
black oak	25.0	25.0%	13.1	12.5%	39.7	2.48	2.25	36.97	33.49
white oak	11.0	11.0%	11.4	10.9%	24.7	0.46	1.13	6.88	16.87
red maple	8.0	8.0%	18.4	17.5%	23.0		1.22		18.13
black birch	8.0	8.0%	8.7	8.2%	39.0	0.38	1.20	5.63	17.87
hickory spp.	3.0	3.0%	10.0	9.5%	24.0	0.11	0.27	1.66	4.09
sassafras	2.0	2.0%	5.1	4.9%	20.0		0.27		4.09
ailanthus	2.0	2.0%	7.9	7.5%	0.0				
Norway maple	2.0	2.0%	0.6	0.6%	16.0		0.23		3.41
beech	1.0	1.0%	0.6	0.5%	24.0	0.05	0.09	0.72	1.38
white ash	1.0	1.0%	0.9	0.9%	32.0	0.07	0.08	1.10	1.22

STAND BASAL AREA

STAND 1 Northern Woods BA 100.0 TPA 105.0 Sampling Method: Variable Radius Plots

ACRES 14.9 Basal Area Factor: 10.00 10 PTS

BASAL AREA (ft2)
BY DBH



	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
Northern red oak	32.0			2.0	5.0	4.0	2.0	4.0	1.0	3.0	4.0	1.0	1.0		5.0
black oak	16.0						1.0	4.0	1.0	3.0	4.0		1.0		2.0
white oak	7.0						1.0	2.0	2.0		1.0			1.0	
red maple	6.0	1.0	1.0	2.0	2.0										
hickory spp.	3.0	1.0		1.0						1.0					
sassafras	2.0		1.0	1.0											
black birch	2.0				1.0	1.0									
ailanthus	2.0	1.0						1.0							
beech	1.0							1.0							
Healthy	71.0	3.0	2.0	6.0	8.0	5.0	4.0	12.0	4.0	7.0	9.0	1.0	2.0	1.0	7.0
Unhealthy															
black oak	9.0		1.0		1.0		1.0		1.0				1.0	1.0	3.0
black birch	6.0				3.0	1.0	1.0				1.0				
Northern red oak	5.0		1.0			1.0	1.0	1.0							1.0
white oak	4.0		2.0				1.0	1.0							
red maple	2.0			1.0	1.0										
Norway maple	2.0										1.0		1.0		
white ash	1.0					1.0									

STAND BASAL AREA

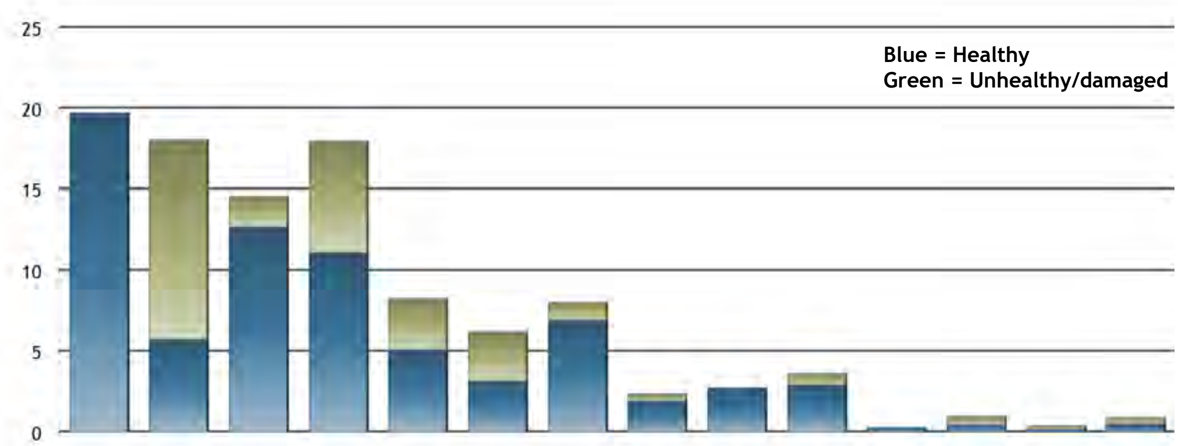
Unhealthy	29.0		4.0	1.0	5.0	3.0	4.0	2.0	1.0		2.0		2.0	1.0	4.0
TOTAL	100.0	3.0	6.0	7.0	13.0	8.0	8.0	14.0	5.0	7.0	11.0	1.0	4.0	2.0	11.0

TREES PER ACRE

STAND 1 Northern Woods BA 100.0 TPA 105.0 Sampling Method: Variable Radius Plots

ACRES 14.9 Basal Area Factor: 10.00 10 PTS

TREES PER ACRE BY DBH



	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
Northern red oak	22.9			3.7	6.9	4.2	1.5	2.4	0.5	1.1	1.3	0.3	0.3		0.8
red maple	15.3	5.1	2.9	4.5	2.8										
hickory spp.	10.0	7.3		2.3						0.4					
ailanthus	7.9	7.3						0.6							
black oak	6.6						0.8	2.3	0.5	1.2	1.3		0.2		0.3
sassafras	5.1		2.9	2.3											
white oak	3.4						0.8	1.1	1.0		0.3			0.2	
black birch	2.5				1.5	0.9									
beech	0.6							0.6							
Healthy	74.3	19.8	5.7	12.7	11.2	5.1	3.2	6.9	1.9	2.7	2.9	0.3	0.5	0.2	1.1
Unhealthy															
white oak	8.0		6.6				0.8	0.6							
black oak	6.5		2.9		1.5		0.7		0.5				0.2	0.2	0.5
black birch	6.2				4.1	1.1	0.7				0.3				
Northern red oak	5.4		2.9			1.1	0.8	0.6							0.1
red maple	3.1			1.8	1.3										
white ash	0.9					0.9									
Norway maple	0.6										0.3		0.3		
Unhealthy	30.8		12.3	1.8	6.9	3.1	3.1	1.1	0.5		0.7		0.5	0.2	0.6

TOTAL	105.0	19.8	18.1	14.6	18.0	8.2	6.2	8.1	2.4	2.7	3.6	0.3	1.0	0.4	1.7

STAND 2 Southern Woods | BA 93.5 | TPA 116.0 | Sampling Method: Variable Radius Plots

ACRES 26.0 | Basal Area Factor: 10.00 | 17 PTS

STATISTICAL ANALYSIS

Confidence Interval: 80	BA	TPA	DBH	MHT	VOLUME PER ACRE MBF	CORDS
Average	93.5	116.0	12.2	23.8	4.80	8.99
Sampling Error	17.2%	23.6%			22.4%	20.5%
Probable Lower Limit	77.4	88.6			3.73	7.06
Probable Upper Limit	109.7	143.4			5.88	10.93

SPECIES COMPOSITION

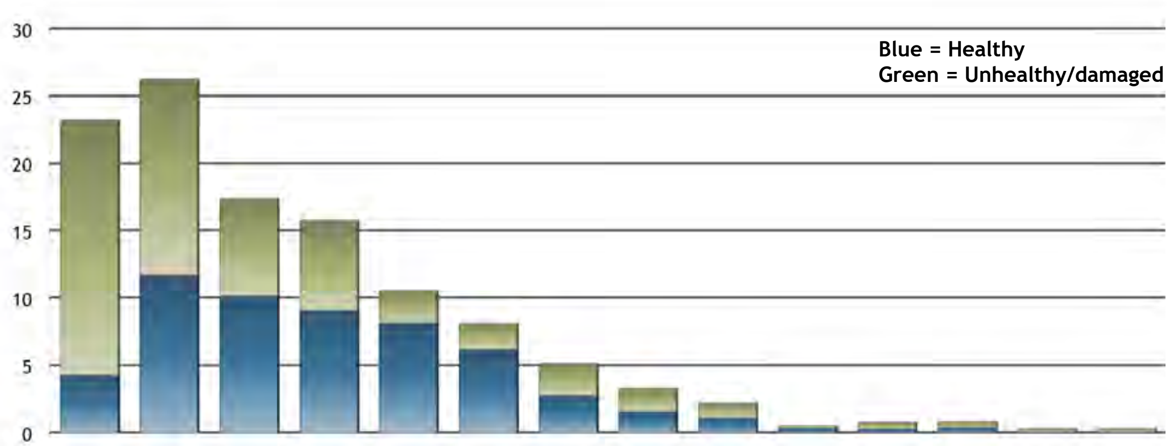
	BA		TPA		AVG MHT	VOLUME PER ACRE MBF	CORDS	TOTAL STAND VOLUME MBF	CORDS
	93.5		116.0		23.8	4.80	8.99	124.93	233.81
Northern red oak	32.4	34.6%	26.7	23.0%	32.9	2.36	3.01	61.35	78.18
black oak	20.0	21.4%	13.1	11.3%	30.8	1.37	1.81	35.70	47.07
red maple	16.5	17.6%	31.4	27.1%	19.4	0.42	1.54	10.84	40.14
white oak	7.6	8.2%	7.8	6.8%	22.8	0.33	0.69	8.56	18.01
black birch	6.5	6.9%	13.9	12.0%	20.4	0.13	0.69	3.33	17.92
other hardwood	2.4	2.5%	1.6	1.4%	22.0	0.07	0.26	1.73	6.64
beech	1.8	1.9%	6.7	5.8%	21.3	0.04	0.16	1.08	4.20
hickory spp.	1.8	1.9%	4.4	3.8%	26.7		0.29		7.63
Norway spruce	1.2	1.3%	0.8	0.7%	36.0	0.09	0.12	2.33	3.18
black locust	1.2	1.3%	0.7	0.6%	32.0		0.23		6.09
white pine	0.6	0.6%	1.7	1.5%	8.0		0.04		1.16
sassafras	0.6	0.6%	3.0	2.6%	0.0				
hornbeam	0.6	0.6%	3.0	2.6%	8.0		0.04		1.16
hemlock	0.6	0.6%	1.1	0.9%	24.0		0.09		2.45

TREES PER ACRE

STAND 2 Southern Woods BA 93.5 TPA 116.0 Sampling Method: Variable Radius Plots

ACRES 26.0 Basal Area Factor: 10.00 17 PTS

TREES PER ACRE BY DBH



	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
Northern red oak	22.4		1.7	4.3	5.1	3.6	4.1	1.7	0.5	0.7	0.2			0.1	0.4
red maple	7.3			1.3		4.7	0.8	0.3					0.1		
black birch	7.2		5.1	1.1	0.9					0.2					
beech	6.7	4.3	1.7		0.7										
black oak	6.3			1.3	1.5		1.3	0.4	1.1	0.2	0.2	0.2			0.2
hickory spp.	4.4		3.4	1.1											
white oak	2.8			1.1	0.9			0.4				0.2	0.1		0.1
other hardwood	0.1												0.1		
Healthy	57.4	4.3	11.8	10.2	9.1	8.2	6.2	2.8	1.6	1.1	0.4	0.3	0.4	0.1	0.7
Unhealthy															
red maple	24.1	8.6	8.9	3.5	1.6	0.6	0.5	0.3							
black oak	6.8			1.3	1.8	0.6	0.5	0.7	0.5	0.7		0.2	0.1	0.1	0.2
black birch	6.7	4.3			1.8			0.3	0.3						
white oak	5.0		3.9			0.6			0.3				0.1		0.1
Northern red oak	4.3			1.3	0.7	0.6		0.3		0.4	0.2	0.3	0.1	0.1	0.1
sassafras	3.0	3.0													
hornbeam	3.0	3.0													
white pine	1.7		1.7												
other hardwood	1.5				0.7		0.5		0.3						

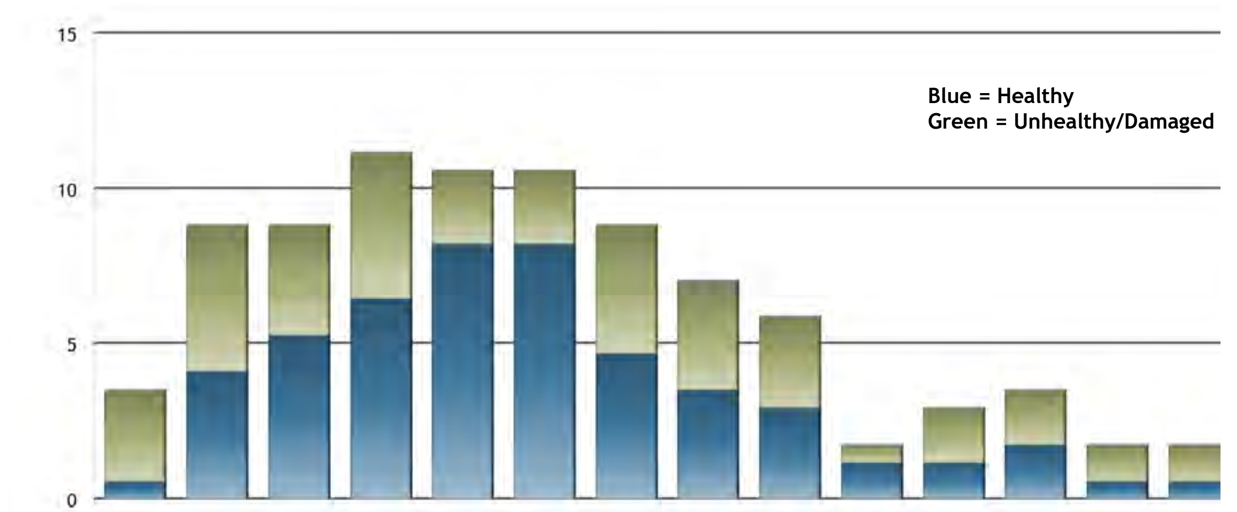
TREES PER ACRE

hemlock	1.1			1.1												
Norway spruce	0.8						0.5		0.3							
black locust	0.7							0.7								
Unhealthy	58.6	18.9	14.5	7.2	6.7	2.4	1.9	2.4	1.6	1.1	0.2	0.5	0.4	0.2	0.5	
TOTAL	116.0	23.2	26.3	17.4	15.8	10.6	8.2	5.2	3.3	2.3	0.6	0.8	0.8	0.4	1.2	

STAND 2 Southern Woods BA 93.5 TPA 116.0 Sampling Method: Variable Radius Plots

ACRES 26.0 Basal Area Factor: 10.00 17 PTS

BASAL AREA (ft2)
BY DBH



	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
Northern red oak	24.7		0.6	2.4	3.5	3.5	5.3	2.9	1.2	1.8	0.6			0.6	2.4
black oak	9.4			0.6	1.2		1.8	0.6	2.4	0.6	0.6	0.6			1.2
red maple	7.6			0.6		4.7	1.2	0.6					0.6		
white oak	4.1			0.6	0.6			0.6				0.6	0.6		1.2
black birch	3.5		1.8	0.6	0.6					0.6					
hickory spp.	1.8		1.2	0.6											
beech	1.8	0.6	0.6		0.6										
other hardwood	0.6												0.6		
Healthy	53.5	0.6	4.1	5.3	6.5	8.2	8.2	4.7	3.5	2.9	1.2	1.2	1.8	0.6	4.7
Unhealthy															
black oak	10.6			0.6	1.2	0.6	0.6	1.2	1.2	1.8		0.6	0.6	0.6	1.8
red maple	8.8	1.2	2.9	1.8	1.2	0.6	0.6	0.6							
Northern red oak	7.6			0.6	0.6	0.6		0.6		1.2	0.6	1.2	0.6	0.6	1.2
white oak	3.5		1.2			0.6			0.6				0.6		0.6
black birch	2.9	0.6			1.2			0.6	0.6						
other hardwood	1.8				0.6		0.6		0.6						
Norway spruce	1.2						0.6		0.6						
black locust	1.2							1.2							

white pine	0.6		0.6												
sassafras	0.6	0.6													
hornbeam	0.6	0.6													
hemlock	0.6			0.6											
Unhealthy	40.0	2.9	4.7	3.5	4.7	2.4	2.4	4.1	3.5	2.9	0.6	1.8	1.8	1.2	3.5
TOTAL	93.5	3.5	8.8	8.8	11.2	10.6	10.6	8.8	7.1	5.9	1.8	2.9	3.5	1.8	8.2

STAND 3 Forested Wetlands BA 73.3 TPA 154.2 Sampling Method: Variable Radius Plots

ACRES 4.8 Basal Area Factor: 10.00 3 PTS

STATISTICAL ANALYSIS

Confidence Interval: 80	BA	TPA	DBH	MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS
Average	73.3	154.2	9.3	15.9	0.89	7.09
Sampling Error	56.2%	97.9%			121.7%	62.2%
Probable Lower Limit	32.1	3.3				2.68
Probable Upper Limit	114.5	305.1			1.98	11.50

SPECIES COMPOSITION

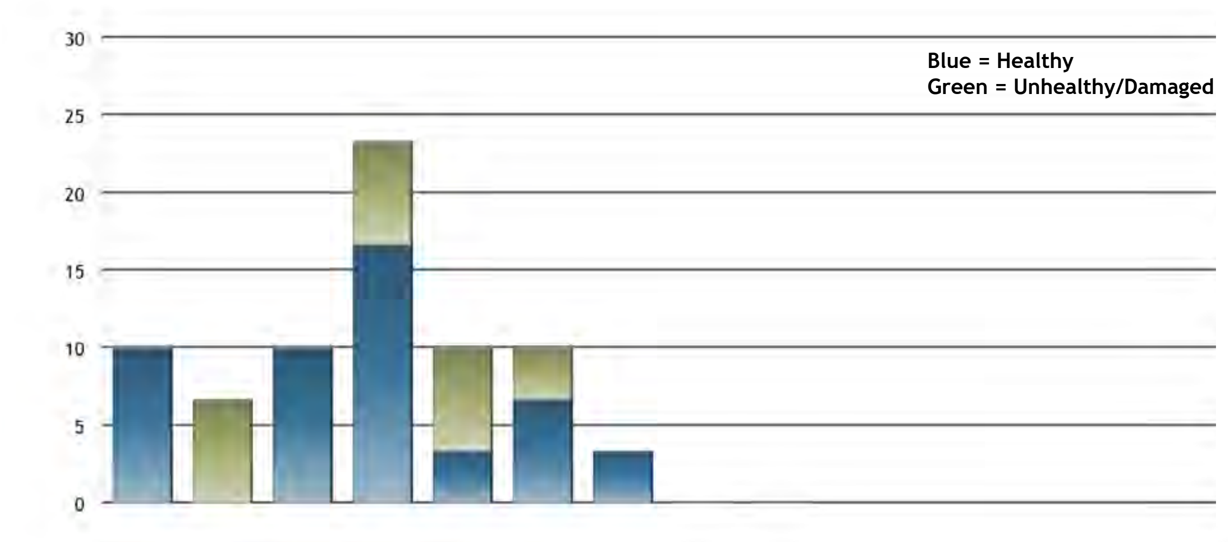
	BA		TPA		AVG MHT	VOLUME PER ACRE MBF	VOLUME PER ACRE CORDS	TOTAL STAND VOLUME MBF	TOTAL STAND VOLUME CORDS
	73.3		154.2		15.9	` 0.89	7.09	4.29	34.01
red maple	63.3	86.4%	141.1	91.5%	15.2	0.24	6.43	1.13	30.89
Northern red oak	3.3	4.5%	2.7	1.8%	32.0	0.34	0.14	1.63	0.66
green ash	3.3	4.5%	4.2	2.8%	32.0	0.32	0.13	1.52	0.64
black gum	3.3	4.5%	6.1	4.0%	16.0		0.38		1.83

STAND BASAL AREA

STAND 3 Forested Wetlands BA 73.3 TPA 154.2 Sampling Method: Variable Radius Plots

ACRES 4.8 Basal Area Factor: 10.00 3 PTS

BASAL AREA (ft2)
BY DBH



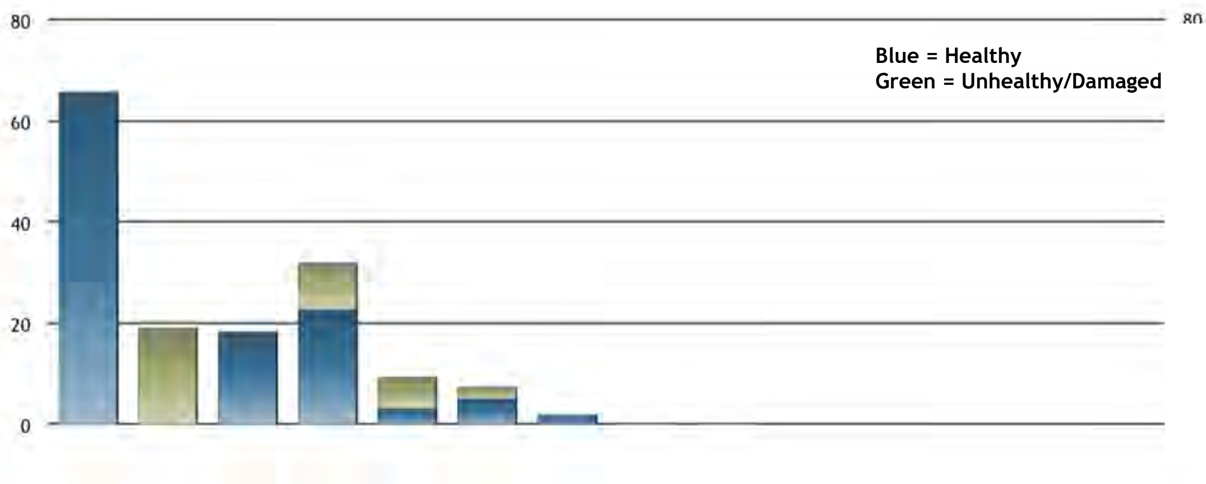
	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
red maple	40.0	10.0		6.7	13.3	3.3	3.3	3.3							
Northern red oak	3.3						3.3								
green ash	3.3				3.3										
black gum	3.3			3.3											
Healthy	50.0	10.0		10.0	16.7	3.3	6.7	3.3							
Unhealthy															
red maple	23.3		6.7		6.7	6.7	3.3								
Unhealthy	23.3		6.7		6.7	6.7	3.3								
TOTAL	73.3	10.0	6.7	10.0	23.3	10.0	10.0	3.3							

TREES PER ACRE

STAND 3 | Forested Wetlands | BA 73.3 | TPA 154.2 | Sampling Method: Variable Radius Plots

ACRES 4.8 | Basal Area Factor: 10.00 | 3 PTS

TREES PER ACRE BY DBH



	TOTAL	6	8	10	12	14	16	18	20	22	24	26	28	30	32+
Healthy															
red maple	104.1	65.9		12.2	18.6	3.1	2.4	1.9							
black gum	6.1			6.1											
green ash	4.2				4.2										
Northern red oak	2.7						2.7								
Healthy	117.1	65.9		18.3	22.8	3.1	5.1	1.9							
Unhealthy															
red maple	37.0		19.1		9.3	6.2	2.4								
Unhealthy	37.0		19.1		9.3	6.2	2.4								
TOTAL	154.2	65.9	19.1	18.3	32.1	9.4	7.5	1.9							

Oak Resiliency Assessment Report

Report generated on: 01/17/2026

Access the Oak Resiliency Assessment Tool at www.uvm.edu/femc/oak_resiliency

Learn more about the Oak Resiliency in Southern New England Project at https://foreststewardsguild.org/oak-resiliency/

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Assessment of Adaptive Capacity 4

Oak Resiliency Assessment Report

Report Summary

Overall Site Vulnerability

Moderate
Vulnerability

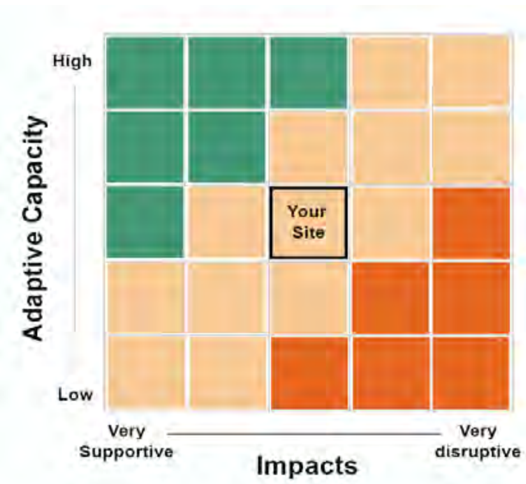
Score Feedback

Your Overall Site Vulnerability is **moderate** based on your rankings of Impact and Adaptive Capacity scores.

Your Impact ranking is **moderate** and your Adapative Capacity rating is **moderate**.

Below you will see potential pathways for management of your oak stand(s) and issues of concern that may need to be addressed.

Site Range



Issues of Concern

Invasive Species Management
Competition
Drought
Extreme Precipitation
Extreme Weather Events

Potential Pathways

Resistance actions are designed to work against the effects of climate change and maintain the forest in its current condition. You can find potential resistance pathways for your site here: www.uvm.edu/femc/oak_resiliency/path_resistance

Resilience actions focus on increasing the capacity of the ecosystem to cope with climate change and other stressors while maintaining its fundamental character. You can find potential resilience pathways here: www.uvm.edu/femc/oak_resiliency/path_resilience

Transition actions intentionally accommodate ecosystem change, rather than resist it. These actions work to move forests toward conditions that are expected to be better adapted to future conditions. You can find potential transition pathways for your site here: www.uvm.edu/femc/oak_resiliency/path_transition

No action - Landowners and forest managers can intentionally decide to take no action in managing their forests. You can find potential no action pathways for your site here:www.uvm.edu/femc/oak_resiliency/path_noaction

Oak Resiliency Assessment Report

Site Description

Acres: 45.7

Location: 41.3549, -72.1217

Site Description: Bates Woods Park stands out as the most recognizeable component of a large forested buffer between densely developed, long-settled neighborhoods of New London and a newer, lower-density residential area of Waterford to the west. Much of area located along the muncipal boundary immediately southeast of the park is forested wetlands that are relatively inaccessible to humans. Only the 15-acre northwestern section of the park with frontage on Chester Street is developed. A paved road from the parking lot off Chester Street extends through a mostly wooded landscape to another gate (providing access from Ashcraft Road) at the northeast corner, dividing the woods into northern and southern sections. South of this road, a public water utility aqueduct pipeline that transports water from reservoirs west of the city to the main urban service area also passes through the park. A standout feature of the undeveloped section of the park is the large variation in topography within a relatively small area. The elevation in the park ranges from approximately 150 feet above sea level in the northwest corner to 50 feet in the wetlands near the southern edge. Several rocky ridges and knobs with a general north-south orientation contrast with small valleys that include two small ponds and two wetlands that drain into ephemeral streams in the low-lying areas. Overall, the terrain on the north side of the road is higher in elevation, rockier, and more undulating than that on the south side. The southern portion of the park includes forested wetlands at the northern edges of the larger wetland complex extending to the southeast. Off the property, these wetlands drain into Fenger Brook. The 46-acre Bates Woods forest that gives the park its name is dominated by mature oak-hardwood forest with old trees. Soils and distance to bedrock influence vegetation: most of the largest trees are in the valleys and on lower slopes, while the canopy has a lower height and is slightly more open on ridges and near ledges. The dominant canopy species are Northern red, black, and white oak, with significant secondary components of red maple and black birch (also known as sweet birch), while a fairly wide range of other species are present. Interspersed at irregular intervals are occasional older legacy trees, almost certainly more than 150 years old, with spreading crowns indicating that they grew in open canopy conditions. Most of these older trees show signs of decay and damage due to their advanced age. Primarily because of their location, these woodlands have high conservation value but known land use history rules out the presence of old-growth forest. All of the forest appears to have been altered and shaped by past land uses.

Assessment of Impacts

Below is the assessment of the site's vulnerability to a variety of different disturbances and climate-related impacts

Increase in extreme precipitation events: Somewhat Disruptive (4)

Increases in storm frequency and intensity: Somewhat Disruptive (4)

Elevated drought risk: Somewhat Disruptive (4)

Elevated risk of wildfire: Somewhat Supportive (2)

Increases in insect pests and forest pathogens: Moderate (3)

Increases in invasive plants: Very Disruptive (5)

Degree affected by deer and other herbivores: Somewhat Supportive (2)

Reduced habitat for some northern tree species: Very Supportive (1)

Higher sea levels: Somewhat Supportive (2)

Damage to forest roads and trails: Somewhat Disruptive (4)

Overall impacts score: Moderate (3)

Assessment of Adaptive Capacity

Below is the assessment of the site's adaptive capacity, or how well it might tolerate impacts without undergoing significant change, based on a variety of characteristics.

Legacy of past land use: Somewhat Low (2)

Level of landscape connectivity: Very Low (1)

Tree health and density: Moderate (3)

Species and structural diversity: Somewhat Low (2)

Level of competition with more shade-tolerant species: Somewhat Low (2)

Degree affected by invasive plants: Very Low (1)

Abundance of species adapted to current and expected conditions: Very High (5)

Regeneration potential: Somewhat Low (2)

Stewardship planning and implementation capacity: Moderate (3)

Overall adaptive capacity score: Moderate (3)

Issue of Concern: Invasive plants

There is considerable potential for increased establishment and vigor of non-native, invasive species under the influence of climate change. Invasive species exploit unstable conditions resulting from the combined stress of multiple climate-related disturbances, and novel invasive species may expand their range into the Northeast under future climate conditions. These factors will vary geographically, by forest community, and over time, and will likely depend heavily on human influence both in terms of treatment and introduction. Various forest adaptation practices may stop invasions before they start, and reduce impacts following establishment.

Climate Change Impacts

The Northeast is a potential hotspot of invasion under projected future climate conditions, with a large increase in the variety of invasive species expected (Bellard et al. 2014). Forest managers and the landowners in the region are likely already familiar with many of the invasive species that have established in upland forests, such as barberry, multi-flora rose, bittersweet, and non-native species of honeysuckle and buckthorn. Though there is substantial uncertainty about which invasive plant species will benefit most and at which sites (Merow et al 2017), models indicate that species with invasive characteristics will disproportionately benefit from projected climate changes due to broad environmental tolerances, extended periods of leaf-out, more effective exploitation of changed environments, and more aggressive colonization of new areas (Dukes et al. 2009, Fridley 2012, Hellmann et al. 2008, Willis et al. 2010, Wolkovich et al. 2014).

Forests that have experienced an increase in disturbances such as flooding, ice storms, or drought, are especially susceptible to higher levels of colonization by invasive plant species. This compromises the adaptive capacity of the forest by limiting the regeneration and planting success of native and desired tree species, and could hinder other management strategies (Wiedlich et al. 2020, Link III et al. 2018). Potential declines in native plants may also provide opportunities for new invaders to fill vacated niches or existing invaders to exploit fluctuating resources (Finch et al. 2021). Additionally, there are invasive species that could expand their ranges in response to climate conditions and become problematic in areas they have not previously been found. One such example is the elmleaf blackberry, which is already invasive farther south in Delaware and Maryland, and forms dense thickets that are capable of excluding other shrubs and understory plants, as well as hindering overstory regeneration (Bradley et al. 2020).

Invasive species can create a host of problems within the ecosystems where they become established. The dominance of even a few new species reduces both the native species and structural diversity of stands, rendering them more vulnerable to future impacts (Hejda et al. 2009; Jäger et al. 2009). Both reed canary grass and Japanese barberry, for example, have demonstrated the ability to reduce native species' regeneration through ground cover dominance, resource competition, and even altered hydrology (Weilhoefer et al 2017; Kurtz & Hansen, 2014; Gebauer et al. 2014; Kurtz & Hansen, 2018; Miniat et al. 2021). Replacement of native species typically reduces the habitat value for wildlife and pollinators, which can contribute to other new stressors to threaten more organisms than just those in direct competition (Burghardt 2010, Tallamy 2009; David et al. 2017).

Invasive species can sometimes fundamentally alter the character of the sites they invade. In riparian areas and on slopes, invasives can increase soil erosion, sedimentation of streams, and degradation of aquatic habitat (Seavy et al. 2009). If sufficiently dominant, they can also alter the fire regimes of the ecosystems they invade, potentially altering the system permanently, and in some cases leading to more severe wildfire (Dibble et al. 2007; Brooks et al. 2006).

Some uncertainties that remain regarding the potential future impact of invasive plant species include: which current and/or novel invasive species will thrive at specific sites, whether climate change will support or hinder a given invasive species, and whether a given invasive species will irrevocably alter a site, or if it can assimilate to the native ecosystem (Merow et al 2017).

Adaptation Actions for Forests

Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Site Condition	Adaptation Approaches	Example Adaptation Actions
Invasive plants not currently present or abundant	● Reduce the impact of biological stressors ● Reduce competition for moisture, nutrients, and light ● Promptly revegetate sites after disturbance ● Guide changes in species composition at early stages of stand development	● Monitor for known or potential invasive species to ensure early detection, especially at trailheads, along roads, and along other pathways known for infestation ● Eradicate existing populations or seed sources (e.g., upstream) of invasive plants through physical or chemical treatments ● Clean equipment before and after forest operations to prevent the spread of invasive plants during site preparation, harvesting, or other activities ● Reroute roads or trails away from at-risk communities to reduce the risk of introducing invasive species ● Maintain closed-canopy conditions to reduce the ability of light-loving invasive species to enter the understory ● Plant desired species immediately following a disturbance or management activities ● Educate staff and volunteers on identification and eradication of current and potential invasive species. ● Use herbicide or mechanical thinning to prevent the encroachment of woody

		competitors and invasive species, especially after disturbance
Invasive species are fundamentally changing the composition of the forest	• Maintain and restore diversity of native species • Restore or maintain fire in fire-adapted ecosystems • Prioritize and maintain sensitive or at-risk species or communities • Realign significantly disrupted ecosystems to meet expected future conditions	• Use natural or prescribed fire to restore the open character of oak woodlands and glades • Eradicate invasive species in order to minimize competition with desired species • Favor oak, pine, and other more drought- and heat-tolerant species on sites that are expected to become warmer and drier • Allow nonnative invasive to remain as part of a novel mix of species, rather than eradicating these species

On-the-Ground Examples

- Mass Audubon's Elm Hill Forest Management Project
  - Managers at this 1,000-acre wildlife sanctuary are mapping and prioritizing the treatment of invasive plants including multiflora rose, Japanese barberry, Japanese knotweed, common buckthorn, glossy buckthorn, burningbush, honeysuckle, goutweed, and Asian bittersweet.
- Mount Philo State Park: Climate Change and Rare Plants
  - This State Park in Vermont is home to many rare plant species, but managers are concerned that longer growing seasons and the park's popularity among the public will lead to increases in invasive plant species. Management actions are being taken to prevent the introduction and establishment of invasive plant species.

Potential Monitoring Items

- Presence/absence of invasive species
- Encroachment of invasive plants into a new area or rate of spread from a current infestation
- Percent coverage by invasive species
- Level of desired tree regeneration in area with invasive species present

Additional Resources

- The Northeast Regional Invasive Species & Climate Change (RISCC) Management Network synthesizes relevant science, and serves as a resource for scientists and managers.

- The Invasive Plant Atlas of New England's (IPANE) acts as a database of invasive and potentially invasive plants in New England that is updated by professionals and trained volunteers. Users can submit suspected invasive species to aid in the early detection of, and rapid response to, new invasions.
- The North American Invasive Species Management Association offers training, membership, and collaboration to professionals managing invasive species.
- Mass Audubon's page on invasive species offers reports and specific information about the invasive species that threaten the region.

Issue of Concern: Extreme Precipitation & Weather Events

Extreme precipitation and more frequent and intense weather events are expected in the Northeast throughout the next century. An increase in these phenomena has the potential to impact the species composition and structure of forests, as well as their soils and hydrology. Where forests are used for recreation, damage from extreme precipitation and weather events can create hazards and increase the need for costly safety interventions. A variety of forest adaptation practices may be able to prevent or ameliorate the negative impacts of increasingly extreme precipitation and storm damage on forest ecosystems.

Climate Change Impacts

Climate change is resulting in a number of changes to precipitation and weather patterns. Between 1901 and 2014, total annual precipitation increased by 7% in the northeastern U.S. (Huang et al. 2017). Because of rising temperatures, a greater proportion of precipitation is arriving as rain rather than snow; heavy rainfall events, which have become substantially more frequent and severe across the region over the last century, are expected to continue increasing (Huang et al. 2017, Easterling & Kunkel et al. 2017, Spierre and Wake 2010). The Northeast in particular has seen a greater increase in heavy precipitation events than any other part of the country, with the amount of precipitation coming in extreme events increasing by 41% between 1901 and 2014 (Huang et al. 2017). The fall season has exhibited the largest increase in precipitation, followed by spring (Easterling et al. 2017).

Extreme precipitation and intense storm events can negatively impact forest ecosystems in a variety of ways, and the effects will depend on site-specific characteristics, such as the current health of the forest, its topography, and location within the landscape. Heavy rain events can lead to intense erosion—resulting in soil loss and sedimentation in nearby streams—as well as flooding, which can damage trees by breaking stems and limbs (Groffman et al. 2014, Furniss et al. 2010). The increased occurrence of these heavy rain events in fall and spring, when there is little to no vegetation to intercept excess precipitation, can lead to greater erosion in forests and riparian areas.

A variety of storm types occur in the region, including thunderstorms, ice storms, tropical cyclones and hurricanes, and nor'easters (Kunkel et al. 2013). Potential impacts from storms include tree damage and mortality, altered forest structure, and altered tree species composition and diversity (Xi and Peet 2011, Holzmueller et al. 2012). Winter ice storms can be particularly damaging, and are expected to become more severe (Klima & Morgan 2015, Campbell et al. 2020). The accumulation of ice on trees can lead to extensive damage to tree limbs, especially in oaks and other species with wide crowns and secondary trunks (Turcotte et al. 2012). High wind events in oak dominated forests within the midwest and central Appalachians have accelerated successional transition, where high levels of damage and mortality in the overstory oak allow for the abundance of shade-tolerant species in the understory, such as red maple and American beech, to dominate (Holzmueller et al. 2012). Fire exclusion from oak dominated forests due to suppression efforts has also contributed to this successional transition.

Forests stressed by other disturbances are likely to be more vulnerable to impacts from extreme precipitation and weather events. For instance, where vegetative cover is reduced by disturbance events such as pest infestations or wildfire, the forest is more susceptible to erosion during extreme precipitation. Likewise, forests impacted by extreme precipitation and weather are likely to be more vulnerable to other disturbances; physical damage to trees can leave them more susceptible to negative impacts from forest pests and diseases (Janowiak et al. 2018).

These conditions also make it more challenging to conduct forestry operations while minimizing impacts on soil and water resources. Decreased climate stability could lead to less predictable seasonal planning of harvesting activities, which could in turn increase logistical costs and enforcement considerations (Giesler et al. 2016, Janowiak et al. 2018). These events can compromise stream crossings, which hinders operations and can negatively impact water quality and aquatic organisms (Gillespie et al. 2014, Boston 2016).

Adaptation Actions in Forests

Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Site Condition	Adaptation Approaches	Example Adaptation Actions
Steep slopes and/or unvegetated areas are susceptible to erosion	• Reduce soil erosion and sediment deposition • Respond to or prepare for excessive overland flows (surface runoff)	• Strategically place downed wood to deflect, slow and pool overland flow water as snow melts over saturated soils and frozen soils • Use wattles and water bars to slow overland flow water velocity and increase retention and recharge into soils • Create anchors with fabric, wire, or natural materials to stabilize eroding stream banks
Trees are exposed to wind and storms due to topography, landscape position, and/or previous harvesting practices	• Alter forest structure to reduce severity or extent of wind and ice damage • Promptly revegetate sites after disturbance	• Thin in order to alter forest composition and structure for increased resistance to blowdown or ice damage • Create canopy gaps that have an orientation and shape informed by the prevailing winds to reduce the risk of windthrow
Harvest operations may exacerbate soil and hydrology impacts	• Maintain and enhance infiltration and water storage capacity of forest soils	• Decommission or temporarily close roads to reduce erosion and

	• Maintain or restore hydrology • Reduce impacts to soils and nutrient cycling	sedimentation and to restore permeability and soil hydrology • Incorporate ecologically based stream crossing designs that allow passage for aquatic organisms

Adaptation Actions in Streams and Adjacent Riparian Areas

Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Site Condition	Adaptation Approach	Example Adaptation Action
Stream edges are unstable or susceptible to erosion and failure during extreme events	• Maintain and restore hydrologic connectivity • Maintain and restore stream channel form and function • Maintain and restore floodplain connectivity • Reduce soil erosion and sediment deposition	• Install large wood additions into streams to improve habitat structure, increase stream complexity, and maintain or improve thermal refugia • Stabilize banks along the main stem of a waterway to prevent further erosion, sedimentation, and bank failure • Use wood additions and other modifications to reconnect the river to its natural forest floodplain

On-the-Ground Examples

- Massachusetts Dept. of Conservation & Recreation: Protecting Riparian Zones with a Focus on Stream Crossings
    - Many of the culverts for streams that enter the Deerfield River within the South River State Forest have already failed or are threatened by increasingly heavy precipitation events. Managers are removing failing culverts and replacing them with bridges, while ensuring stream connectivity and a naturalized stream bottom.
- Franklin Land Trust: Crowningshield Conservation Area Habitat Restoration Project
    - Managers with the Franklin Land Trust are improving conditions on a farm that includes a tributary of the Deerfield River. They are stabilizing banks along the main stem of the river to prevent further erosion, sedimentation, and bank failure, as well as adding large wood to the river to help reconnect it to its natural forest floodplain.

Potential Monitoring Items

- Frequency of intense precipitation and storm events
- Tree damage and mortality after extreme weather
- Streambank erosion and changes in water quality

Additional Resources

- CoCoRahs is a grassroots volunteer network of backyard weather observers of all ages and backgrounds working together to measure and map precipitation (rain, hail and snow) in their local communities.
- The Northeast River Forecast Center produces Quantitative Precipitation Forecasts that can be useful to track during significant rainfall events or times of increased flood potential.
- Emergency Erosion Control on Private Forest Land trials are being conducted by the University of New Hampshire.
- The USDA Northeast Climate Hub hosts information and cost analysis related to storms and stream-crossings.

Issue of Concern: Competition with shade-tolerant species

Some oak forests in the Northeast are experiencing a gradual shift in species composition toward more mesic, fire-intolerant, and shade-tolerant tree species. Many interacting factors are understood to be driving this trend, though it is difficult to determine which are the most influential. Where sustaining oak forest is desired, a variety of adaptation practices may reduce the increasing dominance of these competing species.

Climate Change Impacts

Factors understood to be facilitating a shift toward increased dominance of competing species in the oak forests of Eastern North America include fire suppression and land use across the region, a long-term increase in wetter conditions, and herbivory (Nowacki & Abrams 2008, McEwan et al. 2011, Knott et al. 2019). The tree species that are becoming more dominant in some eastern oak forests as a result of these factors include sugar and red maple, birch, hemlock and American beech (Nowacki & Abrams 2008, Knott et al. 2019).

Fire suppression in oak-dominated forests is considered one of the major drivers of this shift. Evidence from early town proprietor surveys indicates that prior to colonization, more mesic species were rare within the oak- and chestnut-dominated forests of southern New England, with the exception of areas near rivers, lakes or the coast (Cogbill et al. 2002). There is evidence that fire was used as a land management tool by Native Americans in eastern deciduous forests, and that fire was also common on the landscape during early European colonization; however, frequent fires were effectively eliminated around 1940, coinciding with the start of a period of intense maple establishment (McEwan et al. 2011). Without the canopy-opening fire disturbances that are historically characteristic for oak-dominated forests of eastern North America,species less tolerant of fire are better able to proliferate. Red maple, in particular, has been found to alter forest hydrology and nutrient cycling in a way that reduces the overall flammability of the forest and perpetuates conditions more conducive to other mesic, shade-tolerant species (Alexander & Arthur 2014).

Despite the fact that species distribution projections indicate that oak will generally be favored under climate change scenarios (Iverson et al. 2017), certain climate change impacts could create conditions that contribute to a successional transition toward more shade-tolerant species. The substantial increase in precipitation in the Northeast over the last century has already contributed to the establishment of more mesic species in oak forests (McEwan et al. 2011), and annual precipitation is expected to continue increasing, though soil moisture patterns will ultimately depend on location as well as the impacts of increasing drought (Easterling et al. 2017). More physical disturbances to the overstory due to extreme storm events associated with climate change could also release more mesic, shade-tolerant species that may have come to dominate the understory (Janowiak et al. 2018).

Certain land uses have been identified as contributing to the transition of oak-pine forests toward shade-tolerant species. Frequent and intensive overstory tree removal allows for red maple, which establishes competitively after harvest, to monopolize growing space (Hanberry 2019). However, the extent to which shade-tolerant species could ultimately populate the overstory of oak-dominated forests is ultimately still uncertain, and will depend on the frequency and intensity of harvest, as well as management decisions related to fire.

Adaptation Actions for Forests

Additional actions are described in the [Adaptation Strategies and Approaches for Forests].

Site Condition	Adaptation Approaches	Example Adaptation Actions
Species competition leading to composition change	• Reduce competition for moisture, nutrients, and light • Guide changes in species composition at early stages of stand development	• Thin forest stands to remove crowded, damaged, or stressed trees to reduce competition for light, nutrients, and water • Use prescribed fire to maintain growing space for fire-tolerant species or to increase nutrient turnover • Control beech regeneration in areas affected by beech bark disease to reduce competition with the regeneration of other species • Plant or seed sufficient stocks of desired species before undesirable species become established • Use timber stand improvement to favor and promote the growth of desirable growing stock
Altered disturbance regimes favor other species	• Restore or maintain fire in fire-adapted ecosystems • Promptly revegetate sites after disturbance • Favor or restore native species that are expected to be adapted to future conditions • Promptly revegetate sites after disturbance • Realign significantly disrupted ecosystems to meet expected future conditions	• Use prescribed fire to reduce ladder fuels, invasive species, and understory competition • Promote fire- and drought-adapted species and ecosystems in areas that are expected to have increased fire risk as a result of climate change • Use natural or prescribed fire to restore the open character of oak woodlands and glades • Shift prescribed burn seasons to align with projected seasonal precipitation changes, thereby reducing the risk of unintended wildfire conditions • Create suitable physical conditions for natural regeneration through site preparation, for example by chaining after a burn to promote seed establishment

		• Monitor areas of natural regeneration more frequently, and prioritizing planting or seeding where natural regeneration is slow to succeed • Plant larger individuals (e.g., saplings versus seedlings) to help increase survival • Favor or establish oak and other more drought- and heat-tolerant species on sites that are expected to become warmer and drier
Stressors limit oak vigor, regeneration, and recruitment	• Maintain or improve the ability of forests to resist pests and pathogens • Manage herbivory to promote regeneration of desired species	• Use pesticides or biological control methods to manage pest populations (e.g., gypsy moth) in heavily infested areas • Apply repellant or install fences, bud caps, and other physical barriers to prevent herbivory • Use tree tops from forest harvest or plantings of unpalatable tree species as locations for "hiding" desirable species from herbivores to reduce browse pressure • Partner with state wildlife agencies to monitor herbivore populations or reduce populations to appropriate levels

On-the-Ground Examples

- Providence Water: Planting Future Adapted Forests
    - The forests surrounding Providence's Scituate Reservoir provide clean water to over 600,000 people, or two-thirds of all Rhode Islanders. Challenges to northern hardwood regeneration ultimately threaten water quality. Managers are experimenting with actions that promote a variety of oaks and other species that are expected to be better adapted to future conditions.
- Massachusetts Dept. of Conservation & Recreation: Protecting Riparian Zones with a Focus on Stream Crossings
    - Many of the culverts for streams that enter the Deerfield River within the South River State Forest have already failed or are threatened by increasingly heavy precipitation events. Managers are removing failing culverts and replacing them with bridges, while ensuring stream connectivity and a naturalized stream bottom.

Potential Monitoring Items

- Density of more mesic, fire-intolerant, and/or shade-tolerant species in the understory
- Species diversity of regeneration in areas of recent disturbance

Additional Resources

- The Oak Woodlands & Forests fire consortium hosts a webinar recording on mesophication
- Oak, Fire, and Global Change in the Eastern USA: What Might the Future Hold? article in *Fire Ecology*

Issue of Concern: Drought

An increase in the frequency and severity of drought within Northeastern forests is expected over the next century due to climate change. The implications of this increase in drought conditions for forest ecosystems are complex and dependent on site-level characteristics. Moisture stress can hinder regeneration and alter the composition of a forest by impeding germination and establishment, and contributing to tree mortality. Stress created by drought conditions also increases the vulnerability of a forest to secondary impacts such as insect and disease outbreaks, and increased wildfire risk. Evidence supports that a variety of forest adaptation practices may prevent or ameliorate the negative effects of increasingly frequent and severe drought.

Climate Change Impacts

As rates of evapotranspiration increase with rising temperatures, moisture stress and drought conditions will occur more frequently if they are not offset by a corresponding increase in precipitation and soil moisture (Hayhoe et al. 2007, Kunkel et al. 2013). Modeling results suggest a much greater potential for more frequent droughts and moisture stress during the growing season when climate models project both much warmer temperatures and reduced summer precipitation in the Northeast. Even when precipitation is not projected to change substantially, warmer temperatures are also predicted to contribute to increased evapotranspiration and physiological stress if increases in precipitation do not correspond to temperature increases (Janowiak et al. 2018, Lynch et an 2016; Peters and Iverson 2019).

Moisture stress can negatively impact forest ecosystems in a variety of ways, and the potential effects will depend on many factors, including the duration and severity of the drought and site-level characteristics of the forest. Prolonged and/or severe drought conditions may contribute to tree dieback and mortality, particularly as these conditions interact with other forest stressors (Clark et al. 2019). Although mature trees are better able to resist increases in temperature and reductions in available moisture, severe or sustained drought can increase tree mortality, open the forest canopy, alter forest growth and composition, and increase susceptibility to other stressors (Clark et al. 2016, Dale et al. 2001, Millers et al. 1989, Pederson et al. 2014). Drought during the past century has been linked to dieback in sugar maple and some species of birch (Auclair et al. 2010), as well as a decline of oak and ash trees in the Northeast (Millers et al. 1989, Mohan et al. 2009).

Interactions between drought and other disturbances increase the likelihood of tree dieback and mortality (Coble et al. 2017). While purely drought induced mortality events are rather rare in the Northeast, moisture stressed trees are more vulnerable to disturbances, particularly insect pests and diseases (Dale et al. 2001, Millar and Stephenson 2015, Ryan and Vose 2012). Additionally, drought conditions can hinder forest recruitment and regeneration. Germination, establishment, and early seedling survival depend on early-season moisture, and can be limited by drought. When moisture is limited over successive years, the fecundity of adult trees may also be significantly reduced, as greater seed production is correlated with high levels of soil moisture (Clark et al. 2019).

Within oak forests, the dominant species are considered to be relatively drought tolerant and may potentially benefit from or at least endure future drought conditions. However, there are complexities that imply these forests may still be vulnerable. The ability of oak forests to cope with drought conditions may be hindered as species composition shifts toward more drought-intolerant species such as beech and maple. Impacts will be species-specific and are likely to vary based on the timing of drought within the growing season;

for instance, recent research indicates that *Quercus alba* may be particularly sensitive to low water availability early in the growing season (Fung Au et al. 2020).

There are still some uncertainties regarding the potential future impact of drought on forests in the Northeast. Approaches to drought risk assessment are variable and in many cases lack future scenario modelling. Additionally, there is a lack of agreement on drought risk assessment methods (Hagenlocher et al. 2019).

In the eastern US, the effects of increasing drought are becoming better understood at the level of individual trees, but this knowledge cannot yet be confidently translated to predictions of changing structure and diversity of forest stands (Clark et al. 2016).

Adaptation Actions for Forests

Additional actions are described in Adaptation Strategies and Approaches for Forests.

Site Condition	Adaptation Approaches	Example Adaptation Actions
Presence of drought prone soils	• Reduce competition for moisture, nutrients, and light • Maintain or restore hydrology • Favor or restore native species that are expected to be adapted to future conditions	• Thin to improve moisture availability for residual trees • Install berms or dikes to divert surface water to an area affected by decreased precipitation • Favor or establish oak, pine, and other more drought- and heat-tolerant species on narrow ridge tops, south-facing slopes with shallow soils, or other sites that are expected to become warmer and drier
Tree species present are more vulnerable to drought	• Restore or maintain fire in fire-adapted ecosystems	• Promote species that are tolerant of drought conditions • Use prescribed burning to promote fire and drought adapted species
High levels of tree mortality on a drought-prone site	• Favor existing genotypes that are better adapted to future conditions • Introduce species that are expected to be adapted to future conditions	• Plant stock from seeds collected from local trees that exhibit drought tolerance • Plant oaks, pines, and other drought-tolerant species on sites within the current range that are expected to become drier and that

		have not been historically occupied by those species

On-the-Ground Examples

- Massachusetts Department of Conservation & Recreation: Bristol Lot Timber Sale
    - Drought conditions have limited the effectiveness of a soil borne fungus that controls *Lymantria dispar*, making this oak-dominated stand highly susceptible to further heavy defoliation and mortality. In addition to planting blight-resistant American chestnut, managers are encouraging a mix of species, age classes, and stand structures to reduce the availability of host species for pests and pathogens.
- Florence County: Climate-informed Forest Restoration
    - A combination of drought and forest pests have resulted in a 90% mortality rate of trees within this 400 acre area. Managers are identifying healthy pockets of scrub oak and northern red oak to preserve, and planting jack pine, red pine, bur oak, and juneberry, as well as white pine and swamp white oak in riparian areas.

Potential Monitoring Items

- Record and report various drought conditions and impacts via the National Drought Mitigation Center's Drought Condition Monitoring Observation and Reports impact reporter.
- Learn how to assess local precipitation conditions and report them via the Community Collaborative Rain, Hail & Snow Network's (CoCoRaHS) reporting system and map.

Additional Resources

- Access drought forecast and severity ratings via the United States Drought.gov - Northeast webpage.
- Access a variety of drought and precipitation indices via the Northeast Drought Early Warning System webportal.
- Access past drought reports, a drought impact map, and official drought plans for each state through the National Drought Mitigation Center.

Pathway: Resistance

Resistance actions are designed to work against the effects of climate change and maintain the forest in its current condition. In this way, resistance actions can be seen as “playing defense” in trying to prevent changes from occurring. When forests have low vulnerability to climate change, it may be relatively easy to maintain the current forest condition while climate change impacts are minimal. However, as changes in climate intensify and impacts and as vulnerabilities increase, the resistance pathway becomes increasingly challenging. Although resistance actions may be appropriate for defending high-risk or high-value resources in the short term, such as rare species or unique habitats, these actions may require considerable time and resources to maintain effectiveness, ultimately becoming too costly to implement. Additionally, climate change may cause conditions in some areas to fundamentally change so that the resistance pathway is no longer feasible.

It is important to consider site-level vulnerability when deciding whether to pursue this pathway. Based on your assessment responses, your site has **moderate vulnerability** to climate change.

Forests with **moderate** vulnerability may be experiencing impacts from climate change or other stressors. These stressors may create challenges for resisting changes and maintaining current conditions into the future, particularly if pressures increase over time. Resistance actions can focus on reducing the impacts from current and future stressors in the short-term; in the long term, resistance actions may require more effort to remain effective.

In southern New England oak forests, **resistance** actions may have the best chance of success in forests that are currently in good condition and have relatively low levels of risk from climate change and other forest disturbances. You may want to compare this option with the **resilience** and **transition** pathways to determine what option best meets your management goals and objectives, particularly if your forest is already being stressed by invasive species, drought, pests, or other stressors.

Actions for Forests Health and Productivity ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide wood products and other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Condition	Adaptation Approach	Example Action
Ecosystem contains a high-quality native plant community or is of high conservation value	▪ 4.1 Prioritize and maintain unique sites ▪ 4.2 Prioritize and maintain sensitive or at-risk species or communities ▪ 5.4 Establish reserves to maintain ecosystem diversity	▪ Identify area for passive management (no harvest) reserve area when consistent with landowner goals and site capability ▪ Implement forest harvests at lower intensities (e.g., light

		thinning) to maintain desired composition
Invasive plants are present at low levels or nearby.	▪ 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species	▪ Remove existing invasive species with mechanical treatment to promote the current plant community ▪ Use monitoring to support early detection and rapid response to eliminate new infestations
Site exposed to wind	▪ 3.3. Alter forest structure to reduce severity or extent of wind and ice damage.	▪ Use thinning or other silvicultural treatment to reduce tree density and increase the windfirmness of the residual trees
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.1. Maintain or improve the ability of forests to resist pests and pathogens. ▪ 1.4. Reduce competition for moisture, nutrients, and light.	▪ Thin trees or release crop trees to reduce tree density
Forest regeneration is desired; advance regeneration is dominated by maple, black birch or other mesic species	▪ 5.1. Promote diverse age classes. ▪ 5.2. Maintain and restore diversity of native species. ▪ 8.2. Favor existing genotypes that are better adapted to future conditions. ▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development.	▪ Harvest using shelterwood system to release crowns of overstory trees, tend advance regeneration, and allow for new regeneration ▪ Create reserves within harvest areas to protect rare species, sensitive sites, and topographically protected areas ▪ Retain cavity trees and down wood
Forest regeneration is desired; advance regeneration is primarily oak	▪ 5.1. Promote diverse age classes. ▪ 5.2. Maintain and restore diversity of native species. ▪ 8.2. Favor existing genotypes that are better adapted to future conditions.	▪ Use group selection, patch cuts, or final shelterwood cut to release oak regeneration ▪ Retain underrepresented species to increase diversity, emphasizing species expected to be suitable for future conditions ▪ Retain cavity trees and down wood
Forest regeneration is desired; no	▪ 8.1. Use seed, germplasm, and other genetic material from	▪ Harvest using shelterwood system to release crowns of overstory trees and

advance regeneration or lack or regeneration following harvest	across a greater geographic range	create light conditions favorable for regeneration ▪ Create reserves within harvest areas to protect rare species, sensitive sites, and topographically protected areas ▪ Plant existing oak species using seed stock from southerly populations (e.g., Mid-Atlantic states) for artificial regeneration ▪ Retain cavity trees and down wood

Actions for Wildlife ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for wildlife habitat. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Wildlife (in review).

Condition	Adaptation Approach	Action
Forest lacks age class or structural diversity	▪ 8.1. Manage for plant species diversity and complexity	▪ Emphasize size class diversity and patchiness during forest harvests
Rare or sensitive species are present (e.g., plants, turtles)	▪ 8.4. Manage and create suitable microhabitats and microclimates ▪ 10.3. Select reserves that maximize biodiversity protection for a suite of species ▪ 10.7. Protect climate refugia across the landscape	▪ Protect and create small vernal pools in mesic forests. ▪ Implement forest management actions that promote diverse canopy cover, light environments, down woody habitat, and diversity of tree sizes. ▪ Retain snags of large-diameter trees that can be used as cavity nesting habitat. ▪ Establish reserves in high-quality ecosystems ▪ Buffer cool spots on the landscape that may be slower to change
Raptors present	▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape	▪ Retain trees with multi-limbed tree crotches or "basket forks" in live hardwood crowns during harvest

Actions for Water ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for water resources. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Condition	Adaptation Approach	Action
Riparian areas, vernal ponds, and other sensitive wetlands	▪ 1.5 Maintain and restore forested wetlands and lowland areas	▪ Use conservation easements or other land use restrictions to prevent land use change or development. ▪ Identify areas for no- or low- harvest buffers to reduce potential impacts to these systems ▪ Expand buffer areas around sites that may be more vulnerable to extreme weather and climate change ▪ Identify and manage cooler and wetter locations that are expected to be more resistant to changes in climate as refugia for maintaining native plant communities (e.g. Hemlock) in the future
Areas of low vegetative cover	▪ 3.1 Maintain or restore forest and vegetative cover in riparian areas ▪ 3.2: Promptly revegetate areas after disturbance	▪ Plant native vegetation to slow overland flows and improve water infiltration
Tree mortality in riparian areas	▪ 3.1 Maintain or restore forest and vegetative cover in riparian areas ▪ 3.7: Identify, maintain, and enhance important habitats for fish and wildlife	▪ Prioritize stream restoration activities in areas most likely to retain cool late-summer flows that may buffer the survival of aquatic organisms during extreme weather conditions, and at particular life history stages.
Man-made ponds, embankments, etc.	▪ 3.7: Identify, maintain, and enhance important habitats for fish and wildlife	▪ Use water control structures to maintain the hydrologic function and regulate water levels and open water conditions when necessary for migratory birds and wildlife breeding areas ▪ Remove unnecessary barriers to fish passage, such as check dams or failing culverts

		▪ Retain woody debris and beaver dams in streams when possible to enhance

Actions for Recreation and Forest Roads and Trails ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives related to forest roads and trails used for recreation and other purposes. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Recreation.

Condition	Adaptation Approach	Action
Erosion on forest roads and trails following extreme rain	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Avoid machine or foot traffic in vulnerable areas ▪ Use water bars or increase number used to divert water from road surfaces ▪ Use vegetation or rock armoring along roadsides to minimize erosion and reduce risk of failure
Flooding of forest roads and trails	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Harden surfaces or elevate roads/trails
Water crossings missing or undersized on woods roads	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation	▪ Add or replace stream crossings to enhance drainage ▪ Use vegetation or rock armoring along roadsides to minimize erosion and reduce risk of failure

Actions for Forest Carbon ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide carbon sequestration and storage, along with other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forest Carbon.

Condition	Adaptation Approach	Action
Potential for land use change	▪ 1.1 Avoid forest conversion to nonforest land uses	▪ Use conservation easements or other land use restrictions to prevent land use change or development.

Mix of agriculture and forest lands on property	▪ 1.4 Increase or implement agroforestry practices	▪ Integrate trees and shrubs into agricultural landscapes, such as within riparian buffers
Forest of high conservation value and large trees or healthy, mature forest subject to few stressors	▪ 5.1 Prioritize low-vulnerability sites for maintaining or enhancing carbon stocks ▪ 5.2 Establish reserves on sites with high carbon density	▪ Create no-harvest reserve areas (passive management) when consistent with landowner goals and site capability ▪ Expand buffers around riparian zones, wetlands, or other sensitive sites ▪ Implement forest harvests at lower intensities (e.g., light thinning) ▪ Delay harvest or extend time between forest harvest entries
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.4: Maintain or improve the ability of forests to resist pests and pathogens	▪ Thin to reduce competition for light or soil moisture to enhance resistance to stressors
Forest harvest to meet other management goals (e.g., habitat, timber)	▪ 2.1: Reduce impacts to soils and nutrient cycling ▪ 2.2: Maintain or restore hydrology	▪ Minimize the area (footprint) of forest roads and trails ▪ Alter the timing of forest operations to reduce potential impacts on water, soils, and residual trees, especially in areas that rely on particular conditions for operations that may be affected by a changing climate ▪ Retain coarse woody debris (e.g., tree tops, harvest residue) to maintain soil moisture, nutrients, and enhance soil organic matter pools ▪ Use soil amendments to restore or improve soil quality ▪ Restore native herbaceous groundcover following management activities in order to retain soil moisture and reduce erosion

On-the-Ground Examples

- Adaptive Silviculture – Southern New England Oak Forests

    - The Adaptive Silviculture for Climate Change (ASCC) study sites in southern New England include resistance, resilience, transition, and no action treatments in oak forests that are representative of forests across much of the region. The treatments were developed by a team of scientists and managers working to identify options relevant to smaller parcel sizes and varied ownership.

- Mount Philo State Park: Climate Change and Rare Plants
    - This State Park in Vermont is home to many rare plant species, but managers are concerned that longer growing seasons and the park's popularity among the public will lead to increases in invasive plant species. Management actions are being taken to prevent the introduction and establishment of invasive plant species.

- Massachusetts Department of Conservation and Recreation: Tannery Road Timber Sale

    - Managers of this timber sale within Savoy Mountain State Forest were concerned that warmer, drier summers and increased windthrow could lead to wildfire conditions in an already degraded Norway spruce plantation. They thinned the Norway spruce plantations with rows oriented east-west in order to reduce the risk and/or severity of future wildfires.

Pathway: Resilience

Resilience actions focus on increasing the capacity of the ecosystem to cope with climate change and other stressors while maintaining its fundamental character. Resilience actions are designed to enable ecosystems to withstand a variety of stressors and to bounce back from disturbance. For example, greater diversity in ecosystems (in terms of species composition, species functional traits, or age distribution) is generally expected to increase resilience by allowing for multiple pathways for recovery after a disturbance. Resilience is a commonly discussed adaptation option and can be valuable in many systems, but it may not be appropriate in all situations. As with the resistance pathway, greater levels of impact and disturbance from climate change and other stressors will likely create greater challenges to maintaining the current ecosystems using resilience strategies alone.

It is important to consider site-level vulnerability when deciding whether to pursue this pathway. Based on your assessment responses, your site has **moderate vulnerability** to climate change.

Forests with **moderate vulnerability** may be experiencing impacts from climate change or other stressors. These stressors may create challenges for sustaining oak into the future, particularly if pressures increase over time. Resilience actions can focus on reducing the effects of stressors and enhancing the capacity of systems to respond to a variety of future conditions.

Because oak forests are highly adaptable to many disturbances, resilience actions can be effective for many forests where conditions have not been too severely altered. You may also want to consider what capability you have to resist change in the current forest and compare this option with the **Resistance** and **Transition** pathways to determine what option best meets your management goals and objectives.

Actions for Forests Health and Productivity ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide wood products and other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Condition	Adaptation Approach	Example Action
Invasive plants are present at low levels or nearby.	▪ 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species	▪ Remove existing invasive species with mechanical treatment to promote the current plant community ▪ Use monitoring to support early detection and rapid response to eliminate new infestations
High levels of invasive plants are	▪ 2.2 Prevent the introduction and establishment of invasive	▪ Remove existing invasive species with mechanical or chemical

affecting the natural or desired plant community	plant species and remove existing invasive species	treatment to promote the current plant community
Site exposed to wind	▪ 3.3. Alter forest structure to reduce severity or extent of wind and ice damage.	▪ Use thinning or other silvicultural treatment to reduce tree density and increase the windfirmness of the residual trees and increase age and structural diversity
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.1. Maintain or improve the ability of forests to resist pests and pathogens. ▪ 1.4. Reduce competition for moisture, nutrients, and light.	▪ Thin trees or release crop trees to reduce tree density
Forest regeneration is desired; advance regeneration is dominated by maple, black birch or other mesic species	▪ 5.1. Promote diverse age classes. ▪ 5.2. Maintain and restore diversity of native species. ▪ 8.2. Favor existing genotypes that are better adapted to future conditions. ▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development.	▪ Harvest using patch cuts (at least 1/2 acre) to favor oak and hickory regeneration ▪ Use prescribed fire, mechanical scarification, or herbicide to reduce competition of mesic species ▪ Retain underrepresented species to increase diversity, emphasizing species expected to be suitable for future conditions ▪ Plant current- and future-adapted native species, such as oaks, hickories, or American chestnut to diversity composition. ▪ Protect seedlings from browse, as needed.
Forest regeneration is desired; advance regeneration is primarily oak	▪ 5.1. Promote diverse age classes. ▪ 5.2. Maintain and restore diversity of native species. ▪ 8.2. Favor existing genotypes that are better adapted to future conditions. ▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development..	▪ Use group selection, patch cuts, or final shelterwood cut to release oak regeneration ▪ Retain underrepresented species to increase diversity, emphasizing species expected to be suitable for future conditions ▪ Retain cavity trees and down wood

Forest regeneration is desired; no advance regeneration or lack or regeneration following harvest	▪ 8.1. Use seed, germplasm, and other genetic material from across a greater geographic range	▪ Harvest using shelterwood system to release crowns of overstory trees and create light conditions favorable for regeneration ▪ Plant existing oak species using seed stock from southerly populations (e.g., Mid-Atlantic states) for artificial regeneration ▪ Retain cavity trees and down wood
Regeneration of future-adapted species desired	▪ 9.3. Guide changes in species composition at early stages of stand development.	▪ Select species consistent with native plant community, may consider southern genotypes ▪ Reintroduce American chestnut on suitable sites ▪ Plant current- and future-adapted native species suited to site (e.g., soils, light conditions) and management goals ▪ Plant larger seedlings to the extent possible ▪ Protect seedlings from browse, as needed
Forest condition is highly degraded as a result of pests or other disturbance	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 10.2. Allow for areas of natural regeneration to test for future-adapted species	▪ Reinitiate stand using clearcut (with reserves) where existing seedlings, stump sprouts, or nearby seed source can provide source of natural regeneration ▪ Remove all competing vegetation ▪ Retain trees of desired species as seed source
Tree mortality resulted in substantial standing or down dead wood	▪ 3.1. Alter forest structure or composition to reduce risk or severity of wildfire.	▪ Evaluate need for intervention ▪ Remove downed or damaged trees as necessary to meet management goals ▪ Retain some portion of dead trees and downed wood for forest structure and heterogeneity, as appropriate to management goals and forest condition
Disturbance has significantly impacted forest	▪ 3.4. Promptly revegetate sites after disturbance.	▪ Remove downed or damaged trees as necessary, with retention of some portion of wood based on management goals and forest condition

		▪ Plant current- and future-adapted native species suited to site (e.g., soils, light conditions) and management goals ▪ Plant larger seedlings to the extent possible ▪ Protect seedlings from browse, as needed

Actions for Wildlife ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for wildlife habitat. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Wildlife (in review).

Condition	Adaptation Approach	Action
Forest lacks age class or structural diversity	▪ 8.1. Manage for plant species diversity and complexity ▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape ▪ 8.8. Maintain or mimic natural disturbance regimes to enhance habitat quality	▪ Use shelterwood system to create gaps or openings for regeneration to increase age class diversity and patchiness ▪ Retain snags and live trees with cavities or other features for wildlife ▪ Retain or increase down wood during harvest by retaining tree tops in the forest or by girdling or felling live trees
Forests lacks downed wood	▪ 8.1. Manage for plant species diversity and complexity ▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape ▪ 8.8. Maintain or mimic natural disturbance regimes to enhance habitat quality	▪ Retain tree tops in woods or return tops to woods following harvest ▪ Fell trees for new source of dead wood ▪ Reserve standing live or dead trees, particularly of a large size, for future dead wood
Forest lacks tree and plant diversity	▪ 8.1. Manage for plant species diversity and complexity ▪ 8.2. Promote plant genetic diversity	▪ Use forest harvest to create and tend regeneration of a variety of species ▪ Retain conifers and underrepresented tree species during harvest
Rare or sensitive species are present (e.g., plants, turtles)	▪ 10.4. Orient suites of protected areas in ways that span gradients in climate	▪ Establish reserves that run up and down slope to cut across narrow climate zones associated with elevation and water availability.

	▪ 10.5. Create protected areas that maximize topographic and geologic variety	▪ Create reserve areas around wetlands steep slopes, and other landforms that add variety in an otherwise uniform landscape.
Raptors present	▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape	▪ Retain trees with multi-limbed tree crotches or “basket forks” in live hardwood crowns during harvest

Actions for Water

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for water resources. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Condition	Adaptation Approach	Action
Riparian areas, vernal ponds, and other sensitive wetlands	▪ 1.5 Maintain and restore forested wetlands and lowland areas ▪ 1.1 Maintain and enhance infiltration and water storage capacity of forest soils ▪ 5.2 Enhance the ability of systems to retain water	▪ Restore or promote a diversity of tree and plant species to increase stream shading, provide sources of woody debris, stabilize the soil, restore fluvial processes, and provide habitat and connectivity for wildlife ▪ Leave dead and downed wood (coarse woody debris) in upland and riparian areas to enhance soil moisture ▪ Re-engineer or design roads and infrastructure to discharge runoff into natural areas and hillslopes slopes to increase water capture, reduce water losses and minimize runoff velocities
Areas of low vegetative cover	▪ 3.2 Promptly revegetate areas after disturbance ▪ 5.3 Adjust systems to cope with increased water abundance, and high-water levels	▪ Plant native vegetation to slow overland flows and improve water infiltration ▪ Target invasive species control in newly flood-prone areas to retain or recruit desirable riparian species
Tree mortality in riparian areas	▪ 3.1 Maintain or restore forest and vegetative cover in riparian areas ▪ 3.7 Identify, maintain, and enhance important habitats for fish and wildlife	▪ Prioritize stream restoration activities in areas most likely to retain cool late-summer flows that may buffer the survival of aquatic organisms during extreme weather conditions, and at particular life history stages

	▪ 3.6 Enhance species age classes and structural diversity in forests ▪ 4.3 Disfavor species that are distinctly maladapted	▪ Focus salvage operations on creating desired residual stand structures following disturbance, even if less merchantable timber is removed as a result ▪ Protecting healthy trees that fail to regenerate while deemphasizing their importance in the mix of species being promoted for regeneration
Man-made ponds, embankments, etc.	▪ 6.3 Incorporate natural or low-impact development into designs	▪ Use bioretention systems to capture runoff, recharge groundwater, and reduce pollutant loads ▪ Strategically grade soil where needed and avoid disturbance of soils if unnecessary to preserve soil porosity and natural drainages

Actions for Recreation and Forest Roads and Trails ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives related to forest roads and trails used for recreation and other purposes. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Recreation.

Condition	Adaptation Approach	Action
Erosion on forest roads and trails following extreme rain	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Avoid machine or foot traffic in vulnerable areas ▪ Use water bars or increase number used to divert water from road surfaces ▪ Use vegetation or rock armoring along roadsides to minimize erosion and reduce risk of failure
Flooding of forest roads and trails	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Harden surfaces or elevate roads/trails
Water crossings missing or	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation	▪ Add or replace stream crossings to enhance drainage

undersized on woods roads		▪ Use vegetation or rock armoring along roadsides to minimize erosion and reduce risk of failure

Actions for Forest Carbon

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide carbon sequestration and storage, along with other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the [Adaptation Strategies and Approaches for Forest Carbon](#).

Condition	Adaptation Approach	Action
Potential for land use change	▪ 1.1 Avoid forest conversion to nonforest land uses	▪ Use conservation easements or other land use restrictions to prevent land use change or development.
Mix of agriculture and forest lands on property	▪ 1.4 Increase or implement agroforestry practices	▪ Integrate trees and shrubs into agricultural landscapes, such as within riparian buffers
Forest of high conservation value and large trees or healthy, mature forest subject to few stressors	▪ 5.1 Prioritize low-vulnerability sites for maintaining or enhancing carbon stocks ▪ 5.2 Establish reserves on sites with high carbon density	▪ Create no-harvest reserve areas (passive management) when consistent with landowner goals and site capability ▪ Implement forest harvests at lower intensities (e.g., light thinning) ▪ Delay harvest or extend time between forest harvest entries
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.4: Maintain or improve the ability of forests to resist pests and pathogens	▪ Thin to reduce competition for light or soil moisture to enhance resistance to stressors
Forest harvest to meet other management goals (e.g., habitat, timber)	▪ 2.1: Reduce impacts to soils and nutrient cycling ▪ 2.2: Maintain or restore hydrology	▪ Minimize the area (footprint) of forest roads and trails ▪ Alter the timing of forest operations to reduce potential impacts on water, soils, and residual trees, especially in areas that rely on particular conditions for operations that may be affected by a changing climate ▪ Retain coarse woody debris (e.g., tree tops, harvest residue) to maintain soil

		moisture, nutrients, and enhance soil organic matter pools ▪ Use soil amendments to restore or improve soil quality ▪ Restore native herbaceous groundcover following management activities in order to retain soil moisture and reduce erosion

On-the-Ground Examples

- Adaptive Silviculture – Southern New England Oak Forests
    - The Adaptive Silviculture for Climate Change (ASCC) study sites in southern New England include resistance, resilience, transition, and no action treatments in oak forests that are representative of forests across much of the region. The treatments were developed by a team of scientists and managers working to identify options relevant to smaller parcel sizes and varied ownership.
- Massachusetts Department of Conservation & Recreation: Bristol Lot Timber Sale
    - Drought conditions have limited the effectiveness of a soil borne fungus that controls *Lymantria dispar*, making this oak-dominated stand highly susceptible to further heavy defoliation and mortality. In addition to planting blight-resistant American chestnut, managers are encouraging a mix of species, age classes, and stand structures to reduce the availability of host species for pests and pathogens.
- Massachusetts Dept. of Conservation & Recreation: Protecting Riparian Zones with a Focus on Stream Crossings
    - Many of the culverts for streams that enter the Deerfield River within the South River State Forest have already failed or are threatened by increasingly heavy precipitation events. Managers are removing failing culverts and replacing them with bridges, while ensuring stream connectivity and a naturalized stream bottom.

- Massachusetts Dept. of Conservation & Recreation: Protecting Riparian Zones with a Focus on Stream Crossings
    - Many of the culverts for streams that enter the Deerfield River within the South River State Forest have already failed or are threatened by increasingly heavy precipitation events. Managers are removing failing culverts and replacing them with bridges, while ensuring stream connectivity and a naturalized stream bottom.

Pathway: Transition

Transition actions intentionally accommodate ecosystem change, rather than resist it. These actions work to move forests toward conditions that are expected to be better adapted to future conditions. These alterations vary across a continuum from slight changes in species composition and structure in response to expected change (e.g., anticipatory adaptation) to full-fledged transformation to novel communities. Transition approaches are likely unnecessary in ecosystems that are not highly vulnerable, and it may take extreme effort to “push” these systems toward future conditions. Ecosystems that are highly vulnerable, especially those that have reduced adaptive capacity (e.g., degraded sites) or have undergone severe disturbance may be the most suitable locations to explore transition strategies. Because transition actions are often inherently experimental and outside “business as usual”, monitoring and evaluation activities take on even greater importance.

It is important to consider site-level vulnerability when deciding whether to pursue this pathway. Based on your assessment responses, your site has **moderate vulnerability** to climate change.

Forests with **moderate vulnerability** may be experiencing impacts from climate change or other stressors. These stressors may create challenges for sustaining oak into the future, particularly if pressures increase over time. Transition actions can be used to alter systems toward conditions that may be better adapted to future conditions. In the absence of severe disturbance, transition actions may be unnecessary, difficult, and ineffective in ecosystems that have moderate vulnerability to climate change.

You may also want to consider what capability you have to transition your forest, and whether a more gradual or more abrupt transition is most in line with your goals and capability. Compare this option with the **Resistance** and **Resilience** pathways to determine what option best meets your management goals and objectives

Actions for Forests Health and Productivity ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide wood products and other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Condition	Adaptation Approach	Example Action
High levels of invasive plants are affecting the natural or desired plant community	▪ 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species	▪ Remove existing invasive species with mechanical or chemical treatment to promote the current plant community
Site exposed to wind	▪ 3.3. Alter forest structure to reduce severity or extent of wind and ice damage.	▪ Use thinning or other silvicultural treatment to reduce tree density and increase the windfirmness of the

		residual trees and increase age and structural diversity
Stand is overstocked and/or susceptible to drought or forest pests	▪ 2.1. Maintain or improve the ability of forests to resist pests and pathogens. ▪ 1.4. Reduce competition for moisture, nutrients, and light.	▪ Use thinning or other silvicultural treatment to reduce tree density ▪ Use harvest and planting to alter forest composition toward species expected to be less vulnerable
Forest regeneration is desired; advance regeneration lacking or dominated by undesirable species	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 9.7 Introduce species that are expected to be adapted to future conditions	▪ Harvest using large patch cuts or clearcut with reserves and variable retention to eliminate mid-canopy shade ▪ Use mechanical or herbicide treatment to control competative plants ▪ Plant a novel mix of future-adapted species, such as southern red, bur, chestnut, or other oaks, shellbark hickory, hybrid chestnut, southern pines. ▪ Protect seedlings from browse, as needed.
Regeneration of future-adapted species desired	▪ 9.7. Introduce species that are expected to be adapted to future conditions. ▪ 10.3. Realign significantly disrupted ecosystems to meet expected future conditions	▪ Evaluate native and introduced species that may be suitable ▪ Avoid species known to have invasive or aggressive traits ▪ Plant future-adapted tree species that are also suited to current site (e.g., soils, light conditions) and management goals ▪ Plant larger seedlings to the extent possible ▪ Protect seedlings from browse, as needed
Forest condition is highly degraded as a result of pests or other disturbance	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 10.2. Allow for areas of natural regeneration to test for future-adapted species	▪ Reinitiate stand using clearcut (with reserves) where existing seedlings, stump sprouts, or nearby seed source can provide source of natural regeneration ▪ Remove all competing vegetation ▪ Retain trees of desired species as seed source

Disturbance has significantly impacted forest	▪ 9.1. Favor or restore native species that are expected to be adapted to future conditions. ▪ 9.3. Guide changes in species composition at early stages of stand development. ▪ 9.7 Introduce species that are expected to be adapted to future conditions	▪ Reinitiate forest using clearcut (with reserves) where existing seedlings, stump sprouts, or nearby seed source can provide source of natural regeneration ▪ Remove all competing vegetation ▪ Retain trees of desired species as seed source ▪ Plant a novel mix of future-adapted species, such as southern red, bur, chestnut, or other oaks, shellbark hickory, hybrid chestnut, southern pines.

Actions for Wildlife ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for wildlife habitat. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Wildlife (in review).

Condition	Adaptation Approach	Action
Forests lacks downed wood	▪ Create new sources of food, water, and cover in anticipation of future conditions	▪ Retain tree tops in woods or return tops to woods following harvest ▪ Fell trees for new source of dead wood ▪ Reserve standing live or dead trees, particularly of a large size, for future dead wood
Forest lacks tree and plant diversity	▪ 9.1. Use non-local, future-adapted genotypes in habitat management ▪ 9.2. Create new sources of food, water, and cover in anticipation of future conditions	▪ Plant seed sourced from southerly populations based on anticipated future climate conditions for trees and understory plants ▪ Introduce non-local hickory or oak species as a new source of hard mast
Rare or sensitive species are present (e.g., plants, turtles)	▪ 10.7. Protect climate refugia across the landscape ▪ 10.8. Protect sites that are expected to provide future suitable habitat	▪ Buffer cool spots on the landscape that may be slower to change

Raptors present	▪ 8.7. Create or maintain sources of food, water, and cover in a variety of locations across the landscape	▪ Retain trees with multi-limbed tree crotches or “basket forks” in live hardwood crowns during harvest

Actions for Water ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for water resources. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Condition	Adaptation Approach	Action
Riparian areas, vernal ponds, and other sensitive wetlands	▪ 5.3 Adjust systems to cope with increased water abundance, and high water levels ▪ 4.5 Move at-risk species to locations that are expected to provide habitat	▪ Manage riparian areas to include a diversity of species and genotypes, favoring future-adapted native species tolerant to saturated conditions or adapted to high water levels ▪ Plant cold-adapted species in areas likely to maintain persistently cooler temperatures areas (e.g. hemlock in shaded moist areas like ravines)
Areas of low vegetative cover or high tree mortality	▪ 4.4 Introduce species that are expected to be adapted to future conditions	▪ Plant flood-tolerant species, such as swamp white oak, on sites that are expected to become more prone to flooding and that are currently not occupied by flood-tolerant species. ▪ Plant drought-tolerant species on sites within the current range that are expected to become drier and that have not been historically occupied by those specie

Actions for Recreation and Forest Roads and Trails ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives related to forest roads and trails used for recreation and other purposes. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Recreation.

Condition	Adaptation Approach	Action

Forest roads and trails significantly impacted by extreme rain, flooding, or other changes	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation ▪ 2.3 Minimize impacts of existing roads and trails that are compromised by changing conditions	▪ Reroute roads and trails when current road/trail is not consistently passable or improvement is not feasible
Water crossings missing or undersized on woods roads	▪ 2.2 Enhance the capacity of natural systems to accommodate variable precipitation	▪ Replace and redesign stream crossings, including changes such as the replacement of culverts with bridges. ▪ Create water crossings, such as rock fords, that are designed to be overtopped
Buildings or other infrastructure are in at-risk locations	▪ 6.2 Relocate existing infrastructure and opportunities to areas with less risk of climate-induced damage ▪ 6.5 Remove or decommission vulnerable infrastructure	▪ Relocate or remove outbuildings or other infrastructure

Actions for Forest Carbon

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide carbon sequestration and storage, along with other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forest Carbon.

Condition	Adaptation Approach	Action
Potential for land use change	▪ 1.1 Avoid forest conversion to nonforest land uses	▪ Use conservation easements or other land use restrictions to prevent land use change or development.
Mix of agriculture and forest lands on property	▪ 1.2 Reforest lands that have been deforested and afforest suitable lands	▪ Plant desirable or future-adapted tree species on suitable sites, particularly areas marginal for agriculture
Stand is overstocked and/or susceptible to drought or forest pests	▪ 6.3 Increase harvest frequency or intensity because of greater risk of tree mortality	▪ Create gaps and thin areas between gaps (matrix) to reduce tree density and encourage regeneration of drought-tolerant species
Forest harvest	▪ 2.1: Reduce impacts to soils and nutrient cycling ▪ 2.2: Maintain or restore hydrology	▪ Minimize the area (footprint) of forest roads and trails

	▪ Alter the timing of forest operations to reduce potential impacts on water, soils, and residual trees, especially in areas that rely on particular conditions for operations that may be affected by a changing climate ▪ Retain coarse woody debris (e.g., tree tops, harvest residue) to maintain soil moisture, nutrients, and enhance soil organic matter pools ▪ Use soil amendments to restore or improve soil quality ▪ Restore native herbaceous groundcover following management activities in order to retain soil moisture and reduce erosion

On-the-Ground Examples

- Adaptive Silviculture – Southern New England Oak Forests
    - The Adaptive Silviculture for Climate Change (ASCC) study sites in southern New England include resistance, resilience, transition, and no action treatments in oak forests that are representative of forests across much of the region. The treatments were developed by a team of scientists and managers working to identify options relevant to smaller parcel sizes and varied ownership.
- Providence Water: Planting Future Adapted Forests
    - The forests surrounding Providence's Scituate Reservoir provide clean water to over 600,000 people, or two-thirds of all Rhode Islanders. Challenges to northern hardwood regeneration ultimately threaten water quality. Managers are experimenting with actions that promote a variety of oaks and other species that are expected to be better adapted to future conditions.
- South Central Connecticut Regional Water Authority: Maltby Lakes Southern Pine Beetle Response
    - Managers conducted a clearcut in this forested watershed in response to a southern pine beetle infestation that threatened to expand northward into other forests. Silvicultural techniques and supplemental planting were used to support the establishment of future-adapted tree species.

Pathway: No Action

Landowners and forest managers can intentionally decide to take no action in managing their forests. Passive management, which allows forests to mature and be influenced by natural succession and disturbance dynamics rather than human intervention, can be an intentional management decision to help meet landowner goals.

In the context of a changing climate, forests are subject to a wide array of changing weather patterns and climate conditions, regardless of whether they are actively or passively managed. Even if there is no active management, forests will continue to change over time as a result of natural processes, forest disturbances such as storms and pest outbreaks that may or may not be exacerbated by climate change, and the growing direct effects of climate change like warmer winter temperatures.

The current condition of a site and its vulnerability to climate change and other stressors is likely to have a strong influence on how systems will change over time. Forests with greater exposure and sensitivity to environmental changes are more likely to undergo change; while forests that experience fewer impacts are generally expected to maintain their current conditions and expected trajectories for longer.

It is important to consider site-level vulnerability when deciding whether to pursue this pathway. Based on your assessment responses, your site **moderate vulnerability** to climate change.

Forests with **moderate vulnerability** may be experiencing impacts from climate change or other stressors. These stressors may create challenges for maintaining current conditions under passive management into the future, particularly as pressures from climate change and other stressors increase over time. Consideration of current and potential impacts can be useful for understanding how systems may change over time.

You may want to consider whether passive management is most in line with your goals for your forest. Compare this option with the **Resistance**, **Resilience**, and **Transition** pathways to determine what option best meets your management goals and objectives

Actions for Forests Health and Productivity ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide wood products and other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forests.

Condition	Adaptation Approach	Example Action
Ecosystem contains a high-quality native plant community or is of high conservation value	▪ 4.1 Prioritize and maintain unique sites	▪ Identify areas for passive management (no harvest) reserve area when consistent with landowner goals and site capability

	▪ 4.2 Prioritize and maintain sensitive or at-risk species or communities ▪ 5.4 Establish reserves to maintain ecosystem diversity	
Invasive plants are present at low levels or nearby.	▪ 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species	▪ Use monitoring to support early detection and rapid response to prevent new infestations
Regeneration of future-adapted species desired	▪ 10.2 Allow for areas of natural regeneration to test for future-adapted species	▪ Rely on natural succession and shifts in species composition and distribution
Disturbance has significantly impacted forest	▪ 10.2 Allow for areas of natural regeneration to test for future-adapted species	▪ Rely on natural succession and shifts in species composition and distribution

Actions for Wildlife ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for wildlife habitat. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Wildlife (in review).

Condition	Adaptation Approach	Action
Forest lacks age class or structural diversity	▪ 8.1. Manage for plant species diversity and complexity ▪ 8.8. Maintain or mimic natural disturbance regimes to enhance habitat quality	▪ Allow natural succession and stand development to occur following a disturbance from fire, wind, pests, or diseases.
Forests lacks downed wood	▪ 8.1. Manage for plant species diversity and complexity ▪ 8.8. Maintain or mimic natural disturbance regimes to enhance habitat quality	▪ Retain downed wood following a disturbance from fire, wind, pests, or diseases.

Actions for Water ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for water resources. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forested Watersheds.

Condition	Adaptation Approach	Action
Presence of riparian areas, vernal ponds, and other sensitive wetlands	▪ 1.2 Maintain and restore hydrologic connectivity ▪ 1.5 Maintain and restore forested wetlands and lowland areas ▪ 3.5 Prioritize and maintain unique habitats for refugia	▪ Use conservation easements or other land use restrictions to prevent land use change or development. ▪ Create and expand reserve areas around sites that may be more vulnerable to extreme weather and climate change ▪ Identify and protect potential wetland migration corridors

Actions for Forest Carbon ⇳

Here are some examples of adaptation actions that can help maintain oak forests to meet objectives for general forest health to provide carbon sequestration and storage, along with other benefits. The specific actions used in a particular location will vary based on local site conditions, management goals, and climate risks. Additional actions are described in the Adaptation Strategies and Approaches for Forest Carbon.

Condition	Adaptation Approach	Action
Potential for land use change	▪ 1.1 Avoid forest conversion to nonforest land uses	▪ Use conservation easements or other land use restrictions to prevent land use change or development.
Mix of agriculture and forest lands on property	▪ 1.2 Reforest lands that have been deforested and afforest suitable lands	▪ Allow for succesion to forest cover to take place through cessation of mowing, tillage, or other disturbance
Forest of high conservation value and large trees or healthy, mature forest subject to few stressors	▪ 5.1 Prioritize low-vulnerability sites for maintaining or enhancing carbon stocks ▪ 5.2 Establish reserves on sites with high carbon density	▪ Create no-harvest reserve areas (passive management) when consistent with landowner goals and site capability

On-the-Ground Examples

- Adaptive Silviculture – Southern New England Oak Forests
    - The Adaptive Silviculture for Climate Change (ASCC) study sites in southern New England include resistance, resilience, transition, and no action treatments in oak forests that are representative of forests across much of the region. The treatments were developed by a team of scientists and managers working to identify options relevant to smaller parcel sizes and varied ownership.

Providing the information needed to understand, manage, and protect the region's forested ecosystems in a changing global environment