



## CHAPTER 5.

# **NBNERR Flora and Vegetation Communities**

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## NBNERR Flora and Vegetation Communities

This chapter describes terrestrial palustrine and upland plants and plant communities of the NBNERR. Because the properties of the NBNERR occupy only Bay islands, which historically have been largely cleared of native vegetation, theories of island biogeography would predict that plant communities of the Reserve are less diverse than those of mainland coastal Rhode Island. Although no formal studies of island effects have been conducted, the setting of the Reserve certainly offers unique environmental conditions affecting floral ecology. The islands' general lack of top predators and limited emigration opportunities have led to the overpopulation of white-tailed deer (*Odocoileus virginianus*), which may be affecting the entire ecology of the island system due to heavy browsing and grazing pressure (Raposa and Greene, 2003). Also, the narrow shape of the islands offers interior plant species minimal protection from coastal winds and salt spray, which facilitates species adapted to coastal conditions, including aggressively colonizing invasive species such as oriental bittersweet (*Celastrus orbiculatus*) and black swallow-wort (*Vincetoxicum nigrum*).

Anthropogenic factors have strongly influenced the upland flora on Reserve properties and have played a key role in the development of certain upland plant communities. Prudence and Patience islands were almost completely deforested in the 1600s and heavy subsequent farming led to the depletion of much of the fertile topsoil (Chapter 3). Many remnant soils are nutrient poor and excessively drained, which tends to select for species communities adapted to poor soil conditions, such as pitch pine (*Pinus rigida*) dominated mosaics, and relatively stable upland grassland habitats. Human modification of disturbance regimes such as the suppression of fire and localized flooding have limited the occurrence of certain expected early-successional communities and favored progressive change towards more stable forest habitats and associated flora. Former land-use practices have also set the stage for infestation of nuisance and invasive species. For example, historical persistent seasonal clearing in the North Prudence Unit has contributed to a widespread infestation of oriental bittersweet.

Palustrine habitats have also been greatly affected by human impacts, especially since the Navy's occupation of the South Prudence Unit in the mid-1900s. A network of raised Navy roads at least partially impounds every major stream in this Reserve unit. Filling, ditching, and movement of earth, which are evident in aerial photo archives, have also changed natural surficial water regimes. Historic documents indicate that some wetlands were spared from deforestation during the islands' development, but they were not spared from other early ecological impacts such as the likely extirpation of expected ecosystem engineers such as the beaver (*Castor canadensis*) and top predators such as the red wolf (*Canis rufus*), which may partly account for a lack of early successional vegetation and depauperate community composition from overbrowsing, respectively.

### Flora

The flora on Prudence Island, and in the NBNERR, has been surveyed periodically for over 20 years. The first known formal plant survey at the Reserve was conducted by Shaughnessy and Golet (1982). A total of 89 species was identified during their inventory of the upland and wetland habitats of the Narragansett Bay Estuarine Sanctuary, which is now the Reserve's North Prudence, Patience Island, and Hope Island units. The Rhode Island Wild Plant Society (1994) later surveyed upland vegetation of the Prudence Conservancy Unit. George and Nichols (1993) identified 160 vascular plant species in Prudence Park on the west side of Prudence Island during a botanical survey conducted for the ASRI. George (1997a, 1997b) again surveyed the properties of the Reserve in 1997, documenting 93 species. Krebs (1997) collected, identified, and pressed botanical samples for display

in the Reserve's education kiosk. Enser et al. (2001) conducted a preliminary inventory of plants in a wet meadow that the Reserve was restoring along the side of the entrance road to the South Prudence Unit. Gould et al. (2002a) followed up the investigation, and also identified species in two NBNERR upland grassland restoration sites, also located in the South Prudence Unit (Gould et al., 2002b, 2002c). Kutcher and Raposa (2005) conducted the first quantitative vegetation survey on Prudence and identified 64 vascular plant species within an Atlantic coastal pine barren mosaic in the South Prudence Unit during the summer of 2004.

Overall, 312 vascular plant species have been identified at the Reserve, including 232 native species and 80 exotics (Appendix 5.1). This compares to 1,980 species (1,307 native and 673 exotics) known to exist in the state according to *The Vascular Flora of Rhode Island: A List of Native and Naturalized Plants* (Gould et al., 1998).

## Rare Species

Fourteen state rare native species (according to Gould et al., 1998) have been identified in the Reserve properties on Prudence Island. These include one fern species: leathery grape-fern (*Botrychium oneidense*); three wildflower species: sickle-leaved golden aster (*Chrysopsis falcata*), yellow thistle (*Cirsium horridulum*), and spring ladies' tresses (*Spiranthes vernalis*); one annual herb species: woodland goosefoot (*Chenopodium standleyanum*); three grass species: rigid panic-grass (*Panicum rigidum*), bead-grass (*Paspalum setaceum*), and gama grass (*Tripsacum dactyloides*, Fig. 1); one cactus species: eastern prickly pear (*Opuntia humifusa*); one vine: wild honeysuckle (*Lonicera dioica*); one trailing shrub species: sand dewberry (*Rubus recurvicaulis*); and one tree species: slippery elm (*Ulmus rubra*).



**Figure 5.1.** The showy inflorescence of the locally rare grass species, gama grass, growing in a salt marsh-upland transition zone in the Reserve's North Prudence Unit. Photo from NBNERR photo library.

## Invasive Species

Eighteen exotic species and one naturalized southern U.S. native, the black locust (*Robinia pseudoacacia*), identified at the Reserve are listed as invasive in the *Invasive Species Atlas of New England* (Mehrhoff et al., 2003) (Appendix 5.1). Of these, oriental bittersweet is by far the most problematic species affecting Reserve habitats. Oriental bittersweet is an introduced vine that aggressively out-competes native flora by overtopping the plants and extorting light resources and nutrients. It occurs in virtually all properties of the Reserve, smothering flora and burdening shrubs and trees to the point of structural failure in many cases (Fig. 5.2). At least 31 percent (218 ha) of the Reserve's natural upland is affected by this nuisance species, which is drastically affecting the ecology of many habitats, especially coastal shrublands and forests (Kutcher et al., 2004).

Other invasives are also ubiquitous in the NBNERR habitats. Beach rose (*Rosa rugosa*) dominates at least 14 percent of dune shrublands.



**Figure 5.2.** A cherry-cedar woodland infested with the invasive vine oriental bittersweet. Low, open-canopy forests and coastal shrublands are most susceptible to this disturbance-loving invasive. Note that the needle-leaved cedars (left and back-center) appear as conical broad-leaved trees due to nearly complete coverage of bittersweet, while cherries in the foreground are now merely acting as frames supporting the aggressive vine. Photo from NBNERR photo library.

Common reed (*Phragmites australis*) dominates at least 43 percent of emergent freshwater habitat and is present in many of the salt marsh systems; multiflora rose (*Rosa multiflora*) is a staple species in coastal shrublands; the aggressive vine black swallow-wort has taken hold of at least two large areas; and autumn olive (*Elaeagnus umbellata*) is common in certain Reserve shrublands. Black locust occurs throughout coastal forest habitats of the North Prudence and Patience Island units, where the exotic maples sycamore maple (*Acer pseudoplatanus*) and Norway maple (*Acer platanoides*) have also escaped cultivation (Kutcher et al., 2004).

## Vegetation Communities

The first known inventory of vegetative communities on NBNERR properties was a survey of wetlands conducted by RIDEM for the state in 1988–89. RIDEM inventoried 287 ha of wetlands within the NBNERR by photointerpretation of 1:24,000 aerial photographs (available at [www.edc.uri.edu/rigis](http://www.edc.uri.edu/rigis)). Shaughnessy and Golet (1983) conducted a habitat inventory in 1982 for the Narragansett Bay Estuarine Sanctuary and RIDEM. They mapped and inventoried 434 ha of uplands and wetlands in the North Prudence, Patience Island, and Hope Island units via aerial photointerpretation and ground-truthing. An inventory of Reserve plant communities was not conducted again until 2003, when Kutcher et al. (2004) surveyed, mapped, and classified 1,053 ha of upland, wetland, and modified plant communities in GIS format for all lands in

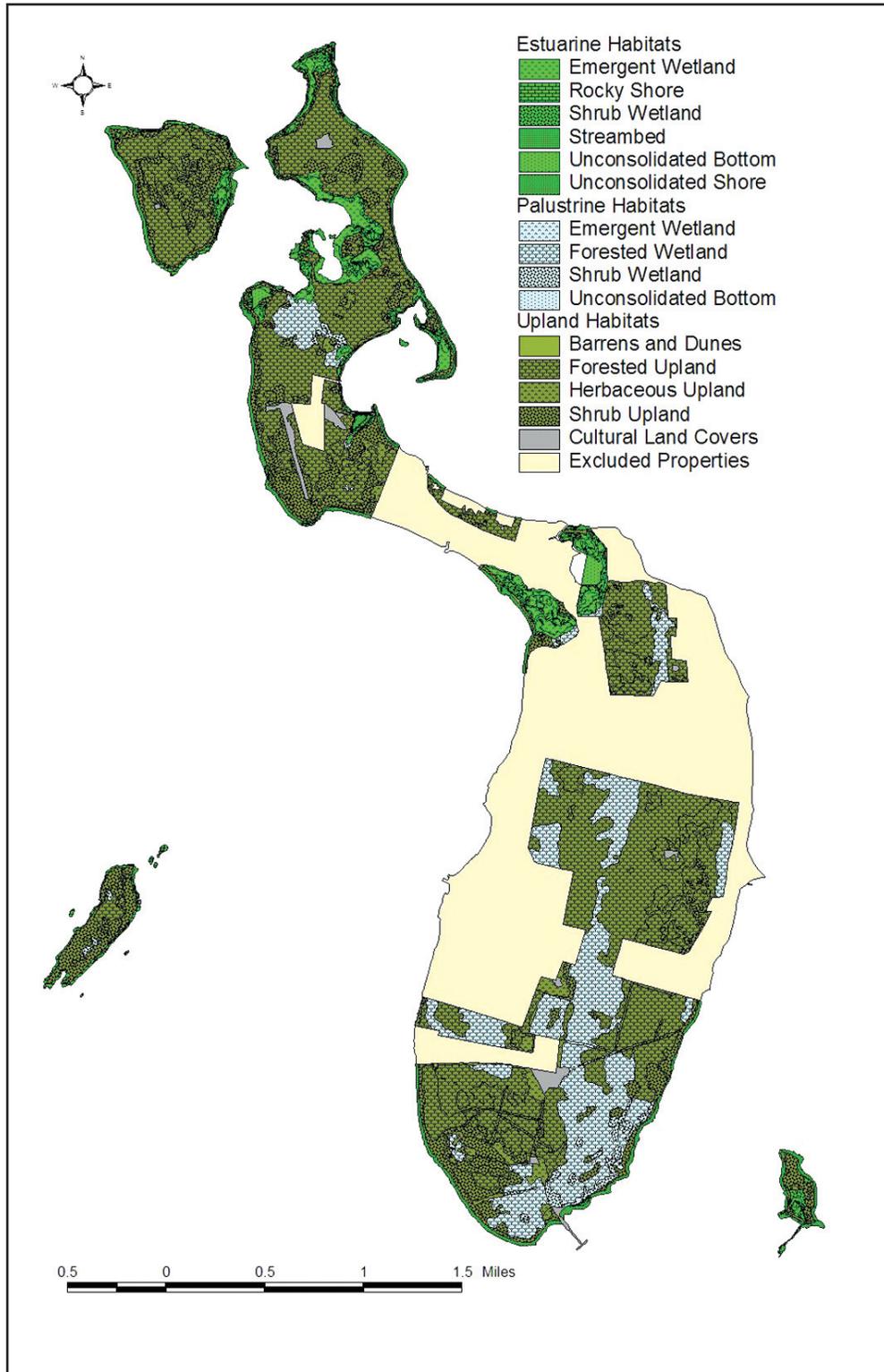


Figure 5.3. Habitats of the NBNERR ordered by system and class. Source: Kutcher et al., 2004.



**Figure 5.4.** Graphic of Prudence Island from Vigness Raposa (2004) comparing the results of supervised automated classification of 30 m imagery (left) versus the aerial-photointerpreted and field-checked Kutcher et al. (2004) habitat inventory.



**Figure 5.5.** A roadside incursion of the invasive common reed dominating the brackish zone in a Reserve salt marsh. Photo from NBNERR photo library.



the Reserve, also via aerial photointerpretation and ground-truthing (Fig. 5.3). Vigness Raposa (2004) mapped the habitats of Prudence Island via supervised algorithmic classification of remote sensing imagery, using ERDAS software (1999, Landsat-7 Enhanced Thematic Mapper Plus) 30-meter (m) resolution imagery, and the NBNERR classification scheme. An overall accuracy of 78 percent was achieved at the class level of the classification when compared to the ground-truthed Kutcher et al., (2004) inventory (Fig. 5.4).

Habitat and species data referred to in this section are derived from the NBNERR habitat inventory conducted in 2003 (Kutcher et al., 2004) unless otherwise noted. (These data may differ somewhat from those presented in Chapter 4, but this is simply due to the use of different GIS data sources; i.e., RIGIS and Kutcher et al., 2004.)

### *Palustrine Plant Communities*

Terrestrial palustrine plant communities occupy 12 percent (191.4 ha) of all terrestrial habitats of the Reserve. Of these, 92 percent (176.6 ha) is forested, 7.2 percent (13.8 ha) is shrubby, and only 0.5 percent (1.0 ha) is emergent. The freshwater wetlands of the NBNERR occupy hydric Scarborough mucky sand loam and Stissing silt loam soils associated with six minor and two major stream systems of Prudence Island, as well as four small perched depressions on Hope Island and two groundwater seeps abutting the south edge of Nag Marsh (RIGIS, 2003).

### Emergent Wetlands

Emergent palustrine wetlands often occur as an early transitional stage in wetland physiognomic development after some type of disturbance (F.C. Golet, personal communication). A lack of emergent wetland habitat in the Reserve may be indicative of a disruption of natural disturbance regimes such as fire and beaver damming. The Reserve contains 0.4 ha of wet meadow habitat, which is maintained by yearly mowing, 0.4 ha of common reed marsh, and 0.1 ha each of cattail (*Typha latifolia*) marsh and fern (*Thelypteris* sp.) wet meadow.

Wet meadows are extremely rich plant communities and, due to the transient nature of their existence and dependence on disturbance, often support uncommon species. Gould et al. (2003a) identified 87 species in a 0.4 ha roadside wet meadow

that the Reserve is restoring in the South Prudence Unit—three of which are Rhode Island State Concern species—while Enser et al. (2001) identified 52 species at this site.

At least 85 percent of NBNERR terrestrial palustrine emergent habitats are affected by colonization of nonnative common reed. Another 2.5 ha of common reed growing in the Reserve's estuarine brackish marshes may act as a seed bank, positioning its colonization in certain disturbance-dependent palustrine emergent wetlands (Fig. 5.5).

### Shrub Wetlands

In New England, shrub wetlands generally represent a median stage in progressive wetland change (F.C. Golet, personal communication). NBNERR shrub wetlands exist as three general types: mixed broad-leaved deciduous (BLD) shrub swamps (10.5 ha), thicket swamps (3.0 ha), and sapling swamps (0.4 ha). Due to a lack of natural retrogressive mechanisms, such as flooding or fire, shrub wetlands of the Reserve tend to be edge communities, acting as transition zones between anthropogenically modified and forested wetland habitats, or transitory communities of regrowth in areas that were formerly mechanically cleared.

Mixed BLD shrub swamps of the NBNERR are typically dominated by highbush blueberry (*Vaccinium corymbosum*), arrowwood (*Viburnum dentatum*), tree saplings, and alder (*Alnus* sp.). Thicket swamps are dominated by Bebb's willow (*Salix bebbiana*) and speckled alder (*Alnus rugosa*). They are located along roadside ditches of the Reserve's South Prudence Unit, where old Navy roads impound natural drainage of wetlands above, and in perched depressions on Hope Island. A single BLD sapling swamp occurs as part of a mosaic of fragmented and disturbed habitats within a red maple swamp in the South Prudence Unit. The sapling swamp is dominated by a mix of red maple (*Acer rubrum*) and gray birch (*Betula populifolia*) saplings.

Shrub wetlands of the NBNERR are moderately affected by invasive species. At least 17 percent (2.3 ha) is infested with greater than 25 percent cover of oriental bittersweet. Wetter habitats, such as thicket swamps, generally show less evidence of bittersweet invasion than drier shrub swamps. Autumn olive (*Elaeagnus umbellata*), an aggressive nonnative shrub, also affects a 0.74 ha area of BLD shrub swamp in the South Prudence Unit.



## Forested Wetlands

Covering the majority of hydric soils in the Reserve, forested wetlands are generally considered to be the climax and most stable palustrine communities in this region. Virtually all NBNERR forested wetlands are dominated by red maple. Most red maple swamps are associated with the Prudence Island's major stream basins, while a single 1.5 ha red maple swamp occurs south of the Little Unit's Nag Marsh as a groundwater seep.

Red maple swamp overstory species include red maple and tupelo (*Nyssa sylvatica*). Dominant understory species are northern arrowwood, highbush blueberry, and sweet pepperbush (*Clethra alnifolia*), with willow (*Salix* sp.), swamp rose (*Rosa palustris*), bayberry (*Myrica pensylvanica*), poison ivy (*Toxicodendron radicans*), and greenbrier (*Smilax* sp.) also commonly present (Shaughnessy and Golet, 1982).

No formal studies have examined the presence or effects of invasive species in forested wetland habitats of the NBNERR, but impacts to community function from exotic species appear to be minor (personal observation); therefore, it is a low research priority.

## Upland Plant Communities

Natural upland plant communities occupy 45 percent (708.1 ha) of all terrestrial properties of the Reserve. Of these, 72 percent (509.2 ha) is forested, 24 percent (166.6 ha) is shrubby, 4.5 percent (31.8 ha) is herbaceous, and less than 0.1 percent (0.4 ha) is barren.

## Coastal Dune Plant Communities

Coastal dune habitats within NBNERR boundaries generally occur along sandy shorelines as components of barrier beaches that separate meadow salt marshes from the open waters of Narragansett Bay. The Reserve contains 10.6 ha of coastal dune habitat types, including coastal dune sparse grassland, coastal dune grassland, coastal dune forbs, and coastal dune shrubland.

Coastal dune grasslands are dominated by American beachgrass (*Amophila breviligulata*) or quack grass (*Elytrigia repens*), a nonnative form of wheat primarily used for hay production (Brown, 1979). The only known natural population of eastern prickly pear cactus in the state occurs in the NBNERR coastal dunes (Gould, personal communication), where it grows among sparse dune grasses



**Figure 5.6.** A locally rare prickly pear cactus blooming in a coastal dune habitat among beach pea (*Lathyrus japonicus*) and quack-grass (*Elytrigia repens*). Photo from NBNERR photo library.

and forb (Fig. 5.6). Coastal dune forb habitats are generally dominated by sparscale (*Atriplex* sp.), beach pea (*Lathyrus japonica*), and water hemp (*Amaranthus cannabinus*), and are usually very dynamic, disturbance-driven communities. Coastal dune shrubland habitats of the Reserve are typically dominated by beach rose, high tide bush (*Iva frutescens*), bayberry, or poison ivy.

Due to their dynamic settings, coastal dune plant communities are susceptible to invasion by aggressive nonnative colonizers. At least 35 percent (3.7 ha) is affected by an invasive plant species. The most common invasive in NBNERR coastal dune habitats is oriental bittersweet. Approximately 1.1 ha of coastal dune habitat is infested by greater than 50 percent cover of bittersweet. Another 0.9 ha is dominated by beach rose, 0.4 ha is severely impacted by the invasion of the nonnative vine black swallow-wort, and 0.7 ha contains the highly toxic, introduced nightshade, jimson weed (*Datura stramonium*). The sea poppy (*Glaucium flavium*) has also been observed recently on the coastal dunes of the Little Unit (personal observation).

## Upland Grass and Forb Plant Communities

The NBNERR contains 28.2 ha of herbaceous upland communities. The majority of these (excluding those occurring on coastal dunes) represent a transient stage of successional development. These habitats exhibit various levels of landscape stability, depending mostly on the characteristics of the strata, with grassland communities on the excessively drained, sandy Poquonock soils generally being the most resistant to progressive change. The collective mosaic of these dryer communities with interspersed, small areas of inland sand barren and pitch pine sapling open shrubland habitats



contributes floral and structural diversity to locally rare and valuable pine barren ecosystems both in the South Prudence Unit and in the southern end of the Barre Unit. Herbaceous communities occurring on richer soils are far less stable and must be regularly maintained to prevent the domination of woody vegetation.

Reserve grasslands are primarily dominated by switchgrass (*Panicum virgatum*, 16.4 ha), mixed cool-season grasses (6.1 ha), or little blue-stem (*Schizachyrium scoparium*, 3.1 ha), while forb meadows are dominated by common milkweed (*Asclepias syriaca*, 1.6 ha) or goldenrod (*Solidago* sp., 0.2 ha). According to species surveys conducted by Gould et al. (2002c) and Enser et al. (2001), the NBNERR grasslands are extremely diverse plant communities. Gould's survey revealed 50 species from a small meadow restoration site in the South Prudence Unit, which is dominated by switchgrass and little blue-stem. Among those species reported are the locally rare wildflowers, yellow thistle (*Cirsium horridulum*) and sickle-leaved golden aster (*Chrysopsis falcata*), and a rare bead-grass (*Paspalum setaceum*).

NBNERR herbaceous communities are widely impacted by nonnative species. In grassland communities dominated by native grasses, many of the secondary species, such as fescues (*Festuca* sp.), English plantain (*Plantago lanceolata*), and black knapweed (*Centaurea nigra*) are nonnative. Some mixed grassland habitats are dominated by introduced hay and lawn species. Of the 1.8 ha of forb meadow, 1.4 ha are heavily infested with oriental bittersweet.

### Upland Shrubland Plant Communities

The upland shrubland communities of the NBNERR generally exist as one of three general types: (1) relatively structurally stable coastal shrubland communities that are consistently maintained by salt spray and high winds; (2) dense, stable greenbrier (*Smilax rotundifolia*) monocultures; and (3) transient habitats occurring as a successional stage between herbaceous and forested uplands. Coastal shrubland types (129.3 ha) cover most of the undeveloped upland perimeters of Prudence and Patience Island properties, and 84 percent of the total vegetated upland area of the more exposed Hope and Dyer islands, equaling 8.2 percent of the total terrestrial properties of the Reserve and 18 percent of the total uplands. Non-coastal shrublands make up less than 4 percent (26.9 ha) of total Reserve uplands. Large, inland monocultures of greenbrier comprise 62 percent (16.6 ha) of non-coastal shrublands.

Coastal shrubland community types identified in the Reserve are coastal shrubland, coastal greenbrier shrubland, coastal sumac thicket, and coastal dune shrubland. Coastal shrubland habitat types are typically dominated by smooth and shining sumacs (*Rhus glabra* and *R. copallinum*), bayberry, greenbrier, or beach rose. They also commonly include stunted black cherry (*Prunus serotina*), stunted eastern red cedar (*Juniperus virginiana*), fox grape (*Vitis labrusca*), and poison ivy. Non-coastal shrublands are typically dominated by highbush blueberry or bayberry, or are dominated by red maple, pitch pine, or gray birch saplings.

Likely due to the stressful nature of the coastal environment, coastal shrublands of the NBNERR are particularly prone to invasion of the nonnative bittersweet. At least 37 percent (48.0 ha) of all coastal shrublands at the Reserve are affected by its presence and at least 12 percent (15.2 ha) is infested with greater than 50 percent coverage of the vine. Other common invasive species affecting coastal shrublands include multiflora rose, black swallow-wort, and autumn olive. A dense stand of the invasive Japanese knotweed (*Polygonum cuspidatum*) exists among the coastal shrublands on the northeast coast of Patience Island.

### Upland Forested Plant Communities

Forested upland plant communities represent the ultimate successional stage in most NBNERR upland settings. The majority (75 percent) of upland habitats on the Prudence and Patience Island units are forested, while the less sheltered uplands of the smaller Dyer and Hope islands are dominated by coastal shrublands. Overall, 72 percent (509.2 ha.) of Reserve upland communities are forested. Of these, 45 percent (227.5 ha) is BLD, 2.0 percent (10.1 ha) is needle-leaved deciduous, 4.1 percent (21.1 ha) is needle-leaved evergreen, and 49 percent (250.6 ha) is mixed.

BLD forested upland habitats of the Reserve generally grow on more protected uplands with fairly rich soils. They are primarily dominated by red maple, white oak (*Quercus alba*), black oak (*Q. veutina*), or black locust. Big-toothed aspen (*Populus grandidentata*), sassafras (*Sassafras albidum*), gray birch (*Betula poulifolia*), tupelo, and naturalized sycamore maple are also common BLD canopy species of the Reserve. Common understory species include greenbrier, blueberry, bayberry, and arrowwood.

A 10.1-ha stand of the nonnative tree, European larch (*Larix decidua*), was planted by the U.S. Navy along the western edge of the South Prudence Unit as a wind break, and has since naturalized and



spread into adjacent grasslands. This is the only needle-leaved deciduous forested habitat type on the Reserve. The understory is dominated by greenbrier (Fig. 5.7).

Needle-leaved evergreen forested uplands of the Reserve are composed of 16.0 ha of coastal eastern red cedar forest, 4.9 ha of pitch pine forests and open woodlands, and 0.2 ha of white pine (*Pinus strobus*). Eastern red cedar forests occur as dense thickets or open woodlands, mostly on the coastal, excessively drained soils of Patience Island. One pure stand of pitch pine covers Pine Knoll in the North Prudence Unit, and open pitch pine woodlands occur at the northern reach of a pine barren ecosystem located in and to the south of the Barre Unit. A single stand of large white pine trees, which was likely cultivated, grows along a trail in the center of the Patience Island Unit.

NBNERR mixed-forest habitats include two general types: oak-pine associations and cherry-cedar associations. Oak-pine associations generally exist along a continuum of seral stages that typically progresses from pitch pine domination to oak (*Quercus* sp.) domination in the absence of a regular, frequent fire regime (Enser and Lundgren, 2003). Typical understory species include high-bush blueberry and greenbrier. A total of 64.5 ha of oak-pine forests dominate the excessively drained Poquonock soils of the Reserve, and are keystone components of locally unique pine barren ecosystems.

A total of 186.0 ha of cherry-cedar forest habitats cover 66 percent of the North Prudence Unit and 46 percent of the Patience Island Unit. They dominate in areas that have relatively rich soils and are somewhat exposed to coastal influence. Cherry-cedar communities are typically open canopy woodlands (30 to 60 percent canopy cover) with dense shrubby understories and are dominated by wild black cherry (*Prunus serotina*) and eastern red cedar (*Juniperus virginiana*), both of which, in stunted form, are major components of coastal

shrubland habitats. Cherry-cedar forests may be co-dominated by red maple or black locust. Shaughnessy and Golet (1983) found the dominant understory species to be arrowwood and bayberry, although recent surveys find the understory largely overgrown with oriental bittersweet (Kutcher et al., 2004).

Oriental bittersweet occurs in at least 33 percent of all upland forests, and infests (with greater than 25 percent total coverage) at least 12 percent. In forests influ-

enced by direct coastal effects, invasion by bitter-sweet is even higher. At least 79 percent of cherry-cedar and eastern red cedar forests are affected by bittersweet and at least 30 percent is infested. The reasons for this extensive invasion are unclear, but Raposa and Greene (2003) suggest that it may be related to selective browsing of over-abundant white-tailed deer on competitive native flora over the unpalatable bittersweet. The invasive common barberry (*Berberis vulgaris*) has also been reported to occur in the understories of Reserve upland forests (George and Nichols, 1993). Another exotic species greatly affecting NBNERR forest ecology is naturalized European larch, which is displacing pitch pine on the Poquonock soils of the South Prudence Unit. Other canopy species, such as naturalized maples and black locust, also displace native forest species in the Reserve's coastal forest habitats.

### Pine Barren Mosaics

Pine barrens are regionally and globally rare ecosystems comprising a mosaic of community types, many of which have been previously described in this chapter.

The NBNERR contains 91 ha of Atlantic coastal pine barrens, which are unique to north and mid-Atlantic coastal uplands. NBNERR pine barrens occur primarily on sandy, well-drained Poquonock soils, most of which are nutrient deprived due to historic farming practices. Pine barrens are structurally diverse habitat mosaics that are generally maintained in early to mid-successional stages by regular fire disturbance. The pine barrens of the Reserve are composed of oak and pitch pine dominated forests and adjacent shrublands, grasslands, and sand barrens (Table 5.2, Fig. 5.8). Without regular fire disturbance, Atlantic coastal barrens normally progress into closed-canopy hardwood forests (Howard et al., 2005). Nearly half of the pine barren area within the reserve has progressed to closed canopy oak-pine forest.

Structurally diverse, NBNERR pine barrens offer a unique set of environmental characteristics that support a wide range of specialized, unique, and rare plant and animal species (Kutcher and Raposa,



**Figure 5.8.** A structurally diverse Atlantic coastal pine barren mosaic located in the NBNERR South Prudence Unit. Photo from NBNERR photo library.

**Figure 5.7.** A stand of European larch located in the Reserve's South Prudence Unit. This introduced species poses a threat to native habitats due to its ability to colonize xeric soils. Photo from





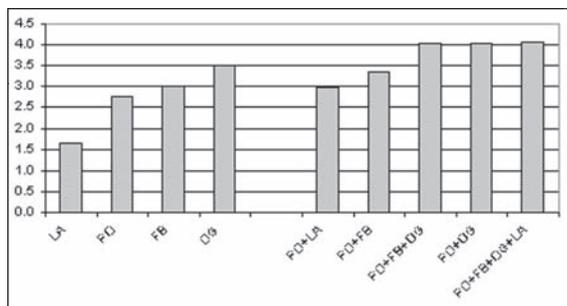
Habitat Type	Count	Area (ha)
Oak-pine forest	10	44.57
Pitch pine-oak forest	12	19.96
Switchgrass grassland	9	7.30
Pitch pine saplings	6	5.89
Pitch pine woodland	3	4.49
Little bluestem grassland	1	2.65
Pitch pine sapling open shrubland	1	2.53
Mixed BLD saplings	1	1.92
Blueberry shrubland	1	0.63
Bayberry shrubland	1	0.54
Pitch pine forest	1	0.38
Mixed grassland	1	0.29
Inland sand barren	3	0.13
<b>Total</b>		<b>91.28</b>

**Table 5.2.** Habitats within the pine barren mosaics of the NBNERR derived from Kutcher et al. (2004).

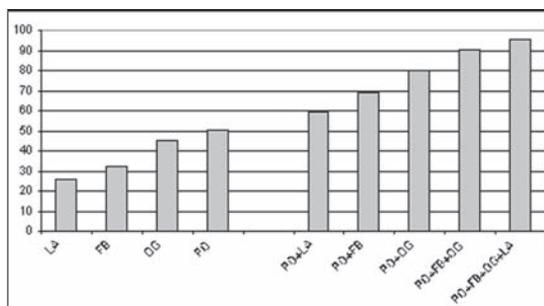
2005). Pine barrens are also a significant contributor to regional and global biodiversity (Howard et al., 2005), but due to fire suppression and development, they are regionally and nationally declining (Grand et al., 2003). The barrens are thus a priority for ecological maintenance and restoration at the NBNERR.

Using quantitative field methods, NBNERR staff assessed the species and structural compositions of vegetation within and across habitats in a 71 ha Atlantic coastal pine barren mosaic located in the South Reserve Unit to serve as an ecological baseline and to identify management priorities (Kutcher and Raposa, 2005). Pine-oak forest habitats managed by prescribed burning until 1998 were found to be dissimilar to unburned areas in crown cover by species and in understory by life form. Pine-oak forest habitat in total was dissimilar to an adjacent

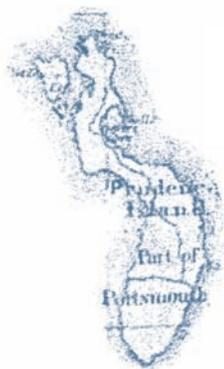
European larch forest habitat in understory by species and life-form. Of four habitat types sampled, pine-oak forest was the richest, while grassland habitat was the most diverse and contributed most to the beta diversity (species diversity across multiple habitats) of the mosaic when added to pine-oak forest. The larch forest was least rich, least diverse, and added the least to beta diversity of the mosaic compared to pine barren communities (Figs. 5.9 and 5.10). Overall, the study suggested that the former burn strategy was effective in stimulating understory function, but ineffective in preventing oak domination; and that refined management strategies should be considered. It also suggested that restoration action may be appropriate in the larch-dominated areas.



**Figure 5.9.** Shannon-Wiener indices of species diversity of habitats and habitat combinations of the Atlantic coastal pine barrens of the NBNERR South Prudence Unit. LA = European larch forest, PO = pine-oak forest, FB = linear shrubby firebreak, OG = open grassland. Source: Kutcher and Raposa, 2005.



**Figure 5.10.** Jackknife estimate of richness of habitats and habitat combinations of the Atlantic coastal pine barrens of the NBNERR South Prudence Unit. LA = European larch forest, PO = pine-oak forest, FB = linear shrubby firebreak, OG = open grassland. Source: Kutcher and Raposa, 2005.



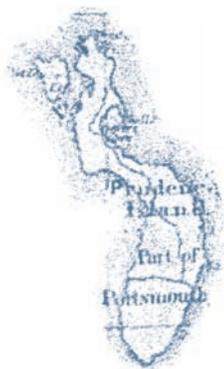
## Appendix 5.1 Vascular Plants of the Reserve

Compiled from Kutcher and Raposa, 2005; Kutcher et al., 2004; Gould et al., 2002a, b, and c; Enser et al., 2001; George, 1997a and b; Krebs, 1997; Prudence Conservancy, 1994; George, 1993; and Shaughnessy and Golet, 1983.

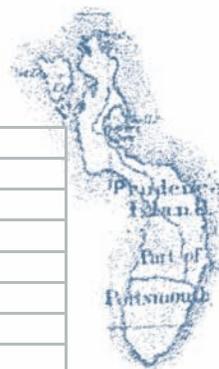
Scientific Name	Common Name	Statewide Abundance
<b>Native Species</b>		
<i>Acer rubrum</i>	red maple	Ubiquitous
<i>Achillea millefolium</i>	common yarrow	Ubiquitous
<i>Agalinis pururea</i>	purple gerardia	Common
<i>Agrostis hyemalis</i>	hairgrass	Ubiquitous
<i>Agrostis perennans</i>	upland bent	Common
<i>Almenchier canadensis</i>	downy shadbush	Common
<i>Alnus rugosa</i>	speckled alder	Common
<i>Amaranthus cannabinus</i>	water hemp	Common
<i>Ambrosia artemisiifolia</i>	common ragweed	Common
<i>Aristida dichotoma</i>	churchmouse three-awn	Common
<i>Aronia arbutifolia</i>	red chokeberry	Common
<i>Aronia melanocarpa</i>	black chokeberry	Common
<i>Asclepias incarnata</i>	swamp milkweed	Common
<i>Asclepias syriaca</i>	common milkweed	Ubiquitous
<i>Aster ericoides</i>	white wreath aster	Common
<i>Aster novi-belgii</i>	New York aster	Ubiquitous
<i>Aster paternus</i>	toothed white-topped aster	Common
<i>Aster racemosus</i>	small white aster	Ubiquitous
<i>Athyrium felix-femina</i>	lady fern	Ubiquitous
<i>Atriplex hastata</i>	orach	Common
<i>Baccharis halimifolia</i>	groundsel-tree	Common
<i>Bartonia virginica</i>	bartonia	Common
<i>Betula alleghaniensis</i>	yellow birch	Common
<i>Betula papyrifera</i>	paper birch	Common
<i>Betula populifolia</i>	gray birch	Ubiquitous
<i>Botrychium oneidense</i>	leathery grape-fern	Rare
<i>Cakile edentula</i>	sea-rocket	Common
<i>Calamagrostis canadensis</i>	blue-joint	Ubiquitous
<i>Calamagrostis cinnoides</i>	reed bentgrass	Common
<i>Carex argyrantha</i>	silvery sedge	Common
<i>Carex bicknellii</i>	Bicknell's sedge	Common
<i>Carex crinita</i>	drooping sedge	Common
<i>Carex debilis</i>	Rudge's sedge	Common
<i>Carex intumescens</i>	bladder sedge	Common
<i>Carex lurida</i>	reddish-yellow sedge	Ubiquitous
<i>Carex scoparia</i>	broom-sedge	Ubiquitous
<i>Carex stipata</i>	awl sedge	Ubiquitous
<i>Carex stricta</i>	tussuck sedge	Common
<i>Carex swanii</i>	Swan's sedge	Common
<i>Carex virescens</i>	ribbed sedge	Common
<i>Carya tomentosa</i>	mockernut hickory	Common
<i>Catalpa speciosa</i>	northern catalpa	Status Undetermined
<i>Celtis occidentalis</i>	northern hackberry	Common
<i>Cephalanthus occidentalis</i>	buttonbush	Common
<i>Chenopodium rubrum</i>	coast blight	Common
<i>Chenopodium standleyanum</i>	woodland goosefoot	Rare
<i>Chimaphila maculata</i>	spotted wintergreen	Common
<i>Chrysopsis falcata</i>	sickle-leaved golden aster	Rare
<i>Cinna arundinacea</i>	wood reedgrass	Common
<i>Cirsium horridulum</i>	yellow thistle	Rare



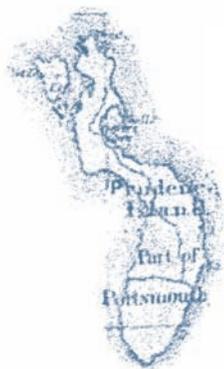
<i>Clethra alnifolia</i>	sweet pepperbush	Common
<i>Comptonia peregrina</i>	sweet fern	Common
<i>Conyza canadensis</i>	horse-tail	Ubiquitous
<i>Cornus amomum</i>	silky dogwood	Common
<i>Crataegus</i> sp.	hawthorne	Common
<i>Cyperus lupulinus</i>	umbrella-sedge	Common
<i>Cyperus strigosus</i>	false nutsedge	Common
<i>Danthonia spicata</i>	poverty-grass	Ubiquitous
<i>Dennstaedtia punctilobula</i>	hay-scented fern	Common
<i>Distichlis spicata</i>	spike-grass	Common
<i>Drosera rotundifolia</i>	round-leaved sundew	Common
<i>Dryopteris carthusiana</i>	spinulose wood fern	Common
<i>Dulichium arundinaceum</i>	three-way sedge	Common
<i>Echinochloa walteri</i>	water millet	Common
<i>Eleocharis ovata</i>	blunt spike-rush	Common
<i>Eleocharis tenuis</i>	(slender) spike-rush	Common
<i>Elymus virginicus</i>	Virginia wild rye	Common
<i>Eragrostis spectabilis</i>	purple lovegrass	Ubiquitous
<i>Erigeron strigosus</i>	daisy-fleabane	Ubiquitous
<i>Eupatorium fistulosum</i>	purple joe-pye-weed	Common
<i>Euthamia graminifolia</i>	grass-leaved goldenrod	Common
<i>Euthamia tenuifolia</i>	fine grass-leaved goldenrod	Common
<i>Fagus grandifolia</i>	American beech	Common
<i>Fragaria virginica</i>	wild strawberry	Ubiquitous
<i>Fraxinus americana</i>	white ash	Common
<i>Galium palustre</i>	marsh-bedstraw	Common
<i>Gaylussacia baccata</i>	black huckleberry	Common
<i>Glyceria canadensis</i>	Canada manna-grass	Common
<i>Gnaphalium obtusifolium</i>	sweet everlasting	Common
<i>Hamamelis virginiana</i>	witch hazel	Common
<i>Hibiscus moscheutos</i>	rose mallow	Common
<i>Hieracium gronovii</i>	hairy hawkweed	Common
<i>Hudsonia tomentosa</i>	woolly hudsonia	Common
<i>Hypericum canadense</i>	narrow-leaved St. John's-wort	Common
<i>Hypericum gentianoides</i>	pinweed	Common
<i>Hypericum mutilum</i>	dwarf St. John's-wort	Common
<i>Hypericum punctatum</i>	spotted St. John's-wort	Common
<i>Ilex laevigata</i>	smooth winterberry	Common
<i>Ilex opaca</i>	American holly	Common
<i>Ilex verticillata</i>	winterberry	Common
<i>Impatiens capensis</i>	jewel-weed	Ubiquitous
<i>Iris versicolor</i>	northern blue flag	Ubiquitous
<i>Iva frutescens</i>	hightide bush	Common
<i>Juglans nigra</i>	black walnut	Status Undetermined
<i>Juncus brevicaudatus</i>	short-tailed rush	Common
<i>Juncus canadensis</i>	Canada rush	Common
<i>Juncus effusus</i>	soft rush	Common
<i>Juncus gerardii</i>	black grass	Common
<i>Juncus greenei</i>	field rush	Common
<i>Juncus tenuis</i>	path-rush	Ubiquitous
<i>Juniperus virginiana</i>	eastern red cedar	Ubiquitous
<i>Kalmia angustifolia</i>	sheep laurel	Ubiquitous
<i>Kalmia latifolia</i>	mountain laurel	Common
<i>Lathyrus maritimus</i>	beach pea	Common
<i>Lechea maritima</i>	seaside pinweed	Common
<i>Lechea mucronata</i>	hairy pinweed	Common
<i>Lechea tenuifolia</i>	narrow-leaved pinweed	Common
<i>Leersia oryzoides</i>	rice cutgrass	Common



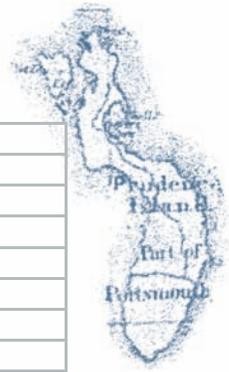
<i>Lemna minor</i>	small duckweed	Common
<i>Lepidium virginicum</i>	peppergrass	Common
<i>Lespedeza capitata</i>	bush clover	Ubiquitous
<i>Limonium carolinianum</i>	sea lavender	Common
<i>Linaria canadensis</i>	old-field toadflax	Common
<i>Lindera benzoin</i>	spicebush	Common
<i>Lobelia cardinalis</i>	cardinal-flower	Common
<i>Lonicera dioica</i>	wild honeysuckle	Rare
<i>Ludwigia palustris</i>	common water-purslane	Common
<i>Lycopodiella appressa</i>	southern bog-clubmoss	Common
<i>Lycopodium hickeyi</i>	Hickey's tree clubmoss	Common
<i>Lycopodium lucidulum</i>	shining clubmoss	Common
<i>Lycopus americanus</i>	American water horehound	Common
<i>Lycopus virginicus</i>	Virginia water horehound	Common
<i>Lyonia ligustrina</i>	maleberry	Common
<i>Lysimachia quadrifolia</i>	whorled loosestrife	Common
<i>Lysimachia terrestris</i>	yellow loosestrife	Common
<i>Myrica pensylvanica</i>	northern bayberry	Ubiquitous
<i>Nymphaea odorata</i>	fragrant water lily	Common
<i>Nyssa sylvatica</i>	tupelo	Common
<i>Oenothera biennis</i>	evening primrose	Common
<i>Onoclea sensibilis</i>	sensitive fern	Ubiquitous
<i>Opuntia humifusa</i>	eastern prickly-pear cactus	Rare
<i>Osmunda cinnamomea</i>	cinnamon fern	Common
<i>Osmunda regalis</i>	royal fern	Common
<i>Oxalis stricta</i>	wood sorrel	Common
<i>Panicum clandestinum</i>	deer-tongue	Ubiquitous
<i>Panicum dichotomiflorum</i>	fall panic-grass	Ubiquitous
<i>Panicum lanuginosum</i>	woolly panic-grass	Ubiquitous
<i>Panicum rigidulum</i>	rigid panic-grass	Rare
<i>Panicum virgatum</i>	switch-grass	Ubiquitous
<i>Parthenocissus quinquefolia</i>	Virginia creeper	Ubiquitous
<i>Paspalum setaceum</i>	bead-grass	Rare
<i>Picea cv.</i>	spruce cultivar	Status Undetermined
<i>Pinus resinosa</i>	red pine	Common
<i>Pinus rigida</i>	pitch pine	Common
<i>Pinus strobus</i>	white pine	Common
<i>Plantago aristata</i>	bracted plantain	Common
<i>Platanthera clavellata</i>	green woodland-orchid	Common
<i>Platanus occidentalis</i>	sycamore	Common
<i>Pluchea odorata</i>	marsh fleabane	Common
<i>Polygala sanguinea</i>	common milkwort	Common
<i>Polygonella articulata</i>	jointweed	Common
<i>Polygonum sagittatum</i>	arrow-vine	Common
<i>Populus grandidentata</i>	big-toothed aspen	Common
<i>Potamogeton sp.</i>	pondweed	Status Undetermined
<i>Potentilla anserina</i>	silverweed	Common
<i>Potentilla canadensis</i>	dwarf cinquefoil	Ubiquitous
<i>Potentilla simplex</i>	common cinquefoil	Ubiquitous
<i>Prunus maritima</i>	beach plum	Common
<i>Prunus serotina</i>	black cherry	Common
<i>Quercus alba</i>	white oak	Common
<i>Quercus coccinia</i>	scarlet oak	Ubiquitous
<i>Quercus ilicifolia</i>	black scrub-oak	Common
<i>Quercus palustris</i>	pin-oak	Common
<i>Quercus rubra</i>	red oak	Common
<i>Quercus velutina</i>	black oak	Common



<i>Rhexia virginica</i>	meadow-beauty	Common
<i>Rhododendron viscosum</i>	swamp azalea	Common
<i>Rhus copallinum</i>	shining sumac	Common
<i>Rhus glabra</i>	smooth sumac	Common
<i>Rhus typhina</i>	staghorn sumac	Common
<i>Rhynchospora capitellata</i>	(small-headed) beak-rush	Common
<i>Robinia pseudoacacia</i>	black locust	Common
<i>Rosa carolina</i>	pasture-rose	Common
<i>Rosa palustris</i>	swamp rose	Common
<i>Rosa virginiana</i>	wild rose	Common
<i>Rubus alleghaniensis</i>	blackberry	Common
<i>Rubus flagellaris</i>	prickley dewberry	Ubiquitous
<i>Rubus hispidus</i>	swamp-dewberry	Ubiquitous
<i>Rubus recurvicaulis</i>	sand dewberry	Rare
<i>Rudbeckia hirta</i>	black-eyed susan	Ubiquitous
<i>Salicornia bigelovii</i>	dwarf glasswort	Common
<i>Salicornia europea</i>	slender glasswort	Common
<i>Salicornia virginica</i>	woody glasswort	Common
<i>Salix bebbiana</i>	Bebb's willow	Common
<i>Salix discolor</i>	pussy willow	Ubiquitous
<i>Salsola kali</i>	common salt-wort	Ubiquitous
<i>Sambucus canadensis</i>	elderberry	Common
<i>Sassafras albidum</i>	sassafras	Common
<i>Schizachyrium scoparium</i>	little bluestem	Ubiquitous
<i>Scirpus americanus</i>	Olney three-square	Common
<i>Scirpus cyperinus</i>	wool-grass	Common
<i>Scutellaria lateriflora</i>	scullcap	Common
<i>Setaria italica</i>	millet	Common
<i>Sisyrhynchium</i> sp.	blue-eyed grass	Status Undetermined
<i>Smilax glauca</i>	catbrier	Common
<i>Smilax rotundifolia</i>	bullbrier	Ubiquitous
<i>Solidago nemoralis</i>	gray goldenrod	Common
<i>Solidago odora</i>	sweet goldenrod	Common
<i>Solidago puberula</i>	downy goldenrod	Common
<i>Solidago rugosa</i>	rough-stemmed goldenrod	Ubiquitous
<i>Solidago semper-virens</i>	seaside goldenrod	Common
<i>Sparganium androcladium</i>	branching burr-reed	Common
<i>Spartina alterniflora</i>	smooth cordgrass	Common
<i>Spartina patens</i>	salt-hay	Common
<i>Spartina pectinata</i>	prairie cordgrass	Common
<i>Spiraea alba</i>	meadowsweet	Ubiquitous
<i>Spiraea tomentosa</i>	steeple-bush	Ubiquitous
<i>Spiranthes cernua</i>	nodding ladies'-tresses	Common
<i>Spiranthes vernalis</i>	spring ladies'-tresses	Rare
<i>Strophostyles helvula</i>	trailing wild bean	Common
<i>Sueda linearis</i>	southern sea-blite	Common
<i>Symplocarpus foetidus</i>	skunk cabbage	Common
<i>Teucreum canadense</i>	American germander	Common
<i>Thelypteris palustris</i>	marsh fern	Ubiquitous
<i>Thelypteris simulata</i>	Massachusetts fern	Common
<i>Toxicodendron radicans</i>	poison ivy	Ubiquitous
<i>Toxicodendron rydbergii</i>	Rydberg's poison ivy	Common
<i>Triadenum virginicum</i>	marsh St. John's-wort	Common
<i>Trientalis borealis</i>	star-flower	Common
<i>Tripasacum dactyloides</i>	gama grass	Rare
<i>Typha angustifolia</i>	narrow-leaved cattail	Common
<i>Typha latifolia</i>	broad-leaved cattail	Common



<i>Ulmus americana</i>	American elm	Common
<i>Ulmus rubra</i>	slippery elm	Rare
<i>Vaccinium corymbosum</i>	highbush blueberry	Ubiquitous
<i>Viburnum dentatum</i>	northern arrowwood	Ubiquitous
<i>Viola cucullata</i>	marsh blue violet	Common
<i>Viola lanceolata</i>	lance-leaved violet	Common
<i>Viola macloskeyi</i>	northern white violet	Common
<i>Viola sagittata</i>	arrowhead violet	Common
<i>Vitis labrusca</i>	fox grape	Ubiquitous
<i>Xyris torta</i>	twisted yellow-eyed grass	Common
<b>Introduced Species</b>		
<i>Agrostis capillaris</i>	Rhode Island bent grass	Ubiquitous
<i>Agrostis gigantea</i>	redtop	Common
<i>Agrostis stolonifera</i>	creeping bent grass	Ubiquitous
<i>Anthoxanthum odoratum</i>	sweet vernal grass	Common
<i>Asparagus officinalis</i>	asparagus	Common
<i>Centauria dubia</i>	blackish knapweed	Common
<i>Cerastium vulgatum</i>	common mouse-ear chickweed	Ubiquitous
<i>Chenopodium album</i>	lamb's quarters	Common
<i>Chrysanthemum leucanthemum</i>	oxeye daisy	Ubiquitous
<i>Cichorium intybus</i>	chickory	Ubiquitous
<i>Cirsium vulgare</i>	bull thistle	Common
<i>Dactylis glomerata</i>	orchard grass	Ubiquitous
<i>Datura stramonium</i>	jimsonweed	Common
<i>Daucus carota</i>	wild carrot	Ubiquitous
<i>Dianthus armeria</i>	Depford pink	Common
<i>Digitaria sanguinalis</i>	common crabgrass	Ubiquitous
<i>Elytrigia repens</i>	quack grass	Common
<i>Euonymus europaeus</i>	European spindle-tree	Rare
<i>Festuca filiformis</i>	hair fescue	Common
<i>Festuca pratensis</i>	tall fescue	Common
<i>Glaucium flavum</i>	sea poppy	Common
<i>Hieracium caespitosum</i>	yellow hawkweed	Ubiquitous
<i>Hieracium lachenalii</i>	common hawkweed	Status Undetermined
<i>Holcus lanatus</i>	common velvet-grass	Ubiquitous
<i>Hypericum perforatum</i>	common St. John's-wort	Ubiquitous
<i>Hypochoeris radicata</i>	spotted cat's-ear	Common
<i>Larix decidua</i>	European larch	Status Undetermined
<i>Leontodon autumnalis</i>	fall-dandelion	Ubiquitous
<i>Linaria vulgaris</i>	butter-and-eggs	Common
<i>Phleum pratense</i>	timothy	Ubiquitous
<i>Pinus sylvestris</i>	Scotch pine	Common
<i>Plantago lanceolata</i>	English plantain	Ubiquitous
<i>Plantago major</i>	common plantain	Common
<i>Poa compressa</i>	Canada bluegrass	Common
<i>Polygonum aviculare</i>	bird knotweed	Common
<i>Populus alba</i>	white poplar	Common
<i>Prunella vulgaris</i>	heal-all	Ubiquitous
<i>Pyrus communis</i>	common pear	Status Undetermined
<i>Pyrus cv.</i>	crabapple cultivar	Status Undetermined
<i>Pyrus malus</i>	apple	Common
<i>Quercus robur</i>	English oak	Common
<i>Ranunculus repens</i>	creeping buttercup	Status Undetermined
<i>Raphanus raphanistrum</i>	wild radish	Ubiquitous
<i>Rumex acetosella</i>	sheep sorrel	Ubiquitous



<i>Rumex crispus</i>	curly dock	Ubiquitous
<i>Rumex salicifolius</i>	triangular-valved dock	Rare
<i>Setaria glauca</i>	yellow foxtail	Common
<i>Silene latifolia</i>	white campion	Common
<i>Solanum dulcamara</i>	bittersweet nightshade	Ubiquitous
<i>Spergularia marina</i>	seabeach sand-spurry	Common
<i>Stellaria graminia</i>	common stitchwort	Common
<i>Sueda maritima</i>	white sea-blite	Common
<i>Tragopogon dubius</i>	fistulous goats-beard	Status Undetermined
<i>Trichostema dichotomum</i>	bluecurls	Ubiquitous
<i>Trifolium arvense</i>	rabbit-foot clover	Common
<i>Trifolium campestre</i>	low hop-clover	Common
<i>Trifolium pratense</i>	red clover	Ubiquitous
<i>Trifolium repens</i>	white clover	Ubiquitous
<i>Verbascum thapsis</i>	common mullein	Common
<i>Veronica officinalis</i>	common speedwell	Ubiquitous
<i>Vicia cracca</i>	cow vetch	Common
<b>Invasive Exotics</b>		
<i>Acer platanoides</i>	Norway maple	Common
<i>Acer pseudoplatanus</i>	sycamore maple	Common
<i>Ailanthus altissima</i>	tree of heaven	Common
<i>Berberis thunbergii</i>	Japanese barberry	Ubiquitous
<i>Berberis vulgaris</i>	common barberry	Common
<i>Celastrus orbiculatus</i>	Oriental bittersweet	Ubiquitous
<i>Centaurea nigra</i>	black knapweed	Ubiquitous
<i>Elaeagnus umbellata</i>	autumn olive	Ubiquitous
<i>Lonicera japonica</i>	Japanese honeysuckle	Ubiquitous
<i>Lonicera morrowii</i>	Morrow's honeysuckle	Common
<i>Lotus corniculatus</i>	birdsfoot trefoil	Ubiquitous
<i>Phragmites australis</i>	common reed	Ubiquitous
<i>Polygonum cuspidatum</i>	Japanese knotweed	Common
<i>Rhamnus</i> sp.	buckthorn	Common
<i>Rorippa nasturtium-aquaticum</i>	true watercress	Common
<i>Rosa multiflora</i>	multiflora rose	Ubiquitous
<i>Rosa rugosa</i>	beach rose	Common
<i>Vincetoxicum nigrum</i>	black swallow-wort	Common

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