LONG ISLAND SOUND HABITAT RESTORATION INITIATIVE

Section 8: Coastal Forests
(Version 1.0, August 2018)

Technical Support for Coastal Habitat Restoration

Juliana Barrett, Ph.D.
Connecticut Sea Grant College Program and Department of Extension, University of Connecticut

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TABLE OF CONTENTS

COASTAL FORESTS	PAGE
Ecoregions	1
Definition	5
Forest Dynamics and History	6
Climate Change and Forests	7
Ecosystem Services of Coastal Forests	8
Vegetation	12
Forest Management and Monitoring	20
Invasive Species	25
Recreational and Research Uses and Issues	32
References	35
Appendix A Ecoregion Cross-Walk	39
Appendix B Vegetation Descriptions CT and NY	42
Appendix C Invasive Plant Control Fact sheets	73

LIST OF FIGURES and TABLE

Figure 1 Long Island Sound Study Boundary	1
Figure 2 Level III EPA Ecoregions of the Continental U.S.	2
Figure 3 Level IV EPA Ecoregions of the Continental U.S.	3
Figure 4 Ecological Subsections (US Forest Service)	40
Table 1 Definitions of monitoring phases	22

COASTAL FORESTS of EPA's Long Island Sound Study Area

Long Island Sound Study Area and Ecoregions

The Long Island Sound Study (LISS) boundary (Figure 1) is based on the nearshore watersheds of Long Island Sound in Connecticut and New York (LISS CCMP 2015). In examining the ecological content and variability of this specific area, it is important to understand the broader context. There are a number of different ecological land classification schemes used within North America. This chapter follows the EPA ecoregion framework derived from Omernik (1987) with mapping by multiple federal agencies including EPA regional offices, states resource management agencies and neighboring North American countries. [See https://www.epa.gov/eco-research/ecoregions for more information on methodology in defining ecoregions.] An ecoregion is an area of similar ecosystems based on biotic, abiotic, terrestrial and aquatic components. New York State similarly defines ecoregions by "similarities in soil, physiography, climate, hydrology, geology and vegetation." (http://www.dec.ny.gov/animals/9402.html)

The concept of ecoregions is important here in terms of coordination and implementation of management strategies that may be applied to different natural resources and systems within the same geographic areas (Omernik and Griffith 2014, McMahon et al. 2001).

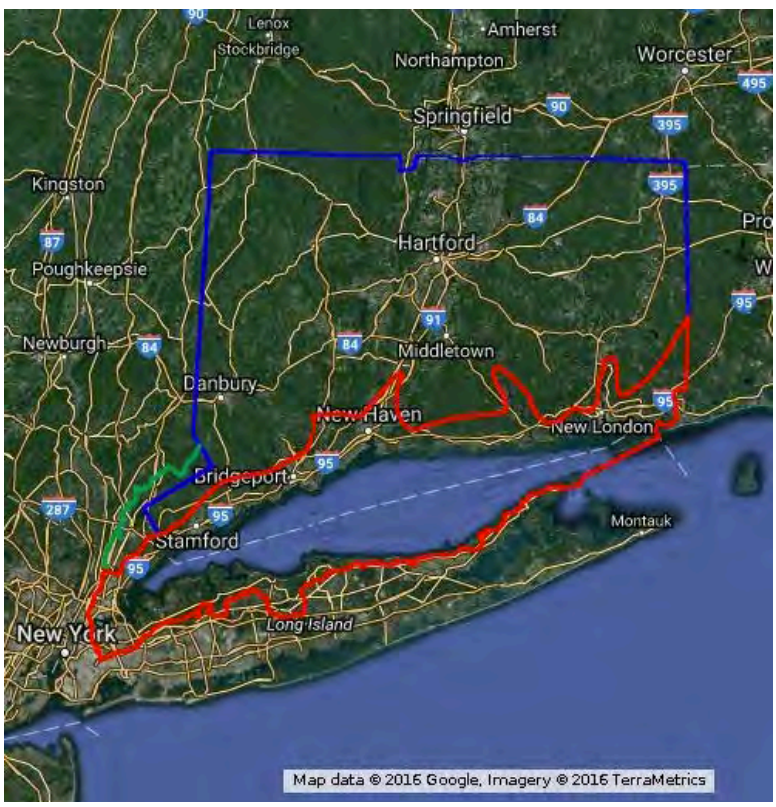

Figure 1. Map of Long Island Sound Study boundary. Any forest within this boundary is loosely considered a coastal forest.

Ecoregion classification schemes have a hierarchical order going from general to more specific. The LISS area lies within the following hierarchical units (maps for each unit may be found at: https://www.epa.gov/eco-research/ecoregions

Level I: Eastern Temperate Forests

Level II: Mixed Wood Plains (8.1) and Mississippi Alluvial and Southeast USA Coastal Plains (8.5)

Level III: Northeastern Coastal Zone (59) and Atlantic Coastal Pine Barrens (84) (see Figure 2)

Level IV: Southern New England Coastal Plains and Hills (59c),
Long Island Sound Coastal Lowland (59g),
Cape Cod/Long Island (84a) (see Figure 3)

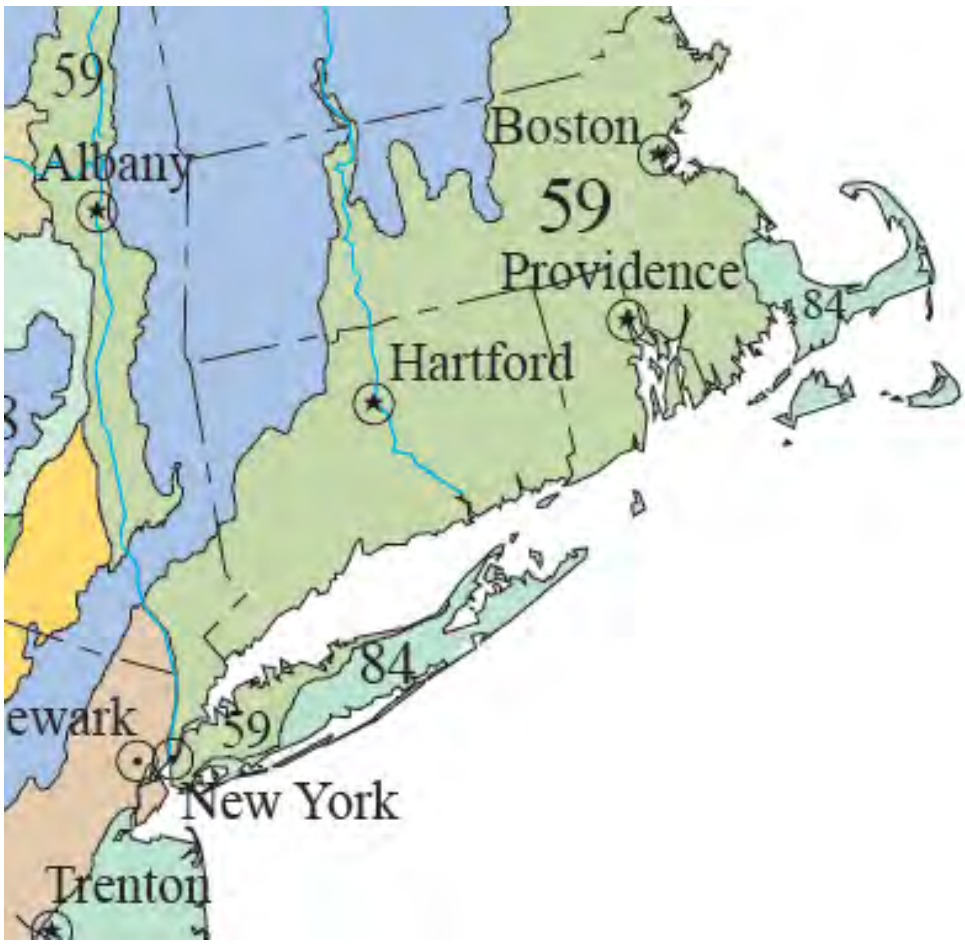

Figure 2. Level III Ecoregions of the Continental United States (US EPA 2013a) with 59=Northeastern Coastal Zone and 84=Atlantic Coastal Pine Barrens.

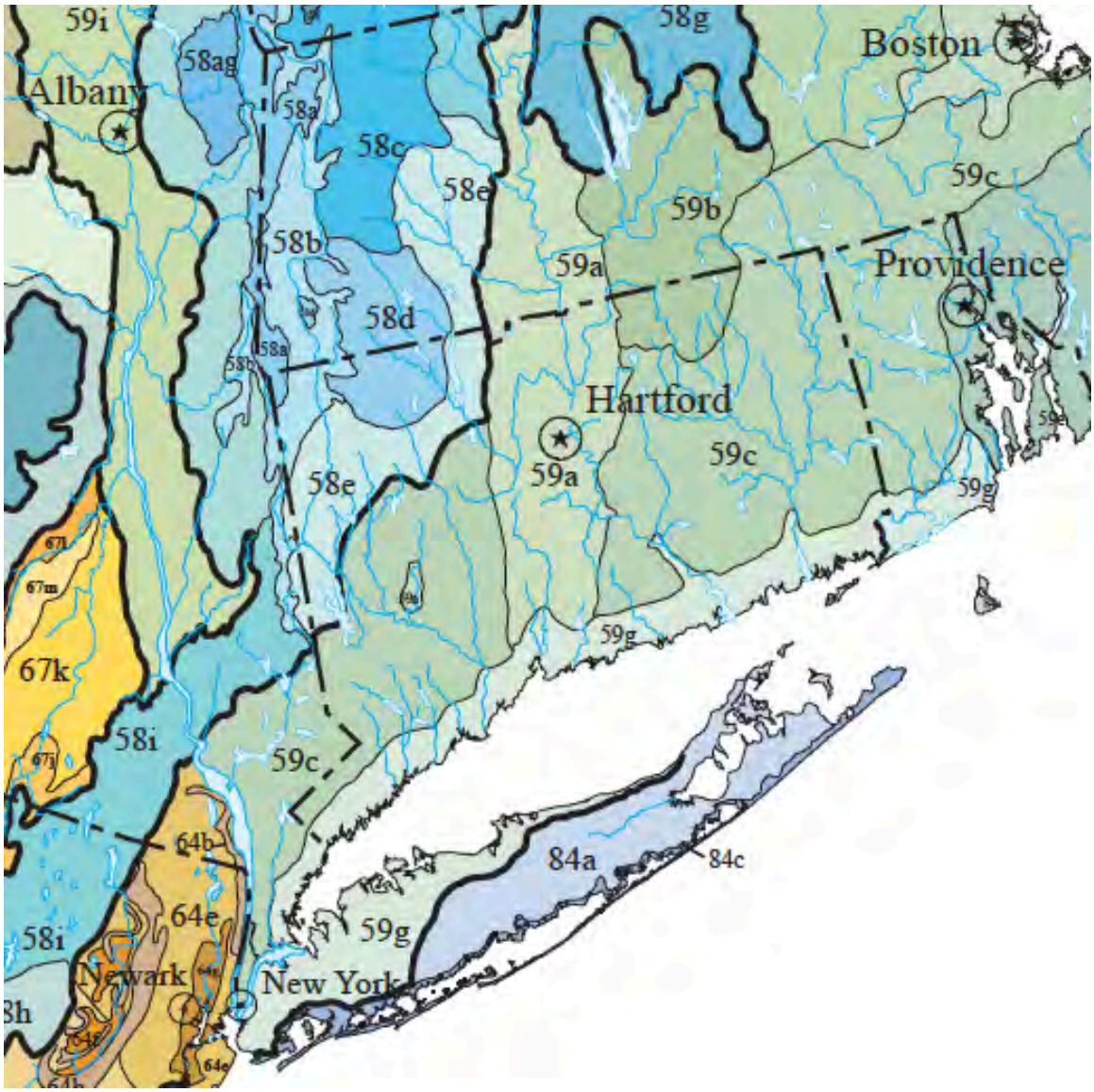

Figure 3. Level IV ecoregions of the conterminous United States (US EPA 2013b) with 59c=Southern New England Coastal Plains and Hills, and 59g=Long Island Sound Coastal Lowland; 84a=Cape Cod/Long Island

These level IV ecoregions are described by Bryce et al. (2010) below:

> *The **Long Island Sound Coastal Lowland** ecoregion follows the shore of southern Connecticut, Rhode Island, and New York and includes the western third of Long Island. Most of this area lies north of the terminal moraines and outwash that compose the coastal strip and barrier islands. As a result, the dominant surficial material is till as opposed to outwash sand and gravel, which dominates eastern Long Island (Ecoregion 84a). This ecoregion has one of the mildest climates of New England due to its coastal location. In addition to the coastal*

influence, prevailing winds from the south and southwest bring warm, humid air to the region. With its mild maritime climate, western Long Island supports a northern variant of Appalachian forest, similar to that on the coastal plain of Connecticut. Some flora of the southeastern Piedmont and Coastal Plain reach their northern limit in this ecoregion, including American holly, post oak, sweetgum, and persimmon. The dominant tree species include tulip tree, black and red oak, beech, black birch, and red maple, with an understory dominated by eastern dogwood. sweet gum (not found in most of Connecticut) *and pin oak occur in moist areas near kettle ponds. Little of the original forest remains on western Long Island as much of the ecoregion is highly urbanized. Small acreages exist in parks and preserves, but species diversity is much reduced.*

Southern New England Coastal Plains and Hills *A small portion of [this] ecoregion enters the southeastern corner of New York north of Long Island Sound, continuing southward to include the Manhattan Prong between the Bronx River and the Hudson River. The Manhattan Prong is a narrow projection of the same Precambrian gneiss and schist that underlies the Hudson Highlands (58i). The landforms of the ecoregion include irregular plains with relief of 100 to 300 feet. Numerous, till-covered bedrock hills rise above the valleys and outwash plains. Historically, forests were dominated by a mix of oaks, American chestnut, hickories, and some hemlock and white pine. As with many other areas of New England, these forests were cleared, either for agriculture and grazing or for the production of charcoal. The Southern New England Coastal Plains and Hills ecoregion is distinguished from the more completely forested Glaciated Reading Prong/Hudson Highlands (58i) in the north by its low rolling topography and mix of woodland, rural residential, urban, and suburban centers.*

The **Cape Cod/Long Island** ecoregion includes all of Cape Cod, Block Island, the Elizabeth Islands, Martha's Vineyard, Nantucket, and eastern Long Island. Only a very small portion of the Long Island Sound Study is within this ecoregion.

Some of the unique ecological features that distinguish this ecoregion from mainland ecoregions include its moderate maritime climate, stunted pine and oak forests, numerous kettle ponds, and unique habitats in salt and freshwater marshes, swamps, bogs, and sand dunes. These landscapes were formed by the advances and retreats of three lobes of Pleistocene glaciers.

The sands of Long Island accumulated behind Pleistocene glacial terminal moraines as they did on Cape Cod. The outwash plains and fans surrounding the moraines contain soils formed from coarse, sandy till. In areas of excessively-drained sand, vegetative diversity is low because of the dry, nutrient-poor soil and frequent-fire regime. Remnant patches of dwarf pine, pitch pine-oak, and oak-pitch pine woodland occur on a continuum based on moisture availability, distance to the water table, and fire return interval. Long Island's mild maritime climate produces a long 200-day growing season that is optimal for the cultivation of truck crops and nursery stock. The freshwater Peconic River and coastal ponds support distinctive plant communities as well as some rare vertebrates such as the tiger salamander, eastern mud turtle, and banded sunfish.

A cross-walk to the US Forest Service ecoregion classification scheme for Connecticut and New York as well as the ecoregion classification scheme for Connecticut by Dowhan and Craig (1976) can be found in Appendix A.

What is a coastal forest?

What is a coastal forest within this area? Any forest within the LISS area is loosely termed a coastal forest based on the moderating influence that Long Island Sound and the major tidal rivers have on the climate (relating back to the definition of an ecoregion). However, because of the wide range of geology/soils and topography, there are numerous forest vegetation types found within the LISS area. Vegetation, referring to the assemblage of plant species in any particular area, is determined by a number of factors including climate, topography, geology and soils, past land use history, and biota. Generally, coastal forests or woodlands have structural complexity with multiple vegetative layers (often dependent on the absence of deer browse) and include numerous lianas.

Before examining forest vegetation in any particular area, it is important to first assess the geology and soils. In Connecticut, CT ECO (Advanced Map Viewer) contains geology (including bedrock, quaternary and surficial materials) and some soils layers. In New York, the New York State Museum GIS includes geology data layers as well as JPG versions (including bedrock and surficial materials). Full soils information for Connecticut and New York can be found at USDA Natural Resource Conservation Service Web Soil Survey.

Forest Dynamics and History

The coastal forests of this region have been molded and changed by numerous factors including anthropogenic activities, natural disturbances and climate change (Whitney 1994, Foster *et al*. 1997). Coastal New England uplands were largely forested until European settlement (Foster and Motzkin 2003) when forests were

cleared for agriculture. More recently, development pressures have significantly impacted, and continue to significantly impact, coastal forests within this area.

In addition to land use, significant weather events have impacted and will continue to impact Connecticut and Long Island forests. The Hurricane of 1938 had a significant impact on forests in Connecticut, particularly those to the east of New Haven with approximately 3 billion board feet of timber blown down (Spurr 1956), followed by a monumental timber salvage operation which resulted in removal of biomass and disruption of the understory and local soil/forest floor environment. The hurricane and salvage work resulted in major changes in forest composition and regional hydrology (Foster *et al*. 1997). Research by Busby *et al*. (2009) and others determined that most moderate hurricanes/cyclone events have had minimal impacts on forest growth and regeneration dynamics, with individual species showing a wide range of responses to disturbances from individual storms. The salt spray from major storm events can also impact forest vegetation several miles inland, depending on storm intensity and wind speed and direction.

Other major events that have shaped the composition of coastal forests of this area are the chestnut blight and hemlock wooly adelgid. American chestnut trees were a significant component of eastern U.S. forests until a fungal pathogen was accidentally imported from Asia. With the pathogen first detected in 1904, the American chestnut was no longer a dominant component of eastern forests by 1950 (The American Chestnut Foundation accessed July 2017), though chestnut sprouts are frequently in oak forests. Eastern hemlock trees are shade tolerant, long-lived and (previously) one of the most abundant in the northeastern United States (Orwig *et al*. 2002). Hemlock woolly adelgid (a small insect native to Japan) has spread throughout the northeast since the first observation on the east coast, in Virginia, in 1951. In 1985, this adelgid was first found in New York State in the lower Hudson Valley and on Long Island and has spread north and west since then (Hemlock Woolly Adelgid, New York State Department of Environmental Conservation website). In Connecticut, the adelgid was first observed in 1985, possibly having been blown across Long Island Sound during Hurricane Gloria (McClure 1987). Infected trees generally die within 4 to 10 years (McClure *et al*. 1996). Eastern hemlock stands in Connecticut and New York have been severely impacted by this insect.

In addition to major tropical storm events and invasive pests and disease, development pressure, tornados (though infrequent), ice storms (Barnes 1991) and climate change are several of the biggest threats to potentially impact coastal forests.

Climate Change and Forests

The U.S. Forest Service is coordinating an approach to helping land managers understand the potential effects of climate change on forest ecosystems and integrating climate change considerations into management called the Climate Change Response Framework. Focusing on large ecoregions, the Framework

Projects use the same general process and four major components: partnerships, vulnerability assessments, forest adaptation resources, and demonstration projects. The forests of the Long Island Sound Study area lie within two major ecoregions of the U.S. Forest Service with New York in the Mid-Atlantic ecoregion and Connecticut in the New England ecoregion. The Forest Ecosystem Vulnerability Assessment and Synthesis for New England and Northern New York identify the following potential direct and indirect impacts due to climate change:

- *Many northern and boreal tree species will face increasing stress from climate change (medium evidence, high agreement).*
- *Habitat will become more suitable for southern species (medium evidence, high agreement).*
- *Forest composition will change across the landscape (medium evidence, high agreement).*
- *Shifts in forest composition will take at least several decades to occur in the absence of major disturbance (medium evidence, medium agreement).*
- *Conditions affecting tree regeneration and recruitment will change (medium evidence, high agreement).*
- *Forest productivity will increase during the next several decades in the absence of significant stressors (medium evidence, medium agreement).*

From: Janowiak et al. 2018. New England & Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis Summary and Highlights, Executive Summary p 4-5.

The Mid-Atlantic Climate Change Response Framework project is currently underway and future climate change impacts on forests of this region are still draft. Main points to date include:

- *Many mesic forest species, including American beech, eastern hemlock, eastern white pine, red spruce, and yellow birch are among those projected to have reductions in suitable habitat, growth potential, and biomass under a high degree of warming over the next century.*
- *Many species are expected to lose regeneration potential over the next century, but mature individuals could continue to grow for much longer in the absence of other mortality factors.*
- *Many southern species – species with ranges extending largely south of the Mid-Atlantic region including post oak, scarlet oak, and southern red oak – are projected to increase in suitable habitat and biomass within the Mid-Atlantic region.*
- *The forest impact models used in this assessment isolate the effects of climate change on tree species' growth and habitat, and do not account for many other factors that influence forests. Scientific literature was used to provide additional information on the effects of climate change on other factors such as: moisture stress, acid decomposition and carbon dioxide fertilization, altered nutrient cycling, invasive species, insect pests, and forest diseases, herbivory on young regeneration, and interactions among these factors.*

From: Mid-Atlantic Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Mid-Atlantic Climate Change Response Framework project, General Technical Report, Pre-Publication Draft From the Executive Summary pp ES-10-11. Further information is available online but is labeled: REVIEW DRAFT – NOT FOR CITATION OR DISTRIBUTION. Therefore, no further information is cited here.

For coastal forests directly bordering Long Island Sound waters and salt marshes, sea level rise impacts are already occurring in some forest understories with the colonization of the understory by salt marsh grasses and the death of trees due to salt water. With estimates of sea level rise for the lower Hudson Valley and Long Island, NY on the order of 19 to 29 in (48 to 74 cm) by the 2050's (Sea level rise with rapid ice-melt scenario) (New York State Sea Level Rise Task Force Report to the Legislature 2011) impacts to some low elevation coastal forests may be significant. (See also LISS Sea Level Affecting Marsh Migration)

Ecosystem Services of Coastal Forests

Coastal forests provide numerous ecosystem services including carbon sequestration, wildlife habitat (for both native species and migrant species), watershed protection, nutrient cycling, coastal protection and erosion control, air and water pollution reduction, microclimate control, and riparian buffer protection (Pearce 2001). Several of these are described in more detail below:

- Carbon Sequestration

  While the coastal forests of Connecticut and New York do not fit the definition of "Blue Carbon," they still play a role in carbon sequestration. Blue Carbon is carbon that is captured by ocean and coastal ecosystems, including tidal wetlands, seagrass meadows, kelp forests and mangrove swamps (NOAA https://oceanservice.noaa.gov/facts/bluecarbon.html) accessed Feb 12, 2018.

  Carbon sequestration refers to the process by which carbon dioxide is removed from the atmosphere or moved from sources of emissions and then stored in the oceans, terrestrial or geologic systems (Sundquist et al., 2008). Within the LISS coastal forests, atmospheric carbon dioxide is stored in trees and soils. For trees, this is through the process of photosynthesis with carbon stored in tree trunks, branches, roots and foliage. Sustainable forestry practices (discussed below) can be used to increase the ability of forests to store carbon such as by using thinning techniques to improve forest health, planting trees and prescribed burn techniques.
  USDA US Forest Service Carbon Sequestration
  https://www.fs.fed.us/ecosystemservices/carbon.shtml

  A study conducted through UConn CLEAR by L. Tomasso (http://cteco.uconn.edu/projects/carbon/index.htm) on land use and

Connecticut's forests indicates that the funds spent on carbon reduction through land conservation are more effective than many of the current emission reducing techniques/strategies. Thus providing strong evidence for support of forest tract protection within the Long Island Sound Study area.

- Habitat Benefits of Coastal Forests
  The animals of coastal forests in Connecticut are essentially the same as those in inland deciduous forests (Hammerson 2004), with some exceptions. Animals found in the Long Island forests of the Long Island Sound Study area are much the same as those listed below. Numerous invertebrates, reptiles and amphibians, mammals, and bird species are part of the native fauna. Invertebrates range from forest canopy insects to invertebrates of the soil and leaf litter. The invertebrates of the soil and litter are important food sources for many amphibians.

  Amphibian/reptile species include: eastern newts, Jefferson, blue-spotted, spotted, marbled, and redback salamanders; American toads, gray treefrogs, spring peepers, wood frogs, eastern box turtle, spotted turtle and snakes such as racer, ringneck snake, eastern rat snake, ribbon, milk snake, and common garter snake.

  Mammals include rodents such as eastern chipmunks, gray squirrels, southern flying squirrels, white-footed mice, red-backed voles, and woodland voles. Other mammals include bat species, shrews, weasels, gray fox, fisher, and white-tailed deer.

  Birds are numerous in deciduous forests and may include wild turkey, ruffed grouse, owls (barred, eastern screech), downy woodpeckers, red-bellied woodpeckers, eastern wood-pewees, great crested flycatchers, blue jays, black capped chickadees, tufted titmice, white-breasted nuthatches, veeries, wood thrushes, red-eyes vireos, warblers, ovenbirds, scarlet tanagers and numerous others (Hammerson 2004).

  Coastal islands were hit hard by recent storms (Irene 2011 and Sandy 2012) with flooding, salt spray and strong winds killing many trees. Where forests do still exist on the coastal islands and regions along Long Island Sound, they provide nesting habitat for wading birds such as black-crowned and yellow-crowned night-herons, snowy egrets, great egrets, and little blue herons (Hammerson 2004). Coastal forests are also important resting and feeding habitat for many migratory songbird species.

  EPA LISS, numerous conservation organizations and federal and state agencies have protected thousands of acres of coastal forest, and continue to work on conservation including connecting fragmented tracts. While some species will definitely benefit from these efforts, research in southern Connecticut forests by Askins (2015) and Dorazio *et al*. (2016) indicate that

for forest migratory bird protection of small, forested tracts is not enough. (Forest migratory birds are defined by Askins (2015) as: *mature forest specialists that migrate to the tropics in the winter*). These forest migrants need forest tracts large enough to minimize edge effects and disturbances (both natural and cultural).

E. Wilson of UConn's Center for Land Use, Education and Research (CLEAR), conducted a forest block analysis for the Connecticut coastal ecoregion using the 2002 CLEAR land cover data in 2006. Forest areas include deciduous and coniferous forest and forested wetlands and excluded all forest polygons under 25 acres. Boundary features consist of lands that are: developed, turf and grass, other grasses and agricultural, non-forested wetlands, tidal wetlands, barren, and utility right-of-way. All forest blocks that intersect the coastal region were included – this means that blocks are not necessarily contained within the coastal ecoregion, but at least intersect it. With the Connecticut coastal ecoregion, Wilson found that the majority of coastal forest polygons (676) are between 25 and 300 acres compared with 4948 for the state in this size category, 69 polygons are between 300 and 500 acres in the coastal ecoregion compared with 590 for the state, 63 polygons are between 500 and 1500 acres (coastal ecoregion) compared with 725, and 14 polygons are greater than 1500 acres (coastal ecoregion) compared with 190 in the state. The majority of large coastal forest blocks are in the central and eastern areas of the state.

- Watershed Health Benefits of Coastal Forests
  Forests (whether coastal or inland) play critical roles within watersheds in terms of five factors: reduction of stormwater runoff and flooding, reduction of stream channel erosion, improvement of soil and water quality, wildlife habitat, and moderating of summer air temperatures and water temperatures (Urban Watershed Forestry website, Center for Watershed Protection, accessed February 21, 2018). For a mid-Atlantic watershed, Goetz et al. (2003) found that there could be no more than 6% impervious cover in a watershed and the forest cover in the riparian area of the watershed to be at least 65% for stream health (based on both physical and biological parameters) to be rated as "excellent." For a rating of "good" stream health, impervious cover could not exceed 10% and riparian area forest cover had to be at least 60%.

  UConn Center for Land Use Education and Research conducted a land cover analysis of the riparian areas within the Long Island Sound watershed including relevant parts of both Connecticut and New York states. The analysis shows land cover within the 300 ft riparian zone in 1985, 2010 and changes in land cover between 1985 and 2010. While the riparian areas are not all forested, forest cover is one of the land use categories. For more information on this analysis see
  http://clear.uconn.edu/projects/riparian_buffer/index.htm

Another analysis of coastal forests with the Connecticut portion of the LISS area, examined forest health based on size, connectivity, and fragmentation (Basso *et al.* 2017). Overall, coastal forests in Connecticut ranked only poor to fair due in large part to land use history and intensive development leading to small size and fragmentation of forest tracts.

Connecticut Vegetation Organized by Natural Community Types for Forests and Woodlands that may occur within the Connecticut LISS Coastal Boundary (Metzler and Barrett 2006) Vegetation descriptions for these Connecticut vegetation types may be found in Appendix B. The Vegetation of Connecticut (Metzler and Barrett 2006) includes several toposequences showing how soils and their characteristics are related to topography position and how vegetation types correlate with soils, topography and moisture regime.

Please note: Plant common and scientific nomenclature were retained from each state classification rather than reconciling one to the other or using a third standard reference.

Forests (Connecticut) defined as *Trees with their crowns overlapping, generally forming 60-100% cover.* (Metzler and Barrett 2006 p. 8)
Woodlands (Connecticut) defined as *Open stands of trees with crowns not usually touching, generally forming 25-60% cover.* (Metzler and Barrett 2006 p. 22)

Terrestrial System – Nonforested Communities (but does include woodlands)
Rocky Summits/Outcrops – Dry to xeric exposed summits, ledges, and other outcrops with a vegetation of low shrubs, grasses, and herbs.

- Acidic Rocky Summits /Outcrops (gneiss, schist, granite, sandstone)
  - Pitch pine (*Pinus rigida*) woodlands
    - Pitch pine / Bear oak (*Pinus rigida / Quercus ilicifolia*) community
- Subacidic Rocky Summits/Outcrops (basalt, diabase, calcareous shales and schists)
  - Eastern redcedar (*Juniperus virginiana*) woodlands
    - Eastern redcedar / Poverty oat grass (*Juniperus virginiana / Danthonia spicata)* community

Coastal Headlands – Dry seaside cliffs, bluffs, and other open headlands exposed to wind and salt spray.

- Pitch pine – Post oak (*Pinus rigida – Quercus stellata*) woodlands

Terrestrial System – Forested Communities

Talus Forest / Woodlands – Dry to moist open woodlands or forests on coarse colluvial deposits with soil and humus in pockets between the rocks.

- Acidic Talus Forest / Woodlands
  - Northern red oak /Rock polypody (*Quercus rubra / Polypodium virginiana*) woodlands

Sub-acidic Talus Forest /Woodlands

Sweet birch – White ash – Robert geranium (*Betula lenta – Fraxinus americana / Geranium robertianum)* woodlands

Maritime Forests – Dry to moist coastal forests mostly showing the effects of salt spray, with low stature, gnarled trees and numerous lianas.

Maritime Forests/Woodlands on Stabilized Dunes and Till Islands (Rozsa unpublished report)

Scarlet Oak – Sassafras (*Quercus coccinea – Sassafras albidum*) woodlands

Maritime Forests on Other Upland Areas

Northern red oak / Flowering dogwood (*Quercus rubra / Cornus florida*) forests

American beech – White oak – Northern red oak – Tulip tree (*Fagus grandifolia – Quercus alba – Quercus rubra – Liriodendron tulipifera*) community

Scarlet oak – Sassafras (*Quercus coccinea – Sassafras albidum*) woodlands

Pitch pine – Post oak (*Pinus rigida – Quercus stellata*) woodlands

Dry Acidic Forests – Poorly growing forests often dominated by oaks with various mixtures of pine, often with dwarf ericaceous shrubs.

Dry Oak Forests on Stratified Sand and Gravel

Northern red oak – Black oak – Chestnut oak (*Quercus rubra – Quercus velutina – Quercus prinus*) forests

Black oak – Chestnut oak/Black huckleberry (*Quercus velutina – Quercus prinus / Gaylussacia baccata*) community

Northern red oak – Black oak/Blue Ridge blueberry *(Quercus rubra – Quercus velutina / Vaccinium pallidum*) community

Pitch pine (*Pinus rigida*) woodlands

Pitch pine / Bear oak (*Pinus rigida / Quercus ilicifolia*) community

Pitch pine / Lowbush blueberry (*Pinus rigida / Vaccinium angustifolium*) community

Dry Pine Forests on Stratfied Sand and Gravel

Pitch pine (*Pinus rigida*) woodlands

Pitch pine / Bear oak (*Pinus rigida / Quercus ilicifolia*) community

Pitch pine / Lowbush blueberry (*Pinus rigida / Vaccinium angustifolium*) community

Dry Acidic Forests on Glacial Till

Eastern hemlock (*Tsuga canadensis*) forests
Northern red oak – Black oak – Chestnut oak (*Quercus rubra – Quercus velutina – Quercus prinus*) forests
Black oak – Chestnut oak / Black huckleberry (*Quercus velutina – Quercus prinus / Gaylussacia baccata*) community
Black oak / Blue Ridge blueberry *(Quercus velutina / Vaccinium pallidum*) community

Dry Subacidic Forests – Slow-growing forests often dominated by white ash, hickories, and hophornbeam, with few shrubs and an open, grassy ground cover.

Northern red oak – Black oak – Chestnut oak (*Quercus rubra – Quercus velutina – Quercus prinus*) forests
Black oak / Blue Ridge blueberry *(Quercus velutina / Vaccinium pallidum*) community see Sharp *et al.* (2013).

Sugar maple – Oak ssp. (*Acer saccharum – Quercus spp*.) forests
Sugar maple – White Ash / Roundlobed hepatica (*Acer saccharum – Fraxinus americana / Hepatica nobilis* var. *obtusa*) community
Sugar maple – White Ash / Wild ginger (*Acer saccharum – Fraxinus Americana /Asarum canadensis*) community – see Sharp *et al.* (2013).
Sugar maple – White Ash / Interrupted fern (*Acer saccharum – Fraxinus americana /Osmunda claytoniana*) community – see Sharp *et al.* (2013).

Pignut hickory – White ash (*Carya glabra – Fraxinus americana*) forests
Eastern redcedar (*Juniperus virginiana*) woodlands
Eastern redcedar / Poverty oatgrass (*Juniperus virginiana / Danthonia spicata*) community
Pitch pine/Bear oak (*Pinus rigida/Quercus ilicifolia)* community – see Sharp *et al.* (2013).

Mesic Acidic Forests – Well-developed forests, often with a dense high shrub layer and scattered herbs.

Mesic Acidic Forests on Stratified Sand and Gravel
Northern red oak / Flowering dogwood (*Quercus rubra / Cornus florida)* forests
Northern red oak / Mapleleaf Viburnum (*Quercus rubra / Viburnum acerifolium)* community
Northern red oak – Yellow birch (*Quercus rubra – Betula alleghaniensis*) forests

Northern red oak – Yellow birch / Cinnamon fern (*Quercus rubra – Betula alleghaniensis / Osmunda cinnamomea*) community

Mesic Acidic Forests on Glacial Till

Eastern hemlock (*Tsuga canadensis*) forests

Northern red oak / Flowering dogwood (*Quercus rubra / Cornus florida)* forests

Northern red oak / Mapleleaf Viburnum (*Quercus rubra / Viburnum acerifolium)* community -

Northern red oak – Yellow birch (*Quercus rubra – Betula alleghaniensis*) forests

Northern red oak – Yellow birch / Cinnamon fern (*Quercus rubra – Betula alleghaniensis / Osmunda cinnamomea*) community

Mesic Circumneutral Forests

American beech – White oak – Northern red oak - Tulip tree (*Fagus grandifolia – Quercus alba – Quercus rubra – Liriodendron tulipifera*) community –Sharp et al. (2013)

Cove Forests – Moist forests at the base of slopes where colluvium accumulates; generally dominated by sugar maple and white ash; nutrients provided by surface runoff.

Sugar maple – White ash – American basswood (*Acer saccharum – Fraxinus americana – Tilia americana*) forests

Sugar maple – White ash / Blue cohosh (*Acer saccharum – Fraxinus americana / Caulophyllum thalictroides)* community

Sugar maple – White ash / New York fern (*Acer saccharum – Fraxinus americana / Thelyperis noveboracensis)* community

Seepage Forests – Moist forests at the base of slopes with groundwater discharge; generally dominated by sugar maple, white ash, and tulip poplar.

Acidic Seepage Forests

Sugar maple – White ash – American basswood (*Acer saccharum – Fraxinus americana – Tilia americana*) forests

Sugar maple – White ash / Silver false spleenwort (*Acer saccharum – Fraxinus americana /Deparia acrosticoides)* community

Circumeutral Seepage Forests

Sugar maple – White ash – American basswood (*Acer saccharum – Fraxinus americana – Tilia americana*) forests

Sugar maple – White ash / Blue cohosh (*Acer saccharum – Fraxinus americana / Caulophyllum thalictroides)* community
Sugar maple – White ash / New York fern (*Acer saccharum – Fraxinus americana / Thelyperis noveboracensis)* community

Alluvial Forests – Mesic forests influenced by seasonal inundation, mostly with well-drained, nutrient-rich soils.

Floodplain Forests
Silver maple – Eastern cottonwood (*Acer saccharinum – Populus deltoides)* temporarily flooded forests
Silver maple / Smallspike false nettle (*Acer saccharinum / Boehmeria cylindrical)* community
Silver maple / Sensitive fern (*Acer saccharinum / Onoclea sensibilis)* community
Pin oak – Green ash (*Quercus palustris – Fraxinus pennsylvanica*) temporarily flooded forests
American sycamore – Boxelder (*Platanus occidentalis – Acer negundo)* temporarily flooded forests

Palustrine System – Forested and Woodland Community

Basin Swamps – Forested and /or shrub swamps with stagnant or slow-moving water; in hydrographically defined basins; on decomposed peats and mucks.

Acidic Red maple / Ericaceous Basin Swamps
Red maple / Highbush blueberry (*Acer rubrum / Vaccinium corymbosum*) seasonally flooded forests
Red maple / Common winterberry – Highbush blueberry (*Acer rubrum / Ilex verticillata – Vaccinium corymbosum)* community
Red maple (*Acer rubrum*) seasonally flooded woodlands
Red maple / Tussock sedge (*Acer rubrum / Carex stricta*) community

Acidic Eastern Hemlock Basin Swamps
Eastern hemlock (*Tsuga canadensis*) seasonally flooded forests

Acidic Atlantic White Cedar Basin Swamps
Atlantic white cedar (*Chamacyperis thyoides*) seasonally flooded forests
Atlantic white cedar / Swamp azalea (*Chamacyperis thyoides / Rhododendron viscosum*) community
Atlantic white cedar – Red maple – Yellow birch (*Chamacyperis thyoides – Acer rubrum – Betula alleghaniensis*) community

Atlantic white cedar / Great laurel (*Chamacyperis thyoides / Rhododendron maximum*) community

Atlantic white cedar (*Chamacyperis thyoides*) saturated woodlands

Atlantic white cedar / Leatherleaf (*Chamacyperis thyoides / Camaedaphne calyculata*) community

Seepage Swamps – Swamps with flowing surface and /or telluric water, on gently sloping to sloping sites/ peat accumulations minimal.

Acidic Seepage Swamps

Red maple / Skunk cabbage (*Acer rubrum / Symplocarpus foetidus*) seasonally flooded forests

Red maple / Northern spicebush (*Acer rubrum / Lindera benzoin*) community

Alluvial Swamps – Swamps influenced by periodic flooding from adjacent rivers or streams, often influenced by runoff from the adjoining upland.

Silver maple – Eastern cottonwood (*Acer saccharinum – Populous deltoides)* temporarily flooded forests

Silver maple / Smallspike false nettle (*Acer saccharinum / Boehmeria cylindrical)* community

Silver maple / Sensitive fern (*Acer saccharinum / Onoclea sensibilis)* community

Intertidal Swamps – Regularly flooded swamps dominated by woody shrubs and scattered trees.

Freshwater Intertidal Swamps

Red maple – Green ash (*Acer rubrum – Fraxinus pennsylvanica*) tidally flooded woodlands

Red maple – Green ash / Knotweed (*Acer rubrum – Fraxinus pennsylvanica / Polygonum* spp.) community

New York Vegetation Organized by Natural Community Types for Forests and Woodlands that may occur within the New York LISS Coastal Boundary
(Edinger *et al.* 2014). Vegetation descriptions for these New York vegetation types may be found in Appendix B.
More information on community types may be found online at:
http://www.acris.nynhp.org/communities.php

Please note: Plant common and scientific nomenclature were retained from each state classification rather than reconciling one to the other or using a third standard reference.

Edinger (2006a and b) provides a concise, two-part history of the documentation of vegetation and ecological communities of Long Island, including but not limited to coastal forests and woodlands. The first article provides an annotated list of all the ecological communities of Long Island, New York. The second article includes a list of significant examples of Long Island ecological community types, including several forest and woodland types.
http://libotanical.org/newsletters/1603.pdf
http://libotanical.org/newsletters/1604.pdf

Forests (New York) defined as: *Communities formed by trees with a canopy cover of at least 60% or more at maturity, with tree crowns usually interlocked*. (Edinger *et al.*, 2014 p.148)
Woodlands (New York) defined as: *Communities composed of trees with a canopy cover of 26 to 60% at maturity. A herbaceous and/or shrub understory is usually present.* (Edinger *et al.* 2014 p.152)

Palustrine System–Forest and Woodland Communities

Forested Mineral Soil Wetlands

Floodplain Forest
Red maple (*Acer rubrum*)–Hardwood Swamp
Red maple–blackgum (*Acer rubrum-Nyssa sylvatica*) Swamps
Red maple–sweetgum (*Acer rubrum-Liquidambar styraciflua*) Swamp
Red maple-swamp white oak swamp (*Acer rubrum-Quercus bicolor* Swamp)
(This wetland occurs on the north fork of Long Island and is likely not found within the Long Island Sound Study boundary)

Terrestrial System–Forest and Woodland Communities

Barrens and Woodlands (*these three woodland types are primarily found in the southern half of Long Island and are likely not found within the Long Island Sound Study boundary*)

Dwarf pine plains (woodland)
Maritime pitch pine (*Pinus rigida*) dune woodland

Pitch pine (*Pinus rigida*)–oak (*Quercus* sp.)–heath woodland

Forested Uplands

Maritime Forests
Maritime oak (*Quercus* sp.) forest
Maritime beech (*Fagus* sp.) forest
Maritime red cedar (*Juniperus virginiana*) forest

Coastal Forests

Coastal oak (*Quercus* sp.)–heath forest
Coastal oak–hickory (*Quercus* sp.–*Carya* sp.) forest
Coastal oak–beech (*Quercus* sp.–*Fagus* sp.) forest
Coastal oak (*Quercus* sp.)–laurel forest

Pitch pine–oak (*Pinus rigida*–*Quercus*) forest
Oak–tulip tree (*Quercus* sp.–*Liriodendron tulipifera*) forest
Hemlock (*Tsuga canadensis*)-northern hardwood forest – possible remnants on western Long Island (personnel communication G. Edinger, April 11, 2017)

Successional Forests

Successional southern hardwoods
Successional maritime forest

FOREST MANAGEMENT AND MONITORING

There are numerous techniques and strategies for forest management and monitoring depending on the issues, current forest status and desired outcomes.

Management Planning

All restoration and management activities should begin with a written plan that outlines the overall goals of the project and how the proposed work fits into a larger context. NYC Parks Natural Resources Group has developed an in-depth guide for urban forest restoration (https://www.nycgovparks.org/pagefiles/84/guidelines-to-urban-forest-restoration.pdf) that includes planning, process and long term management of urban forest restoration projects with in-depth information on each of these topics. Another resource that includes a management plan template can be found at: http://clear.uconn.edu/tools/habitats/open_space/. Both guides emphasize the need for establishing overall goals before attempting a restoration or management project.

A written management plan with agreed upon goals is critical, so that time, energy and funds can be focused on priorities and, as turn over subsequently occurs among staff and volunteers, there is a record of what has been done and why. Goals may certainly change with time, but a written record of events will help refine future goals.

A written management plan can be easily updated to include aspects of climate adaptation and resilience that might be needed over time. For example, plant species that are currently uncommon in the coastal forests of Connecticut and New York may become more prevalent with longer growing seasons and warmer air/soil temperatures. How to manage these extended species ranges, if at all, may be a topic of discussion for potential inclusion in management plans.

Developing a Plan and Implementation: (see NYC Parks Guidelines document above)

- A site assessment is a necessary first step in developing goals for a site. Management and/or restoration may only be needed in certain areas. The site assessment should include an inventory of species, site needs and public use (both current and desired), current trails and usage. With this information, prioritization of sites for management within the parcel can occur. Goals can then be developed for the overall parcel as well as for individual sites within the larger parcel. If the entire parcel is in need of management/restoration, then there is the potential in this step to decide to tackle the entire area or work on parts of the parcel depending on funding and personnel.
- Goal setting will drive management and monitoring actions. This is an opportunity to build consensus with those involved in a project, surrounding neighbors and users of the area.

- Site Design: preparing at least a preliminary design on paper will help with goal setting and will provide another avenue for discussion with stakeholders. A design will also help resource managers think through potential obstacles or issues with management actions. Environmental site conditions should be considered including topography, bedrock, soils and wetlands. Access information in Connecticut on CT ECO (Environmental Conditions Online) and in New York – there is the state GIS website as well as the Environmental Resource Mapper. These websites also provide access to historical aerial images which may be important in considering past conditions or land use.
- Planning and Site Preparation: a detailed action plan to meet the desired goals will help with assessing the cost of the project, timing and feasibility. Different areas within a large parcel may have different action plan items depending on both the management issues and the end goals. For example, treatment techniques may differ depending on the species of invasive plant and level of infestation. Treatment may take only one application, while other invasives/infestations may require multiple years of treatment.
  Site preparation is a critical step in any successful management project. Soils should be tested to determine contamination (if any) or need for amelioration. See more information below for soil testing labs in Connecticut and New York. Other site preparation issues include consideration of the seed bank, which may be full of seeds from invasive/undesireable species, and how to treat it before planting or seeding.
  Depending on where you are in the context of land use, before digging in any area be sure to determine if there are any underground cables or pipes.
  In Connecticut, call toll free: 1-800-922-4455 or dial 811. Call 2 full working days in advance to locate buried utility pipes and cables.
  In New York, call 1-800-272-4480, or
  http://www.digsafelynewyork.com/excv/ocnyc.asp
- Planting and Maintenance: *Planting the right plant in the right place*. The different coastal forest community types described below provide some idea of the native species to be found in specific areas. Technical expertise is available through the Long Island Sound Study for both Connecticut and New York. Planting Guides for Connecticut and New York are also available. The Coastal Landscaping Guide for Long Island Sound provides fact sheets on site preparation and how to plant trees, shrubs and herbaceous perennials, aftercare including watering, mulching and fertilizing. Prevention of browse by animals such as deer and rabbits should also be considered.
- In determining plant species for a particular forest restoration project, consideration should be given to development of different layers within the canopy. Based on the vegetation descriptions below, some management projects may include trees, shrubs and herbaceous perennials, while others may include a subset of these.

- Monitoring Plan – a monitoring plan will guide the short and long term success of management/restoration project. Monitoring will help determine the adaptive management needs of a site over time.

Monitoring

A monitoring plan is part of a successful management project. The following table is from a federal publication on monitoring habitat restoration projects (Woodward and Hollar 2011) showing different types and phases of monitoring.

Table 1. Definitions of monitoring phases.

[Data from Lewis and others (2009)]

Monitoring type	Definition	Example question
Pre-Project or Baseline	Documentation of current site conditions and how they support project selection and design.	What are the existing site conditions and the reasons for implementing a project at the site?
Implementation	Monitoring to confirm that the project was implemented according to the approved designs, plans, and permits. Determining whether the agreed upon work was completed as planned.	Was the project installed according to design specifications, permits, and funding landowner agreements?
Effectiveness	Monitoring to assess post-project site conditions and to document changes resulting from the implemented projects. This is done through comparison with pre-project conditions to establish trends in the condition of resources at the site.	Did attributes and components at the project site change in magnitude as expected over the appropriate time frame?
Qualitative Effectiveness	A type of effectiveness monitoring based on qualitative assessment of the degree of achievement of clearly stated objectives that are often visually obvious. Photograph point monitoring is a very useful qualitative technique.	Did canopy cover increase from 0 percent pre-project to 50 percent or greater at River Mile 13 during mid-July 5 years after fence installation?
Quantitative Effectiveness	A type of effectiveness monitoring that is data-driven with rigorous sampling designs and assesses changes in project site characteristics.	Did a statistically significant change in canopy cover occur pre-project and 5-year post project using the Harris and others (2005) Line Intercept Transect protocol and the Flosi and others (1998) spherical densiometer protocol?
Validation	Monitoring to confirm the cause and effect relationship between the project and biotic (wildlife) or physical (water quality) response. For example, this includes the change in use, presence, or abundance of desired salmon or migratory songbirds at the project site.	Did fish or wildlife populations increase in response to the changes in physical or biological attributes or components brought about by the revegetation project?

As with a management plan, it is important to first identify the questions that a monitoring plan will address, and both short term and long term goals for monitoring. Short-term goals usually address implementation of the management/restoration (was the project carried out according to plan) while long-term goals address the success of restoration goals such as establishment of a particular forest vegetation type (and associated animal species).

Depending on the level of monitoring required or desired for a project, monitoring may be either qualitative or quantitative. Qualitative monitoring is usually a visual assessment such as through photographs. Drone photography is a new field and may be very effective for this. Taking hand held photographs from the same location (using GPS) over time can provide valuable information on establishment and

growth of species. Drone photography (also with GPS) opens up a new venue for monitoring forest plots over time and allows for easy overlay of aerial images to see changes over time.

Quantitative monitoring usually requires that permanent plots or transects of some sort be set up to collect data on such variables as percent cover, number/species of seedlings, success of plantings etc.

Other factors to consider in monitoring plans:

- Aside from monitoring vegetation and establishment of native species, abiotic factors such as soils characteristics may also be monitored over time.
- Monitoring projects on a regular basis, particularly over the short-term, will allow for adaptive management, especially with invasive species (either from the seed bank, roots/rhizomes left in the soil or new occurrences). In addition, factors that may impede success of a project such as deer or rabbit browse can be identified and addressed.
- Animal use of the project area. If one of the goals of a project is to create coastal forest habitat for particular bird species, then a monitoring plan should address this goal.

Resources for developing a monitoring plan:

- Urban Forest Management Plan Toolkit (http://ufmptoolkit.net/)
  This site provides information on developing both a management and monitoring plan under "Urban Forest Management Planning."
- US Forest Service Monitoring and Evaluation Framework (https://www.fs.fed.us/emc/met/)

Long Term Vegetation Monitoring
Dr. William Niering of Connecticut College initiated a long term monitoring program for several forested natural areas in 1953. These areas include Barn Island, Stonington, CT and Bluff Point Coastal Reserve, Groton, CT. Such studies, and similar ones in New York, can be used to monitor change over time in coastal forest vegetation.

Forest Silviculture:
The U.S. Forest Service defines silviculture as, "the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, restoration, and recreation on a sustainable basis." (https://www.fs.fed.us/forestmanagement/vegetation-management/silviculture/index.shtml).

Depending upon management goals, silviculture practices or a silviculture prescription is developed. This prescription is a document that outlines a series of treatments such that current forest stand structure and composition is changed to

meet those management goals. Treatments might include thinning, harvesting, planting, pruning, prescribed burns and site preparation. The U.S. Forest Service and Connecticut and New York Extension Programs have numerous resources for those looking to management forest tracts.

U.S. Forest Service resources on vegetation management are available at: https://www.fs.fed.us/forestmanagement/vegetation-management/index.shtml

The U.S. Forest Service has developed a Forest Vegetation Simulator (FVS) which indicates how vegetation will change in response to various factors such as proposed management actions, succession or disturbance. Information on the software, trainings, documents and support can be found at: https://www.fs.fed.us/fvs/index.shtml. A version of the software that allows users to model the effects of management under changing climate conditions is available for western states and is under development for eastern states.

In New York, resources and technical assistance on forest management are available through:
New York State Department of Environmental Conservation, Private Forest Management: http://www.dec.ny.gov/lands/4972.html

Cornell Cooperative Extension Forestry Program at:
http://www2.dnr.cornell.edu/ext/bmp/contents/cce.html

New York Forest Owners Association: http://www.nyfoa.org/resources

New York City Department of Parks and Recreation Urban Forest:
https://www.nycgovparks.org/trees

In Connecticut, resources and technical assistance on forest management are available through:
Connecticut Department of Energy and Environmental Protection Forestry:
http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322792&deepNav_GID=1631%20

UConn Forestry Extension at:
http://www.ctforestry.uconn.edu/forestryprogram.html

Connecticut Forest and Parks: https://www.ctwoodlands.org/land-conservation/property-management-and-forestry

USDA Natural Resource Conservancy Service in Connecticut and New York also may have resources for groups seeking to manage coastal forests. In Connecticut, NRCS offers the Regional Conservation Partnership Program's (RCPP) Young Forest Initiative focused on practices that will increase the quantity and quality of young

forest habitat for New England Cottontail rabbits (CT), American woodcock, and other species.
In Connecticut:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/programs/farmbill/rcpp/?cid=stelprdb1249616
In New York:
https://www.nrcs.usda.gov/wps/portal/nrcs/main/ny/programs/farmbill/rcpp/

There are numerous other resources and websites available as well. An attempt has been made to provide focused resources for managers of coastal forests within the Long Island Sound Study area.

Forest Management: Invasive Plant/Animal Management
Before tackling an infestation of invasive plants, it is best to develop a management plan for a particular parcel or group of land parcels. All invasive plants should be listed and their extent determined. This will allow land managers to understand the scope and potential cost of management. It could be determined that the infestation in one area is so large as to not be financially or ecologically feasible to control, while infestations in other places may be controllable. Invasive plant control will never be completed. Even if invasive plants are exterminated from a parcel, continued monitoring and maintenance will be required in perpetuity.

State and local experts (e.g., Cooperative Extension Master Gardeners) are available to assist with plant and insect identification and advice on control methodology. Below is a list of the most common invasive plants and the most common control methods. Use of chemicals, in controlled applications, is sometimes considered the most effective control methodology and is therefore provided below. Individuals or groups will need to determine their comfort level with herbicide use to control invasive plants.

Common invasive plants of coastal forests within the Long Island Sound Study Area

The plants listed here are the most common invasive plants of coastal forests. This is not an exhaustive list of invasive plant species. More information on invasive plants in New York and Connecticut can be found online:
New York Invasive Species Information
Connecticut Invasive Species Information

Also, USDA Forest Service has an online publication, Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands by Huebner et al. (2006) that is very helpful with plant identification.

Links to the most current and effective control methods are provided. Resource managers will need to determine if chemical control is a viable option for individual

sites. Chemical control is often the most effective treatment in eradicating an invasive plant infestation, but each situation is unique and many groups avoid the use of chemical control for a variety of reasons. Use of chemical control methods should follow state regulations and all precautions should be followed as directed. Several concerns should be kept in mind with invasive plant management:

- Sites should be monitored annually for new invasive plant establishment as catching invasive plants early in establishment makes for much easier management.
- Once an area is cleared of an invasive plant, several steps should be taken to ensure the successful growth of native plants including:
    - soil testing (e.g. New York State Soil Testing Resources for Gardeners and Univ of Connecticut Soil Nutrient Analysis Lab)
    - Soils may need to be replaced or amended before planting depending on contaminents and nutrient levels.
    - the area should be planted and/or seeded with natives to reduce the potential for reestablishment by invasives in this newly disturbed area. Consider planting a diversity of trees, shrubs and herbaceous plants including some more mature plants in order to provide diversity in the forest layers as well as to provide some canopy coverage to shade out invasive or undesirable species.
- You're never done. Following removal of invasive plants, monitoring for invasive plant reestablishment from the seed bank should be ongoing.
- With climate change leading to warmer air/soil temperatures and longer growing seasons, numerous species have the potential to extend their ranges into the Long Island Sound Study area – both native and non-native.

Invasive Trees:
There are numerous websites available for all these species. For plant identification, try Go Botany at https://gobotany.newenglandwild.org/
Also Extension Centers and Master Gardening programs can be helpful with plant identification and control information.
A US Forest Service publication focuses on invasives plants of forests and woodlands: Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands (Huebner *et al.* 2006) (https://www.fs.usda.gov/naspf/publications/invasive-plants-field-and-reference-guide-ecological-perspective-plant-invaders-fores-1)

Tree of Heaven (*Ailanthus altissima*) – a large fast growing tree (70 to 100 ft) with female plants having the ability to produce thousands of seeds. Leaves are alternate and pinnately compound. This tree is often confused with sumac but emits a foul odor. The trees also reproduce by root suckering and re-sprouting of cut stems. The following document provides several control methods depending on the size of the infestation and age of trees. Continued monitoring of a site after initial work is emphasized.
USDA Field Guide for Managing Tree-of-heaven in the southwest (Appendix C)

Norway maple (*Acer platanoides*) – a large deciduous tree with opposite leaves growing to 90 ft. While leaves are somewhat similar to that of the native sugar maple (*Acer saccharum*), Norway maples exude a milky white sap from cut veins and petioles. Control measures include both manual and chemical options. Manual control includes pulling young seedlings by hand, digging up young saplings, and girdling large trees. Glyphosate or triclopyr are chemical options.
USDA Forest Service Norway Maple (Appendix C)

Glossy buckthorn (*Frangula alnus*) – a large shrub or small tree growing up to 30 ft. Leaves grow alternately along the branches (though some may appear opposite) and are dark green and shiny on the upper surface.
Control measures include both manual, chemical options or a combination of the two. Manual control includes pulling young seedlings by hand, digging up young saplings, and girdling large trees. Glyphosate, triclopyr are among the chemical options.
Michigan Dept of Natural Resources Glossy buckthorn (Appendix C)

Black locust (*Robinia pseudeoacacia*) – a large deciduous tree growing up to 80 ft in height. Leaves are alternate and compound with 7 to 19 leaflets. Twigs have paired spines or thorns at each leaf scar (though may be absent on older twigs.) Reproduction is both through seeds and suckering of roots and stumps. While native to parts of the United States, black locust is considered invasive in New England. Chemical control is the most effective method as mechanical control often results in extensive resprouting. This invasive tree may be particularly problematic on barrier beaches such as Russian Beach in Stratford, CT and Pleasure Beach in Bridgeport, CT.
NRCS Black Locust (Appendix C)

Invasive Shrubs:
Autumn olive (*Eleagnus umbellata*) – a large deciduous shrub reaching 20 ft in height. Leaves are alternate and are egg or lanced shaped. Underside of leaves, buds and stems are covered with silvery to rust colored scales. Reproduction is generally by seed, but some vegetative sprouting does occur. Hand pulling is effective for seedlings, but once established, chemical control is usually the most effective option.
Penn State Extension Autumn Olive Control (Appendix C)

Japanese barberry (*Berberis thunbergii*) – a deciduous spiny shrub that typically grows to 3 ft but can be double that. Leaves are small and shaped like small spatulas. Fruit are bright red berries that persist throughout the winter. Reproduction is largely through the spread of seeds by birds and other animals, as well as some vegetative reproduction of roots and shoots. A great deal of research has been done on Japanese barberry control focused on the use of propane torches. Mechanical and chemical methods (and combinations) can also be effective.
NRCS Japanese Barberry Control (Appendix C)

Also see, Ward, J., S. Williams, and T. Worthley. 2013. Japanese Barberry Control Methods. Reference Guide for Foresters and Professional Woodland Managers. Special Bulletin. Connecticut Agricultural Experiment Station and the University of Connecticut Cooperative Extension System.

Winged euonymus or burning bush (*Euonymus alatus*) – a deciduous multi-stemmed shrub with dark green leaves that turn a brilliant red to purple color in the fall. Leaves are opposite and stems have distinctive "wings." Shrubs typically grow to 5 to 10 ft but can grow to 20 ft. Seed reproduction is prolific and usually dispersed by birds. Hand pulling, ensuring that the entire root system is removed, is effective for seedlings and smaller plants, as is repeated mowing. Chemical control is also effective.
Winged euonymus control (Appendix C)

Honeysuckles (*Lonicera spp.*) – The State of Connecticut Invasive Plant Working Group list the following honeysuckle shrubs as invasive in the state:
Amur honeysuckle (*Lonicera maackii*), Morrow's honeysuckle (*L. morrowii*), Tatarian honeysuckle (*L. tatarica*), Belle honeysuckle (*Lonicera x bella*) and Dwarf honeysuckle (*L. xylosteum*). The Invasive Plant Council of New York State also lists Morrow's and Tatarian honeysuckles. Honeysuckles in general are multi-stemmed, deciduous shrubs with paired, opposite leaves. Morrow's honeysuckle has hollow stems. Honeysuckles spread rapidly in open woodlands, fields and disturbed sites and can develop into a thick understory. Birds and mammals spread the seeds, and many of these species have been planted for ornamental purposes. Control depends on the degree of infestation, with hand pulling sometimes effective for seedlings or small infestations. Herbicides, mowing and prescribed burning are also effective.
Bush Honeysuckle control (Appendix C)

Multiflora rose (*Rosa multiflora*) – a single or multi-stemmed shrub reaching over 10 ft in height and approximately 10 ft or more in width. Leaves are alternate and are pinnately compound with 5 to 11 leaflets. Flowers are white to pinkish with red fruits (rose hips) developing during the summer. This rose can be distinguished from other rose species by the characteristic stipule pair at the base of the leaf stalk. The stipule (leaflike appendage) has hairs along its edges that resembles a small fringe. Mowing combined with chemical application or chemical applications are most effective in treating infestations.
Multiflora rose control (Appendix C)

Invasive Woody Vines:
Oriental bittersweet (*Celastrus orbiculatus*) – a deciduous woody vine with alternate, rounded leavers with fine toothed margins. Flowers occur in the leaf axils with the fruits opening to display fleshy red-orange arils covering the seeds. Reproduction is through seeds (dispersal by both birds and people) with vegetative reproduction also common. Vines can be trailing but are often found twining around other plants, shading them and eventually killing them.

Manual, mechanical and chemical control options are often used singly or in combination.
NRCS Oriental bittersweet Control (Appendix C)

Japanese honeysuckle (*Lonicera japonica*) – a perennial, woody vine that go grow to over 50 ft. Leaves are simple, opposite and up to 3 inches long. Flowers are borne in pairs and are very fragrant. Plants bloom in late spring to early summer with young flowers white or pinkish, turning yellow. Hand pulling, mowing, burning and chemical control may all be effective in treating infestations of this vine.
Japanese honeysuckle control (Appendix C)

Invasive Herbaceous Plants:
Garlic mustard (*Aliaria petiolata*) – this is a biennial herb that forms a rosette in its first year of growth. Leaves are kidney shaped with scalloped edges. During the second year, a stalk with alternate leaves grows reaching 3 to 4 ft in height. Flowers are white with 4 petals. Crushed leaves produce a strong garlic odor. Hand pulling and chemical control are two commonly used control methods.
Forest Service Garlic Mustard Control (Appendix C)

Japanese stiltgrass (*Microstigeum viminium*) – a shade-tolerant, annual grass, with pale green lance-shaped leaves growing to 2 to 3 ft in height. Reproduction is by seed and vegetative growth. Hand pulling as a control measures is effective for small infestations but continued monitoring is necessary as the seeds remain viable for at least 3 years. Mowing and tilling may also be effective but create disturbances that promote stiltgrass colonization so site remediation is critical. Chemical controls have also been found to be effective for larger infestations.
Japanese Stiltgrass Control (Appendix C)

Common invasive animals of coastal forests within the Long Island Sound Study Area

Emerald Ash Borer (EAB) (*Agrilus planipennis*) – a beetle with iridescent green wing covers; adults are approximately 0.3 – 0.55 in long and feed almost exclusively on ash trees. There are three native ash trees in the LISS region: white ash (*Fraxinus americana*), green ash (*F. pensylvanica*) and black ash (*F. nigra*) that are impacted by the EAB. While little can be done once trees are infested with EAB, resource managers should consider how they will manage infested trees and monitor for the presence of new invasive plant species that may replace dead or dying ash trees.

Emerald Ash Borer Information Connecticut DEEP:
http://www.ct.gov/deep/cwp/view.asp?a=2697&q=464598&deepNav_GID=1631%20
Emerald Ash Borer Information New York DEC:
Emerald Ash Borer Information NY: http://www.dec.ny.gov/animals/7253.html

Hemlock Woolly Adelgid (HWA) (*Adelges tsugae*) – HWA are non-native, small aphid like insects that are easily recognizable by the white, wooly substance covering the insect and egg masses on hemlock branches. The insects were first detected in both Connecticut and New York in 1985. Using piercing mouthparts, the insects feed on starch reserves disrupting the flow of nutrients to twigs and branches. Trees usually die between 4 to 10 years from the initial infestation. HWA feed on all hemlock species with Eastern hemlock (*Tsuga canadensis*) the most common hemlock species in New York and Connecticut. A variety of control techniques are available though none have proven to be completely successful. In addition, HWA are susceptible to cold winter temperatures (Cheah 2016) but the increasing variability of winter temperatures means that cold winter temperatures alone are unlikely to control HWA spread.

Hemlock Woolly Adelgid Information CT:
http://ipm.uconn.edu/documents/raw2/The%20Hemlock%20Woolly%20Adelgid/The%20Hemlock%20Woolly%20Adelgid.php?aid=172

Hemlock Woolly Adelgid Information NY:
http://www.dec.ny.gov/animals/7250.html

Gypsy moths (*Lymantria dispar)* – this insect pest was accidentally introduced to the United States in the late 1860's, near Boston, MA. Despite state and federal attempts to control impacts, this species continues to spread. Oaks and aspens are the most common host species and depending on the intensity of the infestation, may be defoliated. While small mammals and birds are natural predators, a virus and fungal species have led to some infestation mortality. The fungus (*Entomophaga maimaiga)* was released in 1910 near Boston as a way to control gypsy moths but researchers could not find evidence of establishment. Then in 1989 the fungus was found in Connecticut during a gypsy moth outbreak. Effectiveness of the fungus is dependent on moisture from spring rains. (Stafford 2018) The spraying of pesticides in some areas has also been effective. Research by the USDA and numerous universities continues with work on infestation rates, predators and other control treatments.)
https://www.fs.fed.us/ne/morgantown/4557/gmoth/

https://foresthealth.fs.usda.gov/portal

Asian Longhorned Beetle (ALB) (*Anoplophora glabripennis*) – this invasive beetle has a shiny black body with distinctive white patches on the wing cases. Females are about 1 to 1.5 in with the males slightly smaller. Their antennae are very distinctive with black and white markings and can be double the body in length. This wood boring insect feeds on numerous tree species including maples, ash, birch, willow, elm, and London plane tree/Sycamores. While not yet detected in Connecticut, ALB was first detected in Brooklyn, NY in 1996. ALB infestation is of great concern given the wide host range and the importance of forests and forest products, such as

maple syrup, in Connecticut and New York. To date, all New York infestations have been detected and eradicated. The role of the public in detection of any new occurrences is critical.

Asian longhorned beetle Information CT:
http://www.ct.gov/deep/cwp/view.asp?a=2697&q=421754&deepNav_GID=1631#concern

Asian longhorned beetle Information NY:
http://www.dec.ny.gov/animals/7255.html

White-tailed deer (*Odocoileus virginianus*) – Populations of this native mammal have undergone many fluctuations over the past several hundred years with hunting and clearing of forests. In Connecticut, efforts at increasing population numbers moved to control when the Deer Management Act was passed in 1974 and changed the status of deer from agricultural nuisance to valuable game animal. The first deer firearms hunting season was held in 1975 in Connecticut. Similarly in New York, efforts in the early part of the 20th century were aimed at increasing deer population numbers. By mid-century, deer were depleting food resources and moving into suburban/urban areas. Both states have determined desired deer densities based on a variety of factors for specific locations, with hunting widely used to control population numbers, though not always successfully. Deer browse can and is significantly impacting forests by preventing establishment of seedlings, reducing the forest understory and in allowing invasive plants to outcompete native plants through selective browsing.
Deer are of special concern in forest restoration projects in terms of protecting seedlings and saplings

White-tailed Deer Information CT:
http://www.ct.gov/deep/cwp/view.asp?a=2723&q=326112&deepNav_GID=1655

White-tailed Deer Information NY:
https://www.dec.ny.gov/animals/6965.html

CT Agriculture Experiment Station publication on: Limiting Deer Browse Damage to Landscape Plants (2000)
http://www.ct.gov/caes/lib/caes/documents/publications/bulletins/b968.pdf

Recreational and Research Uses and Issues

Uses of coastal forest tracts may include trail access (pedestrian, bike, equestrian etc.), birding, botanizing, hunting, fishing access and research. A detailed accounting of allowable uses should be part of any management plan.

Access and Trails – Trail placement and construction is a critical component of both protecting the forest landscape as well as enjoying it. There are many excellent websites on trail development and construction. An annotated list of resources is found below. Considerations of particular importance in trail placement include avoidance of rare species, slopes, wetland crossings, maintenance of trails, and what type(s) of access are allowed: pedestrian, bike, horse, motorized vehicles.

Excellent websites are listed below as well as many PowerPoint presentations. Numerous workshops are offered in New York and Connecticut on trail design and maintenance.

NY Parks info: http://parks.ny.gov/recreation/trails/technical-assistance.aspx
The goal of this website is to provide information and resources for organizations, community groups, land trusts and others in the planning, designing, building, maintaining and restoring trails. The following is a list of various documents and links to other websites to be used as resources to assist trail organizations, community and user groups, planning organizations, interested individuals, and others in planning, designing, developing and maintaining trails.
While created to provide standards and guidelines for trails within New York State Parks, these resources are an excellent resource for any group or individual developing a trail. This website also includes information on criteria used to determine accessibility of trails as well as the Universal Trail Assessment Process used to determine and provide trail characteristics. Information on design standards to conform to the Americans with Disabilities Act and Architectural Barriers Act can also be found on the resources and link provided by this website.

CT Forest and Parks: https://www.ctwoodlands.org/blue-blazed-hiking-trails/trail-maintainer%E2%80%99s-corner-0
Connecticut Forest and Parks Trail Maintainer's Corner also provides useful links as well as a document on Chainsaw Safety and Certification Policy.

USDA Forest Service: http://www.fs.fed.us/recreation/programs/trail-management/trailplans/
Similar to the resources for trails in New York and Connecticut, the Forest Service provides standards and guidelines for trails and trail bridges within the US Forest System that may be used by any groups or individuals interested in creating and maintaining trails.

American Trails: http://www.americantrails.org/resources/trailbuilding/

This website provides numerous documents, resources and examples from around the country on building sustainable trails and greenways including design guidelines, different construction techniques, trail paving and surfacing and trailhead signage and facilities.

National Park Service:
http://www.nps.gov/noco/learn/management/ncttrailconstructionmanual1.htm
While the site is for the North County there is a great deal of information including construction design specifications.

U.S. Department of Transportation Federal Highway Administration, Recreational Trails Program website provides numerous links, documents and other resources on trails for pedestrians, bicycles and some motorized vehicles such as snow mobiles. Also included here is information on safe road crossings.
http://www.fhwa.dot.gov/environment/recreational_trails/guidance/manuals.cfm

Accessibility:
https://www.fhwa.dot.gov/environment/recreational_trails/guidance/accessibility_guidance/
U.S. Department of Transportation Federal Highway Administration, Recreational Trails Program website includes a specific section on accessibility with information to assist States and project sponsors in complying with Recreational Trail Program requirements and provides best practices for trail accessibility, and trail design, construction, and maintenance.

Trails and Mountain Biking:
New England Mountain Biking Association (http://www.nemba.org/)
This Association is very active within Connecticut with five chapters. NEMBA offers training in mountain bike advocacy, trail design and construction, and riding skills. The NEMBA Grants program provides funding for trail projects.

http://www.imbacanada.com/resources/trail-building/mistakes
International Mountain Biking Association provides information on the 10 most common mistakes in building trails for mountain biking with several suggested resources. Information on building and maintaining trails for both pedestrians and bikers can be found on the US DOT website as well as several others listed above.

Resource managers should work closely with biking associations as the creation of unauthorized trails can provide avenues for invasive plants to establish.

Trails and Horses:
U.S. Department of Transportation Federal Highway Administration, Recreational Trails Program website includes a document developed by the U.S. Forest Service, "Equestrian Design Guidebook for Trails, Trailheads and Campgrounds."
https://www.fhwa.dot.gov/environment/recreational_trails/publications/fs_publications/07232816/toc.cfm

Other Uses of Coastal Forests:
Birding: The American Birding Association (http://www.aba.org) has developed the American Birding Association Code of Birding Ethics (http://listing.aba.org/ethics/) which includes promoting the welfare of birds and their environment, respecting laws and the rights of others, ensuring the safety/maintenance of bird feeders and structures, and considerations when group birding.

Botanizing: Botanical forays into coastal forest tracts may require landowner permission. Botanical collecting, where allowed, should follow ethical guidelines for collecting plants, such as the criteria used by the Native Plant Society of Oregon Guidelines and Ethical Code: http://www.glidewildflowershow.org/npso.htm

The Connecticut Botanical Society provides opportunities for members and the public to learn about plants and vegetation.

Hunting and Trapping: Because white-tail deer, beaver and other animals can present problems in coastal forests, the state guidelines for New York and Connecticut are included here as links:

New York Hunting and Trapping:
http://www.dec.ny.gov/outdoor/37136.html

Connecticut Hunting and Trapping:
http://www.ct.gov/deep/cwp/view.asp?a=2700&q=323414&deepNav_GID=1633

Research: Scientific research projects may be considered as an allowable use in coastal forest tracts.
States, municipalities, land trusts and other tract owners should determine what they would consider allowable in terms of scientific research and collections on their properties. An example of a research request form from a land trust can be found at: http://www.skagitlandtrust.org/pages/research.aspx

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Appendix A

Cross-Walk to US Forest Service ecoregions for both Connecticut and New York:

Bailey, R. G.; Avers, P. E.; King, T.; McNab, W. H., eds. 1994. Ecoregions and subregions of the United States (map). Washington, DC: USDA Forest Service. 1:7,500,000. With supplementary table of map unit descriptions, compiled and edited by W. H. McNab and R. G. Bailey.

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McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2007. Description of ecological subregions: sections of the conterminous United States [CD-ROM]. Gen. Tech.Report WO-76B. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p.

Ecosystems of the United States (USFS)
200 Humid Temperate Domain
- 220 Hot Continental Division
  - 221 Eastern Broadleaf Forest (Oceanic) Province (see https://www.fs.fed.us/land/pubs/ecoregions/ch16.html for descriptions of the Sections below)
    - 221 A Lower New England Section
      - 221Ad Southern New England Coastal Lowland Subsection
      - 221Ae Hudson Highlands Subsection
      - 221An Long Island Coastal Lowland and Moraine Subsection

Figure 4. Ecological Subregions: Sections and Subsections of the Conterminous United States. Cleland *et al*. (2007)

In Connecticut:
Long Island Sound Coastal Lowland (59g) crosswalks to Southern New England Coastal Lowland Subsection (221Ad)

In New York:
Southern New England Coastal Plain and Hills (59c) crosswalks to Hudson Highland Subsection (221Ae)

Long Island Sound Coastal Lowland (59g) and Cape Cod/Long Island (84a) crosswalk to Long Island Coastal Lowland and Moraine Subsection (221An)

Cross Walk to the ecoregions descriptions and boundaries for Connecticut by Dowhan and Craig (1976)

In Connecticut, the **Northeastern Coastal Zone/Long Island Sound Coastal Lowland** cross walks to the Western Coastal Ecoregion and Eastern Coastal Ecoregion as defined by Dowhan and Craig (1976). These two ecoregions divide Branford, CT and then go to the New York and Rhode Island borders, respectively.

CT Western Coastal Ecoregion: as defined by Dowhan and Craig (1976)
Topography: this area generally is within five miles of Long Island Sound. The geographic relief ranges from sea level to about 200 ft with a few locally higher areas and includes rolling hills and steep, rocky areas such as the trap rock ridges. Several major rivers are included within this ecoregion, the Housatonic and Quinnipiac with numerous smaller rivers such as the Saugatuck and Norwalk Rivers.

Geology and Soils: the bedrock is mainly metamorphic gneisses and schists with igneous (traprock ridge system) and sedimentary rock in the New Haven area. Bedrock structures are generally oriented in a north-south direction such that there are many east or west facing slopes.
Soils (Gonick 1978): The upland soils of this ecoregion are dominated by soils formed in glacial till derived from gneiss, schist and granite, and soils formed in stratified deposits derived from gneiss, schist and granite. In the New Haven, East Haven, Branford area, there are also soils formed in glacial till derived from sandstone, shale, conglomerate and basalt, and soils formed in stratified deposits derived from sandstone, shale, conglomerate and basalt.
Past Land Use history: This is a highly settled, urban area. Settlement and clearing of land dates back to Native American tribes and subsequent European settlers. (Foster and Motzkin 2003)

Coastal Hardwood Forests (as defined by Dowhan and Craig 1976) predominate on well drained soil. Dominant trees include Oaks (*Quercus velutina, Q. rubra, and Q. alba*), hickories including mockernut (*Carya tomentosa*), tulip poplar (*Liriodendron tulipifera),* black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*) and Eastern hemlock (*Tsuga canadensis*) depending on wooly adelgid impacts.
Forests are generally small in size and fragmented (UConn CLEAR, Basso *et al*. 2017).

CT Eastern Coastal Ecoregion: as defined by Dowhan and Craig (1976)
Topography: this area generally is between five and seven miles of Long Island Sound. The geographic relief ranges from sea level to 400 ft with a few locally higher areas and includes rocky uplands and rolling hills and valleys. The major rivers within this ecoregion are the Connecticut River, the Niantic River and the Thames River, with numerous smaller ones.
Geology: the bedrock is mainly metamorphic and igneous gneisses, schists and granites
Soils (Gonick 1978): The upland soils of this ecoregion are dominated by soils formed in glacial till derived from gneiss, schist and granite, and soils formed in stratified deposits derived from gneiss, schist and granite.
Past Land Use history: Settlement and clearing of land dates back to Native American tribes and subsequent European settlers. (Foster and Motzkin 2003)

Coastal Hardwood Forests (as defined by Dowhan and Craig 1976) predominate on well drained soil. Dominant trees include Oaks *(Quercus velutina, Q. rubra, and Q. alba*), hickories including mockernut (*Carya tomentosa*), black cherry (*Prunus serotina*), sassafras (*Sassafras albidum*) and Eastern hemlock (*Tsuga canadensis*)- depending on wooly adelgid impacts. The coastal influence allows for the growth of representative coastal plain species such as American holly (*Ilex opaca*) and post oak (*Quercus stellata*).

Appendix B. Forest and Woodland Vegetation Types that may occur with the Connecticut and New York LISS Coastal Area

Connecticut
Vegetation descriptions taken with permission from Metzler and Barrett (2006) unless otherwise noted following the classification scheme of this publication.

Metzler, K. J. and J. P. Barrett. 2006. The Vegetation of Connecticut, A Preliminary Classification. State Geological and Natural History Survey of Connecticut. Department of Environmental Protection. Hartford, CT. Report of Investigations No. 12. 109 p

Forests (Connecticut) defined as Trees with their crowns overlapping, generally forming 60-100% cover.

Evergreen Forests: Evergreen species generally contribute more than 75% of the total tree cover.

Eastern hemlock (*Tsuga canadensis*) forests
Found throughout Connecticut though rare in southeastern Connecticut
This forest cover type occurs on dry to moist hillsides and in ravines. Often occurring on sites similar to those dominated by deciduous trees, the distribution of eastern hemlock (*Tsuga canadensis*) forests is a function of former land use history and protection from fire. Eastern hemlock forests can also occur as a linear feature, confined to steep slopes or in protected ravines or as patches throughout the upland landscape. These forests rarely occur as "pure" stands, and are often mixed with eastern white pine (*Pinus strobus*), oaks, maple, birch and other trees, largely dependent on site conditions. Shrub and herbaceous cover is generally sparse. Throughout much of the state, scattered shrubs include flowering mapleleaf viburnum (*Viburnum acerifolium*), American witch hazel (*Hamamelis virginiana*), mountain laurel (*Kalmia latifolia*), lowbush blueberries (*Vaccinium* spp.) and others. Common herbs include wild sarsaparilla (*Aralia nudicaulis*), partridgeberry (*Mitchella repens*), starflower (*Trientalis borealis*), Indian pipe (*Monotropa uniflora),* and Canada mayflower (*Maianthemum canadense*). p. 8

Eastern hemlock (*Tsuga canadensis*) seasonally flooded forest
Found throughout Connecticut, though best expressed in Litchfield County
This community may fill all or part of upland valleys where nutrient-level inputs are moderate to very low and relatively high water levels are maintained throughout the summer. The soil is developed in organic mucks saturated with water even during prolonged dry periods. Surface water is generally present in hollows and depressions well into the growing season. Eastern hemlock (*Tsuga canadensis*) is the dominant tree species and often forms dense stands through

which little light penetrates. Other tree species include yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*) and occasional trees of eastern white pine (*Pinus strobus*). This community is characterized by an irregular topography of mounds and depressions caused by tree uprooting. The shrub layer is poorly developed due to shading by the tree canopy. Shrub species that do occur include northern spicebush (*Lindera benzoin*), winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), common mountain holly (*Nemopanthus mucronata*), and mountain laurel (*Kalmia latifolia*). The presence of various herb species depends on the moisture tolerance of each species. Herbs that often occur include cinnamon fern and royal fern (*Osmunda cinnamomea, O. regalis*), threeleaf goldthread (*Coptis trifolia)* and in wetter areas that receive seepage, sensitive fern (*Onoclea sensibilis*), skunk cabbage (*Sympocarpus foetidus*), and jack-in-the-pulpit (*Ariseama triphyllum*). Bryophytes are conspicuous and include *Sphagnum* spp. and *Bazzania trilobata.* p. 8

Atlantic white cedar (*Chamaecyparis thyoides*) seasonally flooded forests

Atlantic white cedar/Great laurel (*Chamaecyparis thyoides/Rhododendron maximum*) community
Found in southeastern Connecticut
This community typically occurs in basin swamps overlying stratified drift, glacio-lacustrine deposits and till. In this forest community, Atlantic white cedar (*Chamaecyparis thyoides*) dominates the tree canopy. Other tree species that may occur include red maple (*Acer rubrum*), eastern hemlock (*Tsuga canadensis*), yellow birch (*Betula alleghaniensis*) and sometimes blackgum (*Nyssa sylvatica*). The tall shrub layer is dominated by great laurel (*Rhododendron maximum*). This community type is characterized by a poorly developed herbaceous layer due to the closed canopy allowing only low levels of light to penetrate to the forest floor. Mosses that may occur here include *Sphagnum* spp., *Bazzania trilobata*, and *Thuidium delicatulum*. Cedar reproduction seems to be very poor in this community. p. 9

Atlantic white cedar-Red maple-Yellow birch (*Chamaecyparis thyoides-Acer rubrum-Betula alleghaniensis*) community
Found in eastern CT
This forest community occurs under variable habitat conditions, most commonly in seasonally saturated basins. Several occurrences for this community type occur on seasonally flooded streamsides. While Atlantic white cedar (*Chamaecyparis thyoides*) is dominant, tree species that are always found in significant quantity are red maple, (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), and eastern hemlock (*Tsuga canadensis*). The shrub layer is often well developed and very diverse. Common winterberry (*Ilex verticillata*), coastal sweet pepperbush (*Clethra alnifolia*), and highbush blueberry (*Vaccinium corymbosum*) often occur here, with maleberry (*Lyonia ligustrina*), mountain laurel (*Kalmia latifolia*), smooth winterberry (*Ilex laevigata*), and

swamp doghobble (*Leucothoë racemosa*) occurring sporadically. The herbaceous layer is highly variable depending on the amount of light penetration through the tree and shrub layers. Commonly occurring species include: cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), Canada mayflower (*Maianthemum canadense*), threeleaf goldthread (*Coptis trifolia*), eastern teaberry (*Gaultheria procumbens*), starflower (*Trientalis borealis*), eastern marsh fern (*Thelypteris palustris*) and threeseed sedge (*Carex trisperma*). Under poorer light conditions, mountain laurel (*Kalmia latifolia*) and eastern hemlock (*Tsuga canadensis*) become more dominant in the shrub layer, and ferns and mosses become more common (bog fern (*Thelypteris simulata),* eastern marsh fern (*Thelypteris palustris*), *Sphagnum* spp., *Bazzania trilobata* and *Thuidium delicatulum*)). Cedar reproduction is poor in this community. p. 9

Atlantic white cedar/Swamp azalea (*Chamaecyparis thyoides/Rhododendron viscosum*) community
Found in eastern Connecticut
This community typically occurs in semipermanently to seasonally flooded streamside or lakeshore habitats with high water levels and without extreme fluctuations in water level. Atlantic white cedar (*Chamaecyparis thyoides*) typically forms a dense almost monospecific canopy, with red maple (*Acer rubrum*) and yellow birch (*Betula alleghaniensis*) occurring infrequently and sporadically. Shrubs typically include sweet pepperbush (*Clethra alnifolia*), common mountain holly (*Nemopanthus mucronata*), highbush blueberry (*Vaccinium corymbosum*), swamp azalea (*Rhododendron viscosum*), blue huckleberry (*Gaylussacia frondosa*), and glossy buckthorn (*Frangula alnus*)[considered Invasive in Connecticut]. The herbaceous layer is very variable, with starflower (*Trientalis borealis*), threeseeded sedge (*Carex trisperma*), royal fern (*Osmunda regalis*), Virginia marsh St. Johnswort (*Triadenum virginicum*), and marsh fern (*Thelypteris palustris*) commonly found. Common mosses include *Sphagnum palustre* and other species of *Sphagnum*, *Thuidium* spp., *Pallavicinia lyellii*, and *Dicranium* spp. p. 9

Deciduous Forests: Deciduous trees generally contribute more than 75% of the total tree cover; includes some mixed evergreen/deciduous forest types)

Sugar maple-White Ash-American basswood (*Acer saccharum-Fraxinus americana / Tilia americana*) forests

Note that all ash trees are under threat from the emerald ash borer.

Sugar maple-White ash/Blue Cohosh (*Acer saccharum-Fraxinus americana/Caulophyllum thalictroides*) community
Found on rich, moist slopes throughout Connecticut but uncommon in eastern Connecticut

This community occurs on nutrient rich, moist lower slopes. In addition to sugar maple (*Acer saccharum*) and white ash (*Fraxinus americana*), characteristic trees species include yellow birch (*Betula alleghaniensis*), American basswood (*Tilia americana*), hop hornbeam (*Ostrya virginiana*), butternut (*Juglans cinerea*) and scattered red oak (*Querucs rubra*). American bladdernut (*Staphylea trifolia*) can be a dominant shrub, and red elderberry (*Sambucus racemosa var. racemosa*) and roundleaf dogwood (*Cornus rugosa*) are characteristic. The herbaceous layer is predominant, including blue cohosh (*Caulophyllum thalictroides*), Canadian wild ginger (*Asarum canadense*), bloodroot (*Sanguinaria canadensis*), Dutchman's-breeches (*Dicentra cucullaria*), rue anemone (*Thalictrum pubescens*), and burr reed sedge (*Carex sparganioides*). Various fern species frequently occur. p. 12

Sugar maple-White ash/Silvery false spleenwort (*Acer saccharum-Fraxinus Americana/Deparia acrostichoides*) community
Found on rich, bouldery slopes, uncommon in eastern Connecticut
This community develops on the lower portion of rich, rocky slopes, generally below cliffs or ledges. Humus accumulates within crevices of the rocks and boulders, providing a rooting substrate. White ash (*Fraxinus americana*) and sugar maple (*Acer saccharum*) are dominant trees, with bitternut hickory (*Carya cordiformis*) and slippery elm (*Ulmus rubra*) also commonly occurring. The shrub cover often includes northern spicebush (*Lindera benzoin*), American witch hazel (*Hamamelis virginiana*) and American bladdernut *(Staphylea trifolia*). Herbaceous cover is high and includes many fern species (*Deparia acrostichoides, Adiantum pedatum, Onoclea sensibilis, Osmunda claytoniana*). Other herbaceous species include many species of wet soils that grow optimally grow in swamps or floodplains: e.g., rough bedstraw (*Galium asprellum*), false hellebore (*Veratrum viride*), Virginia waterleaf (*Hydrophyllum virginiana*), crinkleroot (*Cardamine diphylla*), and Canadian woodnettle (*Laportea canadensis*). Showy orchid (*Galearis spectabilis*), Clayton's sweetroot (*Osmorhiza claytonia*), and other rich-woods herbs also occur in this community. p. 12

Sugar maple-White ash/New York fern (*Acer saccharum-Fraxinus Americana/Thelypertis noveboracensis*) community
Found throughout Connecticut
This community is the most nutrient poor and driest of the sugar maple-white ash forests occurring on streamsides, drainageways, and wetland borders. Sugar maple (*Acer saccharum*) and white ash (*Fraxinus americana*) are the dominant tree species, with admixtures of oaks (*Quercus rubra, Q. velutina*) and birches (*Betula lenta and B. alleghaniensis*). Shrub cover is generally sparse, with American witch hazel (*Hamamelis virginiana*) and spicebush (*Lindera benzoin*) the most common. Herbaceous cover is generally dense, with New York fern (*Thelypteris noveboracensis*) most abundant. Other herbs may include nightcaps (*Anemome quinquefolia*), fragrant bedstraw (*Galium triflorum*), and interrupted fern (*Osmunda claytoniana*). p.12

Sugar maple – Oak (*Acer saccharum – Quercus* spp.) forests
Sugar maple-White ash/Roundlobe hepatica (*Acer saccharum-Fraxinus Americana/Hepatica nobilis* var. *obtusa*) community
Found mainly on rich, dry slopes in western Connecticut, it is occasionally found on basalt ridges and other rocky slopes.
This community occurs on very rocky slopes that are well drained to moist. White ash (*Fraxinus americana*) and sugar maple (*Acer saccharum*) are common in the tree canopy. Oaks, e.g., northern red oak (*Quercus rubra*), hickories (*Carya* spp.), and sometimes American beech (*Fagus grandifolia*) are present in the tree layer. The shrub layer includes northern spicebush (*Lindera benzoin*) with hop hornbeam (*Ostrya virginiana)* present on drier sites. Herbaceous cover includes differential species such as broadleaf sedge (*Carex platyphylla*), early meadow rue (*Thalictrum dioicum*), roundlobe hepatica (*Hepatica nobilis* var. *obtusa*) and rue anemone (*Thalictrum thalictroides*). Other common herbs include nodding fescue (*Fescue subverticillata),* Christmas fern (*Polystichum acrostichoides*), white baneberry (*Actaea pachypoda*), common blue violet (*Viola sororia*), rock-cress (*Arabis* spp.), roundleaf ragwort (*Packera obovata*), and jack-in-the-pulpit (*Ariseama triphyllum).* This community may be differentiated from the other sugar maple-white ash communities by the occurrence of broadleaf sedge (*Carex platyphylla*), early meadow rue (*Thalictrum dioicum*), roundlobe hepatica (Hepatica nobilis var. *obtuse*), rue anemone (*Anemonella thalictroides*) and perhaps longstalk sedge (*Carex pedunculata*). p.13

Pignut hickory – White ash (*Carya glabra – Fraxinus americana*) forests
Found on traprock ridges/*summits*, conical summits and upper slopes in western Connecticut
These forest communities occur on dry, rocky summits of either acidic or circumneutral soils. Dominant tree species include hickories (*Carya glabra, C. ovalis*, *C. ovata*) and white ash (*Fraxinus americana*), with occasional oaks (*Quercus* spp.), hop hornbeam (*Ostrya virginiana*), and sugar maple (*Acer saccharum*). Tree height is low in stature, and the sporadic shrub layer – combined with an herbaceous layer often dominated by grasses and sedges (*Carex pensylvanica* often dominant) – gives these forests a characteristic parklike appearance. In some occurrences, a patchy to nearly continuous shrub layer of downy arrowwood (*Viburnum rafinesquianum*) is characteristic. Additional herbs include Canada bluegrass (*Poa compressa*), little bluestem (*Schizachyrium scoparium*), tick trefoils (*Desmodium* spp.), whorled milkweed (*Asclepias verticillata),* rock-cress (Arabis spp.), roughleaf ricegrass (*Oryzopsis asperifolia*) and a variety of ferns, such as ebony spleenwort (*Asplenium platyneuron)* and woodsia (*Woodsia obtusa*). Spring ephemerals are also characteristic, and include early saxifrage (*Saxifraga virginiensis*), Virginia spring beauty (*Claytonia virginica*), common blue violet (*Viola sororia*) and dogtooth violet (*Erythronium americanum*). p. 14

Northern red oak/Flowering dogwood (*Quercus rubra/Cornus florida*) forests

Northern red oak/Mapleleaf viburnum (*Querus rubra/Viburnum acerifolium*) community

Found throughout Connecticut

This forest community usually occurs in deep, moderately well to well drained soils on midslopes and on shallow soils influenced by seepage water. This community also occurs on terrace escarpments and on well drained glacial-lake sediments in the Central Valley region. Red oak (*Q. rubra*) is often the dominant tree species, but other trees often co-occur e.g., black oak (*Q. velutina*), sweet birch (*Betula lenta*), red maple (*Acer rubrum*) and hickories (*Carya* spp.). (*Red oak may be less common in the less mesic eastern coastal areas of the state. R. Rozsa pers. comm.*) A subcanopy of flowering dogwood (*Cornus florida*), fragrant bedstraw (*Galium triflorum*) and spotted geranium (*Geranium maculatum*) reflect the greater soil fertility and moisture regime as compared with other oak forest types. [White-tailed deer has and continues to alter the structure of this community], with the characteristic shrub layer eliminated in many parts of the state. p.14

American beech-White oak-Northern red oak-Tuliptree (*Fagus grandifolia-Quercus alba-Quercus rubra-Liriodendron tulipifera*) community

Found in southwestern Connecticut

This forest community is believed to occur along the Connecticut coast in Fairfield County. This community is described as having a mixed canopy of red oak (*Quercus rubra*), white oak (Quercus alba), American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*) and tuliptree (*Liriodendron tulipifera*). The conspicuous occurrence of flowering dogwood (*Cornus florida*) is characteristic. The shrub layer is characterized most commonly by mapleleaf viburnum (*Viburnum acerifolium*). The herb layer includes feathery false lily of the valley (*Maianthemum stellata*), smooth Solomon's seal (*Polygonatum biflorum*), jack-in-the-pulpit (*Arisaema triphyllum*), spotted geranium (*Geranium maculatum*), Virginia creeper (*Parthenocissus quinquefolia*), and upland sedges such as Swan's sedge (*Carex swanii*). p. 14

Northern red oak-Black oak-Chestnut oak (*Quercus rubra-Quercus velutina-Quercus prinus*) forests

Black oak – Chestnut oak/Black huckleberry (*Quercus velutina-Quercus prinus/Gaylussacia baccata)* community

Common on dry upper slopes throughout much of Connecticut, less common in northern Litchfield and southern Fairfield counties.

This forest community occurs on shallow and other dry, rocky soils, usually on upper slopes and summits or on deep, excessively drained sands and gravels. In rocky or other droughty sites, the tree canopy may be open, often forming woodlands. Chestnut oak (*Quercus prinus*) is generally the dominant tree on shallow soils over bedrock, whereas other oaks, e.g., black and scarlet (*Quercus*

velutina, Q. coccinea), are prevalent on sandy sites. White oak (*Quercus alba*) can also be important, particularly in warmer sites along the coast. In many occurrences, pitch pine (*Pinus rigida*) or eastern white pine (*Pinus strobus*) can be an important component of the canopy. A low shrub layer of black huckleberry (*Gaylussacia baccata)* intermixed with patches of lowbush blueberries (*Vaccinium pallidum, V. angustifolia*), and the following drought indicator species distinguish this community from other oak forests: bastard toadflax (*Comandra umbellata*), poverty oatgrass (*Danthonia spicata*), and little bluestem (*Schizachyrium scoparium*), occurring particularly in openings. In some occurrences, mountain laurel (*Kalmia latifolia*) may also co-occur or become dominant. p. 15

Northern red oak – Black oak/Blue Ridge blueberry (*Quercus rubra-Quercus velutina/Vaccinium pallidum*) community
Common on dry upper slopes throughout much of Connecticut, less common in northern Litchfield and southern Fairfield counties.
This forest community occurs on dry to well-drained soil on upper and middle slopes and summits. The soil is shallow, but in contrast to the previous community, are either deeper to bedrock or have a higher soil moisture holding capacity. Red and black oak (*Quercus rubra* and *Q. velutina*) are the dominant tree species, although chestnut oak (*Q. prinus*) and pines can commonly occur. Several variants of this community occur in Connecticut, reflecting differences in climate and substrate. […] Near the coast, sassafras (*Sassafras albidum*) and coastal sweet pepperbush (*Clethra alnifolia*) are frequent. Another variant of this vegetation type occurs on well drained sandy soils, often dominated by white and/or scarlet oak (*Quercus alba, Q. coccinea*), hickories (Carya spp.), and/or eastern white pine (*Pinus strobus*). This community's characteristic ground cover is either an open dwarf-shrub layer of predominantly lowbush blueberry species (*Vaccinium angustifolium* and *V. pallidum*) or a lawn of Blue Ridge sedge and/or Pennsylvania sedge (*Carex lucorum, C. pensylvanica*) intermixed with ericaceous dwarf-shrubs. Mountain laurel (*Kalmia latifolia*) can be sparse or frequent. Additional herbaceous species include narrowleaf cowwheat (*Melampyrum lineare*), moccasin flower (Cypripedium acaule), eastern teaberry (*Gaultheria procumbens*), western bracken fern (*Pteridium aquilinium*) and rattlesnake weed (*Hieracium venosum*), and other species. Black huckleberry (*Gaylussacia baccata*) may occur sporadically throughout this community. p. 15

Northern red oak-Yellow birch (Quercus rubra-Betula alleghaniensis) forests

Northern red oak-Yellow birch/Cinnamon fern (*Quercus rubra-Betula alleghaniensis/Osmunda cinnamomea)* community
Widespread as a wetland transition throughout much of Connecticut. Covers large areas of moist sandy soil in Hartford and New Haven counties.

This community occurs on somewhat poorly drained mineral soil with a soil moisture regime of moist to somewhat wet. This community has a nearly continuous tree canopy, with the tree height reflecting the moisture availability of the site. Dominant tree species include red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), and northern red and black oak (*Quercus rubra* and *Q. velutina).* Shrub layer cover includes American witch hazel (*Hamamelis virginiana*), highbush blueberry (*Vaccinium corymbosum*), and spicebush (*Lindera benzoin*). The herbaceous layer is nearly continuous and is dominated by cinnamon fern (*Osmunda cinnamomea*), New York fern (*Thelypteris noveboracensis*) and sessileleaf bellwort (*Uvularia sessilifolia*). p. 16

Silver maple-Eastern cottonwood (*Acer saccharinum-Populous deltoids*) temporarily flooded forests

Silver maple-Smallspike false nettle (*Acer saccharinum-Boehmeria cylindrica*) community
Found along major rivers with active floodplains
This community occurs on poorly drained and very poorly drained alluvial soils that are regularly flooded during freshets and storm events, even during the summer months. The soil moisture regime is wet. This forest type includes the wettest silver maple (*Acer saccharinum*) forests, frequently with ponding water long after the floodwaters recede. Silver maple is often the only tree present, although eastern cottonwood (*Populus deltoides*) and an occasional green ash (*Fraxinus pennsylvanica*) can occur. This forest is characterized by the conspicuous lack of a shrub layer and a near monoculture of low-growing nettles, e.g., smallspike false nettle (*Boehmeria cylindrica*) and Canadian clearweed (*Pilea pumila*). Other species occur throughout, including sensitive fern (*Onoclea sensibilis*), eastern poison ivy (*Toxicodendron radicans*), and white grass (*Leersia virginica*). In areas with active flood scour, white grass can be the dominant herb. p. 16

Silver maple/Sensitive fern (*Acer saccharinum/Onoclea sensibilis*) community
Found along major rivers, best expressed along the Connecticut River.
This community occurs within the inner floodplain in areas that are above the river level and that are freely drained after floodwaters recede. Along the Connecticut River, south of Cromwell, this community is the predominant floodplain type. Silver maple (*Acer saccharinum*) is the dominant tree species, with eastern cottonwood (*Populous deltoides*) occurring sporadically in the tree and shrub layers. American elm (*Ulmus americana*) and green ash (*Fraxinus pennsylvanica*) also are found as low trees. The presence of shrubs such as northern spicebush (*Lindera benzoin*), southern arrowwood (*Viburnum dentatum* var. *lucidum*), and silky dogwood (*Cornus amomum*) present a sharp contrast to the wetter silver maple forests of the inner floodplain. Typically sensitive fern (*Onoclea sensibilis*) completely covers the forest floor. Additional species include sweet reedgrass (*Cinna arundinacea*), white avens (*Geum*

canadense), white turtlehead (*Chelone glabra*), jewelweed (*Impatiens capensis*), and several characteristic sedges (*Carex crinita, C. lupulina*) and *Carex grayii*, which is differential. p.17

Pin oak-Green ash (*Quercus palustris-Fraxinus pennsylvanica*) temporarily flooded forests

Found in alluvial floodplains of small rivers

These forests occur on alluvial deposits on the floodplains of small rivers that flood during local events, particularly during the winter months. Tree species include pin oak (*Quercus palustris*), green ash (*Fraxinus pennsylvanica*), swamp white oak (*Quercus bicolor*), American sycamore (*Platanus occidentalis*), red maple (*Acer rubrum*), and American elm (*Ulmus americana*). The shrub layer includes northern spicebush (*Lindera benzoin*), dogwoods (*Cornus amomum* and *C. obliqua*), southern arrowwood (*Viburnum dentatum* var. *lucidum*), and common elderberry (*Sambucus nigra* ssp. *canadensis*). The herb layer is nearly continuous, with sedges (*Carex crinita, C. lupulina, C. grayi, C. ampholola*), broadleaf enchanter's nightshade (*Circaea lutetiana* var. *canadensis*), jewelweed (*Impatiens capensis*), white avens (*Geum canadense*), sensitive fern (*Onoclea sensibilis*), lady fern (*Athyrium felix-femina*), jack-in-the-pulpit (*Arisaema triphyllum*), harlequin blue flag (*Iris versicolor*), common blue violet (*Viola soroia*), and eastern poison ivy (*Toxicodendron radicans*). p. 18

American sycamore-Boxelder (*Platanus occidentalis-Acer negundo*) temporarily flooded forests

Occurs along mid-gradient rivers such as the Farmington and Quinnipiac rivers. This floodplain forest occurs on low-lying riverbanks and bars that have an active sedimentation and erosion regime. A number of trees can occur, including American sycamore (*Platanus occidentalis*), boxelder (*Acer negundo*), red maple (*Acer rubrum*), American elm (*Ulmus americana*), bitternut hickory (*Carya cordiformis*), and eastern cottonwood (*Populus deltoides*). Other than sapling trees, the only shrub regularly occurring is black willow (*Salix nigra*). The herbaceous cover is variable, but often includes ostrich fern (*Matteuccia struthiopteris*), white avens (*Geum canadense*), sensitive fern (*Onoclea sensibilis*), and eastern poison ivy (*Toxicodendron radicans*). In many occurrences, invasive species such as creeping jenny (*Lysimachia nummularia*), dame's rocket (*Hesperis matronalis*), and bush honeysuckles (*Lonicera* spp.) are conspicuous. p. 18

Red maple/Skunk cabbage (*Acer rubrum/Symplocarpus foetidus*) seasonally flooded forests

Red maple/Northern spicebush (*Acer rubrum/Lindera benzoin*) community

Found throughout Connecticut

This community occurs along small streams and drainageways that receive seepage water. These swamps have variable soils that are most often poorly drained tills with minimal peat accumulation. Water table fluctuations are

great, with the lowlands usually flooded in the early spring. By the end of the summer, the water table is often well below the surface level. Soil moisture regime is somewhat wet to wet.
Red maple (*Acer rubrum*) is the dominant tree species, with occasional black ash (*Fraxinus nigra*) and American elm (*Ulmus americana*). The shrubs include northern spicebush (*Lindera benzoin*), nannyberry (*Viburnum lentago*), winterberry (*Ilex verticillata),* red maple (*Acer rubrum*), silky dogwood (*Cornus amomum*), and sometimes, coastal sweet pepperbush (*Clethra alnifolia*). The herb layer is nearly continuous, with skunk cabbage (*Symplocarpus foetidus*) and/or green false hellbore (*Veratrum viride*) dominant, particularly in the spring. Other common herbs include sensitive fern (*Onoclea sensibilis*), crested woodfern (*Dryopteris cristata),* cinnamon fern (*Osmunda cinnamomea*), and jewelweed (*Impatiens capensis*). p.19

Red maple/Highbush blueberry (*Acer rubrum/Vaccinium corymbosum*) seasonally flooded forests

Red maple/Common winterberry-Highbush blueberry (*Acer rubrum/Ilex verticillata-Vaccinium corymbosum*) community
Found throughout Connecticut, but absent in the western marble valleys. These swamps form in bedrock depressions where there is a perched water table, and more commonly in flooded lowlands. In the lowlands, the water table fluctuates from above the soil surface in the early spring to below the surface toward the end of summer. The substrate is generally decomposed peat, and there is relatively low nutrient input into the system. The tree canopy is relatively open, composed almost exclusively of red maple (*Acer rubrum*), with scattered blackgum (*Nyssa sylvatica*), eastern hemlock (*Tsuga canadensis*), and/or eastern white pine (*Pinus strobus*). Shrub layer development is dependent upon the density of the tree canopy, which in turn is dependent on the wetness of the site. Where there are only scattered red maples, dense shrub thickets of highbush blueberry (*Vaccinium corymbosum*), swamp azalea (*Rhododendron viscosum*), and common winterberry (*Ilex verticillata*) form. Herbaceous species composition varies and may include tussock sedge (*Carex stricta*), skunk cabbage (*Symplocarpus foetidus*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), eastern marsh fern (*Thelypteris palustris*), sedges (*Carex intumescens, C. folliculata*), and occasionally seedbox (*Ludwigia palustris*) and mannagrass species (*Glyceria* spp.). p.19

A variant of this swamp occurs on poorly drained mineral soils. Seasonal surface flooding occurs, and soil moisture is somewhat wet to wet. The tree, shrub and herb layers are well developed. The tree layer is dominated by red maple (*Acer rubrum*), with scattered pin oak (*Quercus palustris*) and black gum (*Nyssa sylvatica*). The shrub layer comprises a dense thicket of sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), winterberry (*Ilex verticillata*), and swamp azalea (*Rhododendron viscosum*). Skunk cabbage (*Symplocarpus foetidus*) is a common spring herb in open areas.

In both variants, blowdowns are common and tree cover is generally open, less than 75%. p.19

Woodlands (Connecticut) defined as Open stands of trees with crowns not usually touching, generally forming 25 – 60% cover.

Evergreen Woodlands: Open Forest with trees over 5 meters tall forming 25-60% canopy cover. Shrubs, herbs, and nonvascular plants may be present at any cover value.

Pitch pine (*Pinus rigida*) woodlands

Pitch pine/Bear oak (*Pinus rigida/Quercus ilicifolia*)
Small, scattered occurrences are found throughout Connecticut, but are rare in Fairfield County.
This community occurs on both bedrock summits and ledges or on deep sands where the soil moisture regime is extremely dry to very dry. A mixture of pitch pine (*Pinus rigida*) and various oaks (*Quercus* spp.) with a variable shrub layer of bear oak (*Quercus ilicifolia*) characterizes these woodlands. The herbaceous layer may include little bluestem (*Schizachyrium scoparium*), lowbush blueberry (*Vaccinium angustifolium),* narrowleaf cowwheat (*Melampyrum lineare*), poverty oatgrass (*Danthonia spicata*), goldenrods (*Solidago nemoralis, S. bicolor*) and bracken fern (*Pteridium aquilinum*). Mosses (*Polytrichum* spp.) and lichens (*Cladonia* spp., *Cladina* spp.) can be conspicuous. p.22

Pitch pine/Lowbush Blueberry (*Pinus rigida/Vaccinium angustifolium*) community
Found in the Central Valley and other areas with extensive sandy deposits. This woodland community can be best described as a pitch pine heath on nutrient-poor, dry sandy soils. The tree canopy is variable in cover, ranging from open woodlands to a nearly closed forest. In some occurrences, this community is nearly indistinguishable from pitch pine woodlands as described above. In addition to pitch pine (*Pinus rigida*), a number of oaks (*Quercus velutina* and *Q. coccinea*), gray birch (*Betula populifolia*), and eastern white pine (*Pinus strobus*) may occur and/or become dominant with post oak (*Q. stellata*) an irregular component in coastal sites. The ground cover can be dominated by dwarf shrubs, e.g., black huckleberry (*Gaylussacia baccata*) and lowbush blueberries (*Vaccinium pallidum, V. angustifolia*) or can be patchy with open areas of sand or grasses. Characteristic herbaceous species include little bluestem (*Schizachyrium. scoparium*), poverty oatgrass (*Danthonia spicata*), Pennsylvannia sedge (*Carex pennsylvanica*), pinweeds (*Lechea* spp.), frostweeds (*Helianthemum canadense, H. bicknellii*), and others. Mosses (*Polytrichum commune*, *P. piliferum, P. juniperinum*) and lichens (*Cladonia* spp., *Cladina* spp.) can be conspicuous. p. 22

Eastern red cedar (*Juniperus virginiana)* woodlands

Eastern red cedar/Poverty oatgrass (*Juniperus virginiana/Danthonia spicata*) community
Found in the Central Valley.
This xerophytic community, *often referred to as a cedar glade*, is generally restricted to traprock ledges *(and dip slopes with shallow soils and exposed bedrock).* Soil moisture ranges from dry to extremely dry. Locally dominant tree species include eastern red cedar (*Juniperus virginiana*) and white ash (*Fraxinus americana*), chestnut oak (*Quercus prinus*), and occasionally hophornbeam (*Ostrya virginiana*), and post oak (*Quercus stellata*) occurring locally along the coast. Shrubs include oaks (*Quercus ilicifolia, Q. prinoides*) and downy arrowwood (*Viburnum rafinesquianum*). Herb layer cover is discontinuous due to the blocky structure of the bedrock. Major herbaceous species include grasses such as little bluestem (*Schizachyrium scoparium*), poverty oatgrass (*Danthonia spicata*) and panicgrass (*Dichanthelium linearifolium, D. acuminatum*), sedges (*Carex hirsutella, C. rosea*), and a variety of flowering herbs. Characteristic species include red columbine (*Aquilegia canadensis*), rock harlequin (*Corydalis sempervirens*), mountain mints (*Pycnanthemem* spp.), long-leaved bluets (*Houstonia longifolia*) and fall composites such as upland boneset (*Eupatorium sessilifolium*), woodland sunflower (*Helianthus divaricatus*), and goldenrods (*Solidago nemoralis, S. bicolor*). Mosses (*Polytrichum* spp.) and lichens (*Cladonia* spp., *Cladina* spp.) can be conspicuous. p. 22

Atlantic white cedar (*Chamaecyparis thyoides*) saturated woodlands

Atlantic white cedar/Leatherleaf (*Chamaecyparis thyoides/Chamaedaphne calyculata)* Community
This community is uncommon in eastern and south central Connecticut. (May occur within the eastern most LISS boundary area near the Rhode Island border.)
This woodland community is found on saturated sites with largely bog-like conditions. The canopy is open with a well-developed understory. Atlantic white cedar (*Chamaecyparis thyoides*) is scattered throughout, with leatherleaf (*Chamaedaphne calyculata*) or swamp loosestrife (*Decodon verticillatus*) forming a thick understory. Other shrubs may include coastal sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), and swamp azalea (*Rhododendron viscosum*). *Sphagnum* mosses often form a carpet in open areas and beneath low shrubs. Cranberry (*Vaccinium macrocarpon*), purple pitcher plants (*Sarracenia purpurea*), and sundews (*Drosera* spp.) often occur. p. 24

Deciduous Woodlands: Deciduous tree species generally contributing to greater than 75% of the total tree cover.

Scarlet oak – Sassafras (*Quercus coccinea – Sassafras albidum*) woodlands
Found in coastal Connecticut.
Maritime scrub woodlands are poorly developed on the Connecticut coast due to limited coastal dune formation. This community occurs in the sheltered area below the dune crest offering little protection from salt spray. The vegetation is "pruned" by salt spray, and, as a result, it is generally of relatively short stature. Common tree species include black cherry (*Prunus serotina*), scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*), sassafras (*Sassafras albidum*) and Canadian serviceberry (*Amelanchier canadensis*). Shrub species include northern bayberry (*Morella pensylvanica),* southern arrowwood (*Viburnum dentatum* var. *lucidum*), black huckleberry (*Gaylussacia baccata*), Virginia rose (*Rosa virginiana*), and the non-native invasive honeysuckles (*Lonicera morrowii* and *L. japonica*). Many lianas occur, including eastern poison ivy (*Toxicodendron radicans*), roundleaf greenbriar (*Smilax rotundifolia*), Asian bittersweet (*Celastrus orbiculata*), and Virginia creeper (*Parthenocissus quinquefolia*). Herb layer species may include various sedges (Carex spp.), mayflower (*Maianthemum canadense*), and starry false lily of the valley (*Maianthemum stellatum).* p. 24

Northern red oak/Rock polypody (*Quercus rubra/Polypodium virginianum*) woodlands
Found on acidic rock talus throughout Connecticut.
These woodlands occur on acidic, open, boulder talus. The tree canopy is open to moderately closed, generally composed of red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), sweet birch (*Betula lenta*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), and occasionally eastern hemlock (*Tsuga canadensis*). Scattered and clumped tall shrubs/small trees such as mountain maple *(Acer spicatum*) and striped maple (*Acer pensylvanicum*) occur on particularly cold slopes, with blackberries (*Rubus* spp.) and several currants (*Ribes* spp.) usually more common. Vines are also characteristic, including Virginia creeper (*Parthenocissus quinquefolia*) and eastern poison ivy (*Toxicodendron radicans*). Occasionally, Alleghany vine (*Adlumia fungosa*) and fringed bindweed (*Polygonum cilinode*) can be present. Ferns and herbs are scattered in crevices where humus accumulates. p. 24

Sweet birch – White Ash /Robert geranium (*Betula lenta- Fraxinus Americana/Geranium robertianum*) woodlands
These woodlands occur on rich, open talus. A heterogeneous mix of hardwoods and a characteristic rich herb flora dominate these woodlands. The canopy is open to semi-closed, composed of sugar maple (*Acer saccharum*), white ash (*Fraxinus americana*), American basswood (*Tilia americana*), red oak (*Quercus*

rubra), sweet birch (*Betula lenta*), yellow birch (*Betula alleghaniensis*), butternut (*Juglans cinerea*), and hop hornbeam (*Ostrya virginiana*). Scattered and clumped tall shrubs/small trees include mountain maple (*Acer spicatum*), striped maple (*Acer pensylvanicum*), blackberries (*Rubus* spp.), roundleaf dogwood (*Cornus rugosa*), American bladdernut (*Staphylea trifolia*), and several currants (*Ribes* spp.). Scattered ferns and graminoids often include marginal woodfern (*Dryopteris marginalis*), ebony spleenwort (*Asplenium platyneuron*), brittle bladderfern (Cystopteris fragilis), bulblet bladderfern (*Cystopteris bulbifera*), common ladyfern (*Athyrium felix-femina*), bluntlobe cliff fern (*Woodsia obtusa*), sedges (*Carex communis, C. rosea, C. sprengelii, C. platyphylla*), and blackseed ricegrass (*Piptatherum racemosa*). This talus woodland is differentiated by the presence of a diverse flora of herbs associated with alkaline soils, including early saxifrage (*Saxifraga virginiensis*), Robert geranium (*Geranium robertianum*), purple flowering raspberry (*Rubus odoratus*), rockcress (*Arabis* spp.), and Canadian wild ginger (*Asarum canadense*).
p. 25

Red maple (Acer rubrum) seasonally flooded woodlands
Red maple/Tussock sedge (*Acer rubrum/Carex stricta*) community
Found throughout Connecticut
This community forms in flooded depressions that are wet for much of the growing season, on spring-fed slopes or seasonally flooded wetlands with altered hydrology. These swamps commonly form on highly organic silt loams, with strongly fluctuating water levels. The soil moisture regime varies from somewhat wet to wet. Red maple (*Acer rubrum*) trees are often scattered throughout this community. Under extremely wet conditions, red maple cover may be reduced and willows such as silky willow (*Salix sericea*) from the dominant shrub cover. Under more moderate conditions, shrub cover is often low, with shrubs such as alders (*Alnus* spp.), dogwoods (*Cornus amomum* and *C. sericea*), common buttonbush (*Cephalanthus occidentalis*), swamp rose (*Rosa palustris*), coastal sweet pepperbush (*Clethra alnifolia),* white meadowsweet (*Spiraea alba* var. *latifolia*) and other willows (*Salix* spp.) occurring. Tussock sedge (*Carex stricta*) is often dominant and gives these wetlands their characteristic appearance. Other herbaceous species include blunt spikerush (*Eleocharis obtusa*), rattlesnake mannagrass (*Glyceria canadensis*), common rush (*Juncus effusus*), eastern marsh fern (*Thelypteris palustris*), bluejoint (*Calamagrostis canadensis*), and marsh seedbox (*Ludwigia palutris*). p. 26

Red maple-Green ash/Knotweed (*Acer rubrum-Fraxinus americana/Polygonum* spp.) (freshwater tidal swamp along CT River)
Found along the lower Connecticut River.
This community is best described as a freshwater tidal swamp. In Connecticut, its distribution is extremely limited, with known occurrences restricted to coves adjacent to the lower Connecticut River. Red maple (*Acer rubrum*) and green ash (*Fraxinus pennsylvanica*) are predominant, although American elm (*Ulmus americana*) can often be a regular component. Generally, the shrub layer

forms dense patches intermixed with open, wet areas. Characteristic shrubs include common winterberry (*Ilex verticillata*), gray alder (*Alnus incana* ssp. *rugosa*), northern spicebush (*Lindera benzoin*), redosier dogwood (*Cornus sericea*), and common buttonbush (*Cephalanthus occidentalis*). In the openings, the herbaceous cover can be quite dense, with species similar to the adjacent freshwater tidal marsh. These include green arrow arum (*Peltandra virginica*), pickerelweed (*Pontederia cordata*) knotweeds (*Polygonum hydropiperoides, P. hydropiper, P. sagittatum, P. arifolium),* sensitive fern (*Onoclea sensibilis*), rice cutgrass (*Leersia orysoides*), swamp milkweed (*Asclepias incarnata*), and various sedges (*Carex lupulina, C. stricta, C. crinita, C. comosa).* In some areas, patches of bluejoint (*Calamagrostis canadensis*) and reed canarygrass (*Phalaris arundinacea*) occur. p. 26

Mixed Evergreen – Deciduous Woodlands: Evergreen and deciduous species contribute 25 – 75% of total tree cover.

Pitch pine – Post oak (*Pinus rigida – Quercus stellata*) woodlands
Found in coastal counties.
The structure of this woodland can be very variable, dependent on a host of environmental factors including microtopography, soil development/erosion, aspect and salt spray. Generally, these woodlands are xerophytic and may include pitch pine (*Pinus rigida*), hickory species (*Carya tomentosa* and *C. glabra*), oaks (*Quercus stellata* and *Q. velutina*), Eastern redcedar (*Juniperus virginiana*), and black cherry (*Prunus serotina*). Depending on environmental conditions, these shrubs may grown to only low shrub size. Other shrubs may include winged sumac (*Rhus copallinum*), northern bayberry (*Morella pensylvanica*), and desert false indigo (*Amorpha fruticosa*). Tangles of lianas, e.g., Virginia creeper (*Parthenocissus quinquefolia)* and eastern poison ivy (*Toxicodendron radicans*) can be conspicuous.
Along coastal hilltops with exposed ledge, a variant of these woodlands contains eastern redcedar (Juniperus virginiana), post oak (*Quercus stellata),* and hickories (*Carya tomentosa* and *C. glabra*). Here, shrubs such as northern bayberry (*Morella pensylvanica*) occur. Additional herbaceous species on these bluffs include seaside goldenrod (*Solidago sempervirens*), other grasses and sedges (e.g., *Deschampsia flexuosa, Vulpia octoflora, Bromus tectorum, Panicum virgatum, Carex silicea*) and devil's tongue (*Opuntia humifusa*). p. 26

New York

Forest and Woodland Vegetation Types that may occur with the New York Coastal Ecoregions:
Vegetation descriptions taken with permission from Edinger et al. (2014) unless otherwise noted following the classification scheme of this publication.

Edinger, G. J., D. J. Evans, S. Gebauer, T. G. Howard, D. M. Hunt, and A. M. Olivero (editors). 2014. Ecological Communities of New York State. Second Edition. A revised and expanded edition of Carol Reschke's *Ecological Communities of New York State*. New York Natural Heritage Program, New York State Department of Environmental Conservation, Albany, NY.

Palustrine Communities
Forested Mineral Soil Wetlands
Floodplain forest
Extent: throughout upstate New York, primarily north of the Coastal Lowlands ecozone. These forests are likely not well-developed on Long Island.

Typically a hardwood forest that occurs on mineral soils on low terraces of river floodplains and river deltas. These sites are characterized by their flood regime; low areas are annually flooded in spring and high areas are flooded irregularly. Some sites may be quite dry by late summer whereas other sites may be flooded again in late summer or early autumn (these floods are caused by heavy precipitation associated with tropical storms). This is a broadly defined community; floodplain forests are quite variable and may be very diverse.

Characteristic trees include silver maple (*Acer saccharinum*), ashes (*Fraxinus pennsylvanica, F. nigra, F. americana*), cottonwood (*Populus deltoides*), red maple (*Acer rubrum*), box elder (*Acer negundo*), elms (*Ulmus americana, U. rubra*), hickories (*Carya cordiformis, C. ovata, C. laciniosa*), butternut and black walnut (*Juglans cinerea, J. nigra*), sycamore (*Platanus occidentalis*), oaks (*Quercus bicolor, Q. palustris*), and river birch (*Betula nigra*). Other trees include hackberry (*Celtis occidentalis*), tulip tree (*Liriodendron tulipifera*), basswood (*Tilia americana*), and sugar maple (*Acer saccharum*). Introduced trees, such as white willow (*Salix alba*) and black locust (*Robinia pseudo-acacia*), have become established in some floodplain forests. Multiple trunked silver maples are typical in this setting as an adaptation to flooding.

Characteristic shrubs include spicebush (*Lindera benzoin*), American hornbeam (*Carpinus caroliniana*), bladdernut (*Staphylea trifoliata*), speckled alder (*Alnus incana* ssp. *rugosa*), shrubby dogwoods *(Cornus sericea, C. racemosa, C. amomum*), viburnums (*Viburnum nudum* var. *cassinoides, V. prunifolium, V. dentatum, V. lentago*), and sapling canopy trees. Invasive non-native shrubs that may be locally abundant include shrub honeysuckles (*Lonicera tatarica, L. morrowii*), and multiflora rose (*Rosa multiflora*). Other shrubs include meadowsweet (*Spiraea alba* var. *latifolia*), and winterberry (*Ilex verticillata*).

Characteristic vines include poison ivy (*Toxicodendron radicans*), wild grapes (*Vitis* spp., including *V. riparia*), Virginia creeper (*Parthenocissus quinquefolia, P. vitacea*), virgin's bower (*Clematis virginiana*), and less frequently, moonseed (*Menispermum canadense*). Vines may become dense in the tree canopy (*i.e.,* liana) and/or dominate the groundcover.

Characteristic herbs include sensitive fern (*Onoclea sensibilis*), jewelweeds (*Impatiens capensis, I. pallida*), ostrich fern (*Matteuccia struthiopteris*), white snakeroot (*Ageratina altissima* var. *altissima*), wood nettle (*Laportea canadensis*), false nettle (*Boehmeria cylindrica*), goldenrods (*Solidago* spp., *S. gigantea, S. canadensis*), lizard's tail (*Saururus cernuus*), and jumpseed (*Persicaria virginiana*). Invasive non-native herbs that may be locally abundant include moneywort (*Lysimachia nummularia*), garlic mustard (*Alliaria*

petiolata), dame's-rocket (*Hesperis matronalis*), European stinging nettle (*Urtica dioica* ssp. *dioica*), and stilt grass (*Microstegium vimineum*). Other herbs include skunk cabbage (*Symplocarpus foetidus*), enchanter's nightshade (*Circaea lutetiana* ssp. *canadensis*), bluejoint grass (*Calamagrostis canadensis*), white avens (*Geum canadense*), clearweed (*Pilea pumila*), jack-in-the-pulpit (*Arisaema triphyllum*), cutgrasses (*Leersia oryzoides, L. virginica*), American stinging nettle (ssp. *gracilis*), sedges *(Carex lacustris, C. intumescens, C. lupulina, C. stricta*), and many others. p.66

Red maple-hardwood swamp
Extent: throughout New York state, most common on the Great Lakes Plain, in the Hudson Valley, and the High Alleghany Plateau.

A hardwood swamp that occurs in poorly drained depressions or basins, usually on inorganic soil, but occasionally on muck or shallow peat, that is typically acidic to circumneutral. This is a broadly defined community with several regional and edaphic variants. The hydrology varies from permanently saturated to the surface to seasonally flooded/wet with hummocks and hollows. In any one stand red maple (*Acer rubrum)* is either the only canopy dominant, or it is codominant with one or more hardwoods including ashes (*Fraxinus pennsylvanica, F. nigra, and F. americana*), elms (*Ulmus americana* and *U. rubra*), and yellow birch (*Betula alleghaniensis).* Other trees with low percent cover include butternut (*Juglans cinerea*), bitternut hickory (*Carya cordiformis*), blackgum (*Nyssa sylvatica*), American hornbeam (*Carpinus caroliniana*), swamp white oak (*Quercus bicolor*), and white pine (*Pinus strobus*). The trunks of maples are typically single-trunked unlike those of floodplain forests with multiple trunks.

The shrub layer is usually well-developed and may be quite dense. Characteristic shrubs are winterberry (*Ilex verticillata*), spicebush (*Lindera benzoin*), alders (*Alnus incana* ssp. *rugosa* and *A. serrulata*), viburnums (*Viburnum dentatum* var. *lucidum*, *V. nudum* var. *cassinoides*), highbush blueberry (*Vaccinium corymbosum*), common elderberry (*Sambucus nigra* ssp. *canadensis*), and various shrubby dogwoods (*Cornus sericea, C. racemosa*, and *C. amomum*). Swamp azalea (*Rhododendron viscosum*) is more common in southern examples, and poison sumac (*Toxicodendron vernix*) and black ash are more common in mineral-rich examples with slightly higher pH.

The herbaceous layer may be quite diverse and is often dominated by ferns, including sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), and marsh fern (*Thelypertis palustris*), with much lesser amounts of crested wood fern (*Dryopteris cristata*), and spinulose wood fern (*Dryopteris carthusiana*). Characteristic herbs include skunk cabbage (*Symplocarpus foetidus*), white hellebore (*Veratrum viride*), sedgesd (*Carex stricta, C. lacustris, and C. intumescens*), jewelweed (*Impatiens capensis*), false nettle (*Boehmeria cylindrical)*, arrow arum (*Peltandra virginica*), tall meadow rue (*Thalictrum pubescens*), and marsh marigold (*Caltha palustris*). Open patches within the swamp may

contain other herbs characteristic of shallow emergent marsh. p. 67

Red maple – blackgum swamp
Extent: across the Coastal Lowlands, Hudson Valley, Taconic Highlands, Hudson Highlands, and possibly Manhattan Hills ecozones

A maritime, coastal, or inland hardwood swamp that occurs in poorly drained depressions, sometimes in a narrow band between a stream and upland. Coastal plain examples have a shallow layer of acidic, well decomposed peat over saturated sandy loam or loamy sand. Inland examples usually occur on an acidic silt loam. Hummock-hollow microtopography is evident.

Red maple (*Acer rubrum*) and blackgum (*Nyssa sylvatica*) are often codominant, or blackgum (*Nyssa sylvatica*) may be the dominant tree. Pitch pine (*Pinus rigida*) may occur on drier hummock islands in pine barrens settings. Yellow birch (*Betula alleghaniensis*) may be codominant in inland examples.

The shrub layer is usually well developed. Characteristic shrubs are sweet pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), swamp azalea (*Rhododendron viscosum*), fetterbush (*Leucothoe racemosa*), dangleberry (*Gaylussacia frondosa*), and on the coastal plain, inkberry (*Ilex glabra*). Vines such as common greenbrier (*Smilax rotundifolia*), sawbrier (*Smilax glauca*), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*) are present in the understory. The herbaceous layer is not particularly diverse, characterized by cinnamon fern (*Osmunda cinnamomea*), skunk cabbage (*Symplocarpus foetidus*), and on the coastal plain by netted chain fern (*Woodwardia areaolata).* The nonvascular layer may or may not be well developed.

Characteristic nonvascular species are peat mosses (*Sphagnum* spp.) with *S. girgensohnii* occurring in more inland examples. p. 67

Red maple – sweetgum swamp
Extent: probably restricted to Manhattan Hills ecozone and western part of Coastal Lowlands ecozone (Bray 1915). At least one example in the Triassic Lowlands ecozone. Known examples range from Hylan Boulevard and Bedell Avenue in the Tottenville portion of Staten Island (southernmost point in New York) north to Quaker Ridge Woods Scarsdale, Westchester County. Most occurrences are apparently concentrated in Richmond County. The community may occur or was historically present in very small patches farther east in Queens, Kings and Nassau Counties. Also likely to have been present historically in Bronx and New York Counties.

A hardwood swamp that occurs on somewhat poorly drained seasonally wet flats, usually on somewhat acidic gleyed to mottled clay loam or sandy loam. Red maple-sweetgum swamps often occur as a mosaic with upland forest communities.

Sweetgum (*Liquidambar styraciflua*) is often the dominant tree or may be

codominant with red maple (*Acer rubrum*). Other codominant trees include pin oak (*Quercus palustris*) and blackgum (*Nyssa sylvatica*). Other trees occurring at lower densities include swamp white oak (*Quercus bicolor*), red oak (*Quercus rubra*), black ash (*Fraxinus nigra*), and swamp cottonwood (*Populus heterophylla*). Willow oak (*Quercus phellos*) and sweet-bay (*Magnolia virginiana*) are often present in larger occurrences where they may occur at very low density. Trees often have buttressed trunks and exposed roots from hydrological influences.

The shrub layer is usually fairly well-developed. Characteristic shrubs are sweet pepperbush (*Clethra alnifolia*), swamp azalea (*Rhododendron viscosum*), arrowwood (*Viburnum dentatum* var. *lucidum*), spicebush (*Lindera benzoin*), highbush blueberry (*Vaccinium corymbosum*), black chokeberry (*Aronia melanocarpa*) and possibly fetterbush (*Leucothoe racemosa*). Vines such as common greenbrier (*Smilax rotundifolia*), sawbrier (*S. glauca*), wild grapes (*Vitis* spp.), Virginia creeper (*Parthenocissus quinquefolia*), and poison ivy (*Toxicodendron radicans*) are present at low amounts in the understory. The herbaceous layer is often dominated by ferns, including netted chain fern (*Woodwardia areolata*), cinnamon fern (*Osmunda cinnamomea*), and sensitive fern (*Onoclea sensibilis*). Characteristic herbs include lizard's-tail (*Saururus cernuus*), Canada mayflower (*Maianthemum canadense*), jumpseed (*Persicaria virginiana*), skunk cabbage (*Symplocarpus foetidus*) and jewelweed (*Impatiens capensis*). State-reported southern red oak (*Quercus falcata*) and state-extirpated mistletoe (*Phoradendron flavescens*) occur in this community south of New York and may have been historically present in this community in New York. Some occurrences of this community are now severely degraded. p. 68

Red maple–swamp white oak swamp
Extent: Found on the north fork of Long Island; likely that it does not occur within the Long Island Sound Study boundary

A hardwood swamp typically found in small, isolated basins on sandy soils that are underlain by a clay layer. The swamp floods seasonally and draws down in most years exposing a leaf litter substrate. The swamp is codominated by red maple (*Acer rubrum*) and oaks, such as swamp white oak (*Quercus bicolor*) and/or pin oak (*Q. palustris*). Typically swamp white oak is either dominant or codominant with red maple along with several other canopy trees with lower abundance, such as blackgum (*Nyssa sylvatica*), green ash (*Fraxinus pennsylvanica*), swamp cottonwood (*Populous heterophylla*), and elms (*Ulmus americana, U. rubra*). Pin oak can be an associate canopy tree or replace swamp white oak as the codominant. Trees from the surrounding uplands can occur in low abundance within the swamp on drier hummocks, such as pignut hickory (*Carya glabra*) and American beech (*Fagus grandifolia*). Characteristic shrubs include winterberry (*Ilex verticillata*), highbush blueberry (*Vaccinium corymbosum*), buttonbush (*Cephalanthus occidentalis*), and arrowwood (*Viburnum dentatum*). Associated shrubs with low abundance include sweet pepperbush (*Clethra alnifolia*) and spicebush (*Lindera benzoin*). Multiflora rose

(*Rosa multiflora*) is an invasive shrub in some examples.

Characteristic vines with low abundance include poison ivy (*Toxicodendron radicans*), greenbrier (*Smilax rotundifolia*), and wild grapes (*Vitis* spp.).
Herb cover is typically sparse. Characteristic herbs include various sedges (*Carex* spp.), such as *C. crinita C. grayi C. lupulina,* and *C. tuckermanii.* Other characteristic herbs include ferns, such as cinnamon fern (*Osmunda cinnamomea*), royal fern (*Osmunda regalis*), marsh fern (*Thelypteris palustris*), netted chain fern (*Woodwardia areolata*). Associated herbs with low abundance include lady fern (*Athyrium filix-femina*), sweet woodreed (*Cinna arundinacea*), spinulose wood fern (*Dryopteris carthusiana*), soft rush (*Juncus effusus*), marsh seedbox (*Ludwigia palustris*), northern bugleweed (*Lycopus uniflorus*), and blunt-leaved sandwort (*Moehringia lateriflora*).

The unvegetated layer is dominated by leaf litter that typically covers about three-quarters of the swamp basin. p.68

Terrestrial Communities
Barrens and Woodlands

This subsystem includes upland communities that are structurally intermediate between forests and open canopy uplands. Several physiognomic types are included in this subsystem. Savannas are communities with a sparse canopy of trees (25 to 60% cover), and a groundlayer that is predominantly grassy or shrubby […]. Woodlands include communities with a canopy of stunted or dwarf trees (less than 16 ft or 4.9m tall), and wooded communities occurring on shallow soils over bedrock with numerous rock outcrops. The term "barrens" is commonly applied to both savannas and woodlands (*e.g.*, pine barrens).

Dwarf pine plains (woodland) p. 98-99
Extent: restricted to the Coastal Lowlands ecozone; primarily found in the southern half of Long Island, likely that it does not occur within the Long Island Sound Study boundary

A woodland community dominated by dwarf individuals of pitch pine (*Pinus rigida*) and scrub oak (*Quercus ilicifolia*) that occurs on nearly level outwash sand and gravel plains in eastern Long Island. This community is "fire dependent" meaning that frequent fires are necessary to maintain the species composition. The soils are infertile, coarse textured sands that are excessively well-drained. The canopy of dwarf pitch pines are scrub oaks is generally from 1.2 to 2.4 m (4 to 8 ft) tall, and it may form a dense thicket. The community includes very few species of vascular plants.

The majority of the biomass in the community consists of seven woody plant species: pitch pine, scrub oak, black huckleberry (*Gaylussacia baccata*), lowbush blueberry (*Vaccinium pallidum*), golden heather (*Hudsonia ericoides*), bearberry (*Arctostaphylos uva-ursi*), and wintergreen (*Gaultheria procumbens*). The huckleberries and blueberries form a low shrub canopy under the pines

and oaks.

In areas of dwarf pine plains that appear to have never been cleared by humans (based on old aerial photos going back to 1930), there are very few lichens or herbs (M. Jordan *pers. comm*.). Artificially cleared areas may include foliose and fruticose lichens such as *Cetraria arenaria*, several reindeer lichens (*Cladonia mitis, C. stellaris, C. submitis*), British soldier lichen (*Cladonia cristatella*), *Punctelia rudecta, Parmelia saxatilis*, and dog-lichen (*Peltigera canina*). These sandy openings may include a few low herbs such as frostweed (*Helianthemum canadense*), cow-wheat (*Melampyrum lineare*), jointweed (*Polygonella articulate*), stiff-leaf aster (*Ionactis linariifolius*), flat sedge (*Cyperus houghtonii*), and orange-grass (*Hypericum gentianoides*). There are also reports of grassy openings and areas of frost pockets that occur in the lower elevation gullies with Pennsylvania sedge (*Carex pensylvanica*), golden heather, and bearberry.

This community is a favored nesting area for prairie warbler (*Dendroica discolor*) and brown thrasher (*Toxostoma rufum*); pine warbler (*Dendroica pinus*), ovenbird (*Seiurus aurocapillus*), and northern harrier (*Circus cyaneus*) are also characteristic birds.

This community also provides prime habitat for the coastal barrens buckmoth (*Hemiluca maia* ssp. 5); the largest and most dense population of buckmoths in New York occurs in the dwarf pine plains.

This community combined with pitch pine-oak-heath woodland and pitch pine-oak forest with embedded, small patch wetlands makes up the broadly defined ecosystem known as the Central Long Island Pine Barrens. p.98

Maritime pitch pine dune woodland
Extent: restricted to the Coastal Lowlands ecozone; primarily found in the southern half of Long Island, likely that it does not occur within the Long Island Sound Study boundary

A maritime woodland that occurs on stabilized dunes and back-barrier sand flats. The substrate is wind and wave deposited sand that is usually excessively well-drained and nutrient poor although the site may have a shallow depth to groundwater. The litter layer is shallow. The community is subject to high winds, sand-blasting, salt spray, and shifting substrate.

Trees are somewhat stunted (10-12 m high) and salt pruned. The canopy is sparse with some openings. Pitch pine (*Pinus rigida*) is the dominant tree and may have lower branches that grow out horizontally like aprons. Black oak (*Quercus velutina),* white oak (*Quercus alba*) and post oak (*Quercus stellata*) may also occur and can be codominant with pitch pine in more developed examples.

The shrub layer is usually well developed. Characteristic shrubs are bearberry (*Arctostaphylos uva-ursi*), black huckleberry (*Gaylussacia baccata*), highbush blueberry (*Vaccinium corymbosum*), beach heather (*Hudsonia tomentosa*), bayberry (*Myrica pensylvanica*), and scrub oak (*Quercus ilicifolia*).

The vine layer is often well developed. Characteristic vines are common greenbrier (*Smilax rotundifolia*) and poison ivy (*Toxicodendron radicans*).

The herbaceous layer is dominated by hairgrass (*Avenella flexuosa*). Other characteristic herbaceous species include Pennsylvania sedge (*Carex pensylvanica*), little bluestem (*Schizachyrium scoparium*), starflower (*Trientalis borealis*), panic grass (*Panicum* spp.), jointweed (*Polygonella articulata*), blunt-leaved sandwort (*Moehringia lateriflora*), and pine barren sandwort (*Minuartia caroliniana*).

The nonvascular layer is often well developed. Characteristic bryophytes and fungi include reindeer lichens (*Cladonia arbuscula, C. rangiferina*), cup lichen (*Cladonia uncialis*), the barometer earthstar fungus (*Astraeus hygrometricus*), and mosses such as white cushion moss (*Leucobryum glaucum*), hair cap moss (*Polytrichum juniperinum*), and *Tortella tortuosa*. p.99

Pitch pine – oak – heath woodland
Extent: probably restricted to the Coastal Lowlands ecozone; primarily found in the southern half of Long Island, likely that it does not occur within the Long Island Sound Study boundary

A pine barren community that occurs on well-drained, infertile, sandy soils in eastern Long Island (and possibly on sandy or rocky soils in upstate New York). The structure of this community is intermediate between a shrub-savanna and a woodland.

Pitch pine (*Pinus rigida*) and white oak (*Quercus velutina*) are the most abundant trees, and these form an open canopy with 30 to 60% cover. Scarlet oak (*Quercus coccinea*) and black oak (*Q. velutina*) may also occur in the canopy.

The shrub layer is dominated by scrub oaks (*Quercus ilicifolia, Q. prinoides*), and includes a few heath shrubs such as huckleberry (*Gaylussacia baccata*) and lowbush blueberry (*Vaccinium pallidum*). Blackjack oak (*Quercus marilandica var. marilandica)* may also occur in low percentages.

The density of the shrub layer is inversely related to the tree canopy cover; where the trees are sparse, the shrubs form a dense thicket, and where the trees form a more closed canopy, the shrub layer may be relatively sparse. Stunted, multiple-stemmed white oaks may be present in the shrub layer if the site has burned regularly.

Characteristic species of the groundcover include bearberry (*Arctostaphylos uva-ursi),* Pennsylvania sedge (*Carex pensylvanica*), golden heather (*Hudsonia* ericoides), beach heather (*Hudsonia tomentosa*), and pinweed (*Lechea villosa*).

This community is adapted to periodic fires; the fire frequency has not been documented, but it probably burns less frequently than pitch pine-scrub oak barrens (i.e., more than 15 years between fires). This community may have a fairly low species richness; it is more diverse than dwarf pine plains, but less diverse than pitch pine-scrub oak barrens. This community combined with dwarf pine plains and pitch pine-oak forest with embedded, small patch

wetlands makes up the broadly defined ecosystem known as the Central Long Island Pine Barrens. p.100

Forested Uplands
Maritime Forests:

The following three maritime forests, the successional maritime forest described later in this section, and the other "maritime" communities in this classification are generally in immediate proximity to marine and estuarine communities. These communities are heavily influenced by coastal processes including strong salt spray, high winds and dune deposition, shifting sand and overwash processes. Maritime forests generally contain stunted "salt pruned" trees with contorted branches and wilted leaves plus usually have a dense vine layer. Communities often occur as narrow bands under 50 meters wide. Greller (1977) referred to maritime forests as "strand forests" (*i.e.*, linear forests that develop on relatively narrow peninsulas and barrier islands). p.111

Maritime oak forest
Extent: apparently restricted to eastern Long Island and islands in Block Island Sound, in the Coastal Lowlands ecozone.

An oak-dominated forest that borders salt marshes or occurs on exposed bluffs and sand spits within about 200 meters of the seacoast. The trees may be somewhat stunted and flat-topped because the canopies are pruned by salt spray and exposed to winds.

The forest is usually dominated by two or more species of oaks. Characteristic canopy trees include post oak (*Quercus stellata*), black oak (*Q. velutina*), scarlet oak (*Q. coccinea*) and white oak (*Q. alba*). A small number of eastern red cedar (*Juniperus virginiana*) may be present.

The understory usually contains a dense shrub thicket dominated by bayberry (*Myrica pensylvanica*) and black huckleberry (*Gaylussacia baccata*), with saplings of black cherry (*Prunus serotina*) as a common associate. In most stands the small tree and shrubs are covered with a dense vine thicket of common greenbrier (*Smilax rotundifolia*). The presence of greenbrier is not well understood. It is likely a result of natural disturbances, such as exposure to salt spray and wind-throw. However, other disturbances such as insect infestations, heavy browsing by white-tailed deer, clear-cutting, and fires may produce a similar effect. Other vines are common including poison ivy (*Toxicodendron radicans*), wild grapes (*Vitus* spp.), and Virginia creeper (*Parthenocissus quinquefolia*). The sparse groundlayer under this shrub and vine thicket is dominated by common hairgrass (*Avenella flexuosa*).

Several variants of this community are known. The typical post oak-greenbrier forest variant, experiencing the most extreme degree of salt spray, is most widespread. A post oak-basswood variant on windswept sands forming dunes on top of morainal bluffs is report along Long Island Sound (Lamont

1997). A white oak-black oak-scarlet oak-mockernut hickory (*Carya alba*) variant lacking post oak is known from morainal bluffs on the north shore on Montauk Peninsula at Hither Hills (A. Olivero *pers. comm.)*. p.111

Maritime beech forest
Extent: currently known only from the town of Riverhead, Suffolk County. Historically, may have occurred along the north-facing coastal bluffs of Long Island, in the Coastal Lowland ecozone in Suffolk County.

A deciduous forest that occurs near the seacoast on north-facing, exposed bluffs and the back portions of rolling dunes in well-drained, find sands. The dominant tree is American beech (*Fagus grandifolia*); black oak (*Quercus velutina*) and red maple (*Acer rubrum*) may be present at a low density. Occurrences area often associated with coastal oak-beech forest. Wind and salt spray cause the trees to be stunted (average height 4-15m) and multiple-stemmed with contorted branches, especially on the exposed bluffs. Trees are notably taller on the more protected dunes. Shrub and herb layers are not well developed.

Some examples may have a well-developed vine layer that includes common greenbrier (*Smilax rotundifolia*), wild grapes (*Vitus* spp.), poison ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*) (B. Carr *pers. comm*.).

Characteristic herbs are wild sarsaparilla (*Aralia nudicaulis*), and beech drops (*Epifagus virginiana*). The nonvascular layer may or may not be well developed. p.112

Maritime red cedar forest
Extent: known only from the Coastal Lowland ecozone.

A conifer forest that occurs on dry sites near the ocean. Eastern red cedar (*Juniperus virginiana*) is the dominant tree, often forming nearly pure stands. Red cedar is usually present in all tree and shrub layers. Other characteristic trees include post oak (*Quercus stellata*) and black cherry (*Prunus serotina*).

Characteristic shrubs and vines include bayberry (Myrica pensylvanica), groundsel-tree (*Baccharis halimifolia*), poison ivy (*Toxicodendron radicans*), and Virginia creeper (*Parthenocissus quinquefolia*).

Characteristic herbs include eastern prickly pear (*Opuntia humifusa*), common hairgrass (*Avenella flexuosa*), little bluestem (*Shizachyrium scoparium*), switch grass (*Panicum virgatum*), and seaside goldenrod (*Solidago sempervirens*). p.112

Coastal Forests:

The following four coastal forests are non-maritime forests within the coastal plain (*i.e*., generally not in immediate proximity to marine communities). At most, the forests are lightly influenced by coastal processes, including minor

salt spray associated with severe storms (*e.g.*, hurricanes), and lack dune deposition, shifting and overwash processes. Forests generally contain trees of normal stature with uncontorted branches and unwilted leaves. Coastal forests usually have a sparse vine layer. p. 113

Coastal oak-heath forest
Extent: restricted to the interior portions of the Coastal Lowland ecozone, concentrated on outwash plains; possibly knolls and mid to upper slopes of moraines. Known examples range from Hither Hills and Montauk Mountain; and west probably to the morainal hills of northwestern Suffolk County. Numerous examples occur in the central portion of this range (the periphery of the Long Island Pine Barrens) south of the Ronkonkoma Moraine (Greller 1977). Occurrences are more sparse in the eastern and western portions of the range. The community range possibly extends westward into eastern Nassau County on the end moraine of western Long Island and has been reported from a narrow strip of outwash on the north shore of Long Island.

A large patch to matrix hardwood forest of low diversity that typically occurs on dry, well-drained, sandy soils of glacial outwash plains or moraines of the coastal plain.

The forest is usually codominated by two or more species of oaks: scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*) and black oak (*Q. velutina*). Chestnut oak (*Q. montana*) is also a common associate. Pitch pine (*Pinus rigida*), sassafras (*Sassafras albidum*), and other tree species typically have very low cover in the canopy. American chestnut (*Castanea dentata*) may have been a common associate in these forests prior to the chestnut blight; chestnut sprouts are still found in some stands.

The shrub layer is well-developed typically with a low nearly continuous cover of dwarf heaths such as lowbush blueberries (*Vaccinium pallidum, V. angustifolium*) and black huckleberry (*Gaylussacia baccata*).

The herbaceous layer is very sparse; characteristic species are bracken fern (*Pteridium aquilinum var. latiusculum*), wintergreen (*Gaultheria procumbens*), and Pennsylvania sedge (*Carex pensylvanica*). Herb diversity is greatest in natural and artificial openings with species such as frostweed (*Helianthemum canadense*), false-foxglove (*Aureolaria* spp.), bearberry (*Arctostaphylos uva-ursi*), goat's-rue (*Tephrosia virginiana*), bush-clovers (*Lespedeza* spp.), and pinweeds (*Lechea* spp.).

This community can occur with several types of barrens and woodland communities as part of the broadly defined ecosystem known as the Pine Barrens. p. 113

Coastal oak-hickory forest
Extent: Restricted to the interior portions of the Coastal Lowlands ecozone, concentrated on knolls and mid to upper slopes of the moraines. Known examples range from Mashomack west to the morainal hills of northwestern Suffolk County. Numerous examples occur in the western portion of this range

while occurrences are sparse in the eastern portion. The community range possibly extends westward into northeastern Nassau County and on the end moraine of western Long Island (Greller 1977).

A hardwood forest with oaks (*Quercus* spp.) and hickories (*Carya* spp.) codominant that occurs in dry, well-drained, loamy sand of knolls, upper slopes, or south-facing slopes of glacial moraines of the coastal plain. The forest is usually codominated by two or more species of oaks, usually white oak (*Q. alba*), black oak (*Quercus velutina*) and chestnut oak (*Q. montana*). Scarlet oak (*Quercus coccinea*) is also a common associate. Mixed with the oaks are one or more of the following hickories: pignut (*Carya glabra*), mockernut (*C. alba*), and sweet pignut (*C. ovalis*). These hickories can range from nearly pure stands to as little as about 25% cover. There is typically a subcanopy stratum of small trees and tall shrubs including flowering dogwood (*Cornus florida*) and highbush blueberry (*Vaccinium corymbosum*). The shrub layer and groundlayer flora may be diverse. Common low shrubs include maple-leaf viburnum (*Viburnum acerifolium*), lowbush blueberries (*Vaccinium angustifolium, V. pallidum*) and black huckleberry (*Gaylussacia baccata*).

Characteristic groundlayer herbs are Swan's sedge (*Carex swanii*), panic grass (*Panicum dichotomum*), poverty grass (*Danthonia spicata*), cow-wheat (*Melampyrum lineare*), spotted wintergreen (*Chimaphila maculata*), rattlesnake weed (*Hieracium venosum*), white wood aster (*Eurybia divaricata*), false Solomon's seal (*Maianthemum racemosum*), Pennsylvania sedge (*Carex pensylvanica*), and silver-rod (*Solidago bi-color*). Other herbs include Solomon's-seal (*Polygonatum biflorum*) and Canada mayflower (*Maianthemum canadense*) (David Küntsler *pers. comm.*)

Coastal oak-beech forest

Extent: restricted to interior portions of the Coastal Lowlands ecozone, concentrated on north-facing slopes on the moraines. Known examples range from Montauk Point (Brodo 1968) west to the Big Woods along the south shore of Long Island and from Route 48 Southold to Camp Baiting Hollow along the north shore of Long Island. Numerous examples occur in the Riverhead portion of the north shore. The community is also reported from necks of Long Island Sound (Greller 1977). It may occur in small patches farther west on Long Island to western Suffolk, Nassau and eastern Queens Counties (Greller 1977). The community was also apparently reported from New York City by Harper (1917) and Brodo (1968).

A hardwood forest with oaks (*Quercus* spp.) and American beech (*Fagus grandifolia*) codominant that occurs in dry, well-drained, loamy sand of morainal coves of the coastal plain. Some occurrences area associated with maritime beech forest. American beech can range from nearly pure stands to as little as about 25% cover. The forest is usually codominated by two or more species of oaks, usually black oak (*Quercus velutina*) and white oak (*Q. alba*). Scarlet oak (*Q. coccinea*) and chestnut oak (*Q. montana*) are common

associates. Red oak (*Q. rubra*) may be present at low density, and is a key indicator species along with sugar maple (*Acer saccharum*) and paper birch (*Betula papyrifera*).

There are relatively few shrubs and herbs. Characteristic groundlayer species are Swan's sedge (*Carex swanii*), Canada mayflower (*Maianthemum canadense*), white wood aster (*Eurybia divaricata*), beech-drops (*Epifagus virginiana*), and false Solomon's seal (*Maianthemum racemosum*). Typically there is also an abundance of tree seedlings, especially of American beech; beech and oak saplings are often the most abundant "shrubs" and small trees.

Coastal oak-laurel forest

Extent: restricted to interior portions of Coastal Lowlands ecozone, concentrated on knolls and mid to upper slopes of moraines. Known examples range from Hither Hills west possible to the morainal hill of northwestern Suffolk County. Several examples occur along the eastern half of the Ronkonkoma Moraine. The community range possibly extends westward into eastern Nassau County on the end moraine of western Long Island.

A large patch, low diversity hardwood forest with broadleaf canopy and evergreen subcanopy that typically occurs on dry, well-drained, sandy and gravelly soils of morainal hills of the coastal plain. This forest is similar to the chestnut oak forest of the Appalachian Mountains; it is distinguished by lower abundance of chestnut oak (*Quercus montana*) and absence of red oak (*Quercus rubra*), probably correlated with the difference between the sand and gravel of glacial moraines versus the bedrock of mountains.

The dominant tree is typically scarlet oak (*Q. coccinea*). Common associates are white oak (*Q. alba*), black oak (*Q. velutina*), and chestnut oak.

The shrub layer is well-developed typically with a tall, often nearly continuous cover of mountain laurel (*Kalmia latifolia*). Other characteristic shrubs include black huckleberry (*Gaylussacia baccata*) and lowbush blueberry (*Vaccinium pallidum*).

The herbaceous layer is very sparse; characteristic species are bracken fern (*Pteridium aquilinum var. latiusculum*), wintergreen (*Gaultheria procumbens*), and Pennsylvania sedge (*Carex pensylvanica*).

This forest is often associated with coastal oak-heath forest forming a forest complex on morainal hills.

Pitch pine–oak forest

Extent: known from the Coastal Lowlands and Hudson Valley ecozones.

A mixed forest that typically occurs on well-drained, sandy soils of glacial outwash plains or moraines; it also occurs on thin, rocky soils of ridgetops. The dominant trees are pitch pine (*Pinus rigida*) mixed with one or more of the following oaks: scarlet oak (*Quercus coccinea*), white oak (*Q. alba*), red oak (*Q. rubra*), or black oak (*Q. velutina*). The relative proportions of pines and oaks are quite variable within this community type. Examples can range from

having widely spaced pines that are often emergent above the oak canopy to a nearly pure stand of pines with only a few widely spaced oak trees. The shrub layer is well-developed with scattered clumps of scrub oak (*Quercus ilicifolia*) and a nearly continuous cover of low heath shrubs such as lowbush blueberries (*Vaccinium pallidum, V. angustifolium*) and black huckleberry (*Gaylussacia baccata*).

The herbaceous layer is relatively sparse; characteristic species are bracken fern (*Pteridium aquilinum* var. *latiusculum), wintergreen (Gaultheria procumbens*), and Pennsylvania sedge (*Carex pensylvanica*).

Characteristic birds with varying abundance include eastern towhee (*Pipilo erythrophthalmus*), common yellowthroat (*Geothlypis trichas*), field sparrow (*Spizella pusilla*), prairie warbler (*Dendroica discolor*), pine warbler (*Dendroica pinus*), and blue jay (*Cyanocitta cristata*).

This community combined with dwarf pine plains and pitch pine-oak-heath woodland with embedded, small patch wetlands make up the broadly defined ecosystem known as the Central Long Island Pine Barrens. p.115

Oak-tulip tree forest

Extent: most common on the northern half of Long Island in the Coastal Lowlands ecozone, also occurs in the Manhattan Hills, Hudson Highlands, and Triassic Lowlands ecozones.

A mesophytic hardwood forest that occurs on moist, well-drained sites in southeastern New York. […] The dominant trees includes a mixture of five or more of the following: red oak (*Quercus rubra*), tulip tree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), black birch (*Betula lenta*), red maple (*Acer rubrum*), scarlet oak (*Quercus coccinea*), black oak (*Q. velutina*), and white oak (*Q. alba*).

There is typically a subcanopy stratum of small trees and tall shrubs dominated by flowering dogwood (*Cornus florida*): common associated include witch-hazel (*Hamamelis virginiana*), sassafras (*Sassafras albidum*), red maple (*Acer rubrum*), and black cherry (*Prunus serotina*). Common low shrubs include maple-leaf viburnum (*Viburnum acerifolium*), northern blackberry (*Rubus allegheniensis*), and lowbush blueberries (*Vaccinium angustifolium, V. pallidum*). Spicebush (*Lindera benzoin*) may be common in moister areas. A characteristic vine is Virginia creeper (*Parthenocissus quinquefolia*). The shrub layer and groundcover layer may be diverse.

Characteristic groundlayer herbs are white wood aster (*Eurybia divaricata*), New York fern (*Thelypteris noveboracensis*), jack-in-the-pulpit (*Arisaema triphyllum*), wild geranium (*Geranium maculatum*), spring beauty (*Claytonia virginica*), Solomon's-seal (*Polygonatum biflorum*), and false Solomon's-seal *(Maianthemum racemosum*). Purple trillium (*Trillium erectum*) and wild ginger (*Asarum canadense*) may be present at low percent cover in less disturbed examples. Stilt grass (*Microstegium vimineum*) may become invasive in oak-tulip tree forests.

Hemlock-northern hardwood forest
Extent: throughout New York State; Possible remnant forests on western Long Island

A mixed forest that typically occurs on middle to lower slopes of ravines, on cool, mid-elevation slopes, and on moist, well-drained sites at the margins of swamps. In any one stand, eastern hemlock (*Tsuga canadensis*) is codominant with any one to three of the following: sugar maple (*Acer saccharum*), red maple (*A. rubrum*), yellow birch (*Betula alleghaniensis*), black birch (*B. lenta*), red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), chestnut oak (*Quercus montana*), white oak (*Q. alba*), white pine (*Pinus strobus*), Other trees may include hop hornbeam (*Ostrya virginiana*), black cherry (*Prunus serotina*), and basswood (*Tilia americana*). The relative cover of eastern hemlock is quite variable, ranging from nearly pure stands in some steep ravines to as little as 20% of the canopy cover. Striped maple (*Acer pensylvanicum*) is often prominent as a mid-story tree.
The shrub layer may be sparse and typically includes saplings of canopy trees. Characteristic shrubs are witch hazel (*Hamamelis virginiana*), hobblebush (*Viburnum lantanoides*), maple-leaf viburnum (*Viburnum acerifolium*), lowbush blueberry (*Vaccinium pallidum*), and raspberries (*Rubus* spp.). In some ravines, especially in the southern part of the state, rosebay (*Rhododendron maximum*) forms a dense subcanopy or tall shrub layer.
Canopy cover can be quite dense, resulting in low light intensities on the forest floor and hence a relatively sparse groundlayer. Characteristic groundlayer herbs include woodferns (*Dryopteris marginalis, D. intermedia D. campyloptera*), Christmas fern (*Polystichum acrostichoides*), Canada mayflower (*Maianthemum canadense*), white wood aster (*Eurybia divaricata*), sarsaparilla (*Aralia nudicaulis*), partridge berry (*Mitchella repens*), common wood-sorrel (*Oxalis montana*), jack-in-the-pulpit (*Arisaema triphyllum*), star flower (*Trientalis borealis*), lady fern (*Athyrium filix-femina* var. *asplenioides*), and Pennsylvania sedge (*Carex pensylvanica*). Other plants include Indian cucumber-root (*Medeola virginiana*), sessile-leaved bellwort (*Uvularia sessilifolia*), shining fir clubmoss (*Huperzia lucidula*), foamflower (*Tiarella cordifolia*), round-leaf violet (*Viola rotundifolia*), twisted stalk (*Streptopus roseus*), purple trillium (*Trillium erectum*), and white cushion moss (*Leucobryum glaucum*). In forests that have American beech as a codominant tree, beech-drops (*Epifagus virginiana*) is a common herb. Indian-pipe (*Monotropa uniflora*) and American pinesap (*M. hypopithys*) are occasionally found in low light examples. Hay-scented fern (*Dennstaedtia punctilobula*) and New York fern (*Thelypteris noveboracensis*) may be common in canopy gaps.

Successional Forests
Successional southern hardwoods
Extent: primarily in the southern half of New York, south of the Adirondacks.

A hardwood or mixed forest that occurs on sites that have been cleared or otherwise disturbed. Characteristic trees and shrubs include any of the following: American elm* (*Ulmus americana*), slippery elm (*Ulmus rubra*), white ash* (*Fraxinus americana*), red maple* (*Acer rubrum*), box elder* (*Acer negundo*), silver maple (*Acer saccharinum*), sassafras* (*Sassafras albidum*), gray birch (*Betula populifolia*), hawthorns (*Crataegus* spp.), eastern red cedar (*Juniperus virginiana*), and choke-cherry* (*Prunus virginiana*). Certain introduced species are commonly found in successional forests, including black locust (*Robinia pseudo-acacia*), tree-of-heaven (*Ailanthus altissima*), and buckthorn (*Rhamnus cathartica*). Any of these may be dominant or codominant in a successional southern hardwood forest. This is a broadly defined community and several seral and regional variants are known.
*=southern indicators p. 125

Successional maritime forest
Extent: in the Coastal Lowlands ecozone, in low areas near the coast of Long Island.

A successional hardwood forest that occurs in low areas near the seacoast. This forest is a variable type that develops after vegetation has burned or land cleared (such as pastureland or farm fields). The trees may be somewhat stunted and flat-topped because the canopies are pruned by salt spray. The forest may be dominated by a single species, or there may be two or three codominants.

Characteristic canopy trees include black oak (*Quercus velutina*), post oak (*Quercus stellata*), serviceberry (*Amelanchier canadensis*), white oak (*Quercus alba*), black cherry (*Prunus serotina*), blackgum (*Nyssa sylvatica*), sassafras (*Sassafras albidum*), and red maple (*Acer rubrum*). A small number of eastern red cedar (*Juniperus virginiana*) may be present.

Vines that are common in the understory and subcanopy include riverbank grape (*Vitis riparia*), poison ivy (*Toxicodendron radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and greenbriers (*Smilax* spp.).

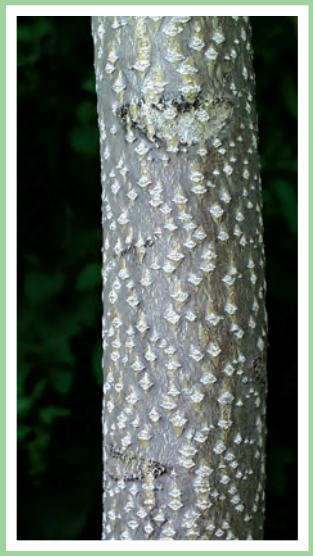
Shrub layer and groundlayer dominants are variable. Bayberry (*Myrica pensylvanica*) is a common shrub. Certain introduced species are commonly found in this forest, including black locust (*Robinia pseudoacacia*), privet (*Ligustrum* spp.), Asiatic bittersweet (*Celastrus orbiculatus*), Japanese honey suckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and wineberry (*Rubus phoenicolasius*). Any of these may be dominant or codominant in a successional maritime forest.

This forest represents an earlier seral stage of other maritime forests, such as maritime post oak forest, maritime holly forest, maritime red cedar forest, and probably others. Soil and moisture regime will usually determine which forest type succeeds from this community. A few disturbance-climax examples occur, maintained by severe and constant salt spray.

Appendix C. Invasive Plant Control Fact Sheets

United States Department of Agriculture

Field Guide for Managing Tree-of-heaven in the Southwest



Forest Service

Southwestern Region

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Tree-of-heaven (*Ailanthus altissima* (Mill.) Swingle; synonyms: *A. glandulosa, Toxicodendron altissinu*)

Quassia family (Simaroubaceae)

Tree-of-heaven is an invasive tree in southwestern states that has been listed as a noxious weed in New Mexico. This field guide serves as the U.S. Forest Service's recommendations for management of tree-of-heaven in forests, woodlands, and riparian areas associated with its Southwestern Region. The Southwestern Region covers Arizona and New Mexico, which together have 11 national forests. The Region also includes four national grasslands located in northeastern New Mexico, western Oklahoma, and the Texas panhandle.

Description

Tree-of-heaven (synonyms: ailanthus, Chinese sumac, stinking sumac, paradise tree, copal tree, Brooklyn palm) is a fast growing tree that was introduced as an ornamental into the United States from China. Its common name and scientific name both refer to its rather tall height (60 to 80 feet). It produces clusters of small, yellow-green flowers mostly in June and July in New Mexico, and April to May in Texas. Tree-of-heaven is dioecious with female trees producing clusters of persistent, one-seeded, winged fruit that resemble those found on maples. Male trees produce groups of staminate flowers that smell like burnt peanuts or cashews. Tree-of-heaven is a prolific seed producer (up to 300,000 seeds per tree in a year). The tree also regrows rapidly from the stump or lateral roots if cut or disturbed. In general, seeds are not long lived and usually do not persist in the seed bank for more than a year or 2.

Growth Characteristics

- Deciduous tree; 60 to 80 feet tall; 80 foot crown width; up to 3 foot trunk diameter.
- Perennial but generally a short-lived tree (30 to 50 years).
- Bark is light brown to pale grey when mature; smooth bark becomes more rough and fissured on trunk.
- Branches are grey, glossy and smooth with raised dots that become fissures with age. Twigs are reddish-brown and velvety.
- Wood is beige to light brown; soft, weak and coarse-grained; breaks easily.
- Pinnately compound leaf (1 to 4 feet long) with 10 to 41 leaflets (2 to 7 inches long).
- Dark green, broadly lanceolate leaflets; margins entire with teeth or lobes at the base; light green veins and whitish green underneath with glandular red dots near lobes.
- Dioecious; numerous, small, yellow-green flowers (8 to 16 inch panicles). Staminate flowers malodorous.
- Persistent propeller-like fruits (1.5-inch-long samaras); fruit turns pale green to tan to reddish as it matures. Fruits occur in dense clusters.

Ecology

Impacts/threats

Tree-of-heaven is an extremely competitive, fast-growing tree with young sprouts growing as much as 10 to 15 feet in a year. Once established, it can overrun native vegetation by developing dense thickets of cloned trees. It can dominate colonized sites indefinitely through resprouting and root suckering. Coupled with its size and structural weakness, the rapid rate of spread and growth of tree-of-heaven makes it an acute hazard along roadsides. In urban areas, tree-of-heaven roots can damage sewer lines and structures.

Location

The species is widespread across the United States (especially in eastern forests and woodlands), but populations tend to be more localized in the Southwest. It establishes readily along roadsides, railways, fencerows, woodland edges, forest openings, or in riparian zones. It is often found in waste areas or disturbed sites such as old fields and abandoned areas (e.g., mining communities). Tree-of-heaven is intolerant of flooding and deep shade; but it can occur in areas where trees normally do not grow such as cliff crevices or paved areas (parking lots, sidewalks, etc.).

Spread

Tree-of-heaven is a prolific seed producer; and its seed may be dispersed via wind, water, birds, and farm or road equipment. However, the majority of new plants within an area are usually from root sprouts. If the top is removed or the stump is cut, new sprouts from lateral roots may occur 50 to 90 feet from the parent tree.

Invasive Features

Tree-of-heaven is highly adaptable and can grow under limiting or harsh conditions such as soils that are saline, nutrient poor, or highly compacted. It will also grow in areas affected by heat, drought, or pollution. Allelopathic chemicals in leaves, bark, roots, and seed inhibit growth and germination of surrounding plants.

Management

Control efforts for tree-of-heaven should focus first on preventing establishment in new areas. Next, small infestations should be treated; mature female trees located on otherwise healthy sites should especially be targeted to help reduce the seed available for germination. Finally, large infestations should be removed or at least controlled. Management efforts should focus on treatments that stress the root system and lead to a reduction in seed production. For example, a treatment regime can be started early in the summer when root reserves are at their lowest and repeated as necessary to keep root reserves low. Since tree-of-heaven is relatively shade intolerant, establishment of desirable competing trees and shrubs should be encouraged following control efforts.

Complete control for tree-of-heaven will likely require 1 to 5 years of continuous planning and integrated management. Consider the following actions when planning a management approach:

- Maintain healthy plant communities to limit tree-of-heaven establishment. Minimize disturbance and/or promptly revegetate disturbed or bare ground areas with desirable native species.
- Conduct surveys, map known infestations, and monitor for tree-of-heaven, especially on roadsides, fence lines, trails, waterways, parking lots, etc. Keep annual records of reported infestations.
- Combine mechanical, cultural, and chemical methods for most effective control of tree-of-heaven.
- Implement a monitoring and followup treatment plan in areas where control practices have been made to further suppress root sprouts and seedlings.

Table 1 summarizes management options for controlling tree-of-heaven under various situations. Choice of individual control method(s) for tree-of-heaven depends on the density and degree of the infestation, current land use, and site conditions (accessibility, terrain, microclimate, other flora and fauna present, etc.). Other important considerations include treatment effectiveness, overall cost, and number of years needed to achieve control. More than one control method may be needed for a particular site.

Physical Control

Tree-of-heaven is very difficult to control by simple cutting or by other mechanical means. Not only do trees resprout with tremendous vigor, but massive root suckering also occurs, which in some cases results in many more new stems spreading over a wider area. There are several practical techniques that can help make physical control of tree-of-heaven more effective. These include: (1) cutting trees before they become too large; (2) cutting trees in early summer when root reserves are lowest; (3) cutting regrowth repeatedly and frequently, and applying herbicide to cut surfaces; and (4) providing shade from competitive native plants after control efforts.

Manual Methods

Hand pulling – Very young seedlings are fairly easy to pull or dig out, depending on soil conditions. Seedlings are easily distinguished from root sprouts by their more slender stems, trifoliate leaflets, and cotyledons (if still present). Pull when soils are moist and be sure to remove the entire root.

Table 1. Management options*

Site	Physical Methods	Cultural Methods	Biological Methods	Chemical Methods
Roadsides, fence lines, rights-of-way, and noncrop areas	Cut larger top growth to ground level in spring or early summer; use mowing as a followup treatment at regular intervals throughout the growing season. Tools for cutting include loppers, machetes, brush cutters, and power saws. A cutting method is more effective as a treatment if followed up with chemical treatment.	Educate road crews to identify and report infestations along roads. Coordinate control efforts with other land managers.	Consider using goats in combination with herbicide spraying. Useful classical biological control agents are currently being researched.	Methods include foliar application, basal bark spray, cut-stump; injection, application of herbicide to cut areas. Use targeted application with a systemic herbicide.
Pasture, rangeland, or riparian corridors	Hand pull or dig out very young seedlings. Older seedlings/ saplings need to be root grubbed or girdled at the base. Physical methods alone are generally not recommended as they often result in significant basal and root sprouting. If used, follow up with a chemical treatment.	After removal of tree-of-heaven, monitor for root sprouts and seedlings; then cut, pull, or spray them. Bag and dispose of seed in a landfill or by burning. Place signs near trailheads or road corridors; educate public to identify and report infestations.	Same as above.	Methods include foliar application, basal bark spray, cut stump, stem injection. In aquatic or riparian areas, use herbicides approved for use in these areas. For mature trees, apply herbicide in cuts made in the bark by a girdling or drilling method. Grooves in the bark should be made all around the trunk, and the cut should be deep enough to go through the cambial layer down into nonliving layers. Girdle or drill in June and early July.
Forest openings, fields, and/ or extensive, dense infestations	Physical methods alone are generally not recommended as they often result in significant basal and root sprouting. If used, followup with a chemical treatment.	Before timber harvest or construction, locate and eradicate all life stages of tree-of-heaven that are present.	Same as above.	Apply herbicide via aerial or broadcast foliar spray, basal bark spray, cut stump, or injection method. Avoid desirable tree species, if present.
Wilderness, other natural areas, and/ or small infestations	Remove very young seedlings by hand; most effective in loose, rain-moistened soils. Be sure to remove entire seedling root. Not practical for older seedlings or root sprouts unless accompanied with herbicide application.	Place signs near trailheads; educate public to identify and report infestations.	Same as above.	Individual plant treatment (IPT) methods including foliar application, basal bark spray, cut stump, or stem injuection. Leave treated plants in place so they can easily be monitored later for regrowth.

* Choice of a particular management option must be in compliance with existing regulations for land resource.

Grubbing – For saplings or young trees, hand grubbing or mechanical extraction of roots may be effective. However, grubbing is usually not practical for mature trees or dense stands. Removal of the entire root is necessary for control of individual trees.

Mechanical Methods

Mowing – After larger trees have been cut to ground level, resprouting wood is soft enough to be mowed at regular intervals which can stress root reserves and lead to fewer root suckers. However, an infrequent mowing cycle may allow the sprouts to spread and become too tall to mow. Mowing is more effective when followed up with a chemical treatment.

Prescribed Fire

Controlled burning is likely to favor further spread of tree-of-heaven since prolific root and stump sprouting occurs in response to fire stress. Scorching or heat girdling individual plants by using a blowtorch or flamethrower may be an option, but monitoring and treatment of root and stump sprouts as a followup will be required.

Cultural Control

Early detection and plant removal are critical for preventing establishment of tree-of-heaven. Coordination efforts should be made between land managers, the local public, and road crews, etc., on identification of tree-of-heaven so suspected infestations can be reported. Vehicles, humans, and livestock should be discouraged from traveling through infested areas; and a program to check and remove seeds from vehicles and livestock after going through infested areas should be considered to help stop seed dispersal.

Biological Control

Grazing

Tree-of-heaven usually has low palatability for grazers; however, livestock (cattle, sheep, and goats) and deer will consume it during certain times of the year under specific circumstances. Goats will eat leaves and bark. Deer will browse leaves during the summer—especially in shady, forested areas. Under heavy grazing pressure, livestock will remove new suckers and sprouts. Use of grazing in combination with herbicide spraying may be effective is certain situations.

Classical Biological Control

A variety of insects and diseases affect tree-of-heaven with varying success; however, there are no biological control agents currently approved for use in the United States. Table 2 summarizes biological agents currently being researched, which includes three fungal pathogens, two weevils, and a moth. Approval for one of the weevil species, *Euchryptorrhynchus brandti*, is anticipated in the near future.

Agents used for biological control in southwestern states should be adaptable to arid environments and local conditions. Public, tribal, and private land managers may obtain biological control agents for release directly from local offices of the USDA Animal and Plant Health Inspection Service (APHIS) when the agents are available. Other sources of biocontrol agents include private companies or locally developed insectaries. A permit must be obtained from APHIS before biological control agents can be transported across state boundaries. Regulations and permit applications (PPQ 526 permit forms) pertaining to interstate shipment of biological control agents can be found on APHIS website at http://www.aphis.usda.gov/ppq/permits/. Although biological control agents may be collected and released within a given state without a permit from APHIS, the state's Department of Agriculture or Agricultural Extension Service should be consulted for any regulations relating to movement of these agents inside the state.

Chemical Control

Herbicides are usually the most effective way to kill the root system of mature tree-of-heaven and to control regrowth from cut trees that occurs as sprouts or root suckers. There are several registered products that can be applied in a variety of ways including: (1) foliage application, (2) topical application to cut stems and stumps, (3) injection into the trunk, and (4) basal spraying. Although aboveground portions of tree-of-heaven are relatively easy to suppress or kill with herbicide treatment, it is also important to control the root system. Therefore, special attention should be paid to selection of the correct herbicide, optimal application rate, and appropriate time to get good results. Care should always be taken when spraying any herbicide near nontarget plants. It is important to read and carefully follow all instructions and warnings provided on the herbicide label.

Herbicide Control Methods

Foliar spraying may be used to control younger trees or low growing tree-of-heaven infestations that can easily be covered with a spray solution. Apply herbicide to fully-

Table 2. Classical biological control agents

Species	Type of Agent	Site of Attack	Impact on Host	Use/Considerations for Release
Verticillium dahliae	fungal pathogen	roots; xylem	Invades xylem and root system; plant responds by stopping flow of water and nutrients to infected areas. May result in death of all or part of tree.	Fungus persists in soil for 10+ years without host. Currently being researched but not yet approved for use.
Verticillium albo-atrum	fungal pathogen	roots; xylem	Similar to *Verticillium dahliae* above.	Currently being researched.
Fusarium oxysporum	fungal pathogen	leaves	Fungus causes leaves to turn yellow and drop earlier than normal, followed by the death of branches or whole tree.	Same as above.
Atteva punctella	Ailanthus webworm	leaves	Selectively feeds on male tree-of-heaven plants.	Same as above.
Euchryptorrhynchus brandti	beetle/ weevil	lower trunk; phloem	Eggs laid in phloem under bark.	Release studies nearly complete; approval anticipated for 2011. Studying whether weevil can be used as a vector for *V. albo-atrum*.
Euchryptorrhynchus chinensis	beetle/ weevil	lower trunk; phloem	Eggs are laid in phloem; life cycle completed under the bark which results in death of tree.	Currently being researched.

expanded leaves using individual plant treatment (IPT) with a backpack sprayer or treat clusters of trees using a tractor- or truck-mounted sprayer (broadcast application). Thoroughly wet all green leaves and shoots, especially near the top of the tree.

Table 3 provides herbicide recommendations for foliar spraying. The two most common herbicides used on tree-of-heaven with the foliar spray approach are glyphosate and triclopyr. These systemic herbicides are absorbed through leaves and stems and then transported to the root system. They have low soil activity so they pose little risk to groundwater if applied properly. However, these products can harm other desirable plants and care should be taken not to spray those nearby. When using a backpack sprayer, a 2 percent solution of either glyphosate (e.g., Roundup®) or imazapyr (e.g., Habitat®) is effective on healthy trees that are fully leafed out. Another new herbicide option that has not been widely tested for foliar application is Viewpoint®. This product is a combination of aminocyclopyrachlor, imazapyr, and metsulfuron. Consult the label closely when mixing or applying any herbicide solution. Use of a nonionic surfactant (0.5 percent or as per label) is often recommended to ensure even coverage and, thus, greater herbicide uptake into the leaves. However, some herbicides come premixed with a surfactant; and the label should always be checked for mixing directions.

Basal bark spraying is an effective control method that does not require cutting. This method is optimally used when tree-of-heaven is fully leafed but before it begins to show fall color. However, basal bark spraying can be labor intensive and is most appropriate for treating small infestations or isolated trees, especially those with trunk diameters between 4 and 8 inches. For trunks less than 6 inches in diameter, a continuous 12-inch wide band should be sprayed around the tree base. For trunks greater than 6 inches, apply a 24-inch band. Add a dye to the solution to aid in determining coverage. Consult the herbicide label for mixing and application directions.

The most commonly recommended herbicide for low-volume basal bark spraying is triclopyr mixed as a 20 percent herbicide:80 percent crop oil solution. Mixing

picloram with triclopyr and crop oil as a 20 percent:20 percent:60 percent mixture can improve the effectiveness of control; however, a certified applicator must be used since picloram is a restricted use product. Stalker® (imazapyr) has also been shown to be effective for basal bark control. It can be used alone or in combination with Garlon 4® (triclopyr) at a concentration of 15 percent Garlon 4® and 5 percent Stalker® in 80 percent oil diluent. Complete coverage by wetting around the entire truck is necessary for good control.

A backpack sprayer fitted with an adjustable cone nozzle can be used for basal bark spraying. Apply herbicide using approximately 30 psi and spray until the bark is wet, but not running off (approximately 3/4 teaspoon of mixture per inch of stem diameter). Leave treated trees standing in place so they can be revisited the next year and, if necessary, new foliage can be spot sprayed.

IPT cut stump treatment is often used in areas where mechanical treatments or foliar applied herbicide spraying are restricted due to logistical considerations or when there is a need to be highly selective for protection of nontarget vegetation. The treatment involves hand cutting or chain sawing a tree as close to the ground surface as reasonable. Herbicide is then applied with a paintbrush, hand-held spray bottle, or backpack sprayer. The cut surface should be horizontal to the ground to minimize runoff, and any residual sawdust over the cut surface should be removed prior to herbicide application. **Herbicide must be applied to the cut surface within 5 minutes after cutting to ensure uptake of the chemical before the plant can seal off the cut area.** For cut stumps larger than 4 inches in diameter, herbicide should be applied to the cambial layer lying just inside the bark ring. The top, sides, and exposed roots of smaller cut stumps (including those occurring in clumps) should be thoroughly wetted with herbicide. Cut trunks, limbs, and other top growth should then be disposed of in an acceptable manner (e.g., stack piles or chipped).

For cut stump treatments, a solution of triclopyr ester or imazapyr should be used in a mixture with bark oil or crop oil. The herbicide:oil mixture ratio can vary from 33:67 to 50:50 v/v depending on the number and size of plants to be treated and the application technique used. A lower ratio (33:67) is typically used when applications are made with a low volume backpack sprayer or hand-held spray bottle, whereas a higher ratio (50:50) can be used when the solution is brushed directly onto the cut stump. A blue indicator dye should be added to the spray mixture to show that a stump has been treated.

The mortality rate from cut-stump treatments is directly related to care taken when treating cut surfaces. Control can be 60 to 80 percent under optimal conditions, but overall plant kills may be much lower due to difficulties associated with this method. Therefore, followup treatment using ground-based foliar applications should be anticipated.

Girdling or frilling with herbicide is effective for larger diameter trunks (i.e., those over 8 inches) of tree-of-heaven with thicker, more mature bark. Using an ax or hatchet, make a horizontal cut or groove (0.5 to 1.5 inches deep and 2 to 8 inches wide) through bark and cambial tissue around the entire circumference of the trunk. The width and depth of the groove should be in proportion to the tree's diameter. Girdling can be done more quickly if a chain saw is used to make two horizontal cuts through the bark that are circumferential around the entire trunk; one cut should be 2 to 4 inches above the other. Frilling is a variation of girdling in which the groove made by an ax or hatchet around the tree still has the partially severed bark and wood attached at the bottom of the groove to allow retention of the applied herbicide.

Tree-of-heaven should not be girdled or frilled without chemical treatment as it will respond by producing fast growing root and stem sprouts. **Cut surfaces from girdling or frilling should be sprayed or painted until thoroughly wet with a herbicide solution within 5 minutes.** Commonly used herbicides for this method include a 2 to 5 percent solution with either glyphosate, imazapyr, triclopyr, or picloram with 2,4-D. The most effective time for using

Table 3. Herbicide recommendations for foliar spraying

Common Chemical Name (active ingredient)	Product Example[1]	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example[2]	Time of Application	Remarks
Glyphosate	RoundUp Pro (41%) and others	2–5 quarts	2% (use with 0.5 percent surfactant and a blue indicator dye)	Summer/early fall; apply when tree is actively growing and fully leafed, but before fall color begins.	Nonselective herbicide; overspray can injure surrounding plants and open more area for weeds.
Imazapyr	Arsenal, Habitat, Chopper, Stalker, and others	Arsenal: 1–1.5 pints Chopper: 2–3 pints	Arsenal: 1–5% Chopper: 5%	Same as above.	Nonselective herbicide; overspray can injure surrounding plants and open additional area for weeds. Nontarget plants may also be killed or injured by root transfer of imazapyr between intertwined root systems.
Aminocyclopyrachlor + imazapyr + metsulfuron methyl	Viewpoint	13–20 ounces	Consult label for spot applications.	Apply as high volume or broadcast foliar spray.	Nonselective herbicide used on noncrop sites; may cause temporary injury to some grass species.
Triclopyr	Garlon 4, Remedy, and others	3–6 quarts	1–2%	Summer/early fall; apply when tree is actively growing and fully leafed, but before fall color begins.	Selective, systemic herbicide; will not impact grasses but can harm other trees, shrubs, and broadleaf plants.
Dicamba	Vanquish, Banvel, and others	2 quarts	5%	Same as above.	Same as above.

[1] Trade names for products are provided for example purposes only, and other products with the same active ingredient(s) may be available. Individual product labels should be examined for specific information and appropriate use with tree-of-heaven.

[2] Herbicide/water ratio - As an example, a gallon of spray water with a 3 percent mixture is made by adding a sufficient volume of water to 4 ounces of liquid herbicide until a volume of 1 gallon is reached (4 oz ÷ 128 oz/gal = 0.03 or 3 percent). For dry formulations, particulates should be added to sufficient water as specified by the label until the required concentration or volume of spray water is reached.

this method is during summer (June or early July) when tree-of-heaven has fully leafed out and is actively growing. Leave the tree in place following girdling or frilling to reduce stump sprouting.

Stem injection (hack-and-squirt) is similar to the frilling method described above except that the bark is not continuously cut around the tree trunk. Using a hand ax or hatchet, a line of downward angled or nearly vertical cuts are spaced about an inch apart around the trunk at a convenient height. Cuts should be made so as to leave a partially severed piece of bark and cambium attached at the bottom of the cut. **With a spray bottle or wand in the other hand, squirt the herbicide directly onto all cut areas within 5 minutes of cutting.** On average, there will be one hack/squirt per each inch of stem diameter. There are some commercially available cutting tools (hatchets) that are equipped to allow the herbicide to be directly injected with

each cut. If using a spray bottle, read the herbicide label to determine the exact quantity of chemical to be used in each cut. About 1 milliliter of a fairly concentrated herbicide solution should be applied to each cut. Generally, 1 to 2 squirts from a quart or pint trigger spray bottle is equivalent to 1 to 2 milliliters (1/4 to 1/2 teaspoon). Apply herbicide so that it is wet within the cut, but the solution is not running out. Triclopyr is most often recommended for the hack-and-squirt method; however, other herbicides (imazapyr, dicamba, and picloram) may also be used. Glyphosate has usually been found to be not as effective with this cut surface approach.

Control Strategies

Numerous strategies have been used for tree-of-heaven control, and the local situation usually dictates the best approach to follow. A popular approach is to use a basal spray or a cut surface treatment initially and then follow this up later by using a foliar active herbicide to spot spray new seedlings, sprouts, and root suckers. Once controlled, restoration activities may be used to help prevent the problem from re-occurring. This includes establishing a thick cover of competing vegetation (i.e., desirable trees, shrubs, and grasses).

Regardless of the strategy used, the key to successful long-term control of tree-of-heaven is to monitor treated areas for several years after initial treatment. Always be prepared to remove any new plants quickly. Failure to perform followup monitoring and treatment could result in a return to pretreatment density levels.

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Suggested Web Sites

For information about calibrating spray equipment:

NMSU Cooperative Extension Service Guide A-613 Sprayer Calibration at http://aces.nmsu.edu/pubs/_a/A-613.pdf

Herbicide labels online:

http://www.cdms.net/LabelsMsds/LMDefault.aspx

Invasive Plant Atlas of the United States:

http://www.invasive.org/weedus/index.html

USDA Plants Database:

http://plants.usda.gov/index.html

For more information or other field guides, contact:

USDA Forest Service
Southwestern Region
Forest Health
333 Broadway Blvd., SE
Albuquerque, NM 87102

Or visit:

http://www.fs.usda.gov/main/r3/forest-grasslandhealth/invasivespecies

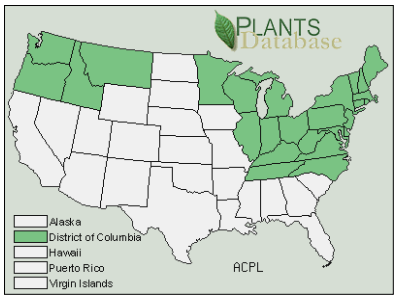
Norway maple *Acer platanoides* L.

Native Origin: Europe and Western Asia

Description: A deciduous tree in the maple family (*Aceraceae*) growing 40-60 feet in height, but can reach heights of 100 feet with dense foliage, broad-rounded crown, and stout stems. The bark of the tree is grayish and shallowly grooved or furrowed. Palmate leaves are opposite, simple, and 10-18 cm across with 5 to 7 sharply pointed lobes. The glossy dark green leaves develop into yellow fall foliage. Leaves often have hairs in axils of veins and a milky sap can be observed when petiole is removed. In spring (April and May), showy clusters of flowers develop before leaves open. The yellow or greenish-yellow flowers are approximately 8 mm in diameter. Fruits mature during summer into wide-spreading wings that look like helicopter blades which split down the middle, releasing each half to the wind. Norway maple can be confused with many maple species, especially sugar maple (*Acer saccharum*). Milky white sap that oozes out of leaf veins and stalks when broken can help distinguish them from native maples. Also bud tips of sugar maple are pointy and sharp to the touch, while those of Norway maple are more rounded and not sharp to the touch.

Habitat: Norway maple prefers full sun, withstands hot dry conditions and tolerates ozone and sulfur dioxide air pollution. It is adapted to extremes in soils (sand, clay, acid, calcareous) and hardy to USDA Zone 4. It can be found in early and late succession forest, forested wetlands, open disturbed areas, roadsides, vacant lots, yards and gardens.

Distribution: This species is reported from states shaded on Plants Database map. It is reported invasive in CT, DC, DE, IL, IN, MA, MD, ME, MI, NH, NJ, NY, OR, PA, TN, VA, VT, WI, and WV.



Ecological Impacts: Trees produce a large quantity of seeds that can germinate rapidly and crowd out native species. Norway maples have been found in woodlands near cities, especially in the northeastern U.S. It has escaped cultivation and invades forests, fields, and other natural habitats. The species can be locally dominant in forest stands, create dense shade, and displace native trees, shrubs and herbs. Its dense canopy also can shade out native wildflowers.

Control and Management: Don't plant Norway maple.

- **Manual**- Pull seedlings when soil is moist. Dig out larger plants, including the root systems. Cut down large tree. Grind out the stump, or clip off re-growth. Girdle tree by cutting through the bark and growing layer (cambium) all around the trunk. Girdling is most effective in spring.

- **Chemical**- It can be effectively controlled using any of several readily available general use herbicides such as glyphosate or triclopyr. Follow label and state requirements.

References: www.forestimages.org, http://plants.usda.gov, www.nps.gov/plants/alien, www.invasive.org, http://oregonstate.edu, Invasive Plant Atlas of New England http://webapps.lib.uconn.edu/ipane, www.mdflora.org/publications/invasives, www.hort.uconn.edu/cipwg/art_pubs/docs/norway_maple.pdf, Plant Invaders of Mid-Atlantic Natural Areas, NPS & USFWS, p. 52-53

Michigan Department of Natural Resources
Michigan Natural Features Inventory
2/2012

Glossy buckthorn

Frangula alnus

Glossy buckthorn is native to Eurasia but has been commonly planted in this country as a hedge and for wildlife food and cover. It was widely recommended for conservation plantings in the Midwest until its invasive tendencies became apparent; it creates dense thickets and out-competes native vegetation. Its fruit is widely dispersed by birds and small mammals.

Glossy buckthorn, like many invasive shrubs, leafs out early in the spring and retains its leaves late into fall, increasing its energy production and shading out native plants. It is a particular pest on wet sites and poses a significant threat to Michigan's rich prairie fens, as well as other wetland communities. It is also successful on many upland sites including old fields, roadsides and open woods.

Glossy buckthorn is an alternate host for alfalfa mosaic virus and crown fungus, which causes oat rust disease. It has also been implicated as a possible host for the soybean aphid.

It is widely distributed in some parts of the state, but is just beginning to appear in others. If it is caught early in its initial invasion, it may be eradicated completely.


Robert Vidéki, Doronicum Kft., Bugwood.org

Identification

Habit:
Glossy buckthorn is a small tree or shrub with a spreading crown growing up to 6 m (20 ft) tall. Typically, it has multiple stems when young, and develops into a tree with a trunk that may reach 25 cm (10 in) in diameter at maturity.

Leaves:


Suzan Campbell, MNFI

Glossy buckthorn has simple, shiny leaves, with 8 or 9 pairs of veins and untoothed margins. Leaves are alternate although they may appear almost opposite near the branch tips.

Bark/Stems:
Glossy buckthorn stems are greenish, often with tiny, soft fine hairs. The bark on older branches is a blotchy grayish-brown with prominent light raised areas. Winter buds lack scales and are rust-colored. The sapwood, just below the outer bark, is yellow and the heartwood is pinkish to orange.


James H. Miller, USDA Forest Service, Bugwood.org

Flowers:
Glossy buckthorn flowers are tiny with five greenish-white petals, arranged in clusters at the bases of the leaves. The flowers contain both male and female parts. They bloom from late May through September.


Suzan Campbell, MNFI

Fruits/Seeds:


Suzan Campbell, MNFI

Buckthorn has pea-sized fruits with 3-4 seeds. They ripen from green to red to dark purple from July through September, although flowers, unripe and ripe fruit may all be present at the same time. Seeds are viable for several years.

Habitat
Glossy buckthorn does best on sunny moist sites, although it can tolerate shade. It is found in a variety of wetlands including fens, as well as pastures, fence rows, roadsides, open woods including aspen stands and woodland edges.

Similar species

Common buckthorn


Paul Wray, Iowa State University, Bugwood.org

The related common buckthorn (*Rhamnus cathartica*) has finely toothed leaves and flowers with four petals rather than five. Often, it has a small thorn at the tip of its branches, between the terminal buds, which are covered by scales. It has 3 to 5 leaf veins rather than the 8 or 9 of glossy buckthorn. It is also invasive.

Alder-leaved buckthorn


Bev Walters, University of Michigan

The native alder-leaved buckthorn (*Rhamnus alnifolia*) is less than 1 m (3 ft) tall and has leaves with tiny rounded teeth and 6 or 7 pairs of veins. Its flowers lack petals but have five sepals, rather than four. It grows in fens and other wetlands.

Dogwoods


Suzan Campbell, MNFI

Dogwoods (*Cornus* spp.) have opposite leaves rather than alternate and their fruit and flowers are arranged in clusters on reddish stems. The fruit is blue or white, rather than deep purplish black.

Reproduction/Dispersal

Glossy buckthorn reproduction is primarily by seed. Buckthorn is insect pollinated and cannot self-fertilize. Plants mature quickly and can produce fruit at heights of less than 1 m (~3 ft) tall. They can also sprout from the root crown when cut. Plants that have been top-killed can produce fruit on new shoots within the same season.

Although many glossy buckthorn seedlings appear under their parent plants, germination and seedling survival rates are highest in full sun on exposed soils. Glossy buckthorn often establishes in open fields, in the sunny edge along paths and roads and along the forest edge. Following removal of mature shrubs, abundant seedlings rapidly germinate and must be considered when formulating control strategies.

Birds are a major dispersal agent for glossy buckthorn. Robins, cedar waxwings, rose-breasted grosbeaks and starlings have been observed feeding on their abundant fruits. The unripe fruit contains the chemical emodin, which has a laxative effect, facilitating its spread. Small mammals also disperse glossy buckthorn seed, particularly rodents. Mice eat and store glossy buckthorn fruit and seedlings sprout from their abandoned caches.

Fruit production is greatest on sites in full sun with moist soils. Plants in shadier conditions can persist without fruiting for years until a gap in the canopy appears and they receive enough sunlight to flower and fruit.

Planning a control program

Resources for invasive species control invariably fall short of the actual need, so it is important to prioritize sites for treatment and plan carefully. Assessing both the scope of the problem and any available resources is a critical first step:

- Map known populations; is the species widely distributed throughout the region? Just beginning to appear?
- Does it occur on high value sites? Important hunting or recreational lands? High quality natural areas? Sites with high cultural value?
- How is it distributed? Is it sparsely scattered in otherwise native vegetation? Does it cover large expanses of low quality habitat?
- Is there the potential to utilize volunteers?

Given this information, develop a strategy for control:

1. Prioritize high value sites where success can be achieved for treatment;
2. Choose appropriate control methods, given site conditions and available resources.
3. Do these control methods require any permits (i.e. herbicide application in wetlands, prescribed burning)?
4. Focus on mature plants, particularly those in full sun with abundant fruit;
5. Eradicate smaller satellite populations;
6. Treat larger core infestations of lower value as resources permit.
7. Monitor to ensure desired results are being achieved; adapt management to improve success.

Best survey period

Because glossy buckthorn leafs out early and retains its leaves late in fall in much of the state, it is often easiest to locate for mapping or control efforts in early spring or late fall when the leaves of native vegetation are absent or have changed color. It is also easier to distinguish from its neighbors when in fruit.

Documenting occurrences

In order to track the spread of an invasive species on a landscape scale, it is important to report populations where they occur. The Midwest Invasive Species Information Network (MISIN) has an easy-to-use interactive online mapping system. It accepts reports of invasive species' locations from users who have completed a simple, online training module for the species being reported. It also offers the potential for

batch uploading of occurrence data for any invasive species.

Herbaria also provide a valuable and authoritative record of plant distribution. The University of Michigan Herbarium's database can be searched online for county records of occurrence, for example. When glossy buckthorn is first encountered in a county where it had not been known previously, specimens should be submitted to the Herbarium to document its presence. Check the "Online Resources" section for links to both of these resources.

Control

A primary goal in controlling this species is to prevent seed production and dispersal. Glossy buckthorn is one of the most difficult invasive shrubs to control. A variety of techniques including both mechanical and chemical controls may be most effective and should be tailored to the specific conditions on the site. It is critical to monitor the site to ensure that cut stumps and treated shrubs do not resprout and that the seedbank is exhausted. Removal of a dense glossy buckthorn thicket "overstory" results in dense seedling response. Where abundant seed sources are present nearby, monitoring may be required indefinitely.

Mechanical control

In the very earliest stages of invasion, when only scattered seedlings and young plants are present, mechanical controls such as pulling and digging may be adequate to control or eradicate glossy buckthorn. Mechanical control methods are particularly useful where volunteers are available. These methods are impractical in larger, established infestations, with mature shrubs, but may effectively supplement the use of herbicide.

Pulling

In loose, sandy soils, glossy buckthorn seedlings can be hand-pulled easily, particularly when the soil is moist and the population is small. Pull steadily and slowly to minimize soil disturbance and tamp down the soil afterwards. In heavier soils, however, roots are so tenacious that the bark strips off the seedling when pulled. Tools such as the Weed Wrench® or Root Talon® provide additional leverage, facilitating the removal of somewhat larger plants.

Cutting/Mowing

Cutting or mowing mature glossy buckthorn shrubs stimulates resprouting unless the cut surfaces are treated with herbicide. Mowing may be helpful in maintaining open areas by preventing the establishment of seedlings.

Girdling

For mature, single-stemmed buckthorn specimens, girdling may be easier than removing the entire tree. Girdling entails the removal of a strip of bark and cambium around the trunk. The cambium, a thin layer just inside the bark, transports water and nutrients between the plant's roots and its leaves. When it is cut, the tree slowly begins to die.

Use an axe or saw to make two parallel horizontal cuts around the trunk several inches apart, cutting through the bark and cambium. Then, knock off the bark between the cuts. The tree should be checked periodically for two years to cut off any resprouts and to ensure that the bark does not heal over. Girdling is more effective when used in conjunction with herbicide.

Flooding

On wetland sites where water levels have been lowered artificially, restoring the hydrology may kill or set back glossy buckthorn. An extended period of flooding during the growing season is required. The duration and timing of flooding is as important as water depth. This is perhaps most appropriate where restoring hydrology is part of a larger management program and should be used in conjunction with other control methods as needed. It is important not to raise water levels higher than they were historically, to avoid harming sensitive native vegetation.

Chemical control

In most cases, effective control of glossy buckthorn requires the use of herbicide. Factors that should be considered when selecting an herbicide for use on a particular site include proximity to water or wetlands, presence or absence of desirable native vegetation, potential for erosion and the effectiveness of the herbicide under consideration on glossy buckthorn. Because glossy buckthorn remains green much later than many native species, fall treatment may minimize damage to desirable broadleaf plants.

General considerations

Anyone applying herbicides as part of their employment must become a certified pesticide applicator. In addition, certification is required for the use of some herbicides under any circumstances. The certification process is administered by the Michigan Department of Agriculture and Rural Development and a link to their website is included in the "Online Resources" section.

A permit from the Michigan Department of Environmental Quality is usually required to apply herbicide where standing water is present—in wetlands, along streams, rivers or lakes, or over open water. A permit is also required for herbicide use below the ordinary high water mark along the Great Lakes or Lake St. Clair shoreline, whether or not standing water is present. A link to their website is included in the Online Resources section.

A number of adjuvants or additives may be used with herbicides to improve their performance including mixing agent, surfactants, penetrating oils and dyes . Some are included in premixed products while others must be added. Adjuvants

do not work with all products; consult the product label to determine which adjuvants may be used with a specific herbicide formulation.

Dyes are useful in keeping track of which plants have been treated and making spills on clothing or equipment apparent. Some premixed herbicide include them or they can be added to others. Clothing dyes such as Rit® can be added to water soluble herbicides, while other products require oil-based dyes. Consult the product label for specific instructions.

Crop Data Management Systems, Inc. (CDMS) maintains a database of agro-chemicals that includes herbicide labels for specific products. Herbicide labels contain information on application methods and rates, specific weather conditions, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization or drift. A link to the CDMS website is included in the "Online Resources" section.

Read the entire pesticide label before use. Follow all directions on the label.

Herbicide specifics

Triclopyr provides effective control of broad-leaved plants but does not kill grasses or some conifers. It is available in both amine (e.g., Garlon 3A®) and ester (e.g., Garlon 4 Ultra®) formulations. The amine formulation can be safely used in wetlands.

Triclopyr can be used as a foliar spray once glossy buckthorn is fully leafed out in spring until just before it changes color in fall. The ester formulation should be used with a vegetable oil based multi-purpose adjuvant (e.g. SprayTech® Oil) and the amine formulation should be used with a wetland-approved non-ionic surfactant (e.g., Cygnet Plus®).

Triclopyr can also be used in conjunction with cut surface treatments; cut-stump, girdling and frilling. Treatments may be applied throughout the year including when snow is present, however control may be reduced in early spring when the sap is beginning to flow or during periods of drought in summer. Ester formulations are particularly effective for root or stem-sprouting species such as glossy buckthorn because the triclopyr persists in the plant until it dies. The ester formulation should be used with a penetrating oil (e.g., AX-IT®), which improves effectiveness and increases the amount of time after cutting in which treatment can occur. Penetrating oil also facilitates absorption in basal bark treatment.

In wetlands or other sensitive areas, the amine formulation may be used for cut-surface treatments but must be painted onto the cut surface immediately. It can also be used for drill and fill techniques.

Triclopyr is particularly effective when used in conjunction with imazapyr (e.g., Arsenal®). Imazapyr acts over an extended period of time and can persist in the soils —an advantage in providing greater control. However, since it is non-selective it can also kill valuable non-target species. Imazapyr is considerably more expensive than triclopyr.

Foliar application

Foliar application of herbicide can be useful on sites with extensive glossy buckthorn populations and few desirable natives. Herbicide should be applied after spring sap flow to actively growing plants, although during periods of drought or other stress, it may not be effective. It can be applied to glossy buckthorn foliage with squirt bottles, backpack sprayers or boom-mounted sprayers.

The product label for the specific herbicide being used provides essential information on coverage; how much of the foliage should be treated and how wet it should be. Herbicide labels also contain information on specific weather conditions, application modes, equipment types, nozzles etc. to provide the desired coverage and minimize the potential for volatilization or drift.

The herbicide applicator is responsible for managing drift and damage to non-target vegetation. Wind speeds between 3 and 10 miles per hour are best for foliar herbicide spraying. At higher wind speeds, herbicide may be blown onto adjacent vegetation or water bodies.

At lower wind speeds, temperature inversions can occur, restricting vertical air movement. Under these conditions, small suspended droplets of herbicide can persist in a concentrated cloud and be blown off-target by variable gusts of wind. Ground fog indicates the presence of a temperature inversion, but if no fog is present, smoke movement on the ground can also reveal inversions. Smoke that layers and remains trapped in a cloud at a low level indicates an inversion, while smoke that rises and dissipates indicates good air mixing.

In hot, dry weather, herbicide can evaporate rapidly. Setting equipment to produce large droplets can help compensate for this. In general, follow all directions on the label of the specific herbicide being used, in order to prevent damage to non-target vegetation or water bodies.

Cut-stump/Girdling/Frilling

Cut-stump treatment, girdling and frilling may be used in any season except during spring, when sap is flowing upwards.

Cut-stump treatment is useful for species like glossy buckthorn that normally resprout after cutting. After the stems have been cut, they are painted with concentrated herbicide, using a squirt bottle or wicking applicator. Small stems can be cut several inches above the ground so that both the sides and the cut surface may be treated. On large stems, cuts should be made as close to the ground as possible and only the cambium—the thin layer where active growth

occurs, just inside the bark—should be treated. Product labels list what adjuvants may be used to increase effectiveness of the herbicide; penetrating oils only work with ester formulations, for example. Similarly, dyes, which are useful in keeping track of which stems have been treated, work with specific herbicide formulations.

Frilling, or the "hack and squirt" method, is useful for larger trees. Downward cuts are made around the circumference of the trunk and the resulting cavity is immediately treated with herbicide using a squirt bottle or backpack sprayer. Because the cambium is exposed and treated immediately, an amine formulation can be used.

Herbicide can also enhance the effectiveness of girdling, which was described under mechanical controls. Following girdling, the exposed cambium along the cuts is painted with concentrated herbicide.

Treated plants should be monitored for at least a year as they may still resprout. New stems may be treated with a foliar spray, or cut and retreated.

Basal bark

Basal bark treatment can be used on stems that are less than six inches in diameter at any time except during heavy sap flow in spring. It should not be used when snow or water prevent herbicide from being applied at the ground level or when stems are saturated. It it is most useful during the dormant season. Typically, ester formulations of herbicide are used with penetrating oils.

For stems that are less than six inches in diameter, concentrated herbicide can be applied to a band of bark around glossy buckthorn stems or trunk. In basal bark treatment, concentrated herbicide is applied to a band of bark around buckthorn stems extending up 18 inches from the ground. Basal bark treatment is most effective on younger stems with thin bark.

Drill and fill/Injection

Drill and fill, and injection techniques are useful on larger trees. They leave the tree in place to break down over time, providing valuable habitat and structure. They can be used any time of year except during spring sap flow.

The drill and fill technique entails drilling holes into the tree at a downward angle and filling them with a measured amount of concentrated herbicide using a squirt bottle. One hole should be drilled for each inch of diameter.

Specialized injection tools are also available to inject herbicide pellets below the bark. They are precise and require little preparation or clean-up. They are also expensive, however and may be unwieldy in dense brush.

Because concentrated herbicide is used it is very easy to exceed the annual per acre amount that is allowed for a given product. Consult the product label for specifics.

Prescribed burning

In fire-adapted communities, prescribed burning may enhance control of glossy buckthorn over the long term, but should always be considered as part of an integrated management plan for the site as it will stimulate the species over shorter time spans. When prescribed burning is initiated, it should be supplemented with other buckthorn control methods.

General considerations

A permit is required before implementing a prescribed burn. The Michigan Department of Natural Resources (DNR) is responsible for issuing burn permits in the Upper Peninsula and Northern Lower Peninsula unless a municipality wishes to do so. Municipalities located in the Southern Lower Peninsula issue burn permits under authority of the state law. A link to the DNR local fire contacts web page is included in the "Online Resources" section. In the Southern Lower Peninsula, contact the local Fire Marshall for permits and more information. Some municipalities require insurance coverage before a permit is issued, to cover the cost of damages if the fire should escape.

Before initiating a program of prescribed burning, a written burn plan establishing the criteria necessary for starting, controlling, and extinguishing a burn is required. The burn plan includes details such as specific weather conditions, locations of control lines, ignition pattern, equipment and personnel needed, contingency plans, and important phone numbers. The burn plan is essentially the "prescription" for how to conduct the burn safely while accomplishing the management objectives.

If other invasive species that are stimulated by burning are present on the site, planning should incorporate additional control methods to eradicate them.

Prescribed burning specifics

Fire alone does not provide effective control of glossy buckthorn as it will only top-kill mature plants. Even small saplings and seedlings seem to survive fire well. Fire is totally useless as a control method unless there is adequate fuel underneath the buckthorn. Fall fires stimulate vigorous resprouting. Early season fires, when root carbohydrate levels are low, do not stimulate as many resprouts.

Prescribed fire also results in lots of seed germinating; glossy buckthorn seeds germinate more readily on bare soils that have been exposed by fire. A plan for follow-up treatment is required as there is rarely enough fuel to kill these densely sprouting seedlings in a regular prescribed burn.

Fire can be useful in fire-adapted communities once mature glossy buckthorn has been removed and the native vegetation that provides fuel recovers. When adequate fuel is present, fire will kill seedlings and help exhaust the seedbank.

A five second treatment with flame from a propane torch around stems that are less than 4.5 cm (1.75 in) in diameter will also kill young plants. In fire-adapted communities. If left untreated, common buckthorn can alter fire ecology as fuels do not accumulate beneath it.

Biological control

Initial efforts to find biological controls for glossy buckthorn were combined with those for common buckthorn. It now appears that these two species are not as closely related as once believed and share few specialized arthropod pests.

A 2008-2009 European effort involved literature review and field surveys. It found one genus-specific leaf hopper, a free living sap sucker (*Zygena suavis*), on glossy buckthorn. Five more arthropod species that were found only on glossy buckthorn were identified from the literature but were not seen in the field.

Researchers noted that "Current indications are that finding species-specific or genus-specific agents for biological control of *F. alnus* will be difficult". Additional field work is needed to identify potential biocontrol agents.

Disposal of plant parts

When seedlings or young shrubs are pulled, they should be disposed of in a manner that will ensure that their roots will dry out completely. In addition, if fruit is present, it should be burned or bagged and placed in a landfill. Where this is not possible, any resulting seedlings will require monitoring and control.

Although landscape waste cannot generally be disposed of in land fills, Michigan law permits the disposal of invasive species plant parts. See the "Online resources" section below for a link to the relevant legislation.

Online resources:

CDMS - herbicide labels:
http://www.cdms.net/LabelsMsds/LMDefault.aspx?t=

Fire Effects Information System, *Frangula alnus*
http://www.fs.fed.us/database/feis/plants/shrub/fraaln/all.html

Invasive.org, glossy buckthorn
http://www.invasive.org/browse/subinfo.cfm?sub=5649

Invasipedia at BugwoodWiki, *Frangula alnus*
http://wiki.bugwood.org/Frangula_alnus

Invasive Plant Atlas of New England, Glossy buckthorn
http://www.eddmaps.org/ipane/ipanespecies/shrubs/Frangula_alnus.htm

Midwest Invasive Species Information Network, Glossy Buckthorn
http://www.misin.msu.edu/facts/detail.php?id=13

The Michigan Department of Agriculture and Rural Development—Pesticide Certification
www.michigan.gov/pestexam

The Michigan Department of Environmental Quality—Aquatic Nuisance Control
www.michigan.gov/deqinlandlakes
http://www.michigan.gov/deq/0,4561,7-135-3313_3681_3710---,00.html

Michigan Department of Natural Resources—Local DNR Fire Manager contact list
http://www.michigan.gov/dnr/0,4570,7-153-30301_30505_44539-159248--,00.html

Michigan's Invasive Species Legislation
Natural Resources and Environmental Protection Act 451 of 1994, Section 324.4130
http://legislature.mi.gov/doc.aspx?mcl-324-41301

Michigan Legislation—landscape waste, disposal of invasive species plant parts
Natural Resources and Environmental Protection Act 451 of 1994, Section 324.11521, 2 (d)
http://legislature.mi.gov/doc.aspx?mcl-324-11521

The Nature Conservancy's Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas
http://www.invasive.org/gist/handbook.html

University of Michigan Herbarium - Michigan Flora Online
http://michiganflora.net/

Quick reference - Glossy buckthorn

This chart has been provided as a convenience, to summarize the pros and cons of each herbicide and to present details on adjuvants, concentrations, etc. that do not fit into the discussion in the preceding sections. Although every attempt has been made to ensure accuracy, the product labels for the listed herbicides are the ultimate authority for their usage. Where there are conflicts, always follow the label directions. Techniques are listed in order of general preference by MDNR Wildlife Division staff but not all are suitable for wetlands or sensitive sites. Site conditions vary—choose a method that is best suited to conditions on the site being treated.

Anyone using herbicides in the course of their employment is required to be a certified pesticide applicator. Treatment in wetlands or over open water requires a permit from the Michigan Department of Environmental Quality.

These chemicals are available in a variety of formulations and concentrations. Concentration is listed below as a percentage of the active ingredient (AI) to facilitate use of different products. Always follow all directions on the product label including mixing instructions, timing, rate, leaf coverage and the use of personal protective equipment.

	Herbicide	% A.I.	Adjuvant	Timing	Pros	Cons
Basal Bark	**Triclopyr ester** (e.g., Garlon 4 Ultra®)	22-30%	Use a penetrating oil (e.g., AX-IT®), unless it is already included in product, e.g. Michigan blend.	Use any time of year, including winter months EXCEPT during heavy spring sap flow OR when snow or water prevent application at ground level OR when stems are wet.	Relatively selective herbicide and technique. Less labor-intensive than many other techniques if conditions are appropriate.	Use only on stems that are >1/4 inch and <6 inches in diameter. Not approved for use in wetlands.
Foliar Spray	**Triclopyr ester** (e.g., Garlon 4 Ultra®)	2-3%	Use a vegetable oil based multi-purpose adjuvant (e.g. SprayTech® Oil).	After spring sap flow, while plant is actively growing but before leaves change color. Fall ideal as many natives go dormant earlier.	Kills buckthorn very effectively. Broad-leaf specific—will not harm sedges and grasses.	Since it is used during the growing season, it is not a suitable technique for high-quality sites with many broad-leaf natives. Not approved for use in wetlands.
Foliar Spray	**Triclopyr amine** (e.g., Garlon 3A®)	2-3%	Use a wetland-approved non-ionic surfactant (e.g., Cygnet Plus®).	After spring sap flow, while plant is actively growing but before leaves change color. Fall ideal as many natives go dormant earlier.	Safe for use in wetlands Kills buckthorn very effectively. Broad-leaf specific—will not harm sedges and grasses.	Since it must be used during the growing season, it is not a suitable technique for high-quality sites with many broad-leaf natives.
Cut-stump	**Triclopyr ester** (e.g., Garlon 4 Ultra®) + Imazapyr (e.g., Arsenal®)	15-18% + 3%	Use a penetrating oil (e.g., AX-IT®).	Use any time EXCEPT during spring sap flow.	Most effective herbicide combination for this technique (in killing buckthorn—as well as many other plants). Can be used on stems >6 inches in diameter.	Imazapyr is highly active in the soil and may kill adjacent plants. Not approved for use in wetlands.
Cut-stump	**Triclopyr ester** (e.g., Garlon 4 Ultra®)	31-44%	Use a penetrating oil (e.g., AX-IT®), unless it is already included in product, e.g. Michigan blend.	Use any time EXCEPT during spring sap flow.	Relatively selective herbicide and technique. Can be used on stems >6 inches in diameter.	Not approved for use in wetlands.
Cut-stump	**Triclopyr amine** (e.g., Garlon 3A®)	31-44%		Use any time EXCEPT during spring sap flow.	Safe for use in wetlands. Relatively selective herbicide and technique. Can be used on stems >6 inches in diameter.	Cuts must be treated IMMEDIATELY - will not mix with penetrating oil.
Injection	**Triclopyr amine** (e.g., Garlon 3A®, Renovate®)	27%		Use any time EXCEPT during spring sap flow.	Suitable for very large specimens. Extremely selective herbicide and technique. Safe for use in wetlands.	Labor intensive. (Inject 1 ml into cambium at 3-4 inch intervals around entire trunk).

Brush Management – Invasive Plant Control
Black Locust – *Robinia pseudoacacia*

Conservation Practice Job Sheet ***NH-314***

Black Locust (*Robinia pseudoacacia*)

Black Locust, Flowers

Black Locust
Black locust has been planted in many temperate climates and is naturalized throughout the United States, within and outside of its historical range, and in some parts of Europe.

Black locust is an early successional plant, preferring full sun, well drained soils and little competition. It is commonly found in disturbed areas such as old fields, degraded woods, and roadsides. Black Locust is normally a shallow rooted species that does not produce a taproot. Thus, it is sensitive to soil conditions; its growth is adversely affected by water logged soils or compaction due to heavy grazing. Black Locust is a legume, so nitrogen-fixing bacteria associated with nodules on the roots increase nitrogen content of the soil in which the tree grows.

Black locust poses a serious threat to native vegetation in dry and sand prairies, oak savannas and upland forest edges, outside of its historic North American range. Native North American prairie and savanna ecosystems have been greatly reduced in size and are now represented by endangered ecosystem fragments. Once introduced to an area, black locust expands readily into areas where their shade reduces competition from other (sun-loving) plants. Dense clones of locust create shaded islands with little ground vegetation. The large, fragrant blossoms of black locust compete with native plants for pollinating bees.

Black locust reproduces vigorously by root suckering and stump sprouting to form groves (or clones) of trees interconnected by a common fibrous root system. Physical damage to the roots and stems increases suckering and sprouting, making control difficult. Although black locust produces abundant seeds, they seldom germinate.

Similar Natives
Prickly ash (*Xanthoxylum* spp.) has reddish buds, leaflets with teeth, and thorny petioles whereas black locust buds are hairy and white, its leaflets are smooth, and its petioles lack spines. The appearance of honey locust (*Gleditsia triacanthos*) is similar to that of black locust except their spines are unpaired and branched.

Description
Black locust is a fast growing tree that can reach 40 to 100 feet in height at maturity. While the bark of young

saplings is smooth and green, mature trees can be distinguished by bark that is dark brown and deeply furrowed, with flat topped ridges. Seedlings and sprouts grow rapidly and are easily identified by long paired thorns. Leaves of black locust are pinnately compound and alternate along the stem and are composed of seven to twenty one leaflets. Leaflets are oval to round in outline, dark green above and pale beneath. Fragrant white flowers appear in drooping clusters in May and June and have a yellow blotch on the uppermost petal. Fruit pods are smooth, 2 to 4 inches long, and contain 4 to 8 seeds.

Control

Presently there are no techniques that provide effective control of black locust mostly because of its resprouting ability. Cutting or burning generally increases sucker and sprout productivity. Consequently most management has focused on the use of chemical control which has resulted in variable success because apparent killed plants can resprout several years after treatment. Annual monitoring should be conducted and follow-up treatments made as needed.

Biological Control

Black locust is susceptible to some damage from two native insects, the locust borer and the locust leafminer. Research on the effectiveness of insects as a control for black locust is incomplete and is not considered a viable option at this time.

Mechanical Control

Non-chemical control of black locust is largely ineffective because of the plant's vigorous re-sprouting ability. Cutting generally increases sucker and sprout productivity. However, seedlings may be hand pulled if the entire root is removed. Repeated cutting or mowing may achieve some level of control but likely will not result in eradication.

Prescribed Burning

Prescribed burning will have a similar effect as cutting or pulling in that it generally results in increased suckering and vigorous re-sprouting.

Chemical Control

CAUTION: ALWAYS READ THE ENTIRE HERBICIDE LABEL. HERBICIDES ARE REGULATED AND MAY ONLY BE USED UNDER SPECIFIC CONDITIONS. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Black locust is difficult to control because of extensive root suckering from the stump and root. Triclopyr is more effective than glyphosate, but both have been used in the control black locust[1]. If possible, foliar sprays are effective when the leaves are fully expanded. For larger trees, cut down and apply undiluted triclopyr into the freshly cut surfaces of the stump.

The best success with herbicides has resulted from basal bark application[1]. It is not as effective on larger trees (girdle then apply around scar for large trees). This method minimizes resprouting from roots and stumps when applied between mid-July and the end of December. Repeated treatments will likely be necessary.

[1]- The Nature Conservancy - Elemental Stewardship Abstract (and references therein)

Important Note

Mention of specific pesticide products in this document does not constitute an endorsement. These products are mentioned specifically in control literature used to create this document.

Disposal

There are a few general rules of thumb that will ensure proper disposal. Be sure the plant is dead before placing in a mulch or compost pile. Either dry it out in the sun, or bag it in a heavy duty black plastic bag. If you have flowers and/or seeds on the plant, put the flowers and seed heads into the bag head first so that there is minimal risk in dispersing seed.

Information and Recommendations compiled from:

- Alien Plant Invaders of Natural Areas (NPS)
- The Nature Conservancy - Elemental Stewardship Abstract (and references therein)
- Missouri Department of Conservation. Vegetation Management Guideline.
- "Invasive Plant Management Guide." Stewardship Subcommittee of the Connecticut Invasive Plant Working Group. http://www.hort.uconn.edu/cipwg/art_pubs/GUIDE/guideframe.htm

Pest Management – Invasive Plant Control
Autumn Olive – *Elaeagnus umbellata*

Conservation Practice Job Sheet *NH-595*

Autumn Olive (*Elaeagnus umbellata*)

Autumn Olive, leaves

Autumn Olive
Autumn olive is native to eastern Asia and was introduced to the United States for ornamental cultivation in the 1800s. It now grows in most northeastern and upper Midwest states.

Autumn olive grows well on a variety of soils including sandy, loamy, and somewhat clayey textures with a pH range of 4.8-6.5. It does not grow as well on very wet or dry sites, but is tolerant to drought. It does well on infertile soils because its root nodules house nitrogen-fixing actinomycetes. Mature trees tolerate light shade, but produce more fruits in full sun, and seedlings may be shade intolerant.

In New England, autumn olive has escaped from cultivation and is progressively invading natural areas. It is a threat to open and semi-open areas. It has the potential of becoming one of the most troublesome invasive shrubs in the area. It exhibits prolific fruiting, rapid growth, is widely disseminated by birds, and can easily adapt to many sites. It is vigorous and competitive against native species, and resprouts after cutting. Due to its nitrogen-fixing capabilities, it has the capacity to adversely affect the nitrogen cycle of native communities. Autumn olive is just beginning to be recognized as a potentially serious problem.

Description
Autumn olive is a large deciduous shrub that can grow up to 20 feet tall. Leaves are alternately arranged, elliptic to lanceolate (shaped like a lance head), and smooth-edged. Mature leaves have a dense covering of lustrous silvery scales on the lower surface. Stems and buds also have silvery scales. Flowers are small, creamy white to yellow and tubular in shape; they grow in small clusters. The abundant fruits look like small pink berries, also with silvery scales.

Similar Natives
Autumn olive has no similar native plants, but is easily confused with Russian olive, which is a less common invader. Unlike autumn olive, Russian olive often has stiff peg-like thorns, and has silvery scales coating both sides of its mature leaves.

Control
The best method of controlling these species is to prevent them from becoming established. Plants should be removed as soon as possible if they are found newly colonizing an area. Small plants and seedlings can be hand-pulled, especially when the soil is moist. Herbicide treatment is probably the best method for eradicating larger, well-established plants,

as cutting only stimulates sprouting and leads to thicker growth.

Biological Control
No biological options are currently known.

Mechanical Control
Seedlings and sprouts can be pulled by hand when the soil is moist enough to insure removal of the root system. Root fragments may resprout if left in the ground.

Cut trees at ground level with power or manual saw. Cutting is most effective after trees have begun to flower, but before they produce seeds. Because autumn olive spreads by suckering, re-sprouts are common after cutting. Cutting is an initial control measure and success will require either herbicide application or repeated cutting.

Prescribed Burning
Burning is not a viable option by itself for autumn olive control. It stimulates growth, resulting in vigorous production of new shoots.

Chemical Control

CAUTION: ALWAYS READ THE ENTIRE HERBICIDE LABEL. HERBICIDES ARE REGULATED AND MAY ONLY BE USED UNDER SPECIFIC CONDITIONS. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Foliar treatment: Foliar applications may be adequate for small patches; glyphosate, triclorypr and dicamba have all been used with positive results. The recommended dilution of glyphosate in this case is a 1-2% solution[1]. Research has shown that the best time for this application is in late August or September when the plant is actively translocating materials to the roots.

Dicamba should be applied in late June at a rate of 4 lbs/gal (2 qts/100 gal/acre) with a surfactant. This prescription provided 90% total kill and severely retarded the growth of surviving stems the following year[1].

Cut stem treatment: Cut stem treatment is accomplished by cutting the main stem of the plant and then painting the herbicide on the stump. Glyphosate is effective and commonly used. A 10-20% dilution is recommended for painting on stumps[1].

Basal treatment: Reports have demonstrated that basal applications (stem injections) in March, of triclopyr alone or in combination with 2,4-D provided excellent control of autumn olive even at very low concentrations (down to 1% triclopyr in diesel oil)[1].

[1]- Kuhns, L. J. 1986. "Controlling autumn olive with herbicides." Proc. 40th Ann. Meet. N. E. Weed Sci. Soc.

Important Note
Mention of specific pesticide products in this document does not constitute an endorsement. These products are mentioned specifically in control literature used to create this document.

Disposal
There are a few general rules of thumb that will ensure proper disposal. Be sure the plant is dead before placing in a mulch or compost pile. Either dry it out in the sun, or bag it in a heavy duty black plastic bag. If you have flowers and/or seeds on the plant, put the flowers and seed heads into the bag head first so that there is minimal risk in dispersing seed.

Information and Recommendations compiled from:

- "Invasive Plant Management Guide." Stewardship Subcommittee of the Connecticut Invasive Plant Working Group. http://www.hort.uconn.edu/cipwg/art_pubs/GUIDE/guideframe.htm
- Kuhns, L. J. 1986. "Controlling autumn olive with herbicides." Proc. 40th Ann. Meet. N. E. Weed Sci. Soc.
- "Maine Invasive Plants." Maine Natural Areas Program. http://www.umext.maine.edu/onlinepubs/htmpubs/2525.htm
- Rhoads, Ann F. and Timothy A. Block. 2002. "Invasive Species Fact Sheet." Morris Arboretum of the University of Pennsylvania. http://www.paflora.org/Elaeagnus%20spp.pdf
- The Nature Conservancy - Element Stewardship Abstract (and references therein)

Brush Management– Invasive Plant Control
Barberries – *Berbis sp.*

Conservation Practice Job Sheet *NH-314*

Japanese Barberry (*Berberis thunbergii)*

Common Barberry (***Berberis vulgaris)***

Barberries
Japanese and common barberries are native to Eurasia. Japanese barberry, the more common species, poses a significant threat to natural areas due to its popularity as a landscape shrub, ability to tolerate full shade, and the dispersal of its prolific seeds by birds. Common barberry is found sporadically in New England, usually establishing in pastures, open-canopied forests, and sometimes along roads.

Japanese barberry forms dense stands in natural habitats including woodlands, wetlands, and pastures, and alters soil pH, nitrogen levels, and biological activity in the soil. Reproduction is primarily through prolific seeds (high germination rate) although there are also reports of sprouting from roots as well as vegetative layering. Seeds are spread by birds and mammals.

Barberries generally leaf-out earlier and retain their leaves longer than many native shrubs. This trait, shared by many invasive shrubs, gives them a competitive advantage over native plants but also allows landowners to easily locate the invasive shrubs and determine their extent on a property.

Description
The barberries are compact, spiny shrubs that commonly grow from two to three feet tall but may reach eight feet with yellow-colored inner bark. Japanese barberry has alternate and entire (smooth margins) leaves with small (<1/2" wide, 6 petals) yellow flowers growing alone or in umbels (flower stems growing from single point) with single spines.

Common barberry has alternate leaves with bristle-toothed margins and spines are typically in groups of three. It has small yellow flowers in a raceme (branching off a main flower stalk). See pictures. The bright red berries persist after leaf off into winter.

Similar Natives
There are no native barberries in New England.

Control
As with all invasive species, barberry is most effectively controlled by recognizing their appearance early and removing isolated plants before they begin to produce seed.

Manual, mechanical and chemical methods are all useful to varying degrees in controlling barberry.

Removing or killing plants will provide increased light at the site which may lead to a surge of seedlings in the following year. Prepare to monitor and control these outbreaks.

Biological Control

There are no known biological controls of barberry.

Mechanical Control

Mechanical controls include grubbing or pulling seedlings and mature shrubs, and repeated clipping of shrubs. Repeated mowing or cutting will control the spread of Japanese barberry but will not eradicate it. Stems should be cut at least once per growing season as close to ground level as possible. Hand-cutting of established clumps is difficult and time consuming due to the long arching stems and prolific thorns. Grubbing or pulling by hand (using a Weed Wrench or a similar tool) is appropriate for small populations or where herbicides cannot be used. Barberry has shallow roots so small plants may be pulled relatively easily when the soil is moist. Because barberry can re-sprout from root fragments remaining in soil, thorough removal of root portions is important. Manual control works well but may need to be combined with chemical in large or persistent infestations.

Because disturbed, open soil can support rapid re-invasion, managers must monitor their efforts at least once per year and repeat control measures as needed. Limit soil disturbance whenever possible. Winter clipping should be avoided as it encourages vigorous re-sprouting.

Prescribed Burning

There is little information about the efficacy of burns.

Chemical Control

CAUTION: ALWAYS READ THE ENTIRE HERBICIDE LABEL. HERBICIDES ARE REGULATED AND MAY ONLY BE USED UNDER SPECIFIC CONDITIONS. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Chemical control methods are best done during the fall when most native plants are dormant yet invasive plants are still actively growing. This lessens the risk of affecting non-target plants. The barberry's green leaves will provide easy recognition and allow for a thorough treatment at this time. Winter application of chemicals has proven to be successful as well, and further lessens the risk of damaging non-target species.

Glyphosate (brand names Roundup, and for use near waterbodies, Rodeo) is a nonselective herbicide which kills both grasses and broad-leaved plants while triclopyr (brand names Garlon, Pathfinder, and others) is a selective herbicide that kills broad-leaved plants but does little or no harm to grasses.

Cut Stump Treatments: For 'cut stump' treatments, horizontally cut the stem near the ground. Leaving some stem will allow another cut and application if there is sprouting. Apply a 20-25% solution of glyphosate or triclopyr and water to the stump being sure to cover the outer, top 20% of the cut stem[1, 2, 3]. Herbicide must be applied immediately following the cutting. This treatment is best applied late in the growing season when the plant is transporting nutrients to its root system (August-October).

Foliar Treatment: For foliar treatments a 2% solution of glyphosate and water can be used[1, 3]. The treatment should be applied to the foliage late in the growing season but can be applied early in the season to minimize non-target impacts. Do not cut down treated plants for at least a full growing season.

Basal Bark Method: This method is effective throughout the year as long as snow cover does not prevent spraying to the ground level. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 12-15 inches from the ground[1, 3]. Be sure to treat entire circumference of the stem in a band at least 12 inches wide. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line. Do not apply to bark that's wet from heavy dews and rain.

[1] – From TNC ESA – Buckthorns
[2] - Wisconsin DNR Control Manual
[3] – Alien Plant Invaders Fact Sheets

Important Note

Mention of specific pesticide products in this document does not constitute an endorsement. These products are mentioned specifically in control literature used to create this document.

Disposal

Small, pulled shrubs should be hung in trees to prevent re-rooting. Larger, pulled shrubs may be piled or piled and burned, roots up, to prevent re-

establishment. Cut stems may be piled or piled and burned. If chipping, do not remove material from the site as barberry will spread by seeds.

Information and Recommendations compiled from:

- The Nature Conservancy - Fact Sheets (and references therein)
- Invasive Plant Atlas of New England (IPANE)
- CT NRCS Invasive Species ID Sheets
- Wisconsin Manual of Control Recommendations for Ecologically Invasive Plants (DNR)
- Tennessee Exotic Plant Management Manual
- Alien Plant Invaders of Natural Areas (NPS)

winged burning bush

(*Euonymus alatus*)

Homeowners Fact Sheet

Tips for identifying, controlling, and monitoring winged burning bush on your property

Background

Winged burning bush (*Euonymus alatus*) is a deciduous shrub that is native to Asia. It was first introduced to the United States in the 1860s for ornamental use. Winged burning bush prefers moist, well-drained, slightly acidic soils in full sun, but is very adaptable to poor soils, heat, drought, periodic shearing, pollution, and partial to full shade. It threatens old fields, open woods, mature second growth forests. Winged burning bush and its cultivars (varieties) are still sold and planted in residential and commercial landscapes; it is very popular due to its attractive, bright red autumn Foliage that can be seen in Cook, DuPage, and Lake Counties.

Why Should You Care?

Winged burning bush spreads by seed and root stem cuttings. Birds and small mammals will eat its fruits and deposit seeds over long distances. As it grows in dense thickets it displaces native plants and the native animals that depend on those plants are deprived of food and shelter. Its shade and dense root system also inhibit growth of plants nearby.

Bright red autumn foliage make winged burning bush a popular garden plant. (Photo taken by Brendon Panke, U Wisconsin–Madison)

Corky wings along greenish stems with autumn foliage. Photo taken from Oregon State website)

Identification

- Perennial, woody, shrub that loses its leaves in autumn.
- Leaves are medium to dark green, 1 to 3 inches long, with a short petiole.
- Leaves are opposite to slightly alternate, elliptical to oval, with finely toothed margins.
- In autumn, leaves are a brilliant flaming red in sunny sites or a faded pink-red in shady sites.
- Matures very slowly and can reach 15 feet tall by 15 feet wide; cultivars are smaller (10' by 10', or less).
- Yellow - green small flowers in late May and early June, usually inconspicuous and hidden among leaves.
- Fruits are small, green in summer and mature to a beige-red capsule, which splits open to show a few orange fruits in September that are often concealed by autumn leaves.
- Green strips occur along the thick stem, surrounded by very prominent tan to brown corky wings.

Some Suggested Control Methods

Do not plant winged burning bush and replace any plants in your landscape or garden with native or non-invasive plants!

Mechanical Small infestations of young plants can be pulled by hand before they produce seeds, but be sure to wear thick gloves and a long sleeve shirt to protect your hands and arms from the spines. A Weed Wrench® can be used to uproot roots of young plants and entire larger plants (stems up to 2.5 inches) when the soil is moist. The entire root should be removed to avoid re-sprouting. Shrubs can also be mowed or cut back repeatedly during the growing season.

Chemical

Basal bark method This method is effective throughout the year as long as the ground is not frozen. Prepare a mixture of 25% triclopyr plus 75% horticultural oil and apply to the base of the shrub to a height of about a foot from the ground. Thorough wetting is necessary for good control, but be careful not to produce runoff at the ground line. A dye added to the mixture will help keep track of treated plants.

Cut stem method This method is most effective if the stems are first cut by hand or mowed to ground level and herbicide (triclopyr or glyphosate) is applied immediately to cut stem tissue. Herbicide applications can be made any time of year as long as rain or snow is not expected for at least 24 hours, and there is little or no wind during application. Fall and winter applications will avoid or minimize impacts to native plants and animals.

Foliar application Because this method involves applying herbicide mix to leaves. it should be considered mostly for large infestations where the risk to non-target species is minimal. The best time to treat is late fall or early spring when rain or snow is not expected for at least 24 hours, and there is little or no wind (less than 8-10 mph) during application. Apply a 2% solution of glyphosate or triclopyr and water to thoroughly wet all leaves. Mix should not be dripping off leaves. If desirable plants are nearby, establish a no-spray buffer area to protect non-target plants.

Follow-up

After winged burning bush is removed from the site, fill the space with native or non-invasive plants by seeding or planting. A variety of attractive shrubs native to the Midwest are available that provide nectar, seed, and host plant material for butterflies, hummingbirds, and other wildlife. They include Eastern wahoo (*Euonymus atropurpureus*), Black Chokeberry (*Aronia melanocarpa*) and its cultivars var. 'Elata,'and 'Aronia Iroquois Beauty,' Blackhaw (*Viburnum prunifolium*), Nannyberry (*Viburnum lentago*), Sugar Shack™ Buttonbush (*Cephalanthus occidentalis* 'Sugar Shack'), Raspberry Tart™ Viburnum (*Viburnum dentatum* 'Rastzam), and Shining Sumac (*Rhus copallina*) and its cultivar 'Prairie Flame Shining Sumac' (*Rhus coppalina* var. *latifolia* 'Morton'). Other shrubs that may also be available at local nurseries include Dwarf Fothergilla (*Fothergilla gardenii*), Itea Little Henry® Virginia Sweetspire (*Itea virginica*) 'Sprich,' Itea Scarlet Beauty™ Virginia Sweetspire (*Itea virginica 'Morton'*), and Red Chokeberry (*Aronia arbutifolia*) 'Brilliantissima.'

Precautions

- In areas where spring wildflowers or other desirable native plants occur, herbicide application should be carefully targeted with protection of surrounding plants or conducted prior to their breaking ground in the spring, delayed until they senesce in late summer or autumn, or after the last killing frost. Foliar application of the herbicide MUST be applied to the target plant while it is in an active growth stage.
- Herbicidal contact with desirable plants should always be avoided. If native grasses are intermingled with winged burning bush, triclopyr should be used because it is selective for broad-leaved plants and will not harm grasses.
- Because triclopyr amine is a water-soluble salt that can cause severe eye damage, it is imperative that you wear protective goggles to protect yourself from splashes. Triclopyr ester is soluble in oil or water, is highly volatile and cannot be used in temperatures above 80˚F; and can be extremely toxic to fish and aquatic invertebrates. It should not be used in or near water sources or wetlands and should only be applied under cool, dry, and low wind conditions.
- If using herbicide, be sure to follow all label instructions
- Monitor treated area and treat resprouts as needed!

Equipment & Supplies You May Need

Loppers or machete

Weed Wrench®

Weed wacker and/or mower

Herbicide (glyphosate and triclopyr)

Rubber gloves and appropriate eye protection

Long pants, long sleeved shirt, closed-toe shoes

Spray bottle and Liquid dye (food coloring or Rit dye works)

Patience, persistence, and commitment (this will take years)

Additional Resources

Midwest Invasive Plant Network Control Database

http://mipncontroldatabase.wisc.edu/

Northeast Illinois Invasive Plant Partnership www.niipp.net

NIIPP

Lake County Forest Preserves
www.LCFPD.org

Brush Management – Invasive Plant Control
Shrub Honeysuckles – *Lonicera sp.*

Conservation Practice Job Sheet *NH-314*

Morrow's honeysuckle (*Lonicera morrowii)*

Tatarian honeysuckle (*Lonicera tatarica)*

Shrub Honeysuckles

The exotic shrub honeysuckles are increasingly common throughout much of the eastern and Midwestern United States where they have contributed to reduced species richness, cover of native herb communities and to reduced tree regeneration in early to mid-successional forests. Although disturbance of some kind usually precedes invasion, the exotic shrub honeysuckles are adapted to a wide variety of habitats. Reproduction is almost entirely by seed. Seed production and short-term seed viability are consistently high, and seeds are readily dispersed by birds and, perhaps, small mammals.

The exotic shrub honeysuckles also generally leaf-out earlier and retain their leaves longer than the native shrub honeysuckles. This trait, shared by many invasive shrubs, gives them a competitive advantage over native plants but also allows landowners to easily locate the invasive shrubs and determine their extent on a property.

Description

Exotic shrub honeysuckles are upright, multi-stemmed, oppositely branched, deciduous shrubs. The exotic honeysuckles have hollow center branches when mature (native honeysuckles do not). The opposite leaves are entire (un-toothed margins) and paired. Axillary flowers (where leaf is attached to stem) are showy with white, pink, and sometimes aging to yellow corollas. The fruits of honeysuckles are usually red but can be yellow, orange or clear and fleshy. The flowers of exotic shrub honeysuckles can be distinguished from all native shrub honeysuckles except swamp fly-honeysuckle (*L. oblongifolia*) by their hirsute (hairy) styles.

Similar Natives

Some uncommon honeysuckles include *Lonicera villosa* and *Lonicera canadensis*, both can be distinguished by having solid white piths.

Control

The potential for large-scale restoration of unmanaged natural areas infested with honeysuckle is probably low. Restoration potential for managed natural areas infested with honeysuckle is probably moderate. If attacked during the early stages of colonization, the potential for successful management is high.

Manual, mechanical, environmental/cultural, and chemical methods are all useful to varying degrees in controlling honeysuckles. Removing or killing plants will provide increased light at the site which may lead to a surge of seedlings in the following year. Prepare to monitor and control these outbreaks.

Biological Control

There are no known biological controls of honeysuckle.

Mechanical Control

Mechanical controls include grubbing or pulling seedlings and mature shrubs, and repeated clipping of shrubs. Effective mechanical management requires a commitment to cut or pull plants at least twice a year for a period of three to five years. Cuttings should be done in the growing season (spring and fall). Grubbing or pulling by hand (using a Weed Wrench or a similar tool) is appropriate for small populations or where herbicides cannot be used.

Any portions of the root system not removed can re-sprout. Because disturbed, open soil can support rapid re-invasion, managers must monitor their efforts at least once per year and repeat control measures as needed. Limit soil disturbance whenever possible. Winter clipping should be avoided as it encourages vigorous re-sprouting.

Prescribed Burning

Repeated annual prescribed burns during the growing season will top-kill shrubs and inhibit new shoot production.

Chemical Control

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Most managers report that treatment with herbicides is necessary for large shrub honeysuckle populations. Formulations of glyphosate (brand names Roundup, and for use near waterbodies, Rodeo) and formulations of triclopyr (brand names Garlon, Pathfinder, and others), have been used as foliar sprays or cut stump sprays and paints with varying degrees of success.

Glyphosate is a nonselective herbicide which kills both grasses and broad-leaved plants while triclopyr is a selective herbicide that kills broad-leaved plants but does little or no harm to grasses.

Cut Stump Treatments: For 'cut stump' treatments, horizontally cut the stem near the ground. Do not cut the stem at ground level. Leaving some stem will allow another cut and application if there is sprouting. Apply a 25% solution of glyphosate or triclopyr and water to the stump being sure to cover the outer, top 20% of the cut stem[1, 2]. Herbicide must be applied immediately following the cutting. This treatment is best applied late in the growing season when the plant is transporting nutrients to its root system (August-October).

Foliar Treatment: For foliar treatments a 2% solutions of glyphosate or triclopyr and water can be used[2]. Both glyphosate and triclopyr should be applied to the foliage late in the growing season. Do not cut down treated plants for at least a full growing season.

Basal Bark Method: This method is effective throughout the year as long as snow cover does not prevent spraying to the ground level. Apply a mixture of 25% triclopyr and 75% horticultural oil to the basal parts of the shrub to a height of 12-15 inches from the ground[1, 2]. Be sure to treat entire circumference of the stem in a band at least 12 inches wide. Thorough wetting is necessary for good control; spray until run-off is noticeable at the ground line. Do not apply to bark that's wet from heavy dews and rain.

[1] – From TNC ESA – Bush Honeysuckles
[2] – Tennessee Exotic Plant Management Manual

Important Note

Mention of specific pesticide products in this document does not constitute an endorsement. These products are mentioned specifically in control literature used to create this document.

Disposal

Small, pulled shrubs should be hung in trees to prevent re-rooting. Larger, pulled shrubs may be piled or piled and burned, roots up, to prevent re-establishment. Cut stems may be piled or piled and burned. Chip once all fruit has dropped from branches. Leave resulting chips on site as buckthorns will spread by seeds.

Information and Recommendations compiled from:

- The Nature Conservancy - Element Stewardship Abstract (and references therein)
- Tennessee Exotic Plant Management Manual
- Invasive Plant Atlas of New England (IPANE)
- Virginia Natural Heritage Program – Invasive Plant Fact Sheets
- Vermont Invasive Exotic Plant Fact Sheets
- CT NRCS Invasive Species ID Sheets

PENNSTATE

Vegetation Management
Department of Horticulture
College of Agricultural Sciences
http://vm.cas.psu.edu

Conservation Reserve Enhancement Program (CREP)
Technical Assistance Series

Factsheet
2

Managing Multiflora Rose

Multiflora rose (*Rosa multiflora*) is an invasive shrub that can develop into impenetrable, thorny thickets. It has the distinction of being among the first plants to be named to Pennsylvania's Noxious Weed List. This plant was introduced from Asia and widely promoted as a 'living fence' to provide erosion control and as a food and cover source for wildlife. Multiflora rose does provide cover and some food value with its fleshy fruit (called 'hips'), but its overall effect on habitat value is negative. Multiflora rose is very aggressive, and crowds planted grasses, forbs, and trees established on CREP acres to enhance wildlife habitat.

Telling Bad Rose from Good

There are least 13 species of rose that that grow 'wild' in Pennsylvania, and most of them are desirable in a wildlife habitat planting. Multiflora rose is readily distinguished from other roses by two features - its white-to-pinkish, five-petaled flowers occur in branched clusters, and the base of the leaf where it attaches to the thorny stem is fringed (Figure 1). Memorial rose (*Rosa wichuraiana*) is the only other species with a fringed leaf base, but its flowers are borne singly.

Individual plants can easily grow to more than 10 feet tall and 10 feet wide. When they grow singly, multiflora rose plants have a mounded form because of their arching stems (Figure 2). When the tips of the stems touch the ground, they can take root (called *layering*) and form a new crown. If near trees, the rose behaves almost like a vine, and can grow 20 feet into the tree.

Figure 1: Two features that distinguish multiflora rose from the other rose species that grow in Pennsylvania are the flowers that appear in branched clusters, and the fringed base of the compound leaf (inset).

Figure 2. Multiflora rose in whole-plant view, with its mounded form from arching stems, and cascades of showy, white-to-pinkish blooms.

Multiflora rose breaks bud early in the spring, quickly developing a full canopy of compound leaves that have seven to nine leaflets. Peak bloom is in early June. Birds and browsing animals eat the fleshy, bright red hips and the seeds pass through their digestive systems intact. These seeds can remain viable in the soil up to 20 years.

Multiflora Rose Control Measures

A single-method control approach will not eradicate a multiflora rose infestation. Like other invasive species, a combination of control tactics is necessary to manage this plant.

Finding multiflora rose early is the best way to simplify control. Controlling rose as small, scattered plants is much easier than trying to eliminate established thickets. Vigorous, competitive vegetation greatly aids control as well.

Brush mowers, or similar equipment can be used to cut and pulverize the top growth of established plants. Mowing alone will not control multiflora rose, but it is a great way to make it easier to treat the plant with herbicides. Top growth of smaller plants can be removed with conventional mowing equipment.

Herbicides can be applied to rose foliage or to the stems. Applications to foliage can be spot-applied with a hydraulic sprayer with a handgun, mounted on an ATV, tractor, or truck; or a backpack sprayer. In a grassland planting, treatments of the herbicide Cimmaron (*metsulfuron*) mixed at

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1 oz per 100 gal of spray solution will be very effective. Apply this solution uniformly to the rose foliage, so that it is visibly wet but the solution is not running off the foliage. Avoid treating the surrounding vegetation. *Metsulfuron* is extremely effective against rose, but it will cause injury to adjacent grasses if you contact their foliage during the application.

In tree plantings, there is some risk of injury by *metsulfuron* through root absorption, so a *glyphosate* (Roundup Pro) treatment is a better choice. If either *metsulfuron* or *glyphosate* is accidentally applied to the foliage of the trees, severe injury will result. When treating multiflora rose, you should also target any other undesirable woody species in your CREP plantings. *Metsulfuron* in combination with *glyphosate* provides an effective treatment against a wide spectrum of woody and herbaceous species (Table 1).

A more selective, but more expensive treatment is a foliar application of the combination of *triclopyr + 2,4-D* (Crossbow). Apply Crossbow as a one percent mixture (one quart in 25 total gallons of spray solution) to multiflora rose in grassland plantings on a spray-to-wet basis. The ingredients in Crossbow will not injure adjacent grasses. This treatment is more likely to cause injury if used in tree plantings than a glyphosate treatment.

The herbicide *triclopyr* (Pathfinder II) can be applied to multiflora rose stems to kill the top growth, either after cutting, or to intact plants as a basal bark application. For either application, apply the ready-to-use Pathfinder II to wet the stems, but not to the point of run-off.

Stump treatment is a very effective way to enhance a mowing treatment. Pathfinder II is oil-based, and can be applied after a mowing to prevent regrowth. The oil solution penetrates the bark of the rose stems and kills the tissue underneath, preventing sprouts. You can apply this treatment with a squirt bottle, but if you have a lot of crowns to treat, it's much easier to use a backpack sprayer.

When it's acceptable to leave the top growth of the rose in place, and when you can actually access the base of the plant with a spray wand, you can control multiflora rose with a basal bark treatment. Apply Pathfinder II to the lower 12 inches of all the stems, completely wetting each stem, but avoiding run-off. Basal bark treatments are best applied from January up to the point of fall coloration.

After making your initial control applications, it is essential to follow-up. If you don't, multiflora rose will re-establish. Where rose was dense, it is unlikely you were able to thoroughly treat all the plants while trying not to get tangled in the thorny stems. When spot treating, it's easy to miss a few stems. When stump treating after mowing, it's almost impossible to find all the crowns that need to be treated. Don't get complacent. If you had a significant infestation, only ongoing maintenance will prevent it from returning.

Table 1. You can effectively treat multiflora rose with herbicides applied to the foliage or to the stems. Metsulfuron (Cimarron) or the combination of triclopyr + 2,4-D (Crossbow) are very useful in grassland plantings, but glyphosate (Roundup Pro) poses less risk of non-target injury through root absorption in tree plantings. Triclopyr (Pathfinder II) is effective for treating stumps (stubble) or the stems of intact plants.

method	treatment	application rate (herbicide/total mix)	comments
foliar	Cimarron	1 oz/100 gal	Cimarron (*metsulfuron*) is extremely active against multiflora rose. Thoroughly spray all the foliage to the point of being wet without running off. Add surfactant according to label directions. *Metsulfuron* is somewhat selective at this rate, but avoid treating adjacent grasses, and limit this treatment to grassland plantings.
foliar	Roundup Pro	128 oz/100 gal	Roundup Pro (*glyphosate*) is not as active against rose as *metsulfuron*, but is a safer option in tree plantings because it has no soil activity. If you have a lot of problem woody species, tank mix this treatment with Cimarron at 0.5 oz/100 gallons for broad spectrum brush control in grassland plantings.
foliar	Crossbow	1 gal/100 gal	Crossbow contains *triclopyr + 2,4-D*, and is safer to grasses than Cimarron, but more expensive. Avoid using this treatment in tree plantings. Crossbow can potentially injure trees through root absorption, or volatilization during high air temperatures.
mow and stump treat	Pathfinder II	ready-to-use	Use when mowing is practical. After cutting, apply Pathfinder II to the point of just wetting the remaining stubble. This treatment can be applied year-round.
basal bark	Pathfinder II	ready-to-use	This application is only feasible when you can access the base of the plant. Apply Pathfinder II to completely wet the lower 12 inches of the stems, without causing run-off. This is best applied from January up to fall color.

By Jon Johnson, Art Gover, and Jim Sellmer, 2007.

Brush Management – Invasive Plant Control
Oriental Bittersweet – *Celastrus orbiculatus*

Conservation Practice Job Sheet *NH-314*

Oriental Bittersweet. *Celastrus orbiculatus*

Oriental Bittersweet blanketing native plants

Oriental Bittersweet

Celastrus orbiculatus is native to temperate East Asia and has been considered weedy in all of New England and most of the Atlantic Coast States since 1971. Oriental bittersweet is a vigorously growing vine that climbs over and smothers vegetation which may die from excessive shading or breakage. When bittersweet climbs high up on trees the increased weight can lead to uprooting and blow-over during high winds and heavy snowfalls.

In addition, oriental bittersweet is displacing our native american bittersweet through competition and hybridization. Upland meadows, thickets, young forests, and beaches are most vulnerable to Oriental Bittersweet invasion and dominance. Similar to most invasive plants, *C. orbiculatus* has a high reproductive rate, long range dispersal, ability to root sucker, and rapid growth rates.

Description

Oriental bittersweet is a deciduous woody perennial plant which grows as a climbing vine and a trailing shrub. The leaves are alternate, glossy, nearly as wide as they are long (round), with finely toothed margins. There are separate female (fruiting) and male (non-fruiting) plants. Female plants produce clusters of small greenish flowers, and each plant can produce large numbers of fruits and seeds.

The fruits are three-valved, yellow, globular capsules that at maturity split open to reveal three red-orange, fleshy arils each containing one or two seeds. The abundance of showy fruits has made Oriental bittersweet extremely popular for use in floral arrangements.

Similar Natives

American bittersweet (*Celastrus scandens*) is a very similar native that may be distinguished from *C. orbiculatus* by the location of its fruit - *C. orbiculatus* has small clusters in the leaf axils while *C. scandens* has clusters at its branch tips. The two species may be capable of hybridizing and since the native is relatively rare it is possible that its distinct genetic identity is threatened.

Control

Manual, mechanical and chemical control methods are all effective in removing and killing Oriental bittersweet. Employing a combination of methods often yields the best results and may reduce potential impacts to native plants, animals and people. The method you select depends on the extent and type of infestation, the amount of native vegetation on the

site, and the time, labor and other resources available to you. Whenever possible and especially for vines climbing up trees or buildings, a combination of cutting followed by application of concentrated systemic herbicide to rooted, living cut surfaces is likely to be the most effective approach. For large infestations spanning extensive areas of ground, a foliar herbicide may be the best choice rather than manual or mechanical means which could result in soil disturbance.

Recovery of natural areas highly infested with *C. orbiculatus* is unpredictable. Previous natural vegetation structure and function are often severely altered, although remnants of the flora may persist. Removal methods often further disrupt remnants of previous plant communities. A number of workers report that even with complete removal and rootkill of *C. orbiculatus*, substantial seedling regeneration occurs in following years, due to a persistent soil seed bank.

Biological Control

There are no known biological controls of bittersweet.

Mechanical Control

Small infestations can be hand-pulled but the entire plant should be removed including all the root portions. For climbing vines, first cut the vines near the ground at a comfortable height to kill upper portions and relieve the tree canopy. Try to minimize damage to the bark of the host tree. Rooted portions will remain alive and should be pulled, repeatedly cut to the ground or treated with herbicide. Cutting without herbicide treatment will require vigilance and repeated cutting because plants will resprout from the base.

Prescribed Burning

Prescribed burning for Oriental Bittersweet is not a viable option for control. It is likely that Oriental Bittersweet is actually favored by fire due to rapid growth in response to opening the canopy and the large nutrient flushes that usually occur after fires.

Chemical Control

CAUTION: ALWAYS READ THE ENTIRE HERBICIDE LABEL. HERBICIDES ARE REGULATED AND MAY ONLY BE USED UNDER SPECIFIC CONDITIONS. CONTACT YOUR STATE DEPARTMENT OF AGRICULTURE FOR USE REQUIREMENTS, RESTRICTIONS OR RECOMMENDATIONS.

Systemic herbicides like triclopyr (i.e., Garlon 3A and Garlon 4) and glyphosate (i.e., Accord, Glypro, Rodeo) are absorbed into plant tissues and carried to the roots, killing the entire plant within about a week[1]. Garlon 4 is soluble in oil or water, is highly volatile and can be extremely toxic to fish and aquatic invertebrates[1]. It should not be used in or near water sources or wetlands and should only be applied under cool, calm conditions. Chemical control is most effective if the stems are first cut by hand or mowed and herbicide is applied immediately to cut stem tissue.

Fall and winter applications will avoid or minimize impacts to native plants and animals. Repeated treatments are likely to be needed. In areas where spring wildflowers or other native plants occur, application of herbicides should be conducted prior to their emergence, delayed until late summer or autumn, after the last killing frost occurs, or carefully targeted. If native grasses are intermingled with the bittersweet, triclopyr should be used because it is selective for broad-leaved plants and will not harm grasses. Follow-up monitoring should be conducted to ensure effective control.

Foliar Treatment: Use this method to control extensive patches of solid Bittersweet. Apply a 2% solution (8 oz per 3 gal. mix) triclopyr ester (Garlon 4) or triclopyr amine (Garlon 3A) mixed in water with a non-ionic surfactant to the leaves[1]. In Rhode Island, concentrations as low as 1% in mid-summer and 0.05% in September have been very effective. Thoroughly wet the foliage but not to the point of runoff. The ideal time to spray is after much of the native vegetation has become dormant (October-November) to avoid affecting non-target species. A 0.5% concentration of a non-ionic surfactant is recommended in order to penetrate leaf cuticle. If the 2% rate is not effective try an increased rate of 3-5%. Ambient air temperature should be above 65°F.

For dense, low patches of bittersweet another alternative is to cut the entire patch to the ground early in the growing season. About one month later, apply

1-2% solution of triclopyr ester (Garlon 4) or triclopyr salt (Garlon 3A) in water to the previously cut patch using a backpack sprayer[2]. This method has resulted in complete rootkill of the bittersweet and no off-target damage or root uptake by adjacent plants.

Cut Stem Treatments: Use this method in areas where vines are established within or around non-target plants or where vines have grown into the canopy. Cut each vine stem close to the ground (about 2 in. above ground) and immediately apply a 25% solution of glyphosate (e.g., Accord) or triclopyr (e.g., Garlon 3A) mixed with water to the cut surface of the stem[1]. The glyphosate application is effective at temperatures as low as 40°F and the triclopyr application remains effective at temperatures <60°F as long as the ground is not frozen. A subsequent foliar application may be necessary to control new seedlings. Homeowners can apply products like Brush-B-Gone, Brush Killer and Roundup Pro Concentrate undiluted to cut surface using a paint brush or a plastic spray bottle.

Basal Bark Method: Use a string trimmer or hand saw to remove some of the foliage in a band a few feet from the ground at comfortable height. To the exposed stems, apply a 20% solution of triclopyr ester (Garlon 4) (2.5 quarts per 3-gallon mix) in commercially available basal oil with a penetrant (check with herbicide distributor) to vine stems[1]. As much as possible, avoid application of herbicide to the bark of the host tree. This can be done year-round although efficacy may vary seasonally; temperatures should be above 50°F for several days.

[1] – Plant Conservation Alliance (PCA) Alien Plant Working Group
[2] – Dreyer, G. 1988. "Efficacy of triclopyr in rootkilling Oriental Bittersweet and certain other woody weeds." Proceedings of the Northeastern Weed Science Society.

Important Note
Mention of specific pesticide products in this document does not constitute an endorsement. These products are mentioned specifically in control literature used to create this document.

Disposal
There are a few general rules of thumb that will ensure proper disposal. Be sure the plant is dead before placing in a mulch or compost pile. Either dry it out in the sun, or bag it in a heavy duty black plastic bag. If you have flowers and/or seeds on the plant, put the flowers and seed heads into the bag head first so that there is minimal risk in dispersing seed.

Information and Recommendations compiled from:

- Dreyer, G. 1988. "Efficacy of triclopyr in rootkilling Oriental Bittersweet and certain other woody weeds." Proceedings of the Northeastern Weed Science Society.
- Howard, Janet L. 2005. "Celastrus orbiculatus. In: Fire Effects Information System." U.S. Department of Agriculture, Forest Service. http://www.fs.fed.us/database/feis/
- Invasive Plant Atlas of New England (IPANE)
- Plant Conservation Alliance (PCA) Alien Plant Working Group
- The Nature Conservancy - Element Stewardship Abstract (and references therein)

Japanese honeysuckle

Lonicera japonica

Fact Sheet

NH Department of Agriculture, Markets & Food, Division of Plant Industry, 29 Hazen Dr, Concord, NH 03301
(603) 271-3488

Common Name: **Japanese honeysuckle**
New Hampshire Invasive Species Status: **Prohibited** (*Agr 3800*)

Latin Name: ***Lonicera japonica***
Native to: **Eurasia**


Leaves-opposite (summer)


Japanese honeysuckle – Rye, NH


Leaf (summer)


Flowers (spring)


Berries (summer)


Berries (fall)


Thicket (spring)


Vines (summer)


Fall foliage (Autumn)

Description: Climbing vine. **Stems/vines:** Reddish-brown, pubescent. **Leaves:** Opposite and not clasping the stem as opposed to the three native honeysuckle vines that do clasp the stem, oblong, $1\frac{1}{2}$-2" long, rounded at base. **Flowers:** Tubular, white or yellow, fragrant, May to mid-July. **Fruit:** Berry, smooth, blackish to slightly purplish. **Zone:** 4-8. **Habitat:** Prefers moist soils and full sun to partial shade. **Spread:** Seeds spread by wildlife. **Comments:** Vines grow quickly, covering native vegetation, resulting in loss of habitat. **Controls:** hand or mechanical removal, cutting, girdling, chemical.

General Considerations

Japanese honeysuckle is a trailing or twining, perennial woody vine that can grow to 30' (9 m) in length. . The young stems are hairy, while the old stems can be glabrous and hollow ranging from 1/8" to as large as 2" (3.17mm-5cm) in diameter. Bark is somewhat corky and peals easily on older stems. The leaves are opposite, dark green and glabrous above and slightly pubescent beneath. They are usually ovate with entire margins, but young leaves can be lobed.
Rooting depth is generally 6" to 12" (15-30 cm) on moist sites, and up to 40" (102 cm) on dry sites. Roots may extend laterally to 8' (2.4 m) from the crown. Japanese honeysuckle often retains its leaves into winter, with abscission sometimes occurring after new leaves have fully developed in spring.

The flowers of Japanese honeysuckle are white or pinkish and fade to yellow as they age. They are borne in axillary pairs on solitary peduncles. The berries are black or dark purple and about $^{3}/_{16}$" to ¼" (6-7 mm) in diameter. Within the berries are 2-5 blackish ovate seeds. One side of the seed is ridged, while the other is flat.

Germination generally occurs the following spring for most seeds and because they are small and contain limited stored carbohydrates, seedlings must begin photosynthesis immediately. It is possible for some seeds to survive into the second year, but this seems to be a rare occurrence. Therefore, seed bank development tends to be a minor concern.

Japanese honeysuckle can create extremely dense thickets as its vines intertwine and overlap in an effort to absorb as much available light as possible. By doing so, Japanese honeysuckle robs light, nutrients and moisture that would otherwise be available for the growth of native species. The shear weight of Japanese honeysuckle vines that overtop native trees and shrubs can break branches and even topple whole trees.

Control Options

See the following control guides: **Integrated Pest Management (IPM) for Woody Plants** or the **Control of Invasive Species by Numbers**

Lonicera japonica Japanese honeysuckle	
Plant Type	Vine
Habitat Type	Forests, field edges, roadsides
USDA Hardiness Zone	4-8
Rooting Structure	Deep and fibrous
Environmental Impacts	Dense concentrations of Japanese honeysuckle can inhibit regeneration of woody forest species.
Wildlife Impacts	Degradation of habitat
Leaf arrangement	Opposite
NWI Ranking	UPL
Soil Type	Adaptable to a variety of site conditions
Soil pH Range	6.1-7.8
Light Requirements	Shade tolerant
Growing Season	
Growth Rate	30 feet (9 m) of stem per year
Mature Height	30' (9 m) in length
Life Span	?
Reproductive Age	3-5 years
Flowering Period	Late May to early June
Flower Type	Both monoecious and Dioecious
Pollination	Insects and hummingbirds
Seed Set	September
Seed Per Plant	Prodigious
Scarification Required	Yes
Cold Stratification	Yes
Seed Longevity	Unknown
Seed Germination Rate	~80%
Seedling Density	?
Other Propagules	Suckering and layering
Dispersal Vectors	Frugivorous birds and small mammals

Sources

Invasive Plant Atlas of New England:
http://www.eddmaps.org/ipane/ipanespecies/vines/Lonicera_japonica.htm

USDA Forest Service invasive species website:
http://www.fs.fed.us/database/feis/plants/vine/lonjap/all.html

Invasives.org:
http://www.invasive.org/browse/subinfo.cfm?sub=3039

A service of the Northeastern Area State and Private Forestry
More resources available online

FOREST INVASIVE PLANTS RESOURCE CENTER

GARLIC MUSTARD

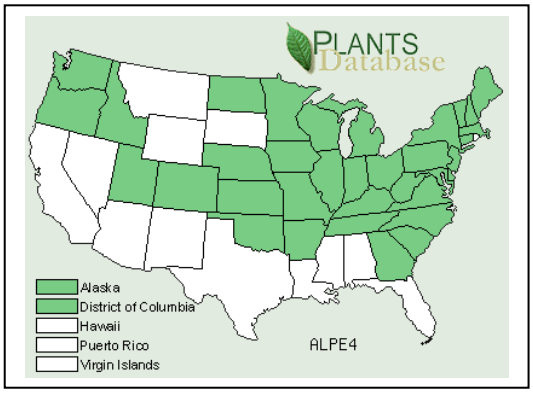
(*Alliaria petiolata*)

Flowering garlic mustard crowds out native species and dominates the forest floor.

IN BRIEF

Garlic mustard is a biennial (two-year life cycle), herbaceous plant that spreads rapidly by seed in many types of woodlands. One of the most invasive and difficult-to-control weeds in the region, it is a major threat to desirable woodland wildflowers, tree seedlings and wildlife. It displaces native species by competing for available light, nutrients and water resources.

DESCRIPTION



Plant habit. First-year plants form low rosettes of 4-8 leaves at ground level. Second-year flowering plants are erect-stemmed, from a few inches to 4 feet tall, and often are multiple-stemmed. Garlic mustard eventually forms extensive stands on the forest floor.

Leaves. First-year rosettes have dark green, kidney-shaped leaves with scalloped margins and deep veins (giving them a wrinkled appearance). In the second spring, a flower stalk rises from the rosette, bearing alternate, coarsely toothed, triangular leaves. Crushed leaves smell like garlic, especially in spring.

Flowers. Clusters of small, white, 4-petaled flowers occur only on second-year plants, which can blossom from late April through June. Flowers appear at the top of stalks and bloom progressively upward.

First-year plant -- a low rosette with kidney shaped leaves.


White, 4-petaled flowers.

Second year plants ready to flower.

Fruits / Seeds. Each flower soon develops into a slender, straight seedpod called a silique. (1–2.5 inches long). Pods are green at first, but turn tan as seeds ripen. Each contains one row of oblong dark brown to black seeds. Dispersion occurs in mid- to late summer. A single plant can produce as many as 3,000 seeds.

Roots. Plants develop a white, slender taproot, which often branches below ground. The top of the root typically has a bend or "S"-shape as it emerges from the ground.

Habitat. Garlic mustard grows in upland and floodplain forests, savannas, urban yards and along roadsides. It thrives in shady conditions, but can tolerate sunny habitats, usually resulting in smaller flowering plants. It prefers non-acidic soils.

DISTINCTIVE FEATURES

- Crushed leaves have the odor of garlic.
- The only tall, broad-leaved, 4-petaled, white woodland flower blooming in early spring.
- First-year basal rosettes remain green through fall and winter. They are one of the earliest plants to begin active green growth in spring.

LOOK-ALIKES

Several white-flowered native plants occur in the same habitats as garlic mustard and may be mistaken for it., These include Cut-leaved toothwort (*Cardamine concatenata*), another 4-petaled mustard, but low-growing with narrow, finger-like leaves; Sweet cicely (*Osmorhiza claytonia and O. longistylis*), with fern-like leaves, five petals; and Early saxifrage (*Saxifraga virginica*), with five white petals.

Sweet cicely with divided leaves

Garlic mustard with undivided leaves

Basal leaves resemble Creeping Charlie (*Glechoma hederacea*), a vine with square stems and purple flowers; Violets (*Viola* spp.), whose heart-shaped leaves have shallow teeth and pointed tip; and Kidney-leaf buttercup (*Ranunculus abortivus*), whose leaves are smooth, shiny, sometimes lobed. Fruiting structure is similar to other kinds of mustards with long capsules.

Violet leaf with shallow teeth and pointed tip

Left: First year garlic mustard leaf, deep veins
Right: Creeping Charlie, rounded leaf margin

Garlic mustard infestation

LIFE HISTORY AND INVASIVE BEHAVIOR

Garlic mustard is a herbaceous biennial that produces hundreds of seeds per plant. Seeds may lie dormant for 20 months before germinating, and remain viable for 5-8 years. They typically germinate in early spring, though some sprout throughout the summer. Reproduction is only by seed.

There are two primary patterns of spread: an advancing front, and satellite population expansion. The invasion of forests usually begins along a roadside or woods edge and progresses via streams, rainwater runoff, trails (including animal) and through human activity – especially shoes and boots, and bicycle and off-road vehicle tire treads. Satellite populations can appear in remote areas, probably introduced by animals that carry the seeds in their fur or on their feet.

Once established, garlic mustard rapidly dominates the forest floor and can displace most native herbaceous species within ten years. Few insects, deer or other herbivores will eat it.

IMPACTS ON FORESTRY AND FORESTERS

On Forestry: Unlike other plants that invade disturbed habitats, garlic mustard spreads readily into high quality forests. Once established, it competes with tree seedlings for available light, nutrients and water resources, thus preventing recruitment of replacement trees. In addition, plant chemicals produced by roots and decaying leaves inhibit the growth of other plants, including trees. Recent research discovered one of the ways this happens. Chemicals released by garlic mustard disrupt the growth of underground mycorrhizal fungi which the roots of tree seedlings depend on for healthy growth.
(For "Recent research" above, link to http://biology.plosjournals.org/archive/1545-7885/4/5/pdf/10.1371_journal.pbio.0040140-p-L.pdf
On Foresters: Seeds are easily spread via mud on tires and other equipment, and by sticking on or falling into boots and shoes. Dispersal-prevention requires careful monitoring and washing of equipment and clothes.

CONTROL METHODS

	Method	Timing
Manual & Mechanical	Dig up by roots anytime	Spring, summer, fall
	Hand pull flowering plants	Spring, early summer
	Propane torch newly emerged seedlings	Spring
	Prescribed burning	Spring, fall
	Cut when flowering	Late spring, early summer
Chemical	Foliar application (glyphosate, triclopyr, 2,4-D)	Spring and fall
Biological	(Research on insects that attack garlic mustard is in progress. See link to website.)	

Once well-established, garlic mustard requires years of sustained effort to eradicate. The most effective strategy to prevent invasion is to monitor uninfested areas and prioritize the treatment of small populations. Heightened vigilance is required if populations exist nearby. Try to prevent the spread of seed by cleaning shoes, vehicles and equipment when leaving infested areas.

Management objectives in infested sites are 1) prevent further spread; 2) prevent seed production; and 3) exhaust the seed bank. First, conduct a thorough survey of the site to determine the extent of invasion, then work from the least infested to most infested areas. Begin control efforts on the leading edges of the invasion and on satellite populations. If resources allow, work on the densest infestations. If nothing else, try to prevent the spread of garlic mustard beyond its known boundaries.

Tailor control methods to the infestation. Hand pulling or cutting flower stalks is effective in small populations, and is necessary for follow-up after other treatments. Controlled burning, weed-torching and herbicide may be useful for larger populations. No single method is 100% effective, and full control often requires a strategy of multiple techniques consistently applied for many years.

Manual Control

Pulling or digging first-year, non-flowering rosettes can be an inefficient use of resources because: 1) many first-year plants will die naturally from overcrowding and drought; 2) it is difficult to remove the entire root without digging. On the other hand, plants uprooted in the rosette stage have no chance of flowering and hence do not need to be removed from the area.

Hand-pulling or digging flowering, second-year plants can be effective, especially in small infestations. Hand pulling alone is usually not practical in large or established patches, but is needed to catch flowering plants missed by other treatments. Plants can be pulled anytime during flowering and up until when seed pods are ready to shatter. (See below about removing pulled plants from the site.) When pulled, stems often break off at the base and the taproot may resprout if not removed. Hand-pulling can increase seed germination through soil disturbance, but this can expedite depletion of the seed bank.

Manual control of garlic mustard

Cutting second-year plants close to the ground by hand or with a weed whip may be effective, depending on timing and weather. **Cutting too early in the season will result in resprouts, cutting too late will allow the seed pods to mature. For best results, cut just as flowering begins.** Resprouting will be reduced because plants will have used up most of their energy reserves producing flowers and seedpods. Try to revisit the site to look for plants that were missed. Note: Some flowering plants are tiny, only a couple of inches tall and easily overlooked. These plants may have only one or two flowers, but still will produce a set of seeds!

After pulling or cutting, it is best to bag and remove all flowering plants. Depending on weather conditions, uprooted and cut plants will continue to develop and may set seed, especially later in the season as seedpods mature. For small populations, plants can be decapitated and just the flowering tops bagged and removed. Garlic mustard should not be composted, because seeds are likely to remain viable. Bagged plants can be landfilled, or dried out and burned. In large patches where removal is not possible, pile stems in the most densely-infested area, where the seed bank is already presumed great. This, at least, will prevent another crop of seeds from being deposited in the forest. Covering with black plastic will help limit the ripening and spread of seed from the pile.

Burning

In spring, the tender, freshly-emerged seedlings can be quickly flame-killed using a propane weed torch. This should be done on a wet day. As the first-year plants develop taproots, this method becomes less effective.

Controlled burning can be an effective way to treat large garlic mustard infestations. Burns conducted in spring will kill seedlings and emerging second-year plants. Woodland burning exposes the soil, however, and may stimulate seed germination. As with hand pulling, this can cause a population increase, but also a more rapid depletion of the seed bank. If an area is burned, follow-up treatments will be needed every year, such as pulling, more burns, propane torch treatments or herbicide applications. Burning every two years without follow-up could actually make a garlic mustard problem worse.

Herbicide

Foliar application of a systemic herbicide is an efficient method for controlling large infestations. First-year plants are most vulnerable, and second-year plants should be treated well before seeds ripen.

Herbicide should be applied to rosettes in very early spring or late fall when most native vegetation is dormant but garlic mustard remains green. Because it begins active growth early in spring and stays green right through winter, identification is easy and spraying should not harm dormant, non-target species. Spring application is effective, and two generations of garlic mustard can be killed if both new seedlings and overwintering rosettes are targeted. By the time seedlings have sprouted, however, many other woodland species have emerged and will be harmed if sprayed. Herbicide can be applied until flowering begins, but if applied too late seeds may still mature. Fall application on first-year rosettes can also be very effective on a warm day, but dry conditions may inhibit translocation of herbicide to roots and limit the kill rate. Fallen leaves in autumn may also cover plants and shield them from the spray.

- Glyphosate (the active ingredient in many commercial brands) is most commonly used to control garlic mustard.
- Triclopyr (the active ingredient in many commercial brands) also is widely used.
- 2,4-D alone gives inconsistent control, but a 1% solution of 2,4-D plus Dicamba applied to the foliage of young plants is effective.

***NOTICE**: Use pesticides wisely. Always read the product label carefully. Follow all mixing and application instructions and wear all recommended protective gear and clothing. Contact your state department of agriculture for any pesticide use requirements, restrictions or recommendations. Many states require individuals involved in the commercial application of pesticides be certified and licensed.*

Click Here for further information on herbicide use.

Biological Control

Several European insects are being tested for biological control of garlic mustard. Among the promising candidates are four tiny weevils of the genus *Ceutorhynchus* that attack roots, stems or seeds.

Biological control of garlic mustard may be possible with European weevils

Strict testing is required by the USDA before any exotic control agent is released, to ensure that it is specific to the intended host and will not damage crops and native plants. These tests are underway, but may take until 2010 or beyond to complete.

Biological control someday may be the best long-term solution for limiting the damage caused by garlic mustard, but there is no guarantee that it will be practical or effective. For the foreseeable future, it is important to use available methods to eradicate this invasive and prevent it from taking over more forests.

HISTORY AND LORE

Pesto anyone?

Alliaria petiolata: Alli refers to the genus *Allium*, which includes garlic. Petiolata means "with petioles" (leaf stalks). Other common names: Hedge garlic, Jack-by-the-hedge, Sauce alone. Garlic mustard is widespread but not especially abundant in its native Europe, due to the many insects and herbivores that have evolved to feed on its roots, stems, leaves and seeds. Few North American insects or vertebrates can tolerate the plant's pungent defensive chemicals.

Garlic mustard was brought by immigrants as a garden plant for food and medicine. It was first reported as an escaped weed on Long Island, New York in 1868.

Although no longer in common use as a medicinal, its edible leaves and flower heads are high in vitamins A and C. First- and second-year plants are edible, but older parts can be bitter and

tough after flowering starts. Garlic mustard is eaten cooked or raw and may be substituted for spinach in many recipes, yielding a strong, distinctive flavor. An internet search will turn up recipes for garlic mustard pesto and other delights. Here is a site with four recipes. http://www.ma-eppc.org/morerecipes.html

Whole plants can be boiled to make a yellow or light green dye, using alum as a mordant. Tie-dyeing makes a fun activity for groups (especially kids) after a hard session of pulling.

LINKS and REFERENCES

Websites

Weeds Gone Wild – Garlic mustard factsheet
http://www.nps.gov/plants/alien/fact/alpe1.htm

Wisconsin DNR – Garlic mustard factsheet
http://dnr.wi.gov/invasives/fact/garlic.htm

Wisconsin State Herbarium – Garlic mustard records
http://www.botany.wisc.edu/wisflora/scripts/detail.asp?SpCode=ALLPET

The Nature Conservancy: 20-page stewardship document for garlic mustard
http://tncweeds.ucdavis.edu/esadocs/documnts/allipet.pdf

Invasive.org Project – Factsheet and biocontrol information
http://www.invasive.org/eastern/biocontrol/29GarlicMustard.html

Invasive Plants Association of Wisconsin – Garlic mustard resources
http://www.ipaw.org/invaders/garlic_mustard/gm.htm

Missouri Vegetation Management Manual – Garlic mustard section
http://www.mdc.missouri.gov/nathis/exotic/vegman/eleven.htm

Iowa Native Plant Society Newsletter – Garlic mustard control
http://www.public.iastate.edu/~herbarium/inps/mar03.htm

Books / Field guides

Invasive Plants Field & Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands, by Cynthia D. Huebner, U.S. Forest Service, 2005.
(Also online -- http://www.fs.fed.us/r9/wildlife/nnis/invasive-species-field-guide.pdf)

Invasive Plants of the Upper Midwest: An Illustrated Guide to their Identification and Control, by Elizabeth J. Czarapata, University of Wisconsin Press, 2005.

PENNSTATE
Vegetation Management
Department of Horticulture
College of Agricultural Sciences
http://vm.cas.psu.edu

Japanese stiltgrass (Microstegium vimineum)

Description

- Refer to the DCNR Invasive Exotic Plant Tutorial stiltgrass page (http://www.dcnr.state.pa.us/forestry/invasivetutorial/Japanese_stiltgrass.htm).
- Herbaceous, annual, warm-season grass.
- Tolerant of full sun to heavy shade.
- Has a sprawling growth habit, with a canopy height between 12 and 24 inches.
- Seedheads emerge late-August to early-September.
- Infestations commonly start along road or trail edges, then spread outward.

Management Keys

As a plant, stiltgrass is not hard to suppress. However, treatment often begins after stiltgrass has spread extensively and established a persistent seedbank, making control difficult.

Target the Seedbank

To eliminate stiltgrass, you have to prevent seed production, and exhaust the seed lying in wait in the soil. You should plan on at least a five-year process.

Prevention is Easier

If stiltgrass is just getting onto your site, determine where it's coming from. Shale and gravel for roadwork are common sources. Roadwork where stiltgrass is already established spreads it even further.

Mechanical Control

Small infestations of stiltgrass are readily pulled. A trimmer can be effective later in the season (Figure 1), if you cut the stiltgrass off at ground level. A lawnmower cuts too high and will not work, as stiltgrass is a common weed in turf.

Early Control

It is common to first observe stiltgrass along roads or trails. The infestation tends spread along the road or trail, then spread away into the understory. It is relatively easy to treat stiltgrass while it occurs as a narrow, linear infestation.

Recommended Herbicides

Stiltgrass is susceptible to a number of herbicides, allowing you to tailor a program that fits your schedule and the plant community you are trying to preserve.

Preemergence herbicides that are effective against stiltgrass include *pendimethalin* ('Pendulum'), *imazapic* ('Panoramic'), and *sulfometuron* ('Oust XP').

Imazapic and *sulfometuron* can also be applied postemergence for effective control of stiltgrass. *Pendimethalin* will have the least effect on non-target species of these three materials, but it is also the least flexible to use. *Pendimethalin* must already be in the soil where the seed is germinating – it has to be absorbed by the emerging root tip to be effective. *Pendimethalin* has no effect on already established vegetation.

Imazapic and *sulfometuron* provide more flexibility in terms of application timing, but they will cause more injury to non-target herbaceous plants than *pendimethalin.*

Three postemergence herbicides that are effective against stiltgrass include *glyphosate* ('Aquaneat'), *glufosinate* ('Finale'), and *quizalofop* ('Assure II'). *Glyphosate* is non-selective and systemic, and will injure all treated vegetation. G*lufosinate* is also non-selective, but it is a 'contact' herbicide, so the damage to treated non-target plants will be limited to where the spray contacted the plant.

The herbicide *quizalofop* only injures grasses. Stiltgrass is affected by *quizalofop* at low rates, so you can control stiltgrass but leave native woodland grasses such as whitegrass (*Leersia virginica*), nimblewill (*Muhlenbergia schreberi*), and autumn bentgrass (*Agrostis perennans*) largely intact.

Alternate Groundcover

If conditions permit, you should try to establish a groundcover to compete with the stiltgrass. If there already is groundcover, try to encourage its growth. Turf that is mowed too short and too often is more prone to stiltgrass infestation than a properly maintained turf.

Be Persistent

Stiltgrass can only be effectively controlled with repeated, annual effort. If you back off one season, the seedbank will be replenished, and your progress to date will be set back.

This work was sponsored by the Pennsylvania Department of Conservation and Natural Resources, Bureau of State Parks (PA DCNR).

Figure 1. The objective of stiltgrass management is to prevent seed set. Stiltgrass is effectively controlled with preemergence or postemergence herbicide applications, and small infestations can be hand-pulled or cut at ground level.

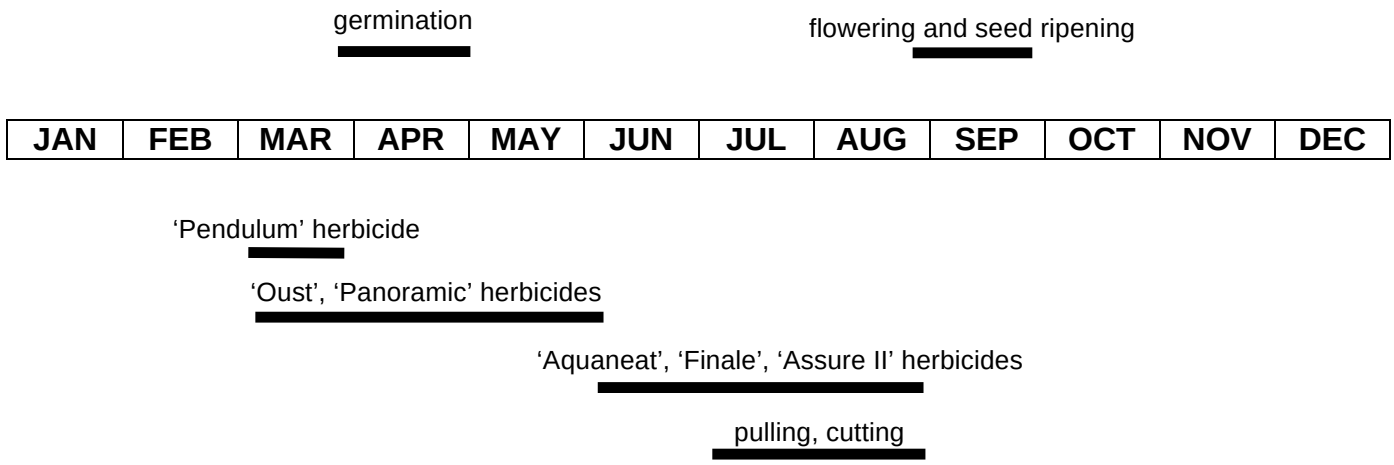


Table 1. Prescriptions for elimination of Japanese stiltgrass focus on preventing seed set. Stiltgrass is susceptible to a number of herbicides suitable for use in parks. Small infestations can be pulled or cut at ground level, which facilitates the use of volunteers.

timing	treatment	product rate	comments
early- to mid-March	'Pendulum Aquacap'	4.2 qts/acre	Preemergence applications of 'Pendulum' (*pendimethalin)* prevent stiltgrass establishment, and have little effect on plants that are already present. It is critical that *pendimethalin* be applied two to three weeks prior to germination to allow rainfall to move it into the soil profile. *Pendimethalin* is also effective against mile-a-minute.
early-March through May	'Panoramic' or 'Oust XP'	8 to 12 oz/acre or 1 to 3 oz/acre	'Panoramic' (*imazapic)* and 'Oust XP' (*sulfometuron)* have pre- and postemergence activity against stiltgrass. Preemergence applications will cause less damage to non-target species than postemergence applications. There comes a point in the season when you are better off using an herbicide that is not soil active (see below), to reduce the impact on non-target plants.
mid-May through August	'Aquaneat' or 'Finale' or 'Assure II'	24 oz/acre or 4 qts/acre or 4 oz/acre	'Aquaneat' (*glyphosate)* and 'Finale' (*glufosinate)* are non-selective herbicides with no soil activity. 'Finale' only injures the parts of the plant it contacts, while 'Aquaneat' is systemic, and will kill the entire plant. 'Assure II' (*quizalofop)* only affects grasses, but the rate used for stiltgrass is low enough that desirable grasses such as whitegrass (*Leersia virginica),* and nimblewill (*Muhlenergia schreberi)* are only temporarily affected.
July through August	pulling or cutting	n/a	Small infestations of stiltgrass can be mechanically controlled. If you're cutting, use a trimmer that will cut the stiltgrass at the ground line to prevent resprouting from the lower nodes of the stem. The key to this treatment is to wait so that more stiltgrass will not germinate, but finish before the seedheads emerge.