# GREAT CEDARS CONSERVATION AREA EAST
# NATURAL RESOURCES ASSESSMENT AND MAPPING STUDY

## OLD SAYBROOK, CONNECTICUT

**October 2005**

# GREAT CEDARS CONSERVATION AREA EAST
# OLD SAYBROOK, CONNECTICUT

# NATURAL RESOURCES ASSESSMENT AND MAPPING STUDY

**October 2005**

*Prepared for:*

Town of Old Saybrook Conservation Commission

*Prepared by:*

Wendy L. Goodfriend, PhD  Penelope Sharp, PWS  Richard Snarski, CPSS, PWS, CPESC

**Connecticut River Coastal Conservation District**
deKoven House Community Center / 27 Washington Street /Middletown, CT 06457
Ph. (860) 346-3282 /Fax (860) 346-3284
www.conservect.org/ctrivercoasal

**Great Cedars Conservation Area East**
**Natural Resources Assessment and Mapping Study**

# TABLE OF CONTENTS

## INTRODUCTION

The Great Cedars Conservation Area East is approximately 120 acres of open space located east of Ingham Hill Road and north of Mill Rock Road and the Connecticut Turnpike (I-95) in Old Saybrook, Connecticut. The property is located in the Oyster River subregional drainage basin. Significant landmark features on and near the property include the 10 acre Chalker's Millpond at the corner of Ingham Hill and Mill Rock Roads, a Connecticut Light and Power transmission line and right-of-way (CL&P ROW) through the eastern portion of the property, a large (approximately 30 acres) quarry situated just west of the northern portion of the property, and an open marsh located in the east-central portion of the property where a population of the State-endangered sedge *Carex exilis* has been found.

To assist the Town of Old Saybrook in developing an open space management strategy for the Great Cedars Conservation Area East, a natural resources assessment and mapping study was undertaken in the Spring and Summer of 2005. This report presents the results of information collected during three field visits, describes observed threats and management opportunities, and offers a number of recommendations for consideration in developing an open space management plan that includes public access for passive recreation.

## DATA COLLECTION, INFORMATION GATHERING AND ANALYSIS

Data collection and information gathering was conducted by Richard Snarski, CPSS, PWS, CPESC, Penelope Sharp, PWS, and Wendy Goodfriend, PhD. Field investigations were conducted on April 19, 2005 and June 28, 2005 and August 30, 2005 to assess the following;

- Major plant communities
- Wetlands and watercourses
- Vernal pools
- Wildlife
- Notable natural features
- Unique species
- Sensitive areas
- Non-native invasive plants
- Existing trails
- Property boundaries

During the field visits notable features and areas of natural resource management concern were photodocumented and georeferenced locations were acquired using a Garmin 12 hand-held GPS unit. Georeferenced locations were also acquired for existing and proposed trails and for property boundaries where pins and monuments could be found in the field.

Features on and near the property were mapped using ESRI's ArcView 3.3 program. A Geographic Information System (GIS) project was created in a NAD27 projection. The GIS was populated with field collected GPS data, a digital orthophotograph acquired from the Town of Old Saybrook, and statewide available GIS data. The following table summarizes the data included in this GIS project.

| DATA LAYER | DATA SOURCE* |
|---|---|
| Digital orthophotograph | Town of Old Saybrook |
| Existing and proposed trails | Field collected GPS |
| Natural community boundaries | Field collected GPS and Penni Sharp |
| Property lines | Town of Old Saybrook and field collected GPS |
| Roads | DEP Statewide |
| Soils | DEP Statewide |
| Topography - 10 ft contours | DEP Statewide |
| Water resources | DEP Statewide |
| Wetlands and watercourses | Field collected GPS and DEP Statewide |

**see Appendix A for a description of data source and type*

Using this GIS project a series of reference maps was created showing topography (Figure 1), soil type boundaries (Figure 2), natural community boundaries (Figure 3), water resources (Figure 4) and existing and proposed trails (Figure 5). Areas of notable features and natural resource management concerns observed during the field visits are referenced to approximate locations on a GIS base map (Figures 6-9).

## SOILS AND TOPOGRAPHY

The site occurs on gentle northwest-facing slopes characterized by a number of rock outcroppings on the summit areas. Slopes range from nearly level in the northern portion of the property to moderately steep in the central and southern portions (see Figure 1). Slopes east of Mill Rock Road are initially short and steep, but then are moderate through the southern and central portions of the property. Short steep slopes are also present on the northwest side of the property just north of the stream flowing southwesterly out of the open marsh. The southern and northern portions of the property are connected by a narrow pinch point in the approximate center of the parcel.

Soils on the property include four very poorly drained organic soils formed in woody, herbaceous, and decomposed organic materials (see Figure 2). These four wetland soil types are grouped into two map units (identified by the USDA-NRCS as map units 17 and 18) and are associated with the two stream corridors and the open marsh in the north-central portion of the property. Upland soils include fine sandy loams, gravelly sandy loams and loamy soils on glacial till plains and ridges. Two of the upland soils have restrictive layers that impede permeability. Woodbridge (identified as map unit 47C) is formed in dense glacial till and has a compact hardpan, and Charlton-Chatfield (identified as map units 73C and 73E) has a shallow depth to bedrock in the Chatfield portion of the complex. These three soil map units are located in the southern portion of the property.

Select properties of the eleven soil map units shown on the property are summarized in Table 1 and limitations on recreational activities are summarized in Table 2. In general, severe limitation on recreational uses are related to wetness, slope, and stoniness of soils found in the southern portion of the property (Woodbridge, Canton, Charlton, and Chatfield) and the wetlands corridor through the north-central portion of the property. Descriptions of the soil series on the property are provided in Appendix B and an explanation of the limitations on recreational uses in Appendix C.

## NATURAL COMMUNITIES

Within a natural landscape, one can observe areas that are characterized by similar ecological conditions, physical characteristics, and plants assemblages. Ecologists refer to such areas as "community types" or "cover types." In any given landscape, many communities may be identified depending upon the degree of resolution desired. For this study, a total of six natural community types have been delineated, a descriptions of each which is provided below. A complete list of plant species observed on the property is provided in Appendix D.

### Upland and Wetland Habitats

Natural communities are found throughout the property with the exception of the area that is maintained for the power line. Most of these communities are upland habitats; however, there is a large marsh situated in the east-central section of the parcel and several small forested wetland areas associated with intermittent and permanent watercourses located on the property (see Figure 3).

***Oak-Dominated Mixed Hardwoods Community***

The prevalent cover type in the southern sections of the property is oak-dominated mixed hardwoods. This cover type encompasses a relatively large portion of the site and is found along moderately sloping to flat terrain on rocky upland soils. Oak species include black oak, red oak, scarlet oak and white oak. Many of the oaks are sizeable trees having diameters of 25 inches or greater. Other common tree species of this community include tulip poplar, American beech, sugar maple, and black birch in the canopy, and beech saplings and flowering dogwood in the understory. Red cedar is also present, particularly on the rocky knolls. The cedars indicate that the land was probably in agriculture or cleared for pastures in the past. There is relatively dense shrub and vine cover, with mountain laurel, Japanese barberry, common greenbrier, Japanese honeysuckle, and common privet occupying much of the shrub layer. Many of the species are considered to be "Widespread and Invasive" on the list entitled "Non-native and potentially invasive vascular plants in Connecticut" published by the Center for Conservation and Biodiversity, University of Connecticut, Storrs, 2003. An oak-dominated community with black birch as a sub-dominant and an understory of dense mountain laurel occurs in the northern section of the parcel west of the stream that feeds the open marsh.

***Sugar Maple Dominated Mixed Hardwoods Community***

The south-central section of the property extending toward the power line contains a mixed hardwood forest dominated by sugar maple. This community type is also prevalent along the north-facing slope at the north-central section of the property. Black birch, red maple, black cherry, and black oak are associated species. Common greenbrier dominates the understory and Japanese barberry is also prevalent. Other species include Japanese honeysuckle and Morrow's honeysuckle. Christmas fern, Pennsylvania sedge, and Canada mayflower are dominant in the herbaceous layer. Loose-flowered sedge is also present.

***Red Cedar Community***

Within the south-central portion of the property near its southern boundary, there are a few small areas that have remained somewhat open that are dominated by red cedars. Black cherry saplings are also present. These areas are mostly on high knolls. Shrubs within these areas include dry site species such as huckleberry, low bush blueberry, and grasses including oatgrass.

***Disturbed Habitat under Power Line***

This community occurs under the power line within the right-of-way. Because the area is maintained to keep vegetation heights low, this is the most open community in terms of its floral composition. A dense thicket of shrubs and vines is present, many of which are invasive species. Found here are common privet, oriental bittersweet, common greenbrier, Morrow's honeysuckle, Japanese honeysuckle, and fox grape. The area also supports a wide diversity of herbaceous species including path rush, hay-scented fern, wild basil, mullein, bull thistle, sweet vernal grass, and deer tongue grass. In one location, several small orchids, the grass pink, were noted. In the past, yellow-fringed orchid (*Platanthera ciliaris*), a state-threatened species has been reported from further north along this power line. It is possible that this orchid could be in the property as well.

***Open Marsh***

One of the most interesting communities on the property is the open marsh located in the east-central portion of the site. The marsh comprises a large expanse of herbaceous species including the State-endangered sedge *Carex exilis*. Other species included within the marsh are three-way sedge, soft rush, wool grass, marsh St. Johnswort, marsh fern, smooth sawgrass, and tussock sedge. At the southern end of the marsh, there is a robust stand of common reed (*Phragmites australis*), which encroaches upon the native vegetation. At the fringes of the marsh are a number of wetland woody plants including buttonbush, alder, sweet

pepperbush, and red maple. Because of its high species diversity and the fact that it is habitat for an endangered species, this marsh is an important ecological resource.

***Forested Wetlands***

There are several areas on the property that contain wetlands belonging to the palustrine ecological system which is one of five systems recognized by the U. S. Fish and Wildlife Service's wetland classification system described in Classification of Wetlands and Deepwater Habitats of the United States, Cowardin, et al. 1979. The classification system is used to describe wetland cover types. The wetlands are best classified as palustrine forested wetlands, broad-leaved deciduous and seasonally saturated.

In the center of the property just south of the narrow pinch-point is an intermittent stream originating on the adjacent parcel to the south that flows in a northwesterly direction. The wetlands associated with the stream for the most part exist as narrow corridor adjacent to the stream. However, at the property boundary the topography flattens out and a broader wetland area is present (see Figure 4, wetland A). Species associated with these wetlands include red maple, tulip poplar, Japanese barberry, common greenbrier, spicebush, and mountain laurel. Japanese barberry is a dominant shrub species. Cinnamon fern is the most common species within the herbaceous stratum.

In center of the northern portion of the property is a stream that flows out of the open marsh in a westerly direction, through a culvert in an earthen dam, off the property to the adjacent parcel (see Figure 4, wetland B). The stream meanders toward the southwest and there are areas of wetlands associated with the watercourse. Red maple is the dominant tree species and white ash is a sub-dominant. Dense stands of sweet pepperbush grow at the wetland margins. Other shrubs include spicebush, highbush blueberry, nannyberry, and mountain laurel. Wetland obligate species within the herbaceous stratum include skunk cabbage, marsh marigold, sphagnum moss, and bitter-cress.

A similar type of wetlands occurs in the north section of the northern portion of the property. These wetlands are associated with a stream that flows from the adjacent parcel to the north (from the

property known as the "Preserve") in a southerly direction to the open marsh (see Figure 4, wetland C). Dominant tree and shrub species include red maple, black gum, ash, spicebush and sweet pepperbush. Skunk cabbage is a prevalent herbaceous plant.

**Wildlife**

As indicated, the property contains a wide diversity of upland and wetland community types and is therefore likely to support a number of wildlife species. During the field investigations a number of bird species were both heard and observed. These include red-winged blackbird, tufted titmouse, black-capped chickadee, great-crested flycatcher, rufous-sided towhee, blue jay, wild turkey, and red-eyed vireo. Many other bird species are likely to utilize these habitats to meet some or all of their needs. Wading birds such as great blue heron, green heron, and great egret may use the marsh upon occasion. Habitat is also present for some of the hawks and owls such as red shouldered hawk, eastern screech owl, and barred owl. The oak forests are ideal for wild turkey. These woodlands also provide resources for small and large mammals including white-tailed deer, gray squirrel, southern flying squirrel, eastern chipmunk, Virginia opossum, striped skunk, and raccoon.

No vernal pools were found on the site; however, red-backed salamander, a common terrestrial species is present. Amphibians and reptiles likely to be found on the property include garter snake, black snake, green frog, and pickerel frog. Habitat is present for the eastern box turtle although this species was not directly observed.

## RECREATIONAL OPPORTUNITIES

The property offers good opportunities for passive recreation, e.g., hiking, bird watching, picnicking, and possibly limited horseback riding and mountain biking. The proximity of the Great Cedars East property to the town center and neighboring open space properties is advantageous. Developing this area for recreational use does, however, present some challenges due to a number of impediments limiting access across and through the property. Two areas in particular, the open marsh/wetlands complex and the dense thorny understory in the east-central portion of the property, will require creative trail development and management strategies to establish public access to the more interesting areas on the property.

### Recommended Loop Trail System

Development of a recreational trail should take advantage of existing trails as well as interesting and unique features on the property. Currently, there are walkable trails in the northern portion of the property but not in the southern portion (See Figure 5). A recommended loop trail system is depicted in Figure 5. This possible loop trail was field located to 1) most simply traverse the pinch-point in the center of the property, 2) provide access to and across the open marsh and wetlands complex, and 3) allow for future connections to potential adjacent open space to the north and east. In total, the largest loop would be approximately 2.5 miles, the central loop 1.75 miles, and the shortest loop 0.65 miles from Chalker's Millpond on Mill Rock Road. Interesting and unique and features that would be observed from the loop trail system include a number of sizable oak and maple trees, bedrock outcrops and rocky knolls, a cedar glade, the open marsh and quarry, and of course the twisted and bent over tree grove (see Figure 6).

To avoid an area in the eastern portion of the property that is dominated by a dense and thorny understory, which is currently impenetrable in some places, the recommended loop trail system includes a portion of the CL&P ROW on the east side of the property. Most of the CL&P ROW is kept cleared and is easily walkable. While not an undisturbed natural community, there is a diversity of herbaceous species on the path edge along the northern section of the CL&P ROW. Using the CL&P ROW as a trail will minimize the amount of effort needed to establish the loop trail system (see Figure 7).

The recommended loop trail system will also require a short section to pass across the adjacent quarry property. This short bypass is required to circumnavigate the broad wetland complex that extends from the quarry outlet pipe across the CL&P ROW into the open marsh. Due to the extensive nature of this broad wetland and watercourse complex suspended walkways and/or

bridges which would be necessary to create a stable recreational trail would not be feasible (see Figure 7).

**Trail Loop System Points of Connectivity**

There are four potential access points to the property; to the south from Mill Rock Road, to the east from the existing quarry site if in the future redeveloped (possibly not a full public access), and to the north from potential future trails on the proposed "Preserve" property. There are no apparent topographic limitations or major impediments to any of these four access points, and therefore adequate opportunities are available to connect the recommended loop trail system to adjacent future open space (see Figure 8).

**Potential Trial Head Parking**

There are two areas on the property that are potentially appropriate for parking to access the recommended trail system. The first area is on the east side of Mill Rock Road directly north of the 50 foot right-of-way to the property of Maynard. This area is currently grass, and if surfaced with pervious grass pavers, could be developed for parking with minimal adverse impacts. As an alternative, there is a small flat area in the 50 foot ROW less than 100 feet east of Mill Rock Road that could be used for parking a limited number of vehicles. This alternative parking area would require trial visitors to use of a small section of the Maynard's paved driveway

**Suggested parking area off of Mill Rock Road. Looking north east from the road (above) and west from the 50 foot ROW to property owned by Maynard (left).**

## MANAGEMENT CONCERNS AND RECOMMENDATIONS

A number of management concerns opportunities were identified during the study. These should be considered during the development of an open space management plan for the property. The most significant observed threat to natural resources on the property is the prevalence of non-native invasive plant species. In addition, there is evidence that off-road vehicles (ATVs) have been on site, and in particular, have traversed the open marsh where a State endangered sedge population is

established. In the spring some of the existing trails were wet, indicated that in some areas soils may be seasonally saturated and well-used trails could become muddy or rutted. Lastly, trails (either existing or proposed) located in the steep portions of the southern and northwestern portion of the property should be constructed/retrofitted and maintained to minimize the long term potential for soil erosion and sedimentation (see Figure 9).

**Invasive Plant Species**

Although the property contains an excellent diversity of vegetation cover types, there is a prevalence of invasive plant species that somewhat mars the overall ecological integrity of the site. Japanese barberry is abundant as is common privet. While it is a daunting task to attempt the removal of all non-native species from the property, small areas could be considered for treatment. In the southern portion of the property, some of the invasive shrubs could be removed in areas where large trees are the key natural features. Perhaps of greater importance would be the removal and control of the common reed (*Phragmites australis*) within the open marsh. This should be done in order to protect the State endangered sedge species (*Carex exilis*) from being overtaken. If left unchecked, it is conceivable that the Phragmites will continue to spread and turn the marsh from a diverse wetland into a reed monoculture (see Appendix E for fact sheets on non-native invasive species observed on the property).

***Recommendations***

1. Develop and implement a long-term management strategy to control Phragmites in the open marsh, possibly in consultation with the CT DEP Geological and Natural History Survey.
2. Once an acceptable plan for a loop trail system has been adopted, identify areas along the trail and in the trail's viewshed for invasive species removal. Develop and implement a long-term strategy to control invasive understory shrubs in these areas.

**Wet Trail Areas**

Seasonally wet trails can become deeply rutted and muddy, and can result in trail by-passing or off-trail uses that can cause downgradient impacts (See Figure 9). Once seasonally or chronically wet trail areas are identified a management strategy for each trail section can be developed. Alternatives include;

1. Relocating trails from low lying, chronically wet areas to higher, drier areas if suitable alternative routes are feasible.
2. Providing adequate cross drainage using drain dips or curtain drains to ensure water does not pool on the trail (see Appendix F).

3. Constructing stabilized crossing points where trails are chronically wet. Consider trail use (e.g., hiking, horseback riding, or mountain biking) when determining appropriate solution. Alternatives include raised walkways (puncheon), bridges, or turnpikes (see Appendix F).
4. Consider seasonal trail closures or limited trail use in areas that are chronically wet.

**Trail Erosion**

Ensuring that new and existing trail sections are built and maintained appropriately will help minimize the potential for soil erosion related to the recreational use of the property. A management strategy for the recommended loop trail system should consider;

1. Marking the approved trail network in a clear and comprehensive manner to discourage cross cutting and off trail recreation.
2. Working with local stakeholders to determine allowed uses on each trail segment (e.g., hiking, horseback riding, biking) and signing trail system appropriately.
3. Posting “no entry - conservation area” signs in critical wetlands areas, e.g., the open marsh.
4. Discouraging motorized use of the trail system through education, signage, blocking unauthorized trails, vigilance, and patrolling.
5. Grading trails to have a 3% to 4% cross-slope that will quickly drain surface runoff. Outsloped trails pitched to drain downslope are easiest to construct when the trail traverses the natural slope (see Appendix F).
6. Control concentrated stormwater flows on steep trail sections by installing water bars at controlled points. Water bars direct excess runoff to a stable vegetated area on the side slope. In very steep areas discharging flows to a small riprap splash pad or stone check dam may be necessary (see Appendix F).

## TABLES

Table 1. Select properties of the predominant soils at the Great Cedars Conservation Area East

| Drainage | Map Symbol | Soil Description | Slope (%) | Stoniness | Local Landform | Hydrologic Group | Prime Farmland | Restrictive Layer | Erosion Potential |
|---|---|---|---|---|---|---|---|---|---|
| Very Poorly | 17 | Timakwa and Natchaug (was Adrian and Palm) | 0-2 | | Plain, lake plain, moraine, outwash plain, till plain | D | | | |
| | 18 | Catden and Freetown (was Carlisle Muck) | 0-2 | | Plain, lake plain, moraine, outwash plain, till plain | D | | | |
| Moderately Well | 23A | Sudbury sandy loam | 0-5 | | Outwash plain, terrace | B | Yes | | Slight |
| | 47C | Woodbridge fine sandy loam | 2-15 | Extremely Stony | Drumlin | C | | Compact hardpan at 20 to 40 inches | Moderate |
| Well | 29B | Agawam fine sandy loam[1] | 3-8 | | Outwash plain, terrace | B | Yes | | Moderate |
| | 62C | Canton and Charlton | 3-15 | Extremely Stony | Till Plain | B | | | Moderate to Severe |
| | 62D | Canton and Charlton | 15-35 | Extremely Stony | Hill, till plain | B | | | Severe |
| | 73C | Charlton-Chatfield Complex (was Charlton-Hollis) | 3-15 | Very Rocky | Till plain, ridge | B | | Bedrock at 20 to 40 inches | Moderate to Severe |
| | 73E | Charlton-Chatfield Complex (was Hollis-Charlton) | 15-45 | Very Rocky | Till plain, hill, ridge | B | | Bedrock at 20 to 40 inches | Severe |
| Somewhat Excessively | 34A | Merrimac sandy loam | 0-3 | | Outwash plain, terrace | B | Yes | | Slight |
| Excessively | 38C | Hinckley gravelly sandy loam[1] | 3-15 | | Esker, kame, outwash plain, terrace | A | | | Moderate |

[1]soil type qualifies as a potentially highly erodible land (USDA/SCS 1980).

Soil map unit names from the USDA/NRCS statewide GIS soil coverage (1995). Differences in naming convention with the Soil Survey of Middlesex County (1979) are shown in parenthesis.

Hydrologic groups A and B have high infiltration and low runoff, groups C and D have low infiltration and high runoff

Table 2. Select limitations of the predominant soils at the Great Cedars Conservation Area East

| Drainage | Map Symbol | Soil Description | Picnic Areas | Camp Areas | Paths & Trails[1] | Hazard of Soil Rutting |
|---|---|---|---|---|---|---|
| Very Poorly | 17 | Timakwa and Natchaug | Severe[a] | Severe[a] | Severe[a] | Severe[a] |
| | 18 | Catden and Freetown | Severe[a] | Severe[a] | Severe[a] | Severe[a] |
| Moderately Well | 23A | Sudbury | Moderate[a] | Moderate[a] | Slight | Moderate |
| | 47C | Woodbridge | Severe[a,b,c] | Severe[a,b,c] | Severe[c] | Moderate |
| Well | 29B | Agawam | Slight | Slight | Slight | Moderate |
| | 62C | Canton and Charlton, 3-15% | Severe[b,c] | Severe[b,c] | Severe[c] | Moderate to Severe |
| | 62D | Canton and Charlton, 15-35% | Severe[b,c] | Severe[b,c] | Severe[b,c] | Moderate to Severe |
| | 73C | Charlton-Chatfield, 3-15% | Severe[b,c] | Severe[b,c] | Moderate[c] | Moderate |
| | 73E | Charlton-Chatfield, 15-45% | Severe[b,c] | Severe[b,c] | Moderate[c] | Moderate |
| Somewhat Excessively | 34A | Merrimac | Slight | Slight | Slight | Moderate |
| Excessively | 38C | Hinckley | Moderate[b] | Moderate[b] | Slight | Moderate |

Limiting Feature: [a]wetness, [b]slope, [c]stoniness

[1]Limitations on hiking, horseback riding, bicycling, and off-road vehicle (e.g., motorcycles) paths and trails

## FIGURES

**FIGURE 1. TOPOGRAPHY**
**Great Cedars Conservation Area East**

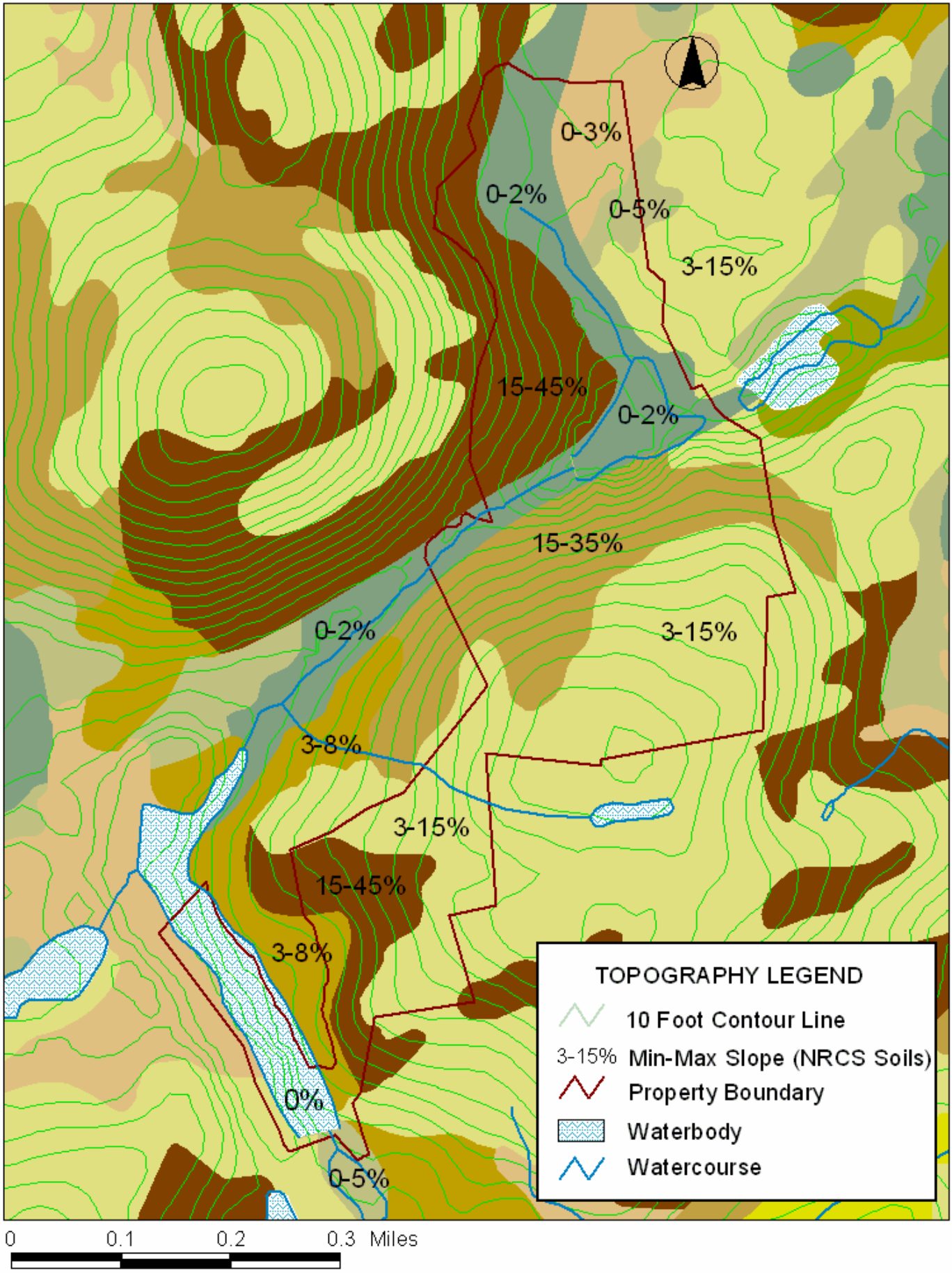
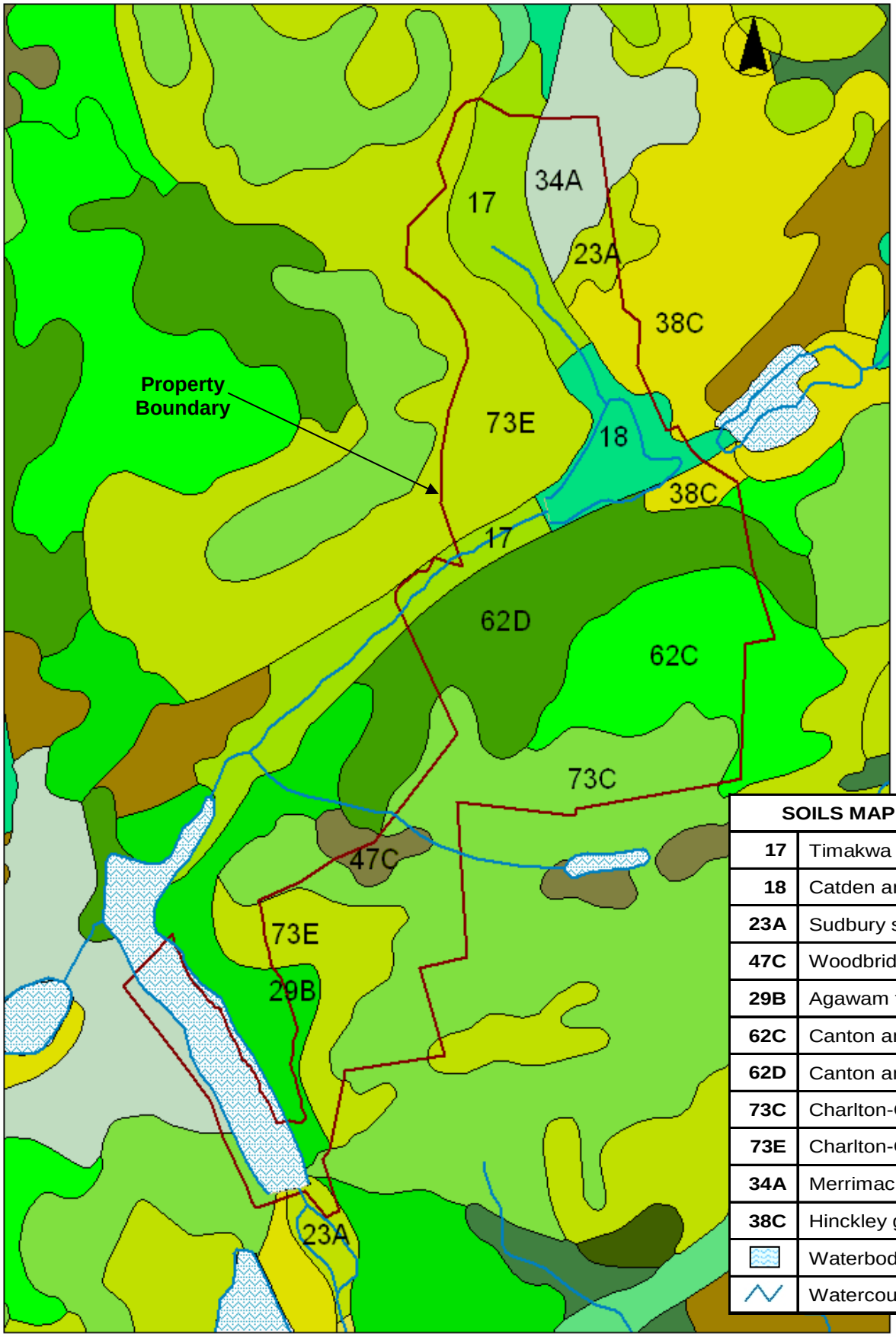


**FIGURE 2. SOIL MAP UNIT BOUNDARIES**
**Great Cedars Conservation Area East**




| SOILS MAP UNIT LEGEND | |
|---|---|
| 17 | Timakwa and Natchaug |
| 18 | Catden and Freetown |
| 23A | Sudbury sandy loam |
| 47C | Woodbridge fine sandy loam |
| 29B | Agawam fine sandy loam |
| 62C | Canton and Charlton |
| 62D | Canton and Charlton |
| 73C | Charlton-Chatfield Complex |
| 73E | Charlton-Chatfield Complex |
| 34A | Merrimac sandy loam |
| 38C | Hinckley gravelly sandy loam |
| | Waterbody |
| | Watercourse |

**FIGURE 3. NATURAL COMMUNITIES**
**Great Cedars Conservation Area East**

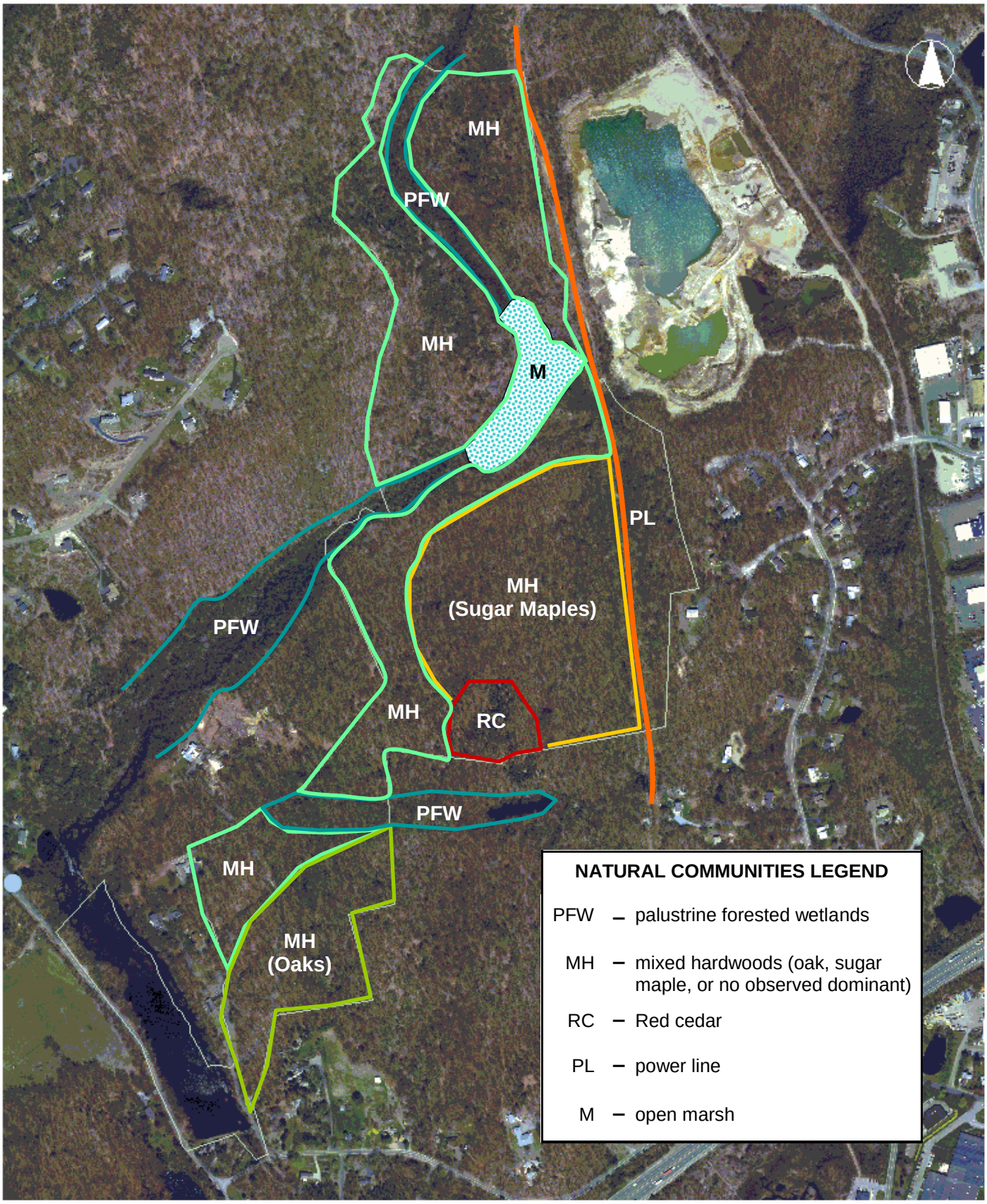


**FIGURE 4. NATURAL COMMUNITIES**
**Great Cedars Conservation Area East**

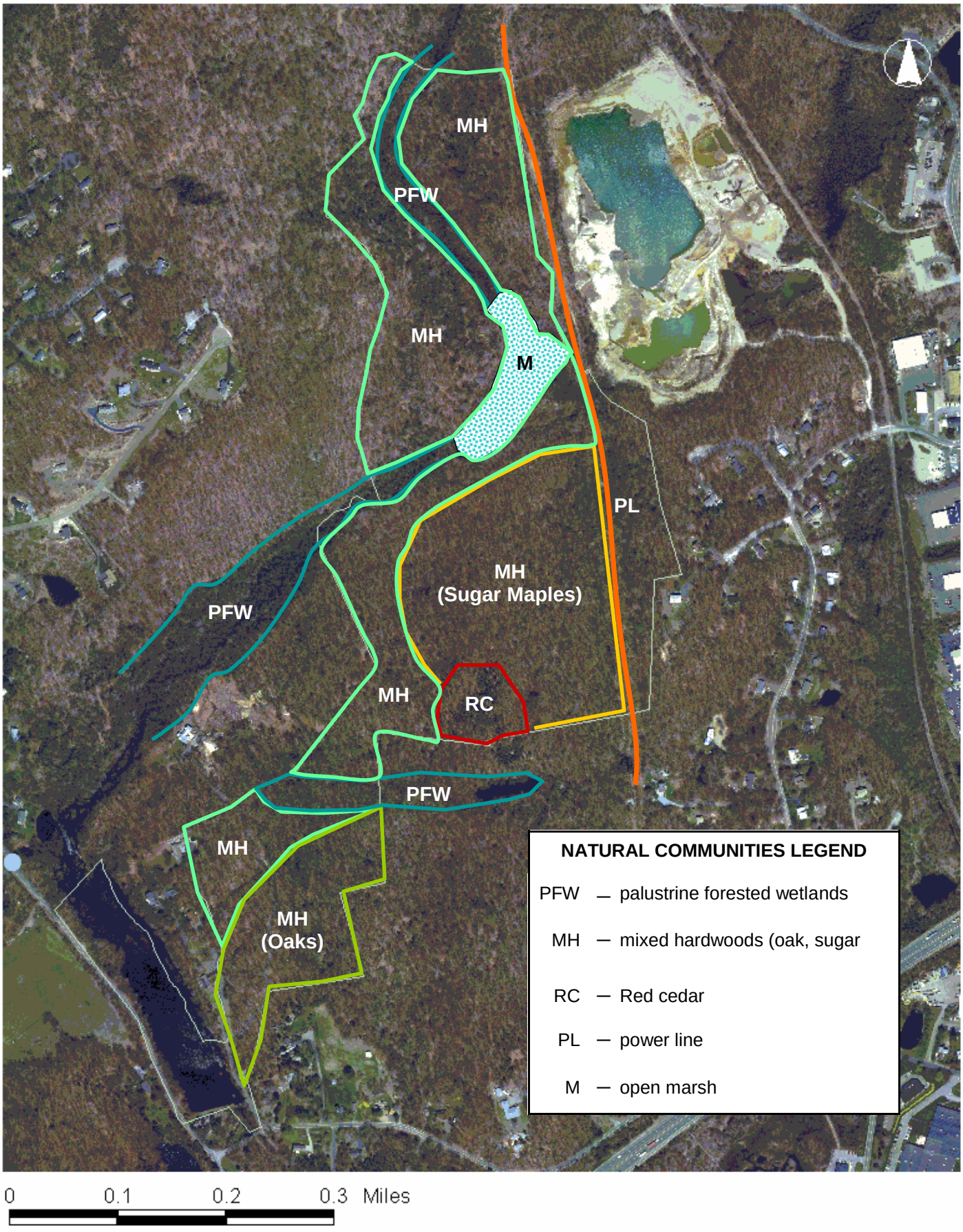


**FIGURE 5. EXISTING AND PROPOSED NEW TRAILS OF THE RECOMMENDED TRAIL LOOP SYSTEM**
**Great Cedars Conservation Area East**

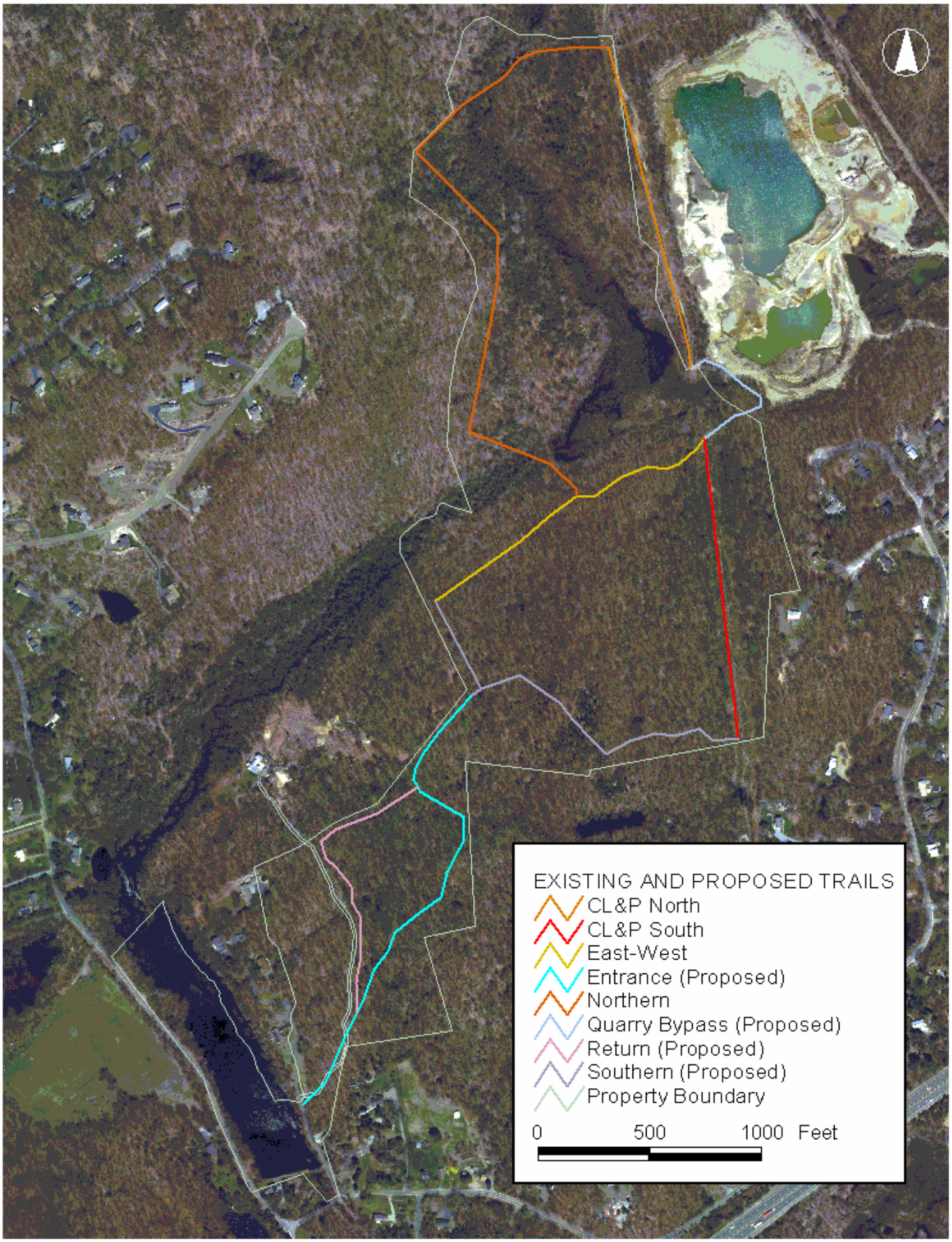


**FIGURE 6. INTERESTING AND UNIQUE AND FEATURES ON THE RECOMMENDED LOOP TRAIL**
**Great Cedars Conservation Area East**

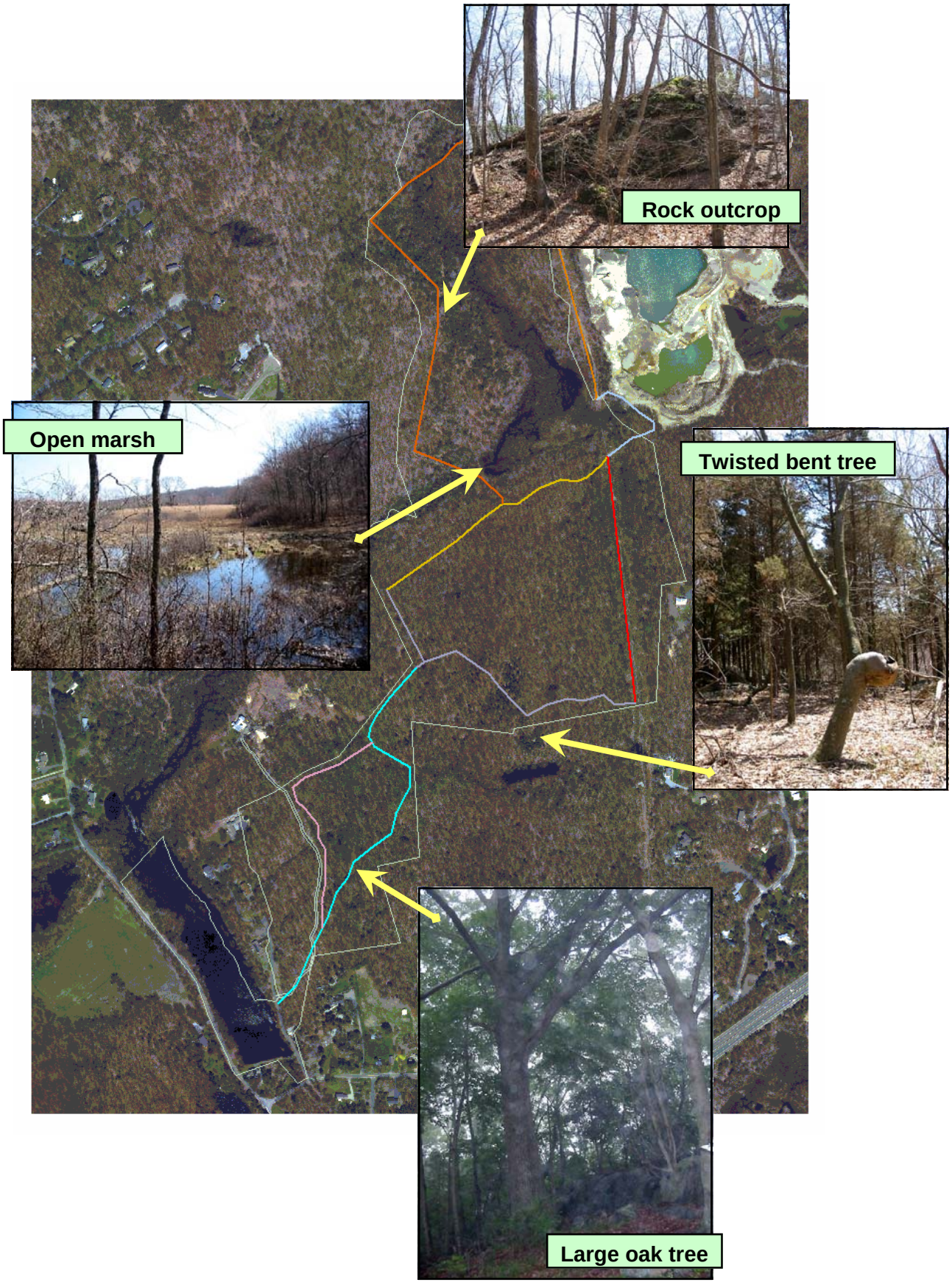


**FIGURE 7. IMPEDIMENTS TO BE CIRCUMNAVIGATED ON THE TRAIL SYSTEM**
**Great Cedars Conservation Area East**

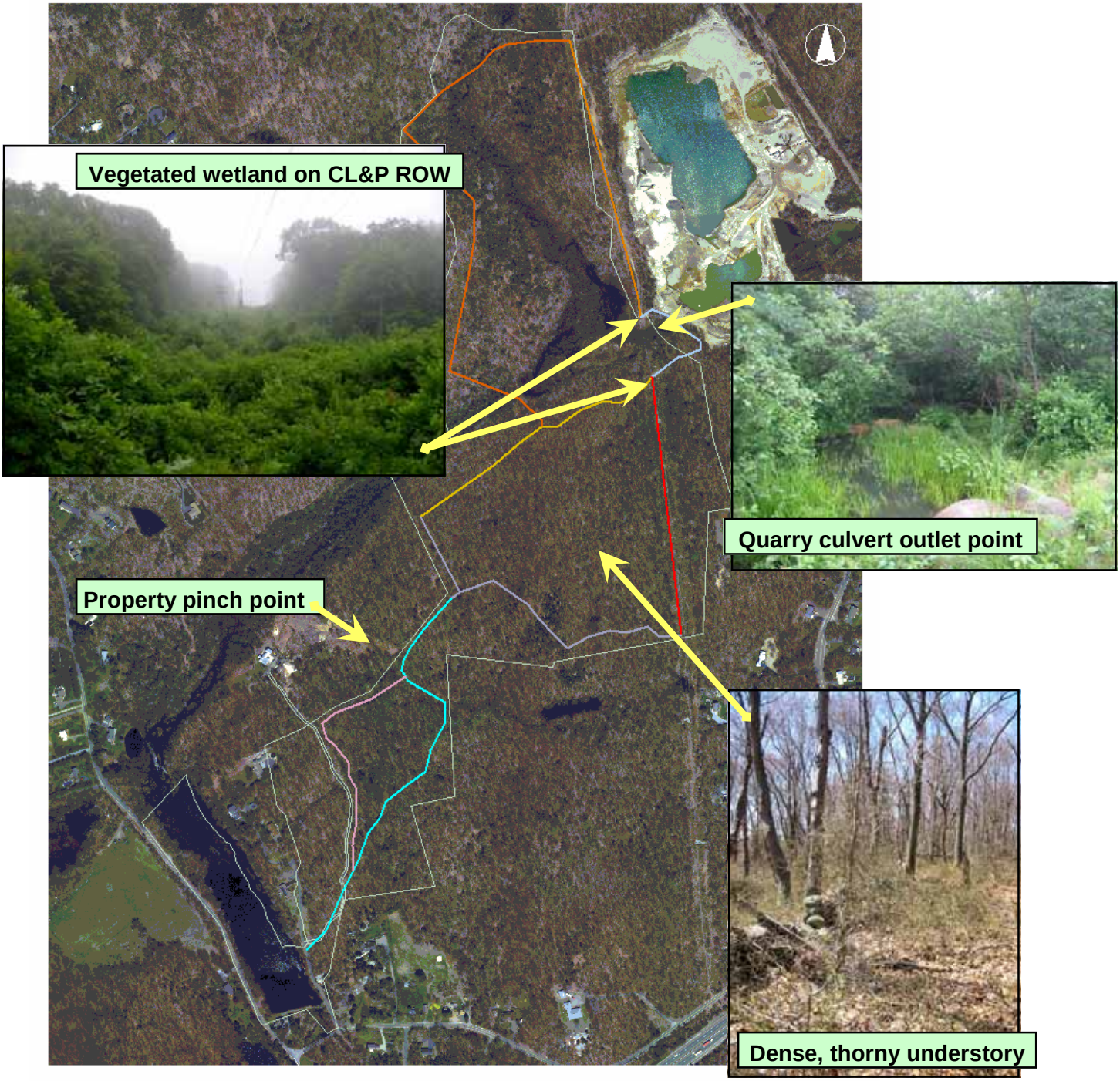


**FIGURE 8. POINTS OF CONNECTION TO RECOMMENDED LOOP TRAIL SYSTEM**
**Great Cedars Conservation Area East**

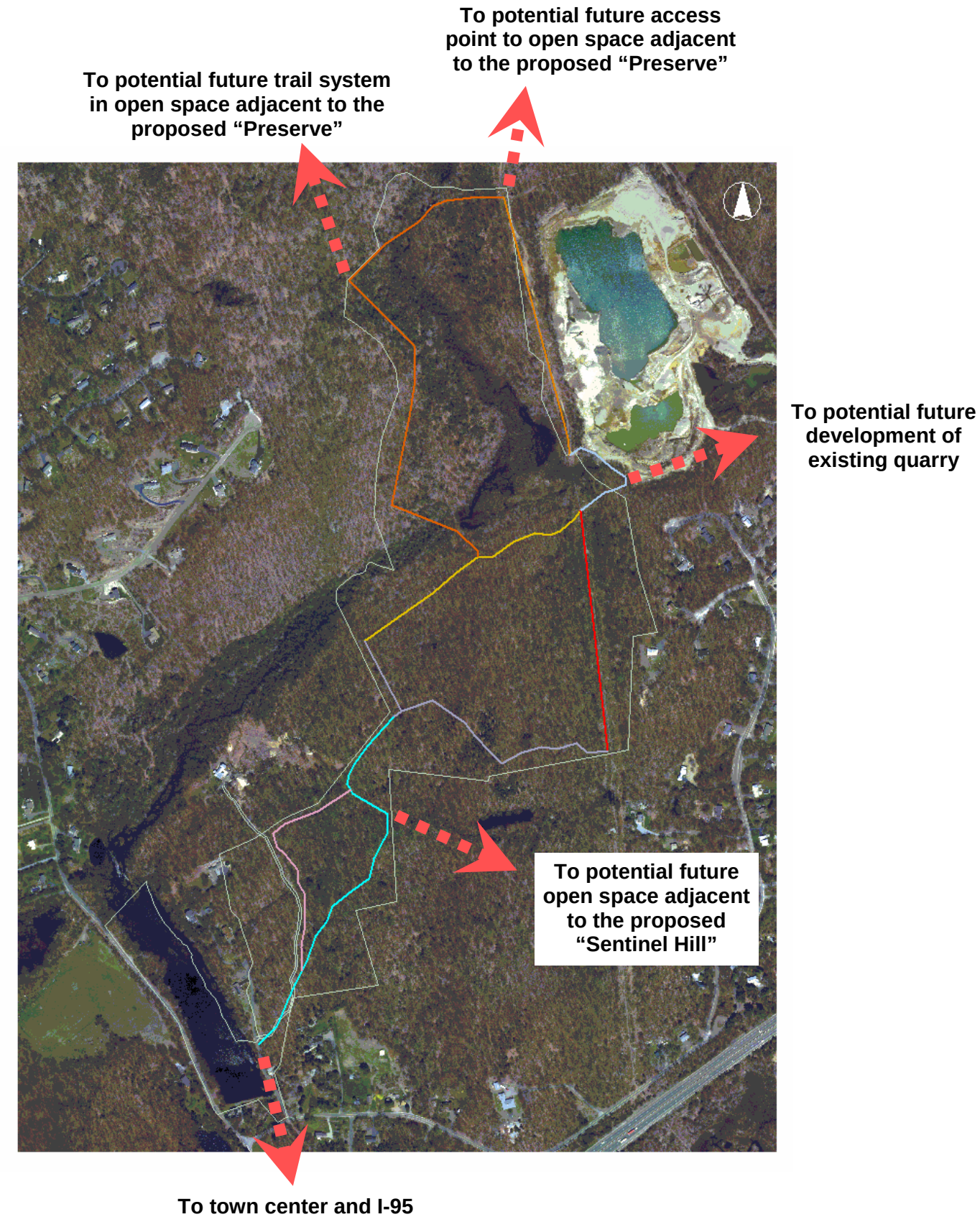
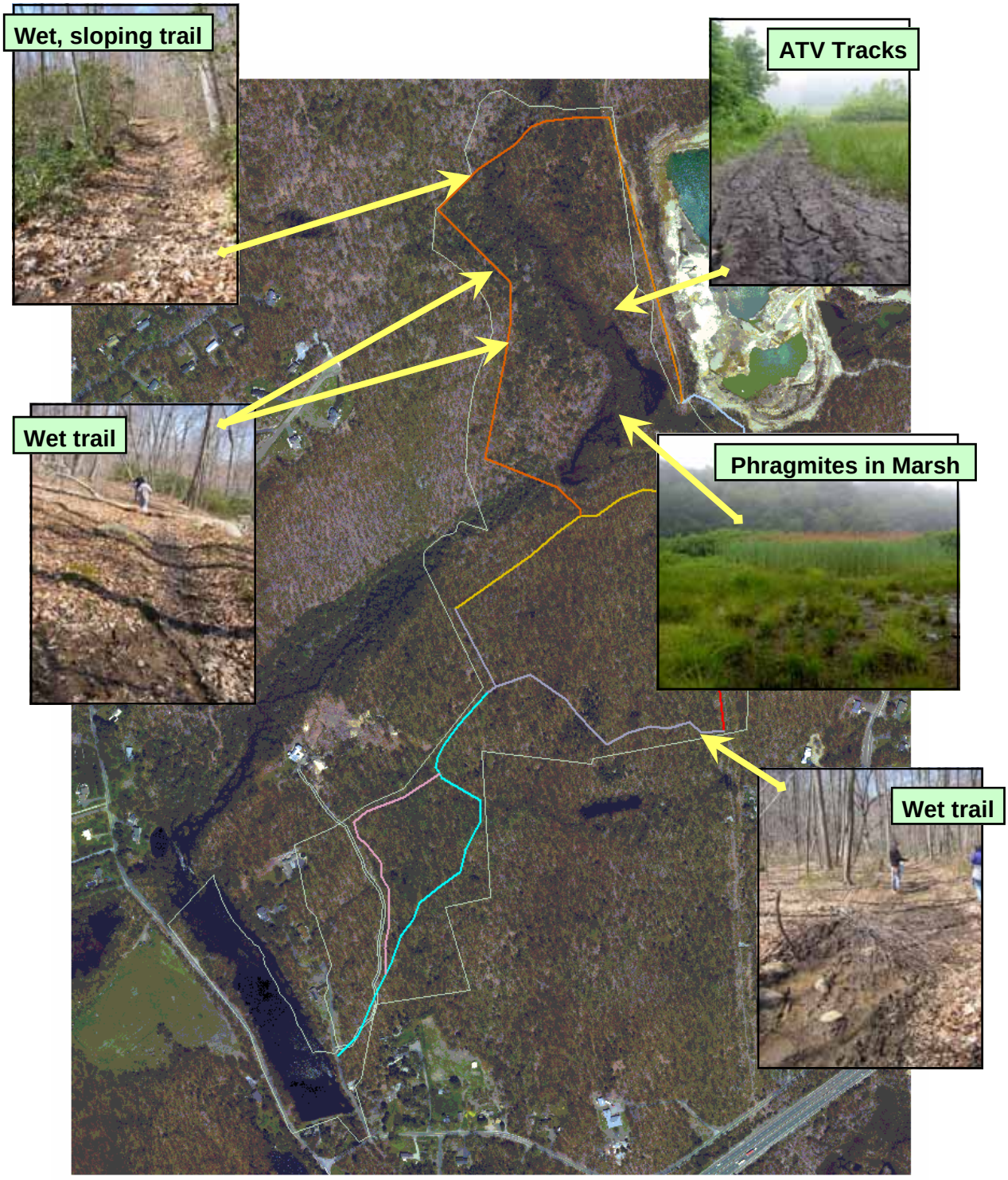


**FIGURE 9. TRAIL MANAGEMENT CONCERNS**
**Great Cedars Conservation Area East**



## APPENDICES

**Appendix A. GIS Metadata Description**

| Data Layer | Creator | Date Created | Date Published | Type | Creation Scale |
|---|---|---|---|---|---|
| Digital orthophotograph | GeoVantage, Inc. | 2003 | 2004 | Image (GeoTif) | — |
| Existing trails | Field collected GPS | 2005 | — | Polyline | — |
| Natural communities | Field collected GPS | 2005 | — | Polygon | — |
| Property lines | Town and field collected GPS | 2005 | | Polyline Polygon | |
| Roads | CT DEP | 1969-1984 | 1995 | Polyline | 1:24000 |
| Soils | USDA, CT DEP | 1962-1995 | 1995 | Polygon | 1:12000 |
| Topography - 10 ft | Based on USGS 7.5 minute DEM[1] | 1969-1984 | 1997 | Polyline | 1:24000 |
| Water resources | CTDEP | 1969-1984 | 1995 | Polyline Polygon | 1:24000 |
| Wetlands and watercourses | Field collected GPS | 2005 | — | Polyline Polygon | — |

[1]*Topographic lines are at a 30 meter resolution*

## Appendix B. Soils Series Descriptions

### WETLAND SOILS

**CATDEN SERIES**
The Catden series consists of very deep, very poorly drained soils formed in woody and herbaceous organic materials in depressions.

GEOGRAPHIC SETTING: Catden soils are in depressions on lake plains, outwash plains, moraines, and flood plains. These soils formed in woody and herbaceous organic materials. Slope ranges from 0 to 2 percent.

DRAINAGE AND PERMEABILITY: Very poorly drained. Depth to the seasonal high water table ranges from 1 ft above the surface to 1 ft below the surface from Sept. to June. Surface runoff is very low or negligible. Permeability is moderate or moderately rapid. Some areas are subject to rare, very brief flooding during March and April.

USE AND VEGETATION: Most areas are used for wildlife, or are in woodland or cutover woodland. Some of these soils are used for pasture. Common vegetation is red maple, skunk cabbage, marsh fern, and sphagnum moss.

**FREETOWN SERIES**
The Freetown series consists of very deep, very poorly drained organic soils formed in more than 51 inches of highly decomposed organic material.

GEOGRAPHIC SETTING: Freetown soils are in bogs that range from small enclosed depressions to bogs of several hundred acres in size. These bogs are on lake plains, outwash plains, till plains and moraines. Slope ranges from 0 to 1 percent.

DRAINAGE AND PERMEABILITY: Very poorly drained. Saturated hydraulic conductivity is moderately high or high.

USE AND VEGETATION: Mostly forested. Native vegetation includes red maple, American elm, green ash, eastern hemlock, Atlantic white cedar, buttonbush, winterberry, swamp azaleas, and leatherleaf. Some acreage has been cleared and is used for truck crops. The main crop is cranberries.

**NATCHAUG SERIES**
The Natchaug series consists of very deep, very poorly drained soils formed in woody and herbaceous organic materials overlying loamy deposits.

GEOGRAPHIC SETTING: Natchaug soils are in depressions on lake plains, outwash plains, moraines, till plains and flood plains. These soils formed in woody and herbaceous organic materials. Slope ranges from 0 to 2 percent.

DRAINAGE AND PERMEABILITY: Very poorly drained. Depth to the seasonal high water table ranges from 1 foot above the surface to 1 foot below the surface from October to June. Surface runoff is negligible or very low. Permeability is moderate to very rapid in the organic layers and moderate or moderately slow in the loamy material. Saturated hydraulic conductivity is moderately low to very high in the organic layers and moderately low to high in the loamy material. Some areas are subject to rare, very brief flooding during March and April.

USE AND VEGETATION: Most areas are used for wildlife habitat, or are in woodland or clear-cut woodland. Some areas are used for pasture. Common vegetation is red maple, skunk cabbage and sphagnum moss.

**TIMAKWA SERIES**
The Timakwa series consists of very deep, very poorly drained soils formed in woody and herbaceous organic materials over sandy deposits.

GEOGRAPHIC SETTING: Timakwa soils are in depressions in lake plains, outwash plains, moraines, till plains and flood plains. These soils formed primarily in woody organic materials with some herbaceous materials. Slope ranges from 0 to 2 percent.

DRAINAGE AND PERMEABILITY: Very poorly drained. Depth to the seasonal high water table ranges from 1 foot above the surface to 1 foot below the surface from October to June. Surface runoff is negligible or very low. Permeability is moderate to very rapid in the organic layers and rapid or very rapid in the sandy material. Saturated hydraulic conductivity is moderately low to high in the organic layers and high or very high in the sandy material. Some areas are subject to rare, very brief flooding from November to May.

USE AND VEGETATION: Most areas are used for wildlife, or are in woodland or clear-cut woodland. Some of these soils are used for pasture. Common vegetation is red maple, skunk cabbage, and sphagnum moss.

## UPLAND SOILS

**AGAWAM SERIES**
The Agawam series consists of very deep, well drained soils formed in sandy, water deposited materials.

GEOGRAPHIC SETTING: Agawam soils are level to steep soils on outwash plains and high stream terraces. Most areas are on slopes that are less than 15 percent. Steeper slopes are on terrace escarpments and steep sides of gullies in dissected outwash plains. The soils formed in sandy water deposited material derived principally from schist, granite, gneiss, and phyllite.

DRAINAGE AND PERMEABILITY: Well drained. Runoff and internal drainage are negligible to low. Saturated hydraulic conductivity is high in the upper solum and high or very high in the lower solum and substratum.

USE AND VEGETATION: Most areas are used for growing cultivated hay, silage corn, tobacco, potatoes, and truck crops. Some areas are used for growing pasture. Native vegetation is forest composed mainly of white pine, gray birch, red maple, red, white, black, and scarlet oaks.

**CANTON SERIES**
The Canton series consists of very deep well drained soils formed in a loamy mantle underlain by sandy till.

GEOGRAPHIC SETTING: Canton soils are on glaciated upland plains, hills, and ridges. Slope ranges from 0 to 35 percent. The soils developed in a fine sandy loam mantle over acid sandy glacial till of Wisconsin age derived mainly from granite and gneiss and some fine-grained sandstone.

DRAINAGE AND PERMEABILITY: Well drained. Runoff is negligible to medium. Internal drainage is medium. Saturated hydraulic conductivity is high in the solum and high or very high in the substratum.

USE AND VEGETATION: Mostly forested or idle. Some areas have been cleared of surface stones and are used for crops and pasture. Native vegetation is forest composed of white pine, red, white and black oaks, hickory, red maple, sugar maple, gray birch, yellow birch, beech, hemlock, and white ash.

**CHARLTON SERIES**
The Charlton series consists of very deep, well drained loamy soils formed in till.

GEOGRAPHIC SETTING: Charlton soils are nearly level to very steep soils on till plains and hills. Slope ranges from 0 to 50 percent. The soils formed in acid till derived mainly from schist, gneiss, or granite.

DRAINAGE AND PERMEABILITY: Well drained. Surface runoff is medium to rapid. Permeability is moderate or moderately rapid throughout.

USE AND VEGETATION: Areas cleared of stones are used for cultivated crops, specialty crops, hay, and pasture. Many scattered areas are used for community development. Stony areas are mostly wooded. Common trees are red, white, and black oak, hickory, sugar maple, red maple, black and gray birch, white ash, beech, white pine, and hemlock.

**CHATFIELD SERIES**
The Chatfield series consists of moderately deep, well drained, and somewhat excessively drained soils formed in till.

GEOGRAPHIC SETTING: Chatfield soils are nearly level to very steep, and are on convex to plane glaciated upland landscapes. The soils formed in a moderately thick mantle of till overlying granite, gneiss, or schist bedrock. Slope ranges from 0 to 70 percent. Rock outcrops are rare to common and are limited to the more resistant bedrock.

DRAINAGE AND PERMEABILITY: Well to somewhat excessively drained. Potential for surface runoff ranges from low to high. Permeability is moderate or moderately rapid.

USE AND VEGETATION: Most areas of Chatfield soils are in woodland. Major tree species include white and red oaks, sugar maple, beech, hemlock, white pine, eastern red cedar, and Atlantic white cedar. Some small cleared areas are used for pasture, are idle, or are sites for residential and recreational development.

**HINCKLEY SERIES**
The Hinckley series consists of very deep, excessively drained soils formed in water-sorted material.

GEOGRAPHIC SETTING: Hinckley soils are nearly level to very steep soils on terraces, outwash plains, deltas, kames, and eskers. Slope is generally 0 to 8 percent on tops of the terraces, outwash plains and deltas. Slope of 8 to 60 percent or more are on the kames, eskers and margins of the outwash plains, deltas, and terraces. The soils formed in water-sorted sand and gravel derived principally from granite, gneiss, and schist.

DRAINAGE AND PERMEABILITY: Excessively drained. Surface runoff is negligible to low. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Cleared areas are used for hay, pasture, and silage corn. In the southern Connecticut River Valley, Hinckley soils are used for growing tobacco and truck crops and in eastern Massachusetts, truck crops. Most areas are forested, brush land or used as urban land. Red, black, white, scarlet and scrub oak, white and pitch pine, hemlock and gray birch are the common trees. Unimproved pasture and idle land support hardhack, little bluestem, bracken fern, sweet fern, and low bush blueberry.

**MERRIMAC SERIES**
The Merrimac series consists of very deep, somewhat excessively drained soils formed in glacial outwash.

GEOGRAPHIC SETTING: Merrimac soils are level to very steep on glacial outwash plains and valley trains, and associated kames, eskers, stream terraces and water deposited parts of moraines. The steeper slopes are on the margin escarpments of terraces and plains, and on eskers and kames. Slope ranges from 0 to 35 percent. The soils formed in water sorted gravelly and sandy material derived mainly from granitic, gneissic and some schistose rocks.

DRAINAGE AND PERMEABILITY: Somewhat excessively drained. Runoff is negligible to medium. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Most areas are cultivated and used for growing hay, pasture, silage, corn, or truck crops. Some areas are used to grow tobacco in the Connecticut River Valley in Massachusetts and Connecticut. Some areas are forested with mostly white pine, gray birch, hemlock, red maple, and red, black, white, and scarlet oaks.

**SUDBURY SERIES**
The Sudbury series consists of very deep, moderately well and somewhat poorly drained soils on outwash plains.

GEOGRAPHIC SETTING: Sudbury soils are nearly level to strongly sloping soils in slight depressions on outwash plains and on gentle foot slopes. Slope ranges from 0 to 15 percent. The soils formed in water sorted sandy and gravelly materials derived mainly from granite, gneiss, and schist.

DRAINAGE AND PERMEABILITY: Moderately well and somewhat poorly drained. Surface runoff is slow to moderate. The internal drainage is restricted by a seasonal high water table. Saturated hydraulic conductivity is high in the upper solum and high or very high in the lower solum and substratum.

USE AND VEGETATION: Most areas used for growing hay, pasture, field and truck crops. Some are forested with mainly red maple, gray birch, hemlock, larch, white pine, and red, black, and scarlet oaks.

**WOODBRIDGE SERIES**
The Woodbridge series consists of moderately well drained loamy soils formed in subglacial till. They are very deep to bedrock and moderately deep to a densic contact.

GEOGRAPHIC SETTING: Woodbridge soils are nearly level to moderately steep and are on till plains, hills and drumlins. Slope commonly is less than 8 percent, but the range includes 0 to 25 percent. The soils formed in acid till derived mostly from schist, gneiss, and granite.

DRAINAGE AND PERMEABILITY: Moderately well drained. Surface runoff is negligible to high. Saturated hydraulic conductivity ranges from moderately low or moderately high in the surface layer and subsoil and low or moderately low in the dense substratum.

USE AND VEGETATION: Many areas are cleared and used for cultivated crops, hay, or pasture. Scattered areas are used for community development. Some areas are wooded. Common trees are red, white, and black oak, hickory, white ash, sugar maple, red maple, hemlock, and white pine.

Official Soil Series Descriptions available from the NRCS Soil Survey Division online at: **http://ortho.ftw.nrcs.usda.gov/osd/** and in the Soil Survey Maps for Middlesex County (USDA/Soil Conservation Service).

## Appendix C. Explanation of Soil Limitations for Recreational Uses

### Select Recreational Limitations

The soils of the survey area are rated according to limitations that affect their suitability for recreation. The ratings indicate the extent to which the soils are limited by all of the soil features that affect the recreational uses. **Slightly** limited indicates that the soil has features that are very favorable for the specified use and that any limitations are minor and can be easily overcome. **Moderately** limited indicates that the soil has features that are moderately favorable for the specified use. The limitations can be overcome or minimized by special planning, design, or special maintenance. **Severely** limited indicates that the soil has one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures, limiting uses, intensive maintenance, or by a combination of these measures.

The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewer lines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation also are important. Soils that are subject to flooding are limited for recreational uses by the duration and intensity of flooding and the season when flooding occurs. In planning recreational facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential. Information on recreational limitations can be supplemented by other information, for example, interpretations for building site development, construction materials, sanitary facilities, and water management.

**Paths and Trails** for hiking and horseback riding should require little or no slope modification (e.g., cutting and filling); therefore the rating is based on soil properties that affect trafficability and erodibility. The best soils for this use are those that are not wet (e.g., firm after rains), dusty when dry, or subject to flooding during the season of use. Soil properties limiting paths and trails include stoniness, depth to a water table, ponding, flooding, slope, and texture of the surface layer. Off-road motorcycle trails require little or no site preparation and are not surfaced or vegetated. Considerable soil compaction is likely. Limitations are based on soil properties that influence trafficability, erodibility, dustiness, and the ease of revegetation, e.g., stoniness, slope, depth to a water table, ponding, flooding, and texture of the surface layer.

**Camp Areas** require site preparation such as shaping and leveling for tent and parking areas, stabilizing roads and any intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils for this use have mild slopes and are not wet or subject to flooding during the period of use. Soil properties limiting the ease of developing camp areas include slope, stoniness, and depth to bedrock or a hardpan. Soil properties that affect the performance of camp areas after development are those influencing trafficability and vegetation growth. For good trafficability, the surface of camp areas should absorb rainfall readily, remain firm under heavy foot traffic, and not be dusty when dry. Trafficability is affected by the texture of the surface layer, depth to a water table, ponding, flooding, saturated hydraulic conductivity (Ksat), and large stones. Good vegetative growth, especially in heavily used areas, is affected by the depth to bedrock or a hardpan, Ksat, and presence of toxic substances in the soil.

**Picnic Areas** are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils are firm when wet, not subject to flooding during the period of use, not dusty when dry, have mild slopes and limited stoniness. Soil properties affecting the ease of developing picnic areas are those influencing trafficability and the growth of vegetation after development (see Camp Areas above).

*From: Soil Survey Maps for Middlesex County (USDA/Soil Conservation Service)*

**Appendix D. Plant Species List for Great Cedars Conservation Area East**

| TREES | | |
|---|---|---|
| **SCIENTIFIC NAME** | **COMMON NAME** | **HABITAT** |
| *Acer rubrum* | Red maple | PFW; MH |
| *Acer saccharum* | Sugar maple | MH |
| *Alnus incana* | Speckled alder | PFW |
| *Betula alleghaniensis* | Yellow birch | PFW |
| *Betula lenta* | Black birch | MH |
| *Fraxinus americana* | White ash | MH; PFW |
| *Juniperus virginiana* | Red cedar | MH; RC |
| *Liriodendron tulipifera* | Tulip poplar | MH |
| *Nyssa sylvatica* | Black gum | PFW |
| *Prunus serotina* | Black cherry | MH |
| *Quercus alba* | White oak | MH |
| *Quercus coccinea* | Scarlet oak | MH |
| *Quercus rubra* | Red oak | MH |
| *Quercus velutina* | Black oak | MH |

| SHRUBS and VINES | | |
|---|---|---|
| **SCIENTIFIC NAME** | **COMMON NAME** | **HABITAT** |
| *Berberis thunbergii* | Japanese barberry | MH; PL |
| *Celastrus orbiculatus* | Oriental bittersweet | MH, PL |
| *Cephalanthus occidentalis* | Buttonbush | M |
| *Clethra alnifolia* | Sweet pepperbush | PFW |
| *Gaylusaccia baccata* | Huckleberry | RC |
| *Kalmia latifolia* | Mountain laurel | MH |
| *Ligustrum vulgare* | Common privet | MH; PL |
| *Lindera benzoin* | Spicebush | PFW |
| *Lonicera japonica* | Japanese honeysuckle | MH; PL |
| *Lonicera morrowii* | Morrow's honeysuckle | MH; PL |
| *Parthenocissus quinquefolia* | Virginia creeper | MH |
| *Rosa palustris* | Swamp rose | M |
| *Rubus flagellaris* | Dewberry | MH; PFW |
| *Rubus phoenicolasius* | Wineberry | MH |
| *Smilax glauca* | Cat brier | MH |
| *Smilax rotundifolia* | Greenbrier | MH; PL |
| *Spiraea latifolia* | Meadowsweet | M |
| *Spiraea tomentosa* | Steeplebush | M |
| *Toxicodendron radicans* | Poison ivy | MH; PFW |
| *Vaccinium angustifolium* | Lowbush blueberry | RC |
| *Vaccinium corymbosum* | Highbush blueberry | PFW |
| *Viburnum acerifolium* | Maple-leaved viburnum | MH |
| *Viburnum lentago* | Nannyberry | PFW |
| *Vitis labrusca* | Fox grape | MH; PL |

PFW – palustrine forested wetlands, MH – mixed hardwoods, RC – red cedar, PL – power line, M – open marsh

| HERBACEOUS SPECIES | | |
|---|---|---|
| **SCIENTIFIC NAME** | **COMMON NAME** | **HABITAT** |
| *Anthoxanthum odoratum* | Sweet vernal grass | PL |
| *Calopogon tuberosus* | Grass pink | PL |
| *Caltha palustris* | Marsh marigold | PFW |
| *Cardamine* sp. | Bitter-cress | PFW |
| *Carex bromoides* | Sedge | PFW |
| *Carex exilis* | Sedge | M |
| *Carex laxiculmis* | Sedge | MH |
| *Carex laxiflora* | Loose-flowered sedge | MH |
| *Carex pensylvanica* | Pennsylvania sedge | MH |
| *Carex stipata* | Sedge | MH |
| *Carex stricta* | Tussock sedge | M |
| *Carex swanii* | Swan's sedge | MH |
| *Carex* spp. | Sedges | MH; M; PFW |
| *Cirsium vulgare* | Bull thistle | PL |
| *Cladium mariscoides* | Smooth sawgrass | M |
| *Danthonia spicata* | Oatgrass | RC |
| *Dennstaedtia punctiloba* | Hay-scented fern | MH; PFW |
| *Dulichium arundinaceum* | Three-way sedge | M |
| *Juncus effusus* | Soft rush | M |
| *Juncus* sp. | Rush | M |
| *Juncus tenuis* | Path rush | M; MH; PL |
| *Ludwigia palustris* | Seedbox | M |
| *Lycopodium lucidulum* | Shining clubmoss | MH |
| *Maianthemum canadense* | Canada mayflower | MH |
| *Monotropa uniflora* | Indian pipe | MH |
| *Osmunda cinnamomea* | Cinnamon fern | PFW |
| *Panicum clandestinum* | Deer tongue grass | PL |
| *Phragmites australis* | Common reed | M |
| *Polystichum acrostichoides* | Christmas fern | MH; PFW |
| *Satureja vulgaris* | Wild basil | PL |
| *Scirpus cyperinus* | Woolgrass | M |
| *Symplocarpus foetidus* | Skunk cabbage | PFW |
| *Thelypteris noveboracencis* | New York fern | MH, PFW |
| *Thelypteris palustris* | Marsh fern | M |
| *Triadenum virginicum* | Marsh St. Johnswort | M |
| *Verbascum thapsis* | Common mullein | PL |
| *Viola blanda* | Sweet white violet | PFW |
| *Viola cucullata* | Marsh blue violet | PFW |

PFW – palustrine forested wetlands, MH – mixed hardwoods, RC – red cedar, PL – power line, M – open marsh

## Appendix E. Non-Native Invasive Species Fact Sheets

# Invasive Plants Fact Sheet

## Bush Honeysuckles Lonicera tatarica L., L. morrowii A. Gray, L. mackii (Rupr.) Maxim, L. xylosteum L., L. x bella Zabel Honeysuckle Family (Caprifoliaceae)

Status: Common and invasive in Connecticut. Description: Bush honeysuckles are upright, generally deciduous shrubs that range from six to sixteen feet in height. Tatarian honeysuckle (L. tatarica L.) has smooth, hairless, bluish-green leaves and pink or white flowers that do not turn yellow as they age. Morrow honeysuckle (L. morrowii A. Gray) has downy leaves and white flowers that turn pale yellow as they age. Bella honeysuckle (L. x bella Zabel) is a hybrid between tatarian and Morrow honeysuckle. Amur honeysuckle (L. mackii [Rupr.] Maxim) has dark green leaves that are hairy on the veins and white flowers that yellow with age. European Fly honeysuckle (L. xylosteum L.) has yellow flowers and leaves that are hairy underneath.

Preferred habitat: Abandoned fields, roadsides, woodlands, and edges of marshes are all places to find bush honeysuckles. They tolerate varying moisture levels and moderate shade, but prefer open areas and achieve the greatest fruit production when in full sun.

Seasonal cycle: Bush honeysuckles leaf out early in the spring before many native species and hold their leaves until November. They flower in May and June and fruit in July and August. The flowers are fragrant, tubular, and borne in pairs. The fruit is a many-seeded, red, orange, to yellow berry. Distribution: In North America, bush honeysuckles have naturalized from New England south to North Carolina and as far west as Iowa. All the bush honeysuckles are found in the central portion of this area, yet each has a slightly different, overlapping range.
Other points of interest: Bush honeysuckles are native to Europe, eastern Asia, and Japan. Most species were introduced as ornamentals in the 1800s; tatarian honeysuckle is a popular ornamental shrub that was introduced from southern Russia in 1752. Amur honeysuckle is a problem in the midwestern United States, where it forms dense stands and shades out native herbaceous groundcover. The spread of bush honeysuckles is generally accomplished by birds, which consume the ripened fruit in the summer.

Control: Light infestations may be cleared by hand with a shovel or hoe. For control to be effective, the entire root must be removed. Severe infestations may be controlled by repeated treatments of cutting, burning or applying herbicide. Cutting should be conducted during the early spring and again in the late summer or early fall. A glyphosate herbicide (20% solution) may be applied to the leaves or freshly cut stumps late in the growing season. If prescribed burning is chosen, it should be conducted during the growing season. Control methods must be repeated for a period of three to five years to inhibit growth of new shoots and eradicate target plants. To prevent re-invasion, "underplanting" disturbed woods with tolerant native woody species may be effective. Additional information sources: Invasive Plant Species of Virginia. Bush Honeysuckles. C. Williams. 1994. Virginia Department of Conservation and Recreation and

Virginia Plant Society. Plants Invasive in Rhode Island L. Gould and I. Stuckey. The Rhode Island Wild Plant Society Newsletter, Vol. 6, No. 2: September 1992. Vegetation Management Guideline: Bush Honeysuckles. R. Nyboer. Natural Areas Journal Vol. 12 (4) 1992. Element Stewardship Abstract for Lonerica tatarica, L. morrowii, and L. X bella. C. K. Converse. 1985. The Nature Conservancy. Unpublished document. Diagnostic information: Tall shrub (6 to 16 feet tall). Leaves: Opposite, simple. Ovate to oblong, 1 to 2-1/2" long, rounded at base. Flowers: Small, fragrant, axillary; lips equalling or longer than the tube; upper four-lobed to its base. Style hirsute. Fruit: Berries many-seeded; red or yellow; 1/4" in diameter; borne in pairs usually on axillary peduncles. Stems and branches: Wide spreading stems; slightly drooping branches. Older branches hollow. 

The Nature Conservancy, Connecticut Chapter 55 High Street Middletown, CT 06457
Department of Environmental Protection Geological and Natural History Survey Natural Diversity Data Base
79 Elm Street Hartford, CT 06106

# Invasive Plants Fact Sheet

## Common Reed Phragmites australis Grass Family (Gramineae or Poaceae)

Status: Common and invasive in Connecticut.

Description: Common reed is a tall perennial wetland grass, up to 15 feet in height, with a distinctive purplish-brown plume that appears in late July. The vertical stems (culms) arise from horizontal shoots that grow either above or below ground. This plant can spread ("run") over large areas.

Preferred habitat: Common reed thrives in sunny wetland habitats and prefers fresh or brackish water. Although it can tolerate salt water, growth is usually stunted. It cannot withstand strong wave action or running water because the vertical stems break easily. Common reed grows in drier elevated marsh areas, but can also be found along lakeshores, riverbanks, and almost any moist area. It is particularly prevalent in disturbed or polluted soils, and can tolerate highly acidic conditions.

Seasonal Cycle: Stands of common reed are established through dispersal of seeds or pieces of underground stems called rhizomes. Once established, stands grow predominately by sending up new shoots each spring from existing rhizomes, or from aboveground runners called stolons. If an aerial shoot is knocked over, it can act like a rhizome, taking root and producing new shoots. This invasive grass can return year after year, and some stands are believed to be 1,000 years old. The purplish flower head turns grey and fluffy as it goes to seed by August. Leaves die and fall off at the end of the season, leaving the familiar tan stalks and plumes that remain standing through winter and eventually decay.

Distribution: Common reed grows in temperate zones all over the world, and can be found in every state in the United States. It is common in the Northeast. Contrary to popular thought, common reed is native to America; remains of it have been found in 3,000-year-old peat deposits from Connecticut tidal marshes. However, a non-native strain of Phragmites australis may have been imported in the early 1900s. Other points of interest: The word phragmites comes from the Greek word phragma, which means fence. It refers to the impenetrable masses of common reed that often form continuous belts in roadside ditches and along upper borders of salt marshes. The largest known stand occupies 7,000 acres in the Hackensack Meadows adjacent to New York City. Although common reed was generally thought to have low wildlife value, preliminary research indicates otherwise. Common reed is part of the diet for geese and muskrats that eat the rhizomes. It particularly attracts redwing blackbirds and sparrows that use it for cover and nesting.

Control: Common reed has become more widespread due to human-induced changes in nutrient and salinity levels. It grows at rapid rates, displacing more diverse marsh vegetation, and has

come to symbolize marsh degradation. However, it must be understood that aggressive common reed growth is a symptom of environmental imbalance, and not the cause. Common reed can be a natural, non-invasive, part of the landscape in undisturbed areas. The first step in containing its spread is to minimize land disturbances (particularly those involving erosion and sedimentation), fluctuating water levels, nutrient loading (especially nitrates) and pollution. Often, reintroduction of tidal flow to coastal marshes helps to limit its growth. Although the role of seeds in establishing new colonies is uncertain, careful disposal of common reed plumes, as from decorative floral arrangements, is recommended. Herbicide control is a two-year, two-step process at the very least. Stands can be treated with Rodeo¨, the herbicide of choice for work in wetlands. It is most effective when applied in the early fall when nutrients are being displaced from the leaves and stems for storage in rhizomes. A permit from DEP (Department of Environmental Protection) is required to purchase and/or use Rodeo¨ in Connecticut wetlands. In the winter, dead culms can be cleared by controlled fire or cutting/mulching to open the area for desired species. The process usually needs to be repeated in the second year to reduce the number of remaining plants, and repeated every three to five years after that. Mechanical cutting may also contain it, and recent efforts with black plastic have had some success. In any case, there is no easy solution to the control of this aggressive species.

Additional information sources: A Field Guide to Coastal Wetland Plants of the Northeastern United States. Ralph W. Tiner, Jr. The University of Massachusetts Press, Amherst 1987. Wetlands -- Audubon Society Nature Guide. William A. Niering. Chanticleer Press, New York 1985. For more detailed information: Natural Areas Journal, 1994. Vol. 14, pp. 285-294. Phragmites australis (P. communis): Threats, Management and Monitoring. M. Marks, B. Lapin, and J. Randall. Diagnostic information: Flowers: dense, many branched terminal inflorescence (panicle 8-16 inches long) with silky hairs longer than lemmas; spreading and ascending branches are purplish when young, white or brown at maturity. Leaves: long, flat, and up to 2" wide, greyish-green, tapering, distinctly arranged in two ranks; sheaths open with ligule at junction of blade. Stems: round, hollow, and upright; persistent throughout fall and winter. 

The Nature Conservancy, Connecticut Chapter
55 High Street Middletown, CT 06457
Department of Environmental Protection Geological and Natural History Survey Natural Diversity Data Base
79 Elm Street Hartford, CT 06106

# Invasive Plant Fact Sheet

## Asiatic Bittersweet Asiatic Bittersweet Celastrus orbiculatus Thunb. Staff Tree Family (Celastraceae)

Status: Common and invasive in Connecticut.

Description: Asiatic bittersweet is a non-native woody vine with yellow fruits which split to reveal showy bright red seeds. It is also commonly referred to as Oriental bittersweet. This highly invasive species entwines its round, brown stems about other plants and structures, climbing as high as sixty feet. Approximately two weeks after autumn foliage's peak, the leaves turn golden-yellow and are easily sighted.

Habitat: In its native Asia, this species dominates lowland slopes and thickets. Here in North America, Asiatic bittersweet is extremely successful in almost any habitat type, such as disturbed edges, abandoned fields, along coast, and the edge of salt marshes. It prefers utility corridors, fence rows, railroads, and roadways (for example, it is prolific along the Merritt Parkway).

Seasonal cycle: Asiatic bittersweet is a deciduous perennial plant. There are typically separate male and female plants, which bloom in May and June. Bees aid in pollination. The fruit (on the female plant) ripens by September and remains on the vine through winter. Numerous bird species, such as black-capped chickadee, northern mockingbird, European starling (non-native), and blue jay, small mammals, and human activity (such as composting ornamental cuttings) widely disperse the Asiatic bittersweet's seeds. Rootsuckering, the ability to send up shoots from the roots, contributes to the vine's high density once established at a site.

Distribution: Asiatic bittersweet is native to temperate East Asia (Japan, Korea, and China). Introduced to North America in the mid-nineteenth century, it quickly became established from Louisiana to Maine. Asiatic bittersweet reached Connecticut as early as 1916 as an ornamental and is now found throughout the state.

Control: Due to its high reproductive rate, long-range seed dispersal, and rootsuckering abilities, Asiatic bittersweet can quickly disperse through an entire area, threatening upland meadows, thickets, young forests, and beaches alike. Growth of native vegetation is extremely limited beneath bittersweet's dense shade, and it tends to strangle small trees and shrubs by growing around their stems, constricting the flow of the plant's fluids. Many supporting plants also succumb to wind and ice storms with the added weight of the vine. Asiatic bittersweet also has the capacity to hybridize with American bittersweet (Celastrus scandens), cross-pollinating to the extent of modifying the genetic differences between the two species. The Connecticut College Arboretum, Connecticut Department of Transportation, and The Nature Conservancy are working to improve the control and management of Asiatic bittersweet. Low patches can be removed by cutting the vine and applying triclopyer herbicide (the active ingredient in Ortho's Brush-B-Gone¨) to the regrowth a month later. For taller patches, the main stems can be cut

and triclopyer herbicide applied immediately to the cut stem and to any subsequent regrowth. Care must be taken to protect the remnant native plant species when cutting to ensure that they revegetate the area. Asiatic bittersweet has a substantial seed bank, and successful removal of the species requires perseverance through two or three years. The Nature Conservancy Connecticut Chapter currently manages Asiatic bittersweet at its Griswold Point Preserve. Other points of interest: Asiatic bittersweet is similar in appearance to the native species American bittersweet. Asiatic bittersweet is distinguished from American bittersweet by the fact that its fruit and flowers are located in clusters of three to seven in the axil of the leaves (between the leaf and the stem). American bittersweet's fruit and flowers are located at the branch tips only. It is very important for land managers, naturalists, and gardeners to distinguish between the native species and the invasive species in any control efforts. Asiatic bittersweet was planted for wildlife food and cover, cultivated to use the fruit-covered vines for decorations, and employed in soil erosion control. Additional information sources: Gray's Manual of Botany. Eighth edition, corrected printing. M. Fernald. D. Van Nostrand Company, New York 1970. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. Second edition. H. Gleason and A. Cronquist. The New York Botanical Garden, Bronx 1991. Diagnostic information: Roots: outer surface is characteristically bright orange. Stem and branches: round and brown. Flowers: small, greenish-yellow, with 5 sepals and 5 petals, clustered in the axil of the leaves. Fruit: 1/4" diameter, change from green to bright yellow as mature, bright scarlet arils. Leaves: 3/4" to 4-3/4" long and 5/8" to 3-1/4" wide, margin is crenate to serrate, base is cuneate to obtuse, tip is acute to rounded, change from green to golden-yellow as mature.



The Nature Conservancy, Connecticut Chapter 55 High Street Middletown, CT 06457
Department of Environmental Protection Geological and Natural History Survey Natural Diversity Data Base
79 Elm Street Hartford, CT 06106

# Invasive Plants Fact Sheet

## Japanese Honeysuckle Lonicera japonica Thunberg Honeysuckle Family (Caprifoliaceae)

Status: Common and invasive in Connecticut.

Description: Japanese honeysuckle is a woody perennial trailing or twining vine. Its individual runners can grow more than 30 feet in length; it roots at the nodes of the pubescent runners. Leaves are simple, opposite and oval to oblong in shape. Occasionally, young leaves are lobed. Japanese honeysuckle's flowers are fragrant, two-lipped, one to two inches in length, and white, changing to yellow with age. Fruit is a many-seeded, purple-black, pulpy berry. Preferred habitat: Japanese honeysuckle is found in thickets, borders of woods and roadsides, and meadows. It occurs primarily in areas where natural or human disturbances have provided a light gap in the canopy. It can also be found in shaded areas, but most rapid growth occurs in areas exposed to sun.

Seasonal cycle: Japanese honeysuckle flowers from late May through the summer, and fruits from July through the fall. Late in the season, it continues photosynthesis after most associated native plants have become dormant. The stem and some of the leaves persist through the winter, resulting in an evergreen or semi-evergreen plant.

Distribution: In North America, Japanese honeysuckle is naturalized from Maine, Massachusetts, and New York, south to Texas and Florida and west to Missouri and Indiana. Other points of interest: Not native to this area, Japanese honeysuckle was introduced to North America from Japan in the 1800s as an ornamental shrub and vine. It has also been used for soil erosion control along railroads and highways. The berries of Japanese honeysuckle are a source of food for wildlife, especially mockingbirds, and other birds that disperse seeds. It is a serious threat to native plant species because of its capacity to strangle and destroy supporting trees and shrubs. Japanese honeysuckle is distinct from two other trailing honeysuckles, the trumpet honeysuckle (L. sempervirens) and wild honeysuckle (L. dioica), found in Connecticut. The fruits of the other honeysuckles are red to orange-red berries, and their uppermost pair of leaves are joined together.

Control: Being semi-evergreen, Japanese honeysuckle is easier to detect during the fall when most native species have dropped their leaves. Control methods for Japanese honeysuckle in areas of heavy and light infestations include mowing, grazing, prescribed burning, and the application of herbicides. Mowing and grazing reduces the spread of vegetative stems but does not completely remove the vegetation; instead, vigorous resprouting increases stem density. Small populations may be controlled by careful hand pulling, grubbing with a hoe or shovel, and removing trailing vines. Glyphosate herbicide (1.5-2% solution, applied during the fall before a hard freeze) is recommended to control Japanese honeysuckle. Care must be taken not to harm

native species as the glyphosate herbicide is non-selective. Additional information sources: Gray's Manual of Botany. Eighth edition, corrected printing. M. Fernald. D. Van Nostrand Company, New York 1970. Japanese Honeysuckle (Lonicera japonica): A Literature Review of Management Practices. J. Evans. Natural Areas Journal Vol.4 (2) 1982. Invasive Alien Plant Species of Virginia, Japanese Honeysuckle (Lonicera japonica Thunberg). C. Williams. 1994. The Department of Conservation and Recreation and the Virginia Native Plant Society. Vegetation Management Guideline: Japanese Honeysuckle (Lonicera japonica Thunb.). R. Nyboer. Natural Area Journal Vol.12 (4) 1992. Diagnostic information: Leaves: ovate or oblong (1-1/2" to 3" long); roundish or broadly cuneate at base; glabrescent or hairy; short petioled, green. Young leaves may be pinnately lobed. Flowers: two-lipped flowers (1"-2" in length); borne in pairs in axils of young branches; the tube about equaling the limb; extremely fragrant; opposite, white, changing to yellow with age. Fruit: a many-seeded, purple-black berry (1/4" diameter). Stems and branches: trailing or twining woody vine. Stems are pubescent. 

The Nature Conservancy, Connecticut Chapter
55 High Street Middletown, CT 06457
Department of Environmental Protection Geological and Natural History Survey Natural Diversity Data Base
79 Elm Street Hartford, CT 06106

Department of Environmental Protection
Environmental and Geographic Information Center
79 Elm St., Hartford, CT 06106 (860) 424-3540

# Invasive Plant Information Sheet

## Japanese Barberry Berberis thunbergii Barberry Family (Berberidaceae)

Ecological Impact: Japanese barberry is commonly planted as an ornamental, as well as for wildlife food and erosion control. Since the fruits are often eaten by birds that subsequently disperse the seeds, the species has easily naturalized. Barberry suppresses the growth of native herbs. It can survive and grow under a broad range of light and soil moisture conditions, from 1-100% full sun and from 10-40+ % soil moisture content. Under high light conditions, removal of barberry is followed by rapid growth of other species. Under low light conditions, response to removal is much slower.

Control Methods: The most effective and least intrusive control for Japanese barberry is physical removal. Shrubs that cannot be removed can be treated with herbicide. For large infestations in fire-adapted communities, burning can be used to kill plants and prevent future establishment.

Mechanical Control: Shrubs can be removed by hand pulling and digging. A hoe, weed wrench, or mattock is suggested to uproot the entire bush and all associated roots. Since roots are fairly shallow, even large shrubs can be uprooted. Thick gloves are recommended to protect hands from the shrubÕs spines. Uprooted plants can be piled to provide cover for small animals.

Chemical Control: Shrubs growing in rock piles, or are otherwise difficult to remove, can be treated with herbicides labeled for brush control, such as glyphosate. Late fall or early spring are the recommended application times since, at these times, most native plants are dormant. Glyphosate is a non-selective herbicide that will kill native species as well as barberry. Thus, managers should be cautious not to spray so heavily that herbicide drips off the target species.

Biological Control: There are no known methods of biological control.

October 1999

## Appendix F. Trail Creation and Maintenance Guidance

***Trail Shorts: A Cursory Look at Trail Maintenance***

***Washington Trails Association Drainage Structures***

***Geosynthetics for Trails in Wet Areas***

# TRAIL SHORTS
# A Cursory Look at Trail Maintenance

## INTRODUCTION

This document focuses on wilderness trails only and is intended to be used as a reference by trail maintenance crews. If you have questions about the contents, please do not hesitate to contact Clay Phillips at the Southern Service Center of California State Parks at (619) 220-5303.

Trail construction and maintenance is an inexact science with many variables. Much depends on the location of the trail, the soil, the climate, and the types of uses. However, there are certain general guidelines which, if adhered to, will prevent most trail deterioration and minimize maintenance costs.

### Trail Problems

Trail users may not be able to articulate what a "perfect" trail looks like, but almost everyone can list the characteristics of a "bad" trail:

1. **Deep Trenching** - The trail is sunken such that hikers feel like they're walking in the bottom half of a pipe and equestrians drag their spurs.
2. **Widening** - The trail has widened from a single or double track to an unsightly wilderness "freeway" of multiple parallel tracks, all trenched to a different degree.
3. **Short Cuts** - Knowing that the shortest distance between two points is a straight line, users create a web of trails, most of which are steep and erosive.
4. **Tripping Hazards** - Regular use and erosion ultimately expose tree roots and rocks.
5. **Steepness** - If a trail is too steep over a long distance one of two things will happen: either people won't use it, or users will not enjoy their excursion.
6. **Impact to Natural / Cultural Resources** - Erosive trails and multiple trails compound the impact that trails have on rare plants and on archaeological sites.

### Causes

All of these problems can be tied to one or more of the following three causes:

1. **Water** is the foremost cause of trail problems. The movement of water causes erosion and deep trenches. It also exposes tripping hazards.
2. **Poor Initial Trail Design** can rarely be overcome, even by regular maintenance.
3. **Inadequate or Inappropriate Maintenance** wastes valuable crew time and can sometimes increase trail problems.

## DESIGNING FOR TRAIL MAINTENANCE

**Ultimately, the most influential component of trail maintenance is the original trail design and alignment.** A well-designed trail will be easier to maintain, will deteriorate more slowly and will be more pleasant to use. On the other hand, a poorly-designed trail is difficult to maintain, deteriorates quickly and, once you lose it, there's not much that can be done to restore it. In addition, a poorly designed trail will always be less pleasant to hike or ride.

**Elements of a Well-Designed Trail**

There are many factors which go into a well designed trail; here we will only look at the elements required from a maintenance perspective.

1. **Gradient**
   Generally, the linear gradient of a trail should be less than 10%. The term "gradient" refers to the ratio of the rise over the run. In other words, an elevation gain of 2 feet in 20 horizontal feet represents a 10% gradient.

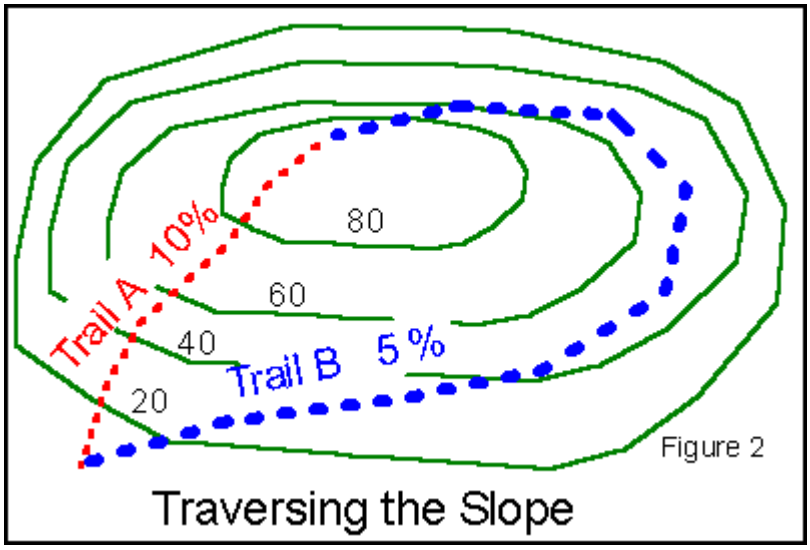

Figure 1

   Ten percent is a good standard, but circumstance may warrant a greater or lesser gradient.

   In highly erosive, sandy soils, a 5% slope may be excessive. Granitic soils are more forgiving and can allow long sections of trail to be constructed at 13 to 15%. It is best to look at existing trail conditions and measure gradients to determine what maximum gradient works best in each unique condition. However, it should be noted that trails less than 10% are far more comfortable to hike and ride. The soils may allow for a trail that exceeds 10%, but the users might not!

2. **Relationship to Existing Contours**
   In map jargon, a contour is a line of points that are at the same elevation. If you walk precisely parallel to a contour, you are walking at a level (0%) grade. If you walk perpendicular to a contour, you are walking either straight uphill or straight downhill. A well-designed trail is laid out to traverse a hillside, closer to parallel than perpendicular to the contours.

   The figure below shows two proposed trail routes to the top of the hill. Although Trail A stays within a gradient of 10%, it is the poorer route because it travels perpendicular to the contours. When a trail runs perpendicular to the contours, water runs down the middle of the trail, causing trenching, even at a 10% gradient. The only way to get water off the trail is for the route to **traverse** the natural slope (Trail B), because then there is always a lower side of the trail. When there is a lower side of the trail, it becomes a simple matter to redirect water across and off the trail, rather than allowing it to cut a channel down the trail's centerline.



3. **Outslope**
   A well-designed trail should be constructed to have a 3% to 4% cross-slope to get the water off the trail as soon as possible. This explains why it is difficult to construct an effective trail in a flat meadow. You can not merely cut out sod and call it a finished trail. It will always be easiest to construct an outsloped trail if the original trail alignment traverses the natural slope as in Trail B, above.

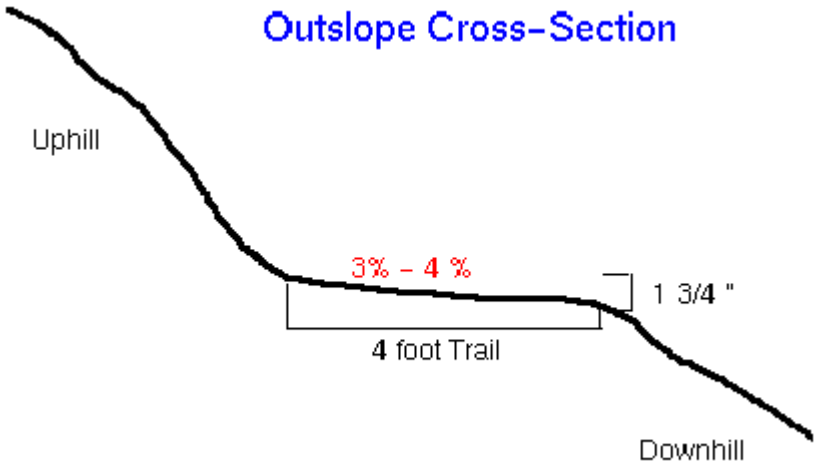


Figure 3

4. **Avoid Switchbacks**
   A "switchback" is any place where the alignment of a trail traverses a slope in one direction and then abruptly "switches back" toward the opposite direction. Switchbacks are often used to run a trail up a steep slope in a constrained location. Although switchbacks are often the only solution to the problems of rock outcrops and steep slopes, they should be avoided where possible. Unless they are perfectly designed and constructed, switchbacks present an irresistable temptation to shortcut the trail and cause erosion over a web of indescriminantly created volunteer routes.

## KEY ELEMENTS OF TRAIL MAINTENANCE

The first step of trail maintenance is to inspect the trail. When erosion problems are evident, the principle questions to ask are, **"Where is the water going and how can I get it off?"**

The following elements represent the primary "tools" to be used in the maintenance of trails. They are generally listed in priority order, but each has its own special application and purpose. Clearly, though, the first 3 (Maintaining the Outslope, Install and Maintain Water Bars, and Maintaining Drainage Dips) are far and away the most important.

### Maintaining the Outslope

This is the first order of business in trail maintenance. It is the simplest, but most labor intensive trail maintenance tool.

Normal trail use will build up a berm along the outside (downhill) edge of the trail (Stage 2 of figure 4). If allowed to continue, the berm will grow and prevent water from flowing off the trail, causing gullying

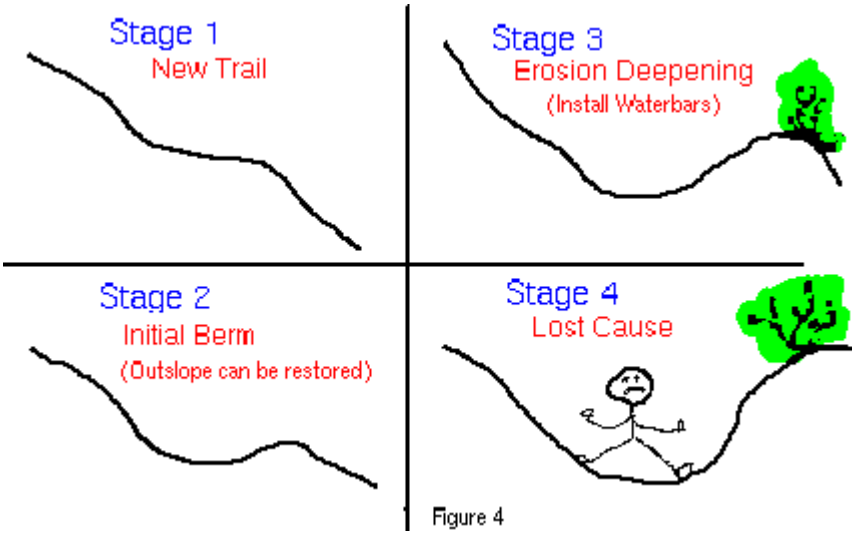


Figure 4

down the centerline of the trail (Stage 3). If this centerline gullying is allowed to continue unchecked, the trail will trench deeper and deeper until it is both unusable and unredeemable (Stage 4).

The outslope is maintained at Stage 2 by simply pulling the small 4" - 5" berm back into the trail tread. This unglamorous work must be performed again and again by trail crews, but in many cases, it the outslope is restored on a regular basis, little or no maintenance is needed of any other kind. However, some use patterns (extensive equestrian use), soil conditions (sandy) and climate conditions (high precipitation) combine to minimize the effectiveness of this maintenance tool; it just has to be done too often to make it worthwhile.

Once a trail has reached Stage 3, the berm is too large and overgrown with vegetation to be removed; the outslope cannot be restored and other maintenance approaches must be employed. When a trail deteriorates to Stage 4, the trail is a lost cause, and the best solution is trail abandonment and relocation.

**Install and Maintain Water Bars**

Water bars divert water off a trail at controlled points along the trail. They can be incorporated in the original construction of a trail, or they can be installed later as a maintenance measure. Done well, a series of water bars can effectively eliminate erosion and stabilize a trail for years. Done poorly, water bars can accentuate trail erosion and become dangerous tripping hazards.

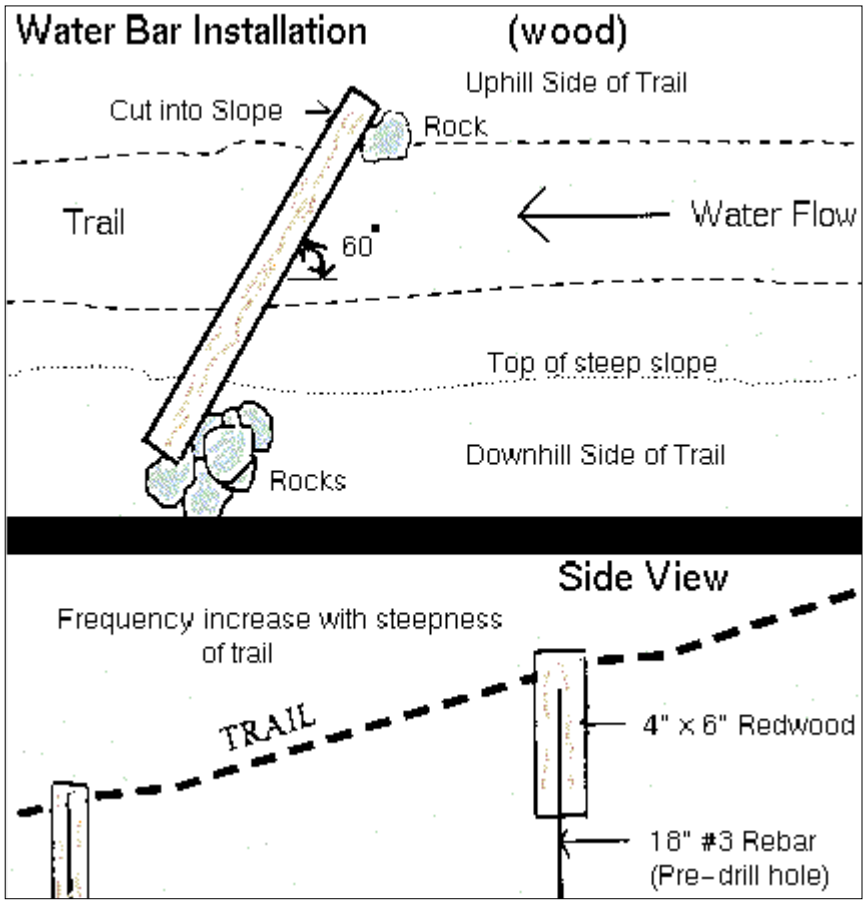
The most permanent water bars are made from native rock obtained on-site. When rock of a suitable size is not available, water bars can be made from 4 x 6 redwood timber, or native logs. Peeler logs or other landscaping products should not be used because their appearance is foreign to a natural environment. Bicyclists prefer a new product made of black rubber that diverts water, but is flexible enough to allow cyclists to easily cross. However, this too, may be inappropriate for a natural environment.

There are many options about the proper installation of water bars. Three trail handbooks will promote three different approaches. Well, here is one more. The elements of a properly installed water bar are:

1. **Set the water bar at a 60 degree angle** across the trail. A water bar set perpendicular (90 degrees) across the trail will not divert the water off. A water bar set 30 degrees across the trail can be awkward to hike or ride over.

2. **Extend the water bar such that water is carried completely off the trail** to a steep side slope. Otherwise, the water flow will bypass the water bar and erosion will occur.
3. **Provide rock at the downslope end** of the water bar to dissipate the energy of the flowing water, thereby minimizing erosion.
4. **The top of the water bar should be nearly flush with the trail tread** to minimize tripping hazards. On first consideration, it may not make sense to make the top of the bar flush with the tread because there would be nothing to "catch" and divert the water. However, we are not concerned about diverting **all** water flowing down a trail, only that amount of water than causes erosion. With the bar flush, its effectiveness only kicks in when there is enough water to erode away a lip on the uphill side of the water bar, which then allows the bar to divert the water flow.
5. **The boulders used for rock water bars must be huge**, otherwise, they will be kicked out of place by a horse. The rocks should overlap like shingles on a roof to prevent water from flowing between rocks and eroding away the integrity of the water bar. In addition, long boulders with one flat side work best to prevent tripping hazards.

Water bars need regular maintenance. The excess soil and debris that build up at the downslope end of the water bar needs to be periodically graded out to assure that water flows off the trail. **Without regular unplugging, a water bar is useless**.



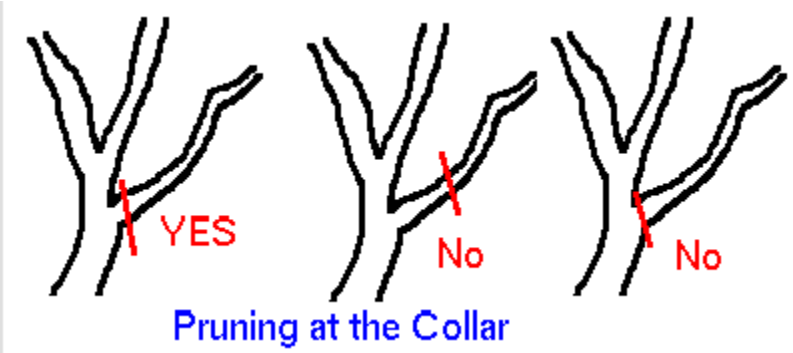
**Maintaining Drainage Dips**
A drainage dip is built into the original trail alignment and is a change in gradient (a "dip" in the trail) that dissipates and diverts water flow (it's like a built-in water bar). Like a water bar, it only remains an effective means of erosion prevention as long as regular maintenance keeps it unplugged.

**Pruning**
Pruning vegetation is an essential and regular part of trail maintenance, especially in brushy chaparral areas. Multi-use trails should have 10' vertical and 8' horizontal clearance (though there will be exceptions for the sake of protecting a tree or skirting around a large boulder).

Too often, trail pruning is accomplished in the most expeditious manner possible -- a branch intrudes within the walking/riding space of the trail and is quickly lopped-off so that it doesn't intrude and the debris is indescriminantly tossed aside. However, our goal in trail maintenance is to **maintain a trail in as natural appearance as possible**. A quick pruning job deals only with the function of trail maintenance, not the aesthetics.

There are 6 elements of acceptable pruning in the State Park System. Each of these elements makes pruning a more tedious maintenance task, but results with a trail that is compatible with the natural environment.

1. **Do not toss debris!** Branches that are randomly discarded usually end up hanging in adjacent shrubs or trees. These dead branches are both unsightly and create a fire hazard.
2. **Place debris out of view.** This element requires the extra effort of dragging branches under and around shrubs.
3. **Place the butt (cut) end away from the trail.** This will help disguise the debris.
4. **Each cut branch should be touching the ground to promote decomposition.** This means that brush piles are not appropriate.
5. **Pruning should be done sensitively so that the trail appears natural** and not as if a chain saw just blasted through. Trail users should not be aware that **any** maintenance work has recently been done.
6. **Prune to the collar of any branch stem** for the health of the shrub and a more natural looking result. At the base of any branch there is a wide section that contains a plant's natural healing agents. Any pruning performed away from this collar will expose the plant to a greater risk of infection. A cut at the collar will naturally heal. For large branches over 2" in diameter, cut from the bottom, then cut down from the top. This prevents tearing of the bark, reducing infection.



**Signing / Mapping**
Adequate signing and mapping keeps trail users on the trail. Uncertainty about which trail is which will lead to new trails being created by trail users. These new trails will become maintenance headaches and will ultimately need to be abolished.

**Check Dams**
Check dams are a popular, though generally ineffective, instrument of trail maintenance. A wood timber is placed 90 degrees across a trail. In theory, the check dam is intended to slow the velocity of water flowing down the trail, thereby reducing erosion. In reality, nearly all check dams only halt erosion in the 2 to 3 feet immediately behind the check dam, but accelerate erosion immediately below and beside the dam. This is because they never take the water off the trail, they only slow it down momentarily. For check dams to be truly useful in stopping erosion, they need to be spaced 3 feet apart, and this effectively makes a stairway out of the trail.

Check dams should not be used in trail maintenance. However, they may have limited application in restoring abandoned trail alignments to natural conditions.

**Import Fill Material**
A deeply trenched trail can be restored by importing dirt or decomposed granite, compacting it, and recreating a well-drained outsloped trail. However, in most situations, this approach is usually both cost prohibitive and far too labor intensive.

## TRAIL REROUTING

Trail rerouting is beyond the responsibilities of a trail maintenance crew. New trail alignments must be flagged by experienced park staff and then reviewed by resource specialists for compliance with the California Environmental Quality Act. Trail maintenance crews can provide valuable assistance by alerting park staff to those trail routes that may need to be rerouted.

There are two measurements that dictate that a trail relocation is needed:

1. When the maintenance crew is dealing with a poorly designed trail that has deteriorated to the extent that remedial measures will not work or will constantly need repair or replacement, AND
2. A significantly better route is available.


The telltale signs of a trail that needs to be relocated are: deep trenching and a gradient exceeding 20% over about 100 feet of trail.

**REFERENCE MATERIAL**

This document represents a cursory look at the basic aspects of trail maintenance and only briefly touches on trail construction techniques. There are many valuable references that dive into much greater detail; a few are listed below. Each of them can be obtained by contacting the sponsoring agency.

**NPS TRAILS MANAGEMENT HANDBOOK**, United States Department of the Interior, National Park Service, Denver Service Center, 1983 (A small, but comprehensive, pocket manual on trails construction and maintenance.)

Trails Coordinator, National Parks Service
P.O. Box 25287, 655 Parfet Street, Denver, CO 80255

**A TRAIL MANUAL**, East Bay Regional Park District, Oakland CA. 1976

**GUIDE FOR MOUNTAIN TRAIL DEVELOPMENT**, United States Department of Agriculture, Forest Service, 1984

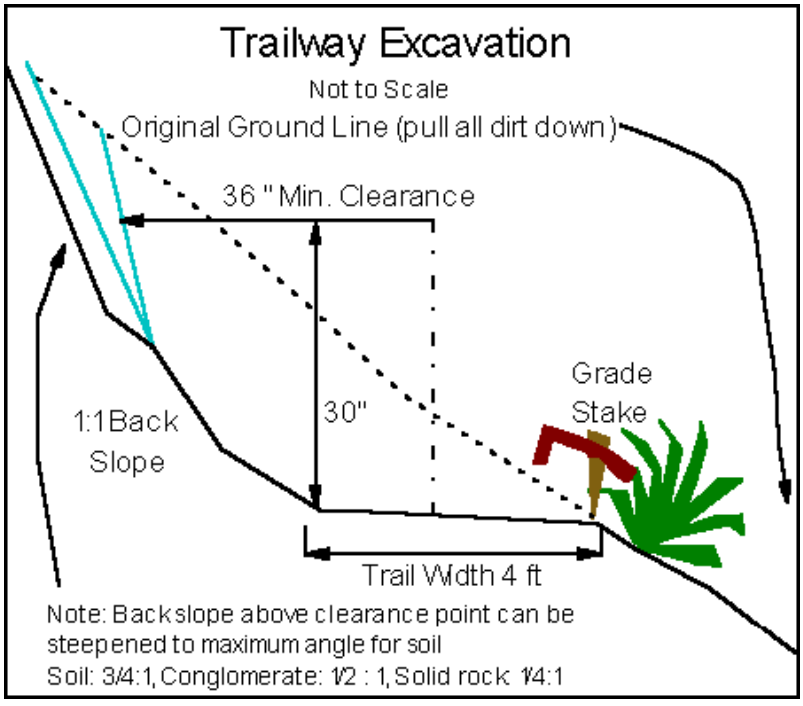
Forest Service - USDA
Engineering Staff - Washington Office, Attn: Publications Specialist
P.O. Box 2417, Washington, D.C. 20013
(703) 235-8198

**TRAIL DESIGN, CONSTRUCTION, AND MAINTENANCE**, Appalachian Trail Conference, Harper's Ferry, 1981

Appalachian Trail Conference
P.O. Box 236, Harpers Ferry, WV 25425
(304) 535-6331

**TRAILS MANUAL,** Charles Vogel, 1968

Equestrian Trails, Inc.
10723 Riverside Drive, North Hollywood, CA



# Trail Work: Drainage Structures

**Available from the Washington Trails Association at:**
**http://www.wta.org/~wta/cgi-bin/wtaweb.pl?6+tw+index**

## WATER PROBLEMS

The biggest natural enemy of our trails system is water. Seasonal stream beds rage across trails ripping out large sections. Standing water from heavy down pours creates boot-sucking mud-holes. Snow melt runs down hillsides and erodes trails. Hillsides saturated with water give way sending tons of mud sliding across trails. Is there anything we can do about it? We certainly can't make it stop raining, not in the Northwest.

There are some practical solutions to keeping water off our trails. Typically the greatest cause of harm by water is when it sees the trail as the path of least resistance and so runs down it turning the trail into a stream-bed washing away the soil leaving exposed roots and rocks. There are two ways to prevent this from happening. The first, explained in the **Rebuilding Tread** section of this guide, is to build a trail with a proper outslope to guide water off the edge. The second is to divert water off the trail or slow its progress before it can do much damage. To do this we turn to some common drainage structures, **drain dips**, **waterbars**, **check dams** and **culverts**.

| The Drainage Structure Order of Operations | |
|---|---|
| **Outslope the trail** | More time consuming, but the best solution. |
| **Drain Dip** | Drain dips are simple and effective, but must be properly built and routinely maintained if they are to last. |
| **Waterbars** | More elaborate structures that require considerable time and materials to build, but are often necessary in heavily used, steep, or very wet trails. |
| **Culverts** | Use in heavily trafficked trails in conjunction with side ditches and turnpikes. |
| **Check dams** | Used only in badly eroded, trenched trails. They don't remove water from the trail, but stop further erosion |

## DRAIN-DIPS

A **drain-dip** or **grade-dip** is a wide, shallow depression sculpted into the tread. Grub hoes and McLeods are great for making drain-dips. The dip should completely cross the trail and be cut at an angle with the outside edge end of the drain-dip further down-trail than the other end. The dip should have an **outslope** (the outside edge should be lower) to carry water off the trail. The up-trail side of the dip should have a gradual slope. A McLeod or shovel is good for doing this. A well constructed drain-dip is often not even noticed by hikers. It appears to be a shallow, naturally occurring dip in the trail. If the dip is expected to carry a lot of water it's a good ideal to build a small rock **spillway**. Piling rocks at the outlet of the drain-dip will slow the erosion of the outside edge of the trail.

Drain dips are great, but they don't last very long. They can quickly become filled in with silt. For a long term solution we need something hardier.

## WOOD WATER BARS

**Waterbars** are drain-dips that have transcended to a higher state of being. They are like drain-dips, but are re-enforced with either rock or a log to help sustain a greater volume of water. Rock waterbars last much longer than wood waterbars, but take longer to make and require a long search for suitable rocks.

To build a wood **waterbar** dig a deep trench across the trail at somewhere between a 45 and 60 degree angle. The angle is important to to reduce the rate at which the waterbar collects silt. If the waterbar is placed straight across the trail it will collect silt quickly and stop working. Next place a peeled log between six to eight inches in diameter in the trench. The log should be embedded at least a foot deep into the hill on the inside edge of the trail. This will help hold it in place. The log should be long enough to span the entire width of the trail. The outside-edge end of the log should be held in place either by wooden stakes, the weight of a large rock, or even steel rebar passing through the log. The down-trail side of the log should be completely back-filled with mineral soil so that no more than one or two inches of the log appears above the surface. The uphill side of the log should have a wide, shallow dip with an outslope much like a drain-dip. At low volumes water will follow the drain-dip off the trail. At higher water volumes the log itself will catch and direct water off. Waterbars should also have a rock spillway to slow erosion.

## ROCK WATER BARS

**Rock Waterbars** last much longer than wood water bars but can be more time consuming to build. First you must construct a trench at a 45 to 60 degree angle across the trail as with a wood waterbars, then place rocks in the trench to re-enforce the down-trail, water-catching side. Finding and positioning the rocks is the challenge. The ideal waterbar rock is a solid rectangular shape about .5 meters long by .3 meters high and .1 meters thick. Rocks like these don't exist in the back country. Nothing even close to this exists in the back country, but it pays to invest some time in finding rocks that are as rectangular as possible.

The rocks should be placed in the drainage ditch so that they are 2/3 buried and they should be overlapping such that the outside-edge-most rocks are fit behind their inside edge most neighbor. This will reduce the chance of the water sneaking through any cracks between the rocks. The rocks should be fit as closely together as possible and any gaps between them should be filled in with smaller rocks, gravel and mineral soil.

Complete the project by back-filling the down-trail side of the waterbar with mineral soil so that no rock is sticking above the surface. Grade the up-trail side to produce a gradual, out-sloped trail-bed leading into the waterbar.

## CULVERTS

When large volumes of water need to be moved across the trail at a single spot, culverts are used. Culverts are often used in conjunction with **turn pikes**. The culvert must be buried at least 8" deep and packed in a surrounding layer of rock and gravel to keep them from being damaged by trail traffic. Water is fed into the culvert by uphill ditches running parallel to the trail. When a turnpike isn't used, the ends of the culvert must be covered with arches of large rock to prevent them from being dented. Today, most culverts are made from attractive stealth-black plastic so they don't show up on radar. Older culverts may be made of aluminum or even wood. Culverts require extra work to maintain and should only be installed in heavily used or heavily impacted areas.

## ROCK CHECK-DAMS

When a trail becomes so badly eroded that it has turned into a deep trench, it can be difficult to divert the water off the trail. This is when we need to get water to work for us by building a **check-dam**. Check-dams (also known as **check-steps**) can be made by building a sturdy wall from large rocks across the trail. The rocks should be large and securely embedded into the ground with as much as 2/3 of the rock buried to insure it won't move. Fill behind the wall with rocks and **mineral soil**. Large flat rocks should be embedded in the trail beneath check steps to prevent erosion from trail users when they step down. The completed project will look like a step. Water will continue to run down the trail, but the check-dam will trap sediment behind it keeping it filled. When a long stretch of trail is badly eroded it is best to build a long series of check-dams like a staircase. Make sure none of the steps are higher than 9". Rock check-dams are very natural in appearance and will continue to do their job for many years. If you're an avid hiker you've probably stepped over hundreds of them with out realizing it.

## WOOD CHECK-DAMS

Check-dams are often built out of wood. Begin by selecting a log about 12" in diameter and 2' longer than the width of the rutted trail. Cut notches a foot back into the banks on either side of the trail. Place the peeled log into cuts. It should be spanning the trail at a 90° angle. Place stakes on the down-trail side of the logs or use rebar to hold the log in place. Fill in behind the log with rock and **mineral soil**. Large flat rocks should be embedded in the trail beneath check steps to prevent erosion from trail users when they step down.

When several wooden check-dams are built in a series the final effect is a handsome flight of steps that will withstand years of water running down the trail.

# Building Turnpikes

If you've hiked much in the Northwest you've probably encountered a **mud-hole** or two. Sometimes mud-holes are caused by a small amount of organic matter on the trail in an area that's poorly drained. These are easy to fix with a little scraping and a drain-dip. More often then not, however, mud-holes are caused by large deposits of organic material, perhaps a large, buried tree that fell hundreds of years ago or may be the trail was built through a bog. The soft, rotting organic material traps water and foot-traffic stirs it up into a muddy mess. As people try to go around the mud-hole it gets bigger and wider. When well-intending people start throwing bark, sticks, logs or pine bows into the the mud-hole it just makes it worse. They're just adding more organic material.

Big mud-holes or boggy areas are ideal locations for a **turnpike**. A turnpike is an elevated walkway constructed of two parallel logs or rock walls filled in with rock and **mineral soil**.

To build a turnpike scrape out as much of the muck as possible. Next dig two shallow, but wide parallel trenches 2-3' apart from one another running along either side of the trail. Put peeled logs 10-12" in diameter into the trenches and place stakes along the outside edges to hold the logs in place. Logs may also be held in place by driving rebar though them into the ground or by connecting them with cross pieces as shown here. When using cross pieces, lap-joints should be used when nailing the pieces together. Rocks may also be used instead of logs. When building rock turnpikes, very large rocks must be used and they must be deeply embedded into the ground to ensure they don't slip out of place. Turnpikes should also have **end caps** - a piece of wood or line of embedded rocks on each end to retain all the fill you'll be putting in the turnpike in the next step.

Fill the turnpike with large, flat rocks as big as you can carry, but not so large that they stick up higher than the logs. Next fill the turnpike with smaller rocks and then even smaller rocks filling in the empty spaces between larger rocks as you go. Finally fill the turnpike with fine mineral soil putting enough to form a crown higher than the logs on either side. This will keep water from pooling in the turnpike.

Trenches on either side of the turnpike should be dug and connected to drain-dips or culverts to allow water to flow around the turnpike and off the trail. Often culverts are placed underneath turnpikes. The final product can be very attractive and durable.

# Building Puncheon

When drainage structures just don't work, when the ground is just too wet and muddy for a turnpike, it's time to build some puncheon. Puncheon is an elevated wooden walkway built to cross swampy or boggy areas. In the back country they're often built from felled logs. Building a piece of puncheon this way is challenging and time consuming. If the puncheon to be built is close to a trailhead it's often easier to bring in dimensional lumber. The puncheon shown below is built from treated cedar -- the material of choice.

**Step 1: Setting the mud-sills:**

The most crucial part of building a stretch of puncheon is setting the **sills**. The sills are the part of the puncheon that make contact with the ground and upon which the rest of the structure sets. The sills must be properly positioned to ensure the puncheon is level and headed the right way. This means excavating, positioning the sills, measuring with a level and guide string, then repeating the whole process over again until every thing is perfect. Any errors made here will be amplified in further steps. Placing mud-sills can be particularly challenging when you're standing in half a foot of mud under half a foot of water.

**Step 2: Placing and connecting the stringers:**

**Stringers** are placed on top of the sills. They run length-wise along the puncheon. Stringers are connected to the sills by drilling through the stringer into the sill and then nailing it down with a large nail. Sometimes a drill hole is made all the way through the sill and a piece of steel **rebar** is pounded deep into the ground as well.

**Step 3: Placing the decking:**

The **decking** is the traveling surface of the puncheon. In the back country it's often made from thick slices of split cedar. Here we're using cedar 2x4s for our decking. The decking is carefully placed to make sure there's just enough space between each piece to allow loose change and car keys to fall between them. After a piece of decking is positioned it's nailed to the stringers.

**Step 4: Admiring your work:**

This piece of puncheon built by the WTA on March 20-21 1997 can be found on the Champion Tree Farm Nature Trail near lake Kapowsin just south of Orton. The trail is being built with the help of WTA volunteers to allow Champion's wildlife biologist to give disadvantaged youth a chance to enjoy some of the great outdoors that those of us who are avid hikers often take for granted.

The trail leads into an environmentally sensitive wetland area set aside by Champion. The puncheon itself runs along the edge of a pond traveling over several inches of water and mud. It will allow young nature-lovers to get a closer look at ducks, cat-tails, water bugs and a chorus of Pacific Tree frogs.


**A review of basic puncheon terminology**

showing the relationships between **sills**, **stringers** and **decking**.

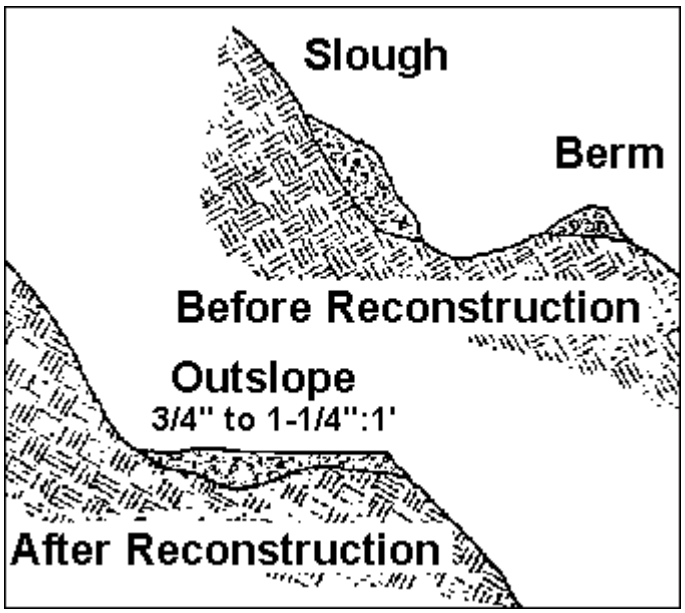
# Rebuilding Tread

To keep a trail in good shape we need to keep water off of it as much as possible. Our job is made much easier if we build the tread properly in the first place. A typical hiker trail should be two feet wide and have a gentle **out-slope**. This means the **outside edge** of the trail should be lower than the **inside edge** of the trail -- about two inches lower for a two-foot wide tread. This will encourage water to run off the trail rather than down it. The forces of nature don't care much for this design and are continually working to undermine it.

Three major factors work together to ruin a trail. First, mud and other debris slide down onto the trail. This is called **slough**. Slough blocks or narrows trails. Second, plants growing along the outside edge of the trail cause the formation of **berms**. Berms trap water on the trail leading to erosion. Lastly, trail users whether wheels, hooves or boots wear down the tread with heavy use.

When rebuilding trails we use McLeods, Pulaskis, grub hoes and shovels to remove slough, dig out berms and widen the path and restore the tread to its proper design. The completed tread should be two feet wide with the outside edge of the trail being about 2" lower than the inside to facilitate run-off. All **duff** should be removed from the trail leaving behind only **mineral soil**. Duff is the term for the organic matter that litters the forest floor: leaves, pine needles, twigs, bark, etc. Mineral soil is soil that is low in organic content. Soil high in organic content holds water and forms boot-sucking **mud-holes**.

When a trail is too eroded from over-use or heavy water damage, we need to consider building raised trail structures such as **turnpikes** or **puncheon bridges**.



# THE TRAIL FORUM

Conducted by Kim Frederick, Jefferson County Open Space
Lois Bachensky, U.S. Forest Service, Rocky Mountain Region

## Geosynthetics for Trails in Wet Areas

**By Steve Monlux, USFS R1 Engineering**

***Trails on soft, water-saturated soils present special challenges. Improper construction of trails in wet areas leads to soil compaction, sedimentation, multiple trails, and unhappy trail users. Turnpike or puncheon has worked well where rock or wood materials are readily available, but the use of geosynthetics can increase the effectiveness of trail construction methods and offers additional alternatives. Geosynthetic materials have been used increasingly in trail construction over the past 10 years. We present here some guidelines and product informationfor trail managers.***

**Geotextile**, *often called* "*construction fabric,*" *is primarily used for* **separation** *and* **reinforcement** *over wet, unstable soils. It can both support loads and allow water but not soil to seep through.*
**Geonet** *has a thin polypropolene drainage core covered on both sides with geotextile, which provides more* **reinforcement** *in addition to* **separation** *and* **drainage.**
**Geogrid** *is a more open polyethylene structure with high tensile strength that can interlock coarse aggregate into the grid structure.*

### General Guidelines for Geosynthetic Use

Geosynthetics are usually placed directly on the natural ground without prior excavation and covered with trail tread material. Less tread fill can be used over geosynthetic products that are rigid or have high bending strengths because the weight of fill is distributed over a larger area. For example, much more tread fill is required for a single layer of geotextile than for geocell with geotextile. In this example, the cost of importing tread fill must be compared to the increased cost of the geocell.

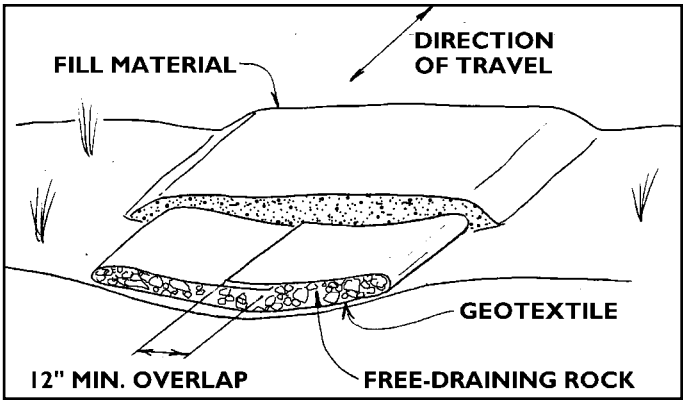
Alternatives that use tread fill should have a crowned surface to shed water quickly, improve stability, and control erosion and sediment. After backfilling, there will be some settlement depending on soil type, level of saturation, and the weight and depth of fill. Additional fill may then be necessary to maintain the crown due to settlement or tread wear. In all cases keep geosynthetics covered to protect them from ultraviolet light and traffic abrasion.

### Geotextile or Geonet (single layer)

This basic application places fill on a single layer of geotextile or geonet which (a) separates fill material from saturated soils, and (b) distributes fill weight so less settlement takes place. Since geonets cost more, use them only where drainage and subsurface moisture conditions are worst. Avoid using organic, silty, or clayey soils for trail tread material since little subsurface drainage will occur, and the trail tread will become muddy in wet weather. Rocky soils or crushed aggregate are the best tread materials since they retain much of their strength when saturated. Excess surface moisture can drain off through these permeable materials if the trail is located on a grade or side slope.

### Geotextile with Encapsulated Free Draining Rock (Sausage Technique)

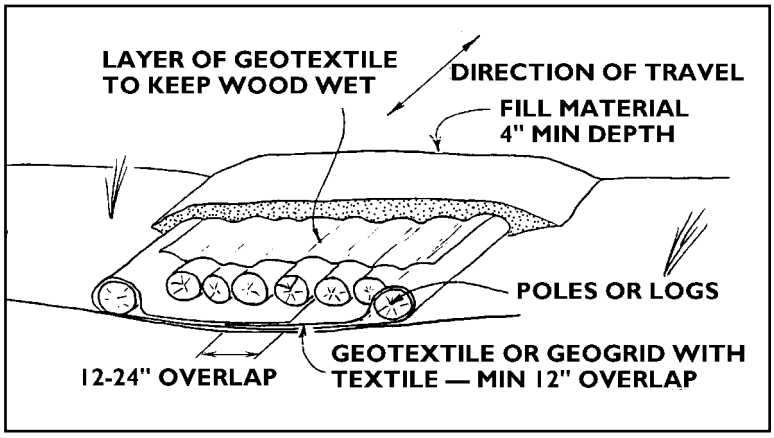
This application involves encapsulating native or free-draining rock in a piece of geotextile and placing fill on top. The geotextile provides separation from the saturated soil, and the rock provides drainage for excess water. One-inch flexible plastic pipe outlets for subsurface water may be desirable where trails are constructed on very flat terrain to avoid the 'bath tub' effect. If the trail has grade, and or if built on a side slope, other drainage options exist.



The rock may be single size material from pea gravel to cobbles (3-12") or a mixture of rock material that does not contain silt or clay. The free-draining rock can be placed to a thickness equal to the largest rock if only drainage is desired. If reinforcement is also needed, at least 3" of rock is recommended. The geotextile is wrapped over the rock layer with a 12" overlap to ensure encapsulation, since settlement of saturated soil can pull the overlap joint apart.

## Geotextile with Poles, Logs

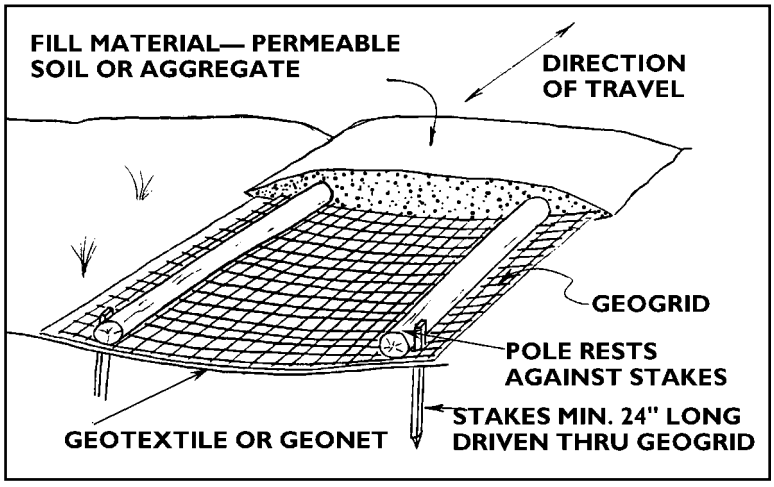
This turnpike application involves wrapping poles, logs, or saplings in geotextile with the poles parallel to the trail. This structure requires less fill and resists being pushed down into soft soils. No subsurface drainage is provided with this design, but longitudinal drainage may occur along the poles if the trail slopes. Another approach is to cut logs to the trail width and place them crosswise, but it does not use log bending strengths as effectively and is more labor intensive. Use an outlet pipe to provide drainage where trails are on a grade or side slope.




Soil settlement is minimal because the wood structure is light weight; the bending strength of wood distributes the weight of fill and traffic; and wrapping trees together with geotextile distributes loads. This method is attractive for areas with wood but not much rock for drainage, and for swampy areas where flotation and bending strength of wood is used. Wood must be kept constantly wet or dry to control rotting. A layer of geotextile down the centerline over the logs will help keep them saturated and securely positioned below the trail tread surface.

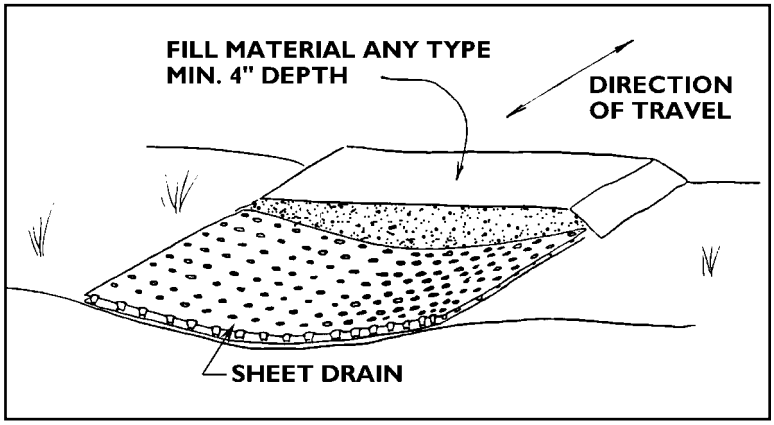
## Geogrid with Geotextile or Geonet

Geogrid placed on top of the geotextile or geonet adds bending strength to the system, and decreases settlement and amount of fill material required. Very little drainage is required with this design unless geonets are used, or if the tread material is permeable (rocky soils or crushed aggregate). The geogrid should be pulled taut to remove wrinkles prior to staking. The stakes and poles provide some pre-tension of the grid, to better utilize its strength. The geotextile or geonet provides separation from the saturated soil and keeps the drainage paths along the bottom of the fill material from clogging.

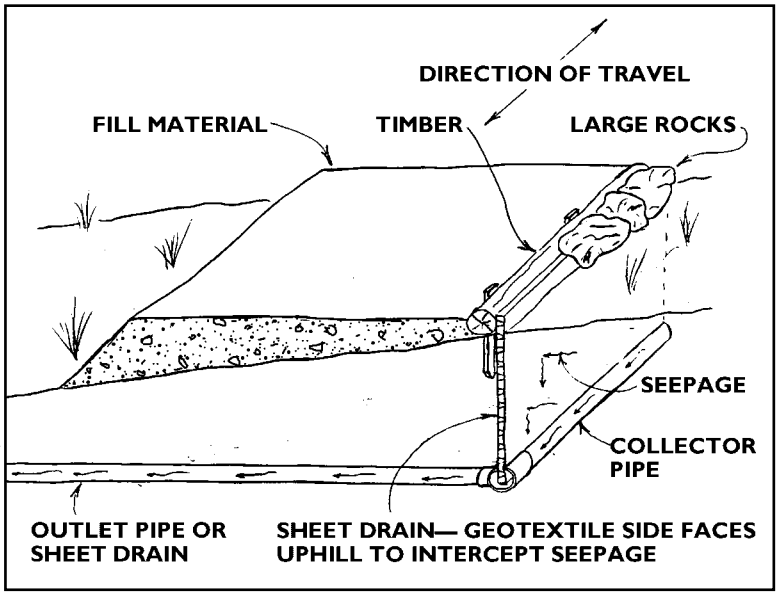



## Sheet Drains under Tread Fill

The sheet drain provides separation from saturated soils and distributes the trail tread weight to limit settlement. Install the product with the plastic core side facing up, and the fabric side facing down. This orientation takes advantage of the plastic core compressive strength and the fabric's tensile strength to reduce settlement and fill required. One-inch diameter flexible plastic pipe can be used as a drainage outlet to take full advantage of the drainage capability of the sheet drain.



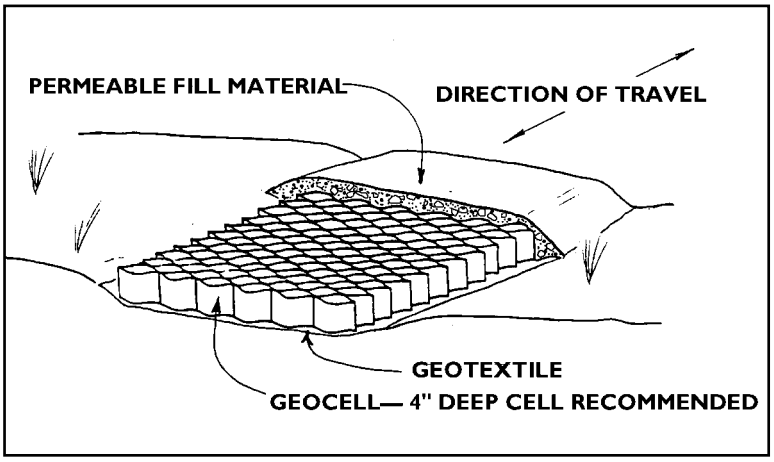
## Sheet Drains Used as Drainage Cutoff Walls




If the trail section is on a side slope where subsurface water saturates the uphill side of the trail, a cutoff wall will intercept surface and subsurface moisture and help drain and stabilize the trail section. This application is especially beneficial where cut-slope sloughing fills in ditches. The sheet drain is placed vertically along the uphill side of the trail within 3 feet of the trail's edge.

Probe the saturated soil with a short length of #4 reinforcing steel to determine the proper depth of the collection pipe and location of the sheet. Collector and outlet pipes can be made from flexible plastic pipe. Keep the top edge of the drain above ground to capture surface runoff moving downslope. Cover the exposed sheet drain with large rocks to protect it from deterioration from sunlight. The collector pipe can be drained into an outlet pipe or with a sheet drain panel under the trail section. This application requires ditching for proper interception and drainage of water. More ditching is normally required on flatter terrain.

## Geocell Backfilled with Geotextile and Permeable Tread Material




The geocell provides confinement chambers which distribute the trail tread loads over a wider area and reduce settlement. The net effect is it increases the load bearing capacity of the tread and prevents feet and hooves from punching down into the trail. The geotextile provides separation between saturated soil and the tread fill. There is no subsurface drainage if the trail is on flat groundl, but on a side slope, drainage will occur through the permeable tread fill. Sandy or rocky soils, crushed aggregate, or rock are desirable fill for geocells. Geocell itself does not increase the load bearing strength of clay or silt.

# GEOSYNTHETIC PRODUCT INFORMATION

The listed manufacturers and products were obtained from the *Geotechnical Fabrics Report, 1995 Specifier's Guide.* The products listed are ones that are readily available. Many other products from these and other manufacturers may be appropriate. Most manufacturers and Geotechnical/Materials Engineers can assist in selecting products if you provide details on soil and moisture conditions, expected loads (light loads for trails), etc.

Prices vary throughout the country due to shipping costs, but for comparison purposes prices are shown in dollars per square yard. Price ranges in parenthesis are in dollars per square yard although manufacturers may use other units or full roll quantities. All geosynthetic products can be either field cut or pre-cut by the manufacturer to meet width requirements and weight handling capability.

### GEOTEXTILES Manufacturers

| Company Name | Phone Number | Product Name/Number |
|---|---|---|
| AMOCO | (800) 445-7732 | 4545 |
| Nicolon/Mirafi Group | (800) 234-0484 | 140N |
| Linq Industries | (803) 873-5800 | 130 EX |

**Price range:** $.63 to $.72 per square meter ($.53 to $.60 per square yard)
**Typical product unit weight:** 0.13 Kg/square meter (0.25 lb/square yard)

**Notes:** These products are non-woven felt-like fabrics that are easier to work with than heat-bonded or slit film products that have a slick surface texture. Compare desired widths with standard roll widths for field or factory cutting. Costs are based on one roll quantities which normally cover 400 to 500 square meters (475 to 600 SY).

**GEONET Manufacturers**

| Company Name | Phone Number | Product Name/Number |
|---|---|---|
| Tenax | (800) 874-7437 | Tenax TNT 204042 |
| Tensar Corporation | (800) 292-4459 | DC 4205 |

**Price range:** $3.50 to $4.60 per square meter ($2.97 to $3.87 per square yard)
**Typical product unit weight:** 0.89 kg/square meter (1.64 lb/square yard)

**SHEET DRAINS Manufacturers**

| Company Name | Phone Number | Product Name/Number |
|---|---|---|
| Mirafi | (800) 234-0484 | Miradrain 6000 |
| Contech | (513) 425-2165 | C-Drain 15K |
| Presto | (800) 558-3525 | Amerdrain 500 |

**Price range:** $6.50 to $8.50 per square meter ($5.40 to $7.11 per square yard)
**Typical product unit weight:** 2.3 Kg/square meter (4.25 lb/square yard)
**Notes:** Compare desired widths with standard sheet widths and consult with manufacturers for field or factory cutting. Various core thicknesses are available. For example, Presto makes a product called Akwadrain with a 25mm core thickness with fabric on both sides, that has significantly greater bending strength which limits the settlement in soft soils, and reduces the amount of fill material required.

**GEOGRID Manufacturers**

| Company Name | Phone Number | Product Name/Number |
|---|---|---|
| Contech | (513) 425-2165 | Tensar BX1100 |
| Tensar | (800) 292-4459 | Tensar BX1100 |
| Carthage Mills | (513) 761-4141 | FX-3000 |
| Tenax | (800) 874-7437 | MS 300 |
| Huesker | (800) 942-9418 | Fortrac 35/20-20 |
| Mirafi | (800) 234-0484 | Miragrid 5T |

**Price rRange:** $2.15 to $4.75 per square meter ($1.80 to $4.00 per square yard). Low-cost products are made from polypropylene, higher-cost products from coated polyester. Both product types are adequate for trails
**Typical product unit weight:** 1.75 Kg/square meter (0.34 lb/square yard)
**Notes:** Specify desired product widths and lengths for the project application.

**GEOCELL Manufacturers**

| Company Name | Phone Number | Product Name/Number |
|---|---|---|
| Presto | 800-558-3525 | Geoweb |
| AGH | 713-552-1749 | EnviroGrid |
| WEBTEC | 800-438-0027 | TerraCell |

**Price range:** $7.50 to $11.30 per square meter ($6.30 to $9.45 per square yard)
**Typical product unit weight:** 1.55 Kg/square meter (2.9 lb/square yard)
**Typical product dimensions:** 4" x 8" (Depth x Length) and 20ft x 8ft (Length x Width)
**Notes:** Specify desired product widths for the project application. The 100 mm (4 inch) cell depth should be adequate for trails - depths from 50 mm to 200 mm (2 to 8 inches) are available. Consult manufacturers for availability of different section widths and alteration of standard section widths to fit your project needs.

***This information is taken from a draft report by Steve Monlux of the U. S. Forest Service's Missouula Technology Development Center in Montana. The full report on geosynthetics and their applications for trail construction will be available by October, 1995. For more information on this topic, contact Lois Bachensky, U.S. Forest Service Engineering, Rocky Mountain Region, 740 Simms, Lakewood CO 80225 (303) 275-5199.***

**The next issue of The Trail Forum will appear in the July issue of Colorado State Trails News. Our planned topic is accessible trails for natural-surface, less-developed areas. Beneficial Designs of Santa Cruz, California, has been doing research on mapping, trail difficulty levels, and improving trail access, and we will report on some of their work and available publications.**