

Red Hill

Ecology, History & Invasive Species Solutions

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Red Hill represents the last remaining undeveloped glacial delta deposit in Union County, providing habitat for plants characteristic of Southern New Jersey's Coastal Plain. This document provides an outline for land management focusing on first of invasive species followed by old field maintenance.

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Executive Summary

Red Hill is a small, 9-acre undeveloped knoll within the Union County Ash Brook Reservation. It is a County owned open space located in Scotch Plains. The reservation was purchased as part of a larger property in the 1950s. Red Hill's portion of the reservation has been the focus of human activities for thousands of years, and it is punctuated by prehistoric sites that have been identified since late 1800s. People through the ages have been attracted to Red Hill by its prominent sandy knoll and proximity to freshwater wetlands.

Red Hill is a glacial outwash delta. It was formed by the Wisconsin Glacier's grinding on the underlying Passaic Formation. The sandy sediment was deposited on Union County's portion of the North American Piedmont as the glacier retreated. Time, climate and vegetation over the succeeding centuries created a soil described by the Union County Soil Survey as Dunellen sandy loam. The more recent history of Red Hill includes forest clearing and farming. Farming has occurred on Red Hill since at least the middle of the 19th century. It continued until the site was added to the Union County inventory of open spaces. The plant cover that has developed on Red Hill is an old field and young woodland. Unlike other Union County natural vegetation, Red Hill's is composed of Coastal Plain species. These plants are an unusual extension of a southern New Jersey habitat in an area otherwise dominated by common Piedmont flora. The vegetation on Red Hill is an important relic of a flora that once had continuity with the southern sand habitats of the Coastal Plain. 20th century urban development isolated Red Hill, making it one of the remaining undisturbed sandy knolls on New Jersey's eastern Piedmont.

The recognition of this unique natural feature prompted the development of this management plan. The area is identified by amateur and professional naturalists alike as an unusual landscape worthy of protection. Protection, in the case of Red Hill, is the management of the Coastal Plain vegetation and the old field succession community. There are two threats to the Hill: Succession into forest and invasive species. Forest will eventually engulf the hill if woody plants are not kept in check. The current invasive species problems are now minor but should be addressed to remove completion with the native relic vegetation. Site management should be low intensity and require the dedication of few resources. The plan relies on the cooperation by Union County land owners and volunteers to implement a hand-cutting and observation driven management plan to maintain the site's integrity. The first task would eliminate the most invasive plants using manual techniques followed by the implementation of a standard 6-step plan to retain the native vegetative.

The 6-steps are 1) developing a stakeholders team, 2) establishing a hierarchy and 3) cooperation channels for 4) clear directions to volunteers. Volunteers would provide the muscle needed to cut woody plants and invasive species while establishing the repeating 5) early detection and rapid response visits necessary to 6) prevent re-invasion and spot new threats necessary to maintain Red Hill's ecological integrity.

Introduction

Red Hill is a natural upland sandy knoll. A sandy feature such as this is uncommon in Union County. Recent investigations by experienced botanists and ecologists describe the small upland hill, called Red Hill, on the northern edge of Ash Swamp. Ash Swamp is a portion of Union County Park's *Ash Brook Reservation*. There are recent written accounts (Bio-Blitz, 2006) that document a flora reminiscent of the New Jersey Southern Coastal Plain Counties. This is contradictory to what one would expect on the Piedmont Physiographic location on which Red Hill exists.

The undeveloped woodland of Ash Brook Reservation and its Red Hill anomaly are a stark difference to the surrounding highly developed Union County landscape. Union County's Piedmont can be described by its geology and the soils derived from the geological deposits. These are normally fine silt, loam and clay over shallow silt rock fragipan. Triassic shale is Union County's base geology and the common red shale produce iron stained red soils. These are the typical conditions found surrounding Ash Brook Reservation. Red Hill's sandy soil, in contrast, is an anomaly. The most recent glacial period applied physical processes that resulted in an isolate sandy knoll within a landscape dominated by silts and clays.

The Rahway River Association is well aware of Red Hill's importance to Union County's inventory of natural features. The Rahway River Association has proceeded to develop a management plan that would protect Red Hill's ecological integrity. The plan outlined in this document would provide short and long term actions for stakeholder participants whose goal is to manage the area for its native Coastal Plain flora.

This document outlines the Red Hill's ecology, its history and proposes a series of steps to maintain the Hill's native flora. The goal is to promote the site's unique Coastal Plain old field vegetation. The Red Hill invasive species plan institutes a few simple steps to address existing immediate problems, followed by maintenance prescription to keep the Hill invasive species free. Federal and State invasive species guidelines provide a ready available and workable framework, following a set of well- tested protocols. Implementing the suggested management tasks would eliminate the problem caused by invasive plants. The ecological management goal would preserve the desired relic old field and succession coastal plain vegetation.



Photo #1: Native Red Hill Tree, Black Oak, *Quercus velutina*

Part I: Red Hill's Description

Physical Features

Site Location

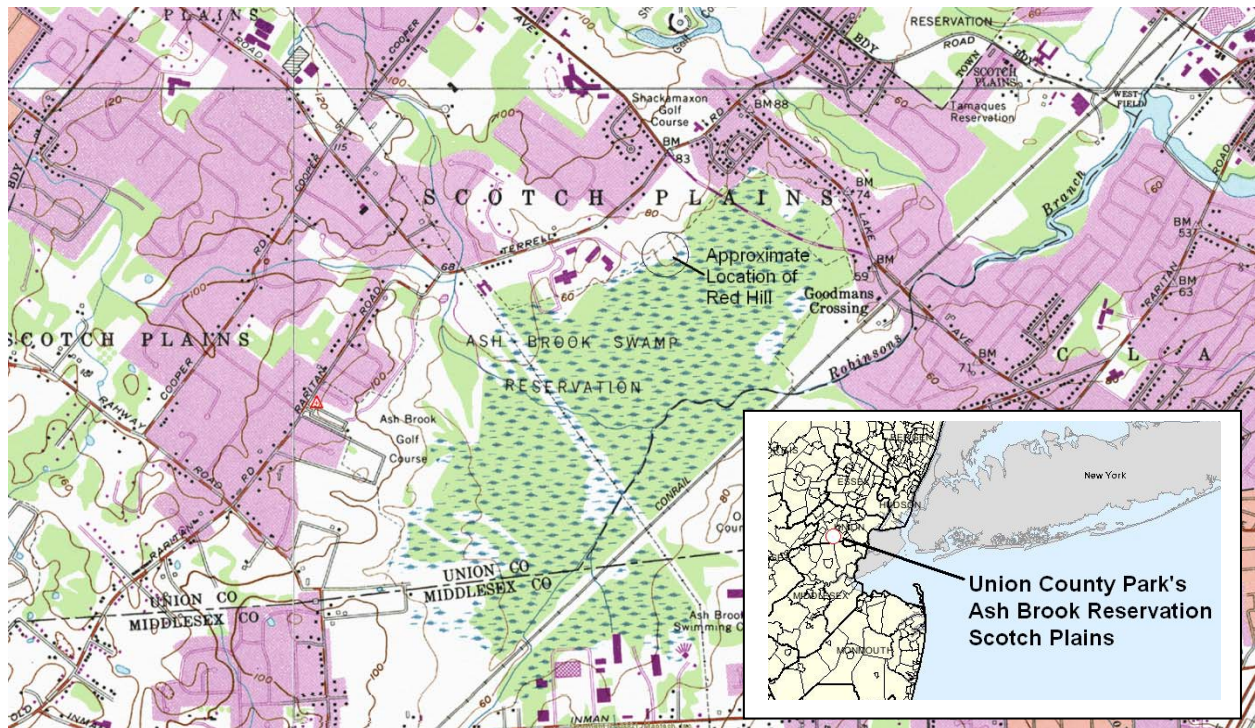


Figure 1: Ash Brook Reservation illustrated on USGS Topographic Map, Perth Amboy, NJ; Inset NJ DEP i-Map Municipal Boundaries

Red Hill occupies a position within the Ash Brook Reservation. This is part of the Union County park system, and is associated with the well-known Ash Brook Golf Course, a 6,500 yard par 72 public facility. Created between 1950 and 1952, the Ash Brook Reservation began with the golf course. The remaining acreage was added as a wildlife sanctuary. Money for the purchase of the Reservation began with funds received for compensation from the development of the Garden State Parkway. The Parkway paid the Union County Park Commission \$709,000 for 46 acres impacted by the State highway's expansion into County owned land. The compensation for the 46 acres of parkland provided sufficient funds to purchase an additional 405 acres elsewhere in the County. Part of the purchase was between 1950 and 1954, when 195 acres were bought within Ash Swamp. This was the first step in obtaining title to the 650-acres present in the Reservation today (Cunningham, 1971). A proposal to use the tract for recreation has been around since 1979 (*The Times* news article, November 1979) and continues to be discussed as a possible use of the Reservation's remaining upland acres.

The Reservation is located in or immediately adjacent to several Union County municipalities: Scotch Plains, Clark, Westfield, and Plainfield. A portion of the swamp is not within the Union County park system and is found in adjacent South Plainfield, Middlesex County.

Physiographic Location

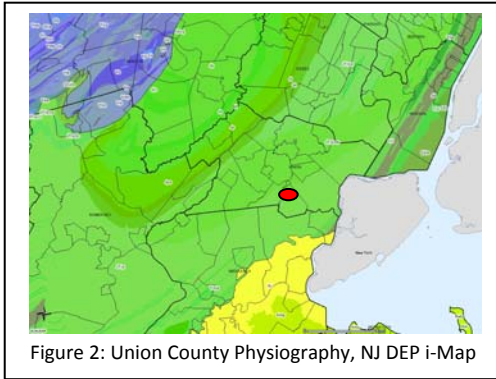


Figure 2: Union County Physiography, NJ DEP i-Map

Red Hill (red dot, left, i-Geology GIS) occupies a position on North America’s Piedmont Plateau Province. The Piedmont Plateau presents the Continent’s first exposure of hard rock geology. New Jersey’s Piedmont is well known for its Jurassic / Triassic red shale and other red and gray silt stones. The Piedmont is sandwiched between the unconsolidated Coastal Plain’s Late Cretaceous Period - Mesozoic Era / Tertiary Period -Holocene Era sand and clay deposits, and the ancient Highland Region’s Precambrian bed rocks. New Jersey’s Piedmont provides an ideal

landscape for many human uses. First agriculture then residential uses cleared forest from most of Union County’s Piedmont, resulting in one of the most densely developed landscapes in New Jersey.

Red Hill is a prominent topographic rise situated within the Reservation’s northeastern corner. It is an oblong sand deposit 1,600’ due south of the Old Raritan Road and Martine Avenue intersection (place name *Willow Grove*). The sandy knoll occupies 8.99-acres, centered around New Jersey State Plain Coordinate 650,077 North, 532,870 East (1983 NAD). Red Hill is found at the junction of Block 13901 Lot 3 and Lot 10; Block 14101 Lot 1. It is presently undeveloped, found behind residential and educational uses.

Surface Geology:

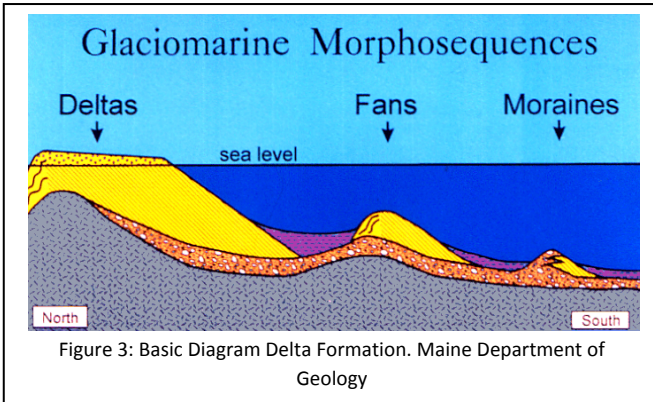


Figure 3: Basic Diagram Delta Formation. Maine Department of Geology

The recent Wisconsin glacial epoch created conditions that allowed advancing and retreating glaciers to cut and ground the underlying Jurassic / Triassic shale, mixing this material with deposits carried from lands previously eroded by the glacier. As the glacier finally retreated for the last time, outwash processes created a delta, composed of fine sandy loam soil, a texture uncharacteristic of Union County. The Red Hill is the

southwestern edge of a deltaic deposit, and is a relic land form with few remaining intact local analogs. Once free of glacial influences, Red Hill became exposed to wind and rain. Many of years of battering katabatic winds and seasonal rains eroded this sandy deposit into the form present today. Red Hill survived the development onslaught by a series of chance events as well as its location and orientation. This sand knoll has a southeast-northwest orientation, with exposed southern slopes.

Bedrock Geology

The NJ Geological Survey (i-Map, 2009) identifies the base geology under Red Hill is Triassic (245 Million YBP) / Jurassic (208 Million YBP) Period Passaic Formation mudstone facies. The sedimentary mudstone was deposited in playas and similar quite water conditions. The Passaic formation mudstone and its

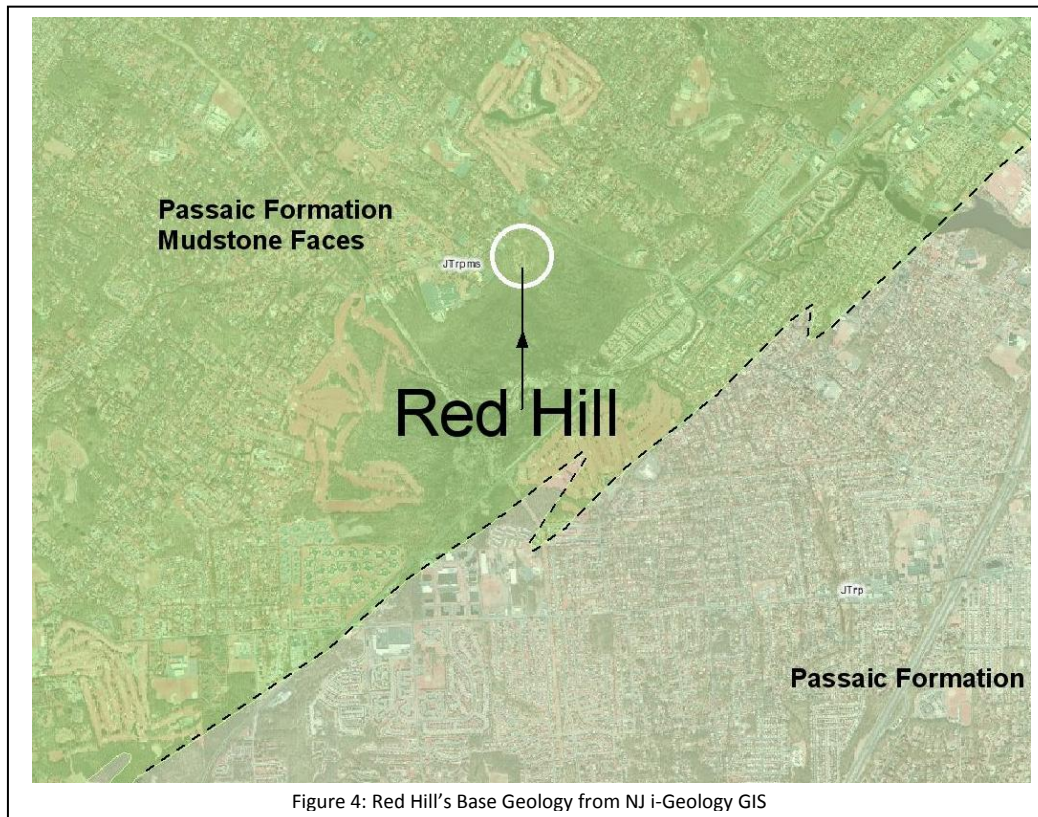


Figure 4: Red Hill's Base Geology from NJ i-Geology GIS

derivatives are the classic New Jersey Piedmont bedrocks. Mudstone differs from shale by a block granular aspect in contrast to shale platy or parallel bedding (Leet, et al, 1978). Two types of mudstone exist in the Red Hill vicinity. The classic Passaic Formation is located southeast of Red Hill. It is composed of siltstone and shale. Figure 4 clearly shows Red Hill is situated directly on the Passaic Formation Mudstone. The mudstone origin is from ancient erosion and is composed of fine grained detritus of sand and silt.

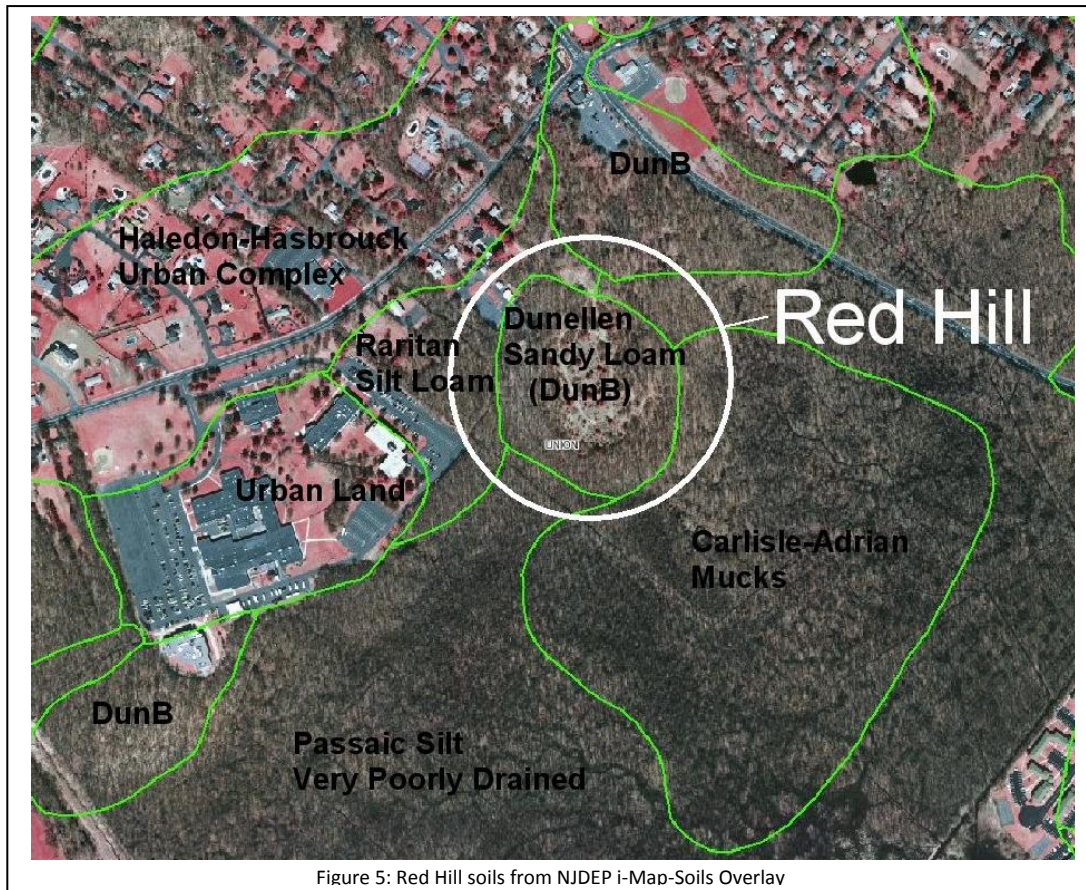
Soils

Union County soil mapping identified one soil type for Red Hill: Dunellen sandy loam, 3-8% slopes (map unit DunB). The Dunellen soil distribution in New Jersey is limited to similar glacial deltaic settings. This soil type is not widely distributed and most analogous settings east in the Hudson Valley and south of the Watchung have been developed into urban land uses. Dunellen sandy loam soils are well drained. The fine sand soil texture allows rapid rain infiltration and is locally important for groundwater replenishment. Such soils may have a depth to seasonal high water table in excess of 5'.

The wetlands surrounding Red Hill are within the Ash Swamp. The soils formed in this wetland are deposits from a glacial lake and more recent marsh. Today, the Natural Resource Conservation Service mapped its soils as Carlisle-Adrian muck, 0-2% slope (map unit CarbAt). The general description for Carlisle-Adrian muck is a histic (organic) and hydric (saturated) deposit that is frequently flooded. The hydric Carlisle soils are very poorly drained. Soils north and west of Red Hill that are not mapped as

Dunellen sandy loam have been mapped as Raritan silt loam (RarAr) or Passaic silt loam (PcsAt). Both represent silt and clay textures typical for Union County's Piedmont.

Field investigations completed for this report verified Red Hill's soil is accurately mapped. Borings made on the top and slopes of the hill confirmed the Dunellen sandy loam designation. The soil profile for the upper 24" is a very fine sand gradually that transition into a sandy loam. Both layers exhibit a consistent Munsell Chart 5Y 5/4 color. The red and gray Triassic Passaic Formation shale and mudstone parent material is responsible for the Dunellen chroma and hue.



Climate

Climate is the average of a region's weather. NOAA weather data records a warm, moist temperate climate for Northeastern New Jersey, including Union County. Union County's climate is based on an average rainfall of 42 inches, with average temperatures reaching the measurements at 87°F in July and 23°F in January. The County usually has 205 sunny days and 117 precipitation days per year. Snow fall is below the National average of 37". Union County's average snow fall is 14".

Part II: Red Hill's Biotic Resources

Red Hill Existing Conditions

Vegetation

There are seven basic selective forces affecting vegetation. Soil, water, temperature, light, atmosphere, biotic factors and fire all promote or eliminate plants, resulting in a plant community. Red Hill's



Photo #2: Woodland / old field ecotone on Red Hill

vegetation is a reflection of its soils, hydrology and its land use history. Today, xeric old field vegetation occupies the majority of Red Hill. This herbaceous-dominated cover occupies approximately 4.6 acres, or more than 51% of Red Hill. A grass dominated habitat occupies the highest portions of the Hill on clearings created decades ago by farm uses. Native warm season grasses such as Little blue stem, Indian grass, and rosette panic grasses mix with coastal plain composites such as narrow-leaf goldenrod, dwarf dandelion, hairy thoroughwort, and

sweet everlasting. This suite of species requires well drained sandy soils more commonly found on New Jersey's Coastal Plain. It is this distinct southern flora that makes Red Hill vegetation unique to Union County.



Photo #3: Shrub / woodland ecotone on Red Hill

Surrounding and interwoven with the old field vegetation is a shrub dominated community. Shrubs capable of drought prone soils are scattered within the grass dominated areas as well as becoming a site dominant cover around the Hill's periphery. It is difficult in some parts of Red Hill to separate a distinct shrub community from the encroaching recovering forest. Northern bayberry, high bush blueberry and southern arrowwood mingle with sweet gum, American holly and gray birch saplings. The shrubs are a common component to the

open sandy soils in the southern Delaware Valley counties and are a rarity in Union County. Shrub dominated areas are a minor Red Hill plant community and occupy less than one acre (0.53 acres) of the available upland.



Photo #4: Young Sweet Gum / Gray Birch Woodland

The remaining 3.31 acres are covered by a canopy of young trees. This young woodland occupies the outer edge of Red Hill, most prominently on its lower slopes. There are, however, small patches of woodlands throughout Red Hill's upland. The lower slopes have moist soil, more so than the soils found on the hill's highest elevations. The young forest on the lower slopes are composed of 3-6" DBH (diameter at breast height) specimens of sweet gum, gray birch, river birch, pin oak, black oak, swamp white oak, white oak and big tooth

aspens. A minor conifer component, represented by invasive Scotch pine and native eastern white pine, exist where patches of woodland occupy higher and drier positions. Pin oak, swamp white oak and white pine are species expected in a Piedmont recovering forest. The presence of black oak, white oak, sweet gum, and American holly, however, are indicators of a Coastal Plain influence.

Red Hill is surrounded by Ash Swamp, a large natural forest composed of a variety of native trees, shrubs and herbs. The wetland forest immediately surrounding the hill is a deciduous hardwood forest with a canopy composed of red maple, sweet gum, and American beech. The forest floor is covered by skunk cabbage, cinnamon fern, royal fern, wood reed, marsh violet and jack in the pulpit. It is a forest strikingly reminiscent of those found throughout the Lower Delaware River basin, specifically in the Pennsauken Creek headwater forests. Bio-Blitz 2006, a Union County Parks sponsored outing, attempted to document the natural features of Ash Brook Reservation. This effort identified 215 species within 83 families. Dr. Joan Ehrenfeld, a well-known New Jersey ecologist, independently identified a list of 96 species that tallied 17 trees, 12 shrubs, 10 vines and 57 herbs, grasses and ferns. Each list identified native and alien species, many of which have an affinity to Southern New Jersey's Coastal Plain.



Photo #5: Ash Swamp, a red maple forest surrounding Red Hill

The Hill's vegetation is composed of suite of species tolerant of sandy soil. Native herbaceous species are Red Hill's dominants, but the old field flora is slowly yielding space to woody plants, moving the succession process toward the ultimate forest cover. Many of the Red Hill species are reminiscent of Coastal Plain habitats, specifically those associated with the sandier portions of the Inner Coastal Plain. Ubiquitous coastal plain old field species such as little blue stem, whorled loosestrife, poverty grass, grass leaved goldenrod, and sweet vernal grass give the impression the site lies within one of the southern counties, rather than its northern Union County position.

The Red Hill flora is composed of a relative small number of drought tolerant species. A list of approximately 68 species has been recorded from field investigations made May and September 2009. This subset of the greater Ash Brook Reservation flora is dominated by coastal plain native species, similar to unconsolidated deposits of Southern New Jersey's Inner Coastal Plain. Characteristic coastal plain old field species such as *Krigia virginica*, *Andropogon virginicus*, *Dichanthelium sphaerocarpon*, *Euthamia tenuifolia*, *Eupatorium pilosum*, *Danthonia spicata* and *Smilax glauca* show a flora defined by the fine sandy soils. Sweet gum, swamp white oak, pin oak, arrowwood, sassafras, American holly, river and black birch, and big tooth poplar have similar analogous communities on soils derived from unconsolidated fine textured geologic deposits. Reference plant communities with nearly identical species compositions can be found in Eastampton, Mt. Laurel, Springfield and Southampton Townships, Burlington County; Gloucester Township, Camden County; and Deptford, Mantua, South Harrison, and Washington Townships, Gloucester County. Each has similarities to the mosaic of Red Hill plant communities.



Photo #6: *Krigia virginica*, Dwarf Dandelion

References to Pine Barrens plant communities are not substantiated by the flora identified for this report. Although many of the Red Hill species are found in most xeric habitats on the coastal plain, none are restricted to the Outer Coastal Plain deposits. The species assemblage is much more characteristic of drier sites within the Inner Coastal Plain than core Pinelands habitats. Stone (1910), in the seminal work on the flora of Southern New Jersey, made reference to the often made mistake of comparing the sandy flora of New Jersey's coastal plain to the characteristic flora of the Pine Barrens (pp. 72-92). Nineteenth century New Jersey botanists clearly recognized the coastal plain similarities observed on the Piedmont glacial outwash deltas. They described these outlier plant communities, such as the flora found on Red Hill, on sandy conditions north of the Raritan River. Then, as now, the similarities are to the so called "Middle District" of Stone, today recognized as the flora of the Inner Coastal Plain.

Red Hill's sandy loam has many of the same characteristics of Inner Coastal Plain sandy soils. Galestown sand and Tinton sand are two southern New Jersey soils that have a very similar composition and texture to Red Hill's Dunellen sandy loam. These southern Coastal Plain soils are characteristic of the Inner Coastal Plain's interior uplands. Tinton sand is a wind-blown deposit formed on glauconitic geologic formations whereas Galestown sand is found on Lower Delaware River upland terraces. Both are well drained with a fine to medium textured sand composition that resembles other sand deposits on New Jersey's coastal edge. Both soils support drought tolerant species, many of which are common throughout Southern New Jersey's sandier soils. Dunellen sandy loam, in comparison, has similar textural and floristic similarities, making its affinity toward Inner Coastal Plain environmental conditions.

Wildlife

The Red Hill vegetation, with its succession gradient from open sands to woodlands, provides a varied plant community structure suitable as wildlife habitat. The site vegetation is varied enough to support a variety of insects and other invertebrates. It also supports many vertebrates represented by amphibians, reptiles, birds and mammals. The Bio Blitz 2006 yielded a significant contribution to the knowledge of Ash Brook Reservation. This work, completed by volunteer amateurs and professionals, provides a list for the entire swamp. Many teams distinctly identified Red Hill as a target site. Most mentioned its unique setting and some commented specifically about its history and the effects past land uses had on its vegetation. The effort produced 28 species of fungi, 304 insects, 9 amphibians and reptiles, 57 birds and 8 mammals.

Red Hill lies within the Northern Piedmont-Plains section of New Jersey (WAP, 2008). Grasslands are regionally scarce and Red Hill provides more than 4 acres of grassland and scrub-shrub habitat. This habitat provides nesting opportunities for species restricted to open old field and scrub-shrub communities. Birds such as Yellow-throat, Carolina wren and catbird have evolved to use this type of vegetative cover. Northern Piedmont-Plains grasslands provide habitat for birds such as savannah, grasshopper and vesper sparrows, northern bob white quail, bobolinks, and northern harrier. The sandy soils are ideal for aquatic and terrestrial reptile nests. Aquatic turtles such as paint and snapping turtles commonly use open sand to lay eggs. Snakes also use open sandy soils such as Red Hill's Dunellen soils to lay eggs. The Landscape Project (NJ DEP, 2009) maps the Ash Brook Reservation as critical habitat for wood turtle, a State listed threatened species. Wood turtle, if present, would seek out the open sand such as Red Hill for nesting. Most of Red Hill's mammals are wide ranging and less restricted to the habitats found on Red Hill. Red Hill provides some of the only den sites within the urban environment of Scotch Plains. Evidence from sightings, tracks and scat identified gray squirrel, eastern chipmunk, white tailed deer, red fox, opossum and woodchuck using Red Hill as part of the daily routine.

White tailed deer are common throughout New Jersey. They have adapted to the suburban and urban landscape and now can be found in every New Jersey municipality. The Reservation's population has access to wetland and upland opportunities for normal breeding, bedding and foraging behavior. This large mammal occupies Red Hill as part of its regional home range and is one few mammals having an impact on the flora of Red Hill. Selective grazing and browsing pressures are observable. Sapling and seedling trees are selectively browsed and rubbed differentially over shrubs. This impact is clearly visible as a brose line in the wetlands surrounding the base of Red Hill. No other vertebrate has as much impact on Red Hill or its immediate vicinity as this does this single species.

Invasive Species

The 2008-2012 National Invasive Species Management Plan defines an invasive species as: *"An alien species whose introduction does or is likely to cause economic or environmental harm or harm to humans"*. The alien definition for New Jersey is best articulated by Snyder and Kaufman (2004). They define an alien plant as a species that is introduced outside of their natural range as a result of human influence. Some alien plants are continental natives, introduced eastward into altered habitats, whereas some are native to other continents and are distributed by agriculture or commerce. All of New Jersey's

aggressive alien species have their origins in Northern Europe, the Mediterranean region or Asia. Australia, equatorial Africa, and South America contribute a meager few species to the list of New Jersey invasive plants primarily because of their adaptations to equatorial climates.

The species list created by the efforts of the Bio-Blitz and other field work identified many typical Piedmont invasive plant species. Most of the more frequent species are absent from the sandier soils of Red Hill. The Red Hill species subset includes widespread invasive plants commonly found in New Jersey’s Coastal Plain. Field investigation for this report recorded 14 of the 68 species as alien (21%). Only 5 (7%) of these are species worthy of immediate eradication.

Table 1: Red Hill Invasive Plants * = Aggressive Species
<i>Achillea millefolium</i>
<i>Alliaria petiolata*</i>
<i>Anthoxanthum odoratum</i>
<i>Artemisia vulgaris*</i>
<i>Dactylis glomerata</i>
<i>Hieracium paniculatum</i>
<i>Hieracium pilosella</i>
<i>Lonicera japonica*</i>
<i>Microstegium vimineum*</i>
<i>Pinus sylvestris</i>
<i>Poa pratensis</i>
<i>Rhamnus frangula</i>
<i>Rumex acetosella</i>
<i>Taraxacum officinale</i>

There are numerous possible reasons for the stability of the Red Hill old field community, but nutrient poor, drought prevalent soils are probably major reasons for this community immunity. Recent literature (Deither and Hacker, 2004; Von Holle, et al, 2001) indicates two major community properties that may be responsible for this resistance to invasive plants. Biotic inertia and biotic resistance, defined as the function of the community’s cohesion and complexity, are possible reasons for Red Hill’s exclusion of most invasive species. Extreme environmental selective parameters, such as Red Hill’s drought prone soils, do not provide suitable soil moisture conditions needed by many common alien species. Plants such as Japanese barberry, Japanese knotweed, multi-flora rose, common reed grass, bush honeysuckles, burning bush, porcelain berry, field garlic, and tree of heaven are plants that do not occur on Red Hill yet would

otherwise be expected to quickly establish if suitable conditions exist. Dunellen’s sandy soil appears to exclude many common highly invasive plants. Only four of the Red Hill listed non-native plants are aggressive invasive species (garlic mustard, Japanese honeysuckle, common mugwort and Nepalese stilt grass) and only three species (garlic mustard, common mugwort and Nepalese stilt grass) have populations large enough to be an immediate concern. Japanese honeysuckle is scattered on the eastern side of Red Hill. Most invasive honeysuckle plants occupy separate discrete small patches near the northern and western edge, close to the horse paddocks. Scotch pine is not normally considered a problem invasive species. The Red Hill population is successfully reproducing around a small cluster of mature specimens. Its advance into the site is supported by the open sandy soil. Most pines require open soils for germination and successful growth.

Six alien species listed in Table 1 are not considered aggressive, and most have a long New Jersey tenure and considered adapted members of the flora. These are assimilated into our local flora in such a way that they are not aggressive or significant community competitors. This includes ubiquitous plants such as sweet vernal grass, sheep sorrel, orchard grass, common dandelion, yarrow, blue grass, and the hawkweeds.

Part III: Red Hill's History

The Human Component

Natural resources have always been selective forces on human land use. Resources derived from vegetation and nearby water provide all of the physical assets needed to prosper, aptly meeting the old anecdote "location, location, location". Red Hill's location in what is today called Union County met the criteria. It provided access to the desired resources and has been a focus of human occupation since prehistoric times. This occupation proceeded through time nearly unbroken until the present, modern era.

Pleistocene glaciations made occupation of Red Hill impossible until the Wisconsin glacier retreated and exposed the delta's sandy deposit. Descriptions of the glacial epoch (Witte, 1998) indicate the Wisconsin glacier covered all of Union County during the glacial maximum. Its moraine extended many miles east into what is today the open Atlantic Ocean. The glacial front began to melt and retreat northward sometime after 30,000 YBP (Christensen, 2007). As the glacier slowly retreated north through Union County, the underlying sediments that had been ground under the weight of the glacier were able to be deposited seaward. One such outflow created the delta that eventually became Red Hill. Once the land became exposed and the delta dewatered, it would have been available for colonization by the near glacier flora and fauna, eventually evolving into a post glacial condition suitable for early human use.

New Jersey's earliest documented human evidence is associated with the middle to late Paleo-Indian culture. Evidence for the upper Delaware River Valley and southern New Jersey indicate people occupied our landscape at least 12,000 YBP (Mounier, 2003). Shawnee-Minisink is a paleo-indian site near the Delaware Water Gap that is an example of an upland landscape use soon after land became exposed from the glacier. The A.C. site in Atlantic County shows early re-occupation within a rapidly changing palustrine to marine environment (Kraft, 2001). An Ocean County find (28OC100, Mounier et al 1993) is an open air paleo-indian site on a sand dune similar to Red Hill. Recent archaeological evidence for the Northeast United States has possibly pushed the documented first American arrival time back to nearly 20,000 YBP. Sites such as Cactus Hill (Virginia), Meadowcroft (Pennsylvania), Topper (South Carolina) and newly discovered Chesapeake Bay sites (Maryland), point to people occupying Eastern North America well before the classic Paleo-Indian Clovis culture. If these people were present, they would have been the first to glance at the exposed Red Hill.

Recent paleo-geographical studies, however, indicate New Jersey's early post glacier environment was too harsh to support a sustained population. Demitroff (2004) and French, et al (2007) describe an inhospitable near-glacial environment within the State's coastal plain interior. Harsh, fluctuating conditions would have allowed only a limited human use. Any indigenous people would have occupied land closer to large rivers and the sea. Both provided access to richer sources of fish, shell fish and sea mammals. Those present would have been confined to the large river valleys such as the Delaware and Hudson, glacial lake edges and the ocean frontage. The ocean edge at the time was approximately 60 miles east, today under the Atlantic Ocean.

The State's dry interior was a wind-blown landscape punctuated by periods of permafrost thaw and slumping. A polar desert or similar condition is thought to have persisted until the glacier retreated well beyond the State's political boundaries. This type of harsh environment was expected to exist at Red Hill until the late paleo-indian period. This would have made Red Hill an interior setting with similar desert-like conditions. It would have windblown and unstable as the lands described for all Coastal Plain sandy environments.

Red Hill because of its location and prominent position would have been one of the first areas settled once the climate became favorable. It was south of the glacial lake and surrounded by a marsh occupied today by Ash Swamp. Any person traveling along the lake's western edge would have found this site superior to others for a variety of reasons, each dealt with its sandy soil, location and topographic setting.

Archaeological evidence for prehistoric use of Red Hill has been known for at least 94 years. Spier (1915) identified three sites in the Red Hill vicinity. One was a large camp with debris scattered for a ¼ mile along the edge of Ash Swamp. The early 20th century report also describes two other camps on sandy hills about ½ mile and 1 mile respectively southwest of Willow Grove. Today, both are within the Ash Brook Reservation and one is Red Hill. Willow Grove was the place name for the land north of the intersection of Martine Avenue and Old Raritan Road. Debris from the prehistoric camp identified the camp described in the 1915 report. Many fragments of fractured rocks (fire and impact) and flakes from tool making (*photo #7*) are visible today on the sand roads and openings.



Photo #7: Early American artifacts-Large and small flint flakes (Left, center), leaf-form projectile base (right) found on open sand paths of Red Hill.

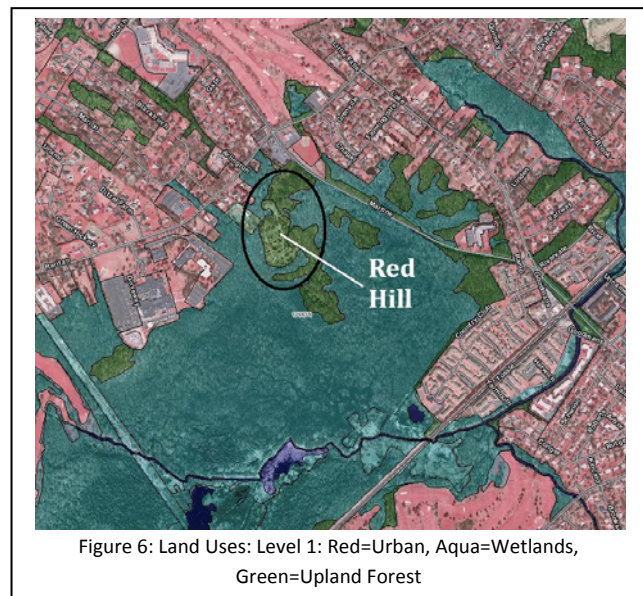
The same features that drew the early American's residents to Red Hill also drew latter European settlers. Tillable soil within a region with a pleasant climate made this part of New Jersey desirable to early Dutch and English settlers. Elizabethtown and the surrounding land were first settled in the early 1600s by the Dutch. Elizabethtown became the site of the first English settlement after it was seized by the English mid 17th century. The new landowners began their written history with a land purchase for Elizabethtown from Native Americans in 1664. There are many records of people expanding away from the coastal Elizabethtown into the State's interior. The early history of Elizabeth (Hatfield, 1968) cites many individual stories of settlers purchasing land north and west of Elizabeth in the proximity of today's Scotch Plains. Some personal stories include references to swampland that is suspected to be Ash Swamp. Each story documents and describes active clearing, draining or some other subsistence use that would disturbed the natural vegetation. This clearing and subsequent farming would have altered the original vegetation, replacing it with an agrarian landscape with more meadow than forest.

The early New Jersey topographic surveys show Red Hill a separate and distinct knoll. The 1884-1888 Vermeule Manuscript illustrates Ash Swamp surrounded by open land, with forest limited to small

patches within a cleared landscape. Approximately 50% of the swamp surrounding Red Hill was identified as open meadows that were probably used for grazing livestock or planting crops during drier summer conditions. The 1930 New Jersey Airplane Atlas Mosaic, Panel # 78, clearly shows Red Hill and surrounding land within a larger farmland landscape. Red Hill is visible on this photo as an open field between two small streams, on the eastern edge of farmland. The top of the Hill is open, with a curious ring clearing. This circle occupies the top of Red Hill and surrounds a faint signature of a planted crop. The origin of the circle is unknown but is suspected to be a recreational dirt track. The rows visible on the 1930 photo are in the same location where large specimens of high bush blueberries exist today. The lower Red Hill slopes and the adjacent Ash Swamp, once shown as cleared forest for the 1888 mapping, is visible as young forest on the 1930 photo. This is evidence the clearing along with farming becoming abandoned and started recovering into the forest we see today.

Current Land Use

Today, Red Hill occupies a vacant portion of Ash Brook Reservation. This is a natural refuge within a sea of urban land uses. The Hill is surrounded on its immediate borders by vacant forest of Ash Brook's palustrine red maple dominated wetland. Beyond the forest, the nearest active uses are north and west. A High density urban use including residential, commercial, educational, recreational and governmental uses abuts the forests nearest Red Hill. The residential uses predominate north of Raritan Road and east of Martine Avenue. The Union County Police Academy and Union County vocational school operate on the land west of Red Hill. This large complex is carved into Ash Swamp. The nearest use is a horse boarding stable that occupies the land immediately northwest of the Hill. The expansive undeveloped Ash Swamp occupies all land within 1 mile south and southeast of Red Hill. The Northeast Corridor Amtrak railroad right of way crosses the southeast edge of the swamp. Residential uses occupy the land south and east beyond the railroad.



Part IV: Ecosystem Restoration

The purpose for this report is to document Red Hill's natural resource components. The process includes recording and tallying species as well as determining its significance within Union County's landscape. The physical and biotic description provided in previous paragraphs show how this knoll, situated in the New Jersey Piedmont, expresses characters more suitable for the Southern New Jersey's Coastal Plain. The sandy soil imparts a drought prone environment that mimics conditions found on Coastal Plain sediments. This anomaly exists today because of the chance purchase of Ash Brook Reservation by Union County. Red Hill was not mentioned as a significant component to the Reservation at the time of purchase. Surveys and observation by naturalist familiar with this region found Red Hill unusual, making the site a destination and point of interest in recent years. Its unusual setting, an upland knoll surrounded by swamp, has been the focus of environmental preservationists for more than a decade. During this time, it has become apparent the plant community found on the Red Hill is unique in Union County. The species and old field habitat was so different from the surrounding forests that it became clear the site was worthy of a dedicated effort to maintain the existing vegetation.

The Red Hill ecosystem is a constructed of the matrix of succession stage plant and animal communities supported by soil, water and nutrient features. This system provides natural services associated storm water (detention, infiltration, filtration), microclimate (temperature moderation, local humidity, wind speed attenuation) and wildlife habitat (nesting, breeding, roosting, home-range, foraging). Red Hill's vegetation provides a large irregular surface area that is important for metering water into the soil. The Hill's porous Dunellen sand allows rainwater to rapidly infiltrate, providing roughly 10-acres of storm water storage service for flood attenuation. This service is desperately needed in most urban environments. The old field and young forest cover reduces the site's surface albedo, scattering sunlight and reducing surface heating. Red Hill together with the surrounding large deciduous palustrine forest helps reduce local air temperatures. Vegetation creates a complex surface texture that reduces surface wind speeds, buffering the severity of severe storms and winter prevailing gusts. Each of the separate services is important in an urban and suburban landscape such as the one found on land surrounding Ash Brook Reservation.

Retaining the native vegetative cover also provides an island of Coastal Plain species at their New Jersey northern limits. There are plants within this isolated, Coastal Plain island with genetic code that may differ from the main populations found south of the Raritan River. Additionally, Red Hill provides cover type diversity to Union County by supporting an old field and a mosaic of hardwood/herbaceous cover within an otherwise hardwood forest where native vegetation exists. Today, forests dominate open land in the vicinity of Red Hill. There are numerous representative examples of forested uplands and forested wetlands near Ash Brook Reservation and within greater Union County area. Old fields and older succession stages are a different matter. Most open fields in Union County are maintained by mowing, and support cool season grasses and ubiquitous mowing tolerant weeds. The old field habitat was once a common plant community throughout New Jersey. Modern development, however, replaced most upland with residential, commercial or other land uses. The loss of this once common upland community creates a convincing argument to target maintenance of the old field habitat.

Retaining the open old field vegetation would be beneficial to wildlife habitat services and provide space for unusual plant species.

A decision must be made on the vegetation that would be maintained and what techniques would be applied to achieve the desired vegetation mixture. Possible restoration targets would be managing the current vegetation to include one or more of the existing variations. Restoration specialist could remove all woody vegetation, keeping the site in a perpetual early old field succession cover. A second option would allow the forest to envelop the hill. Either vegetation type would be beneficial. Both would be an appropriate choice for the landscape based on its vegetative potential. Considering the surrounding forest vegetation and the documented lack of the old field habitat in the Northern Piedmont Plains wildlife district (NJ DEP, 2008), it is recommended that at least a portion of the vegetative cover be retained as old field, allowing for the persistence of coastal plain herbs and grasses that would otherwise be lost from Union County's landscape. Including a shrub and sapling scrub component would increase the wildlife value and present a slightly different environment suitable for additional Coastal Plain species.

It is recommended to use the vegetative cover percentages present in 1995 as a starting point for each old field, shrub dominated or upland woodland cover type. This would require the removal of trees and shrubs from the area delineated as old field. It would also require a limited cutting of trees within the area dedicated as shrub dominated. The selected vegetation mosaic as the ecological restoration target is somewhat subjective. During Red Hill's post glacial history, the vegetation has probably changed from forest to old field and back to forest multiple times. The archaeological evidence of early American use through the 1930 subsistence farming that is visible on the air photos provides an equally valid rationale for any step on the path from open sand to mature forest. If Red Hill's unique conditions are reviewed, it becomes clear the obvious restoration target would be to maintain the current old field and shrub / sampling mosaic and retaining the existing species mixture. The current vegetation cover is an anomaly on the Piedmont and it represents a significant Coastal Plain outlier. Any similar habitats have long been eliminated by Union County's late 20th century urban development. Vegetation is a moving target, with its influences and species composition changing over time (Jackson and Hobbs, 2009). It has been stated that even an early 20th century target vegetation cover type would not be appropriate in the 21st century. Thomson et al (2009) suggest land managers should consider spatial and temporal aspect of habitat restoration and quality. Therefore, the best Red Hill managers can do is to reduce outside influences, eliminate the most prominent invasive species and maintain a selected suite of native plants within an open old field or hardwood woodland.

The restoration effort should concentrate on maintaining the existing species assemblage, allowing for natural recruitment. Any concentrated efforts should be focused on invasive species eradications needed to maintain this natural Coastal Plain environment. Without a nearby vegetation analogy, there is no site to compare the Red Hill flora and vegetative components. Without an analogous cover type, it would not be appropriate to introduce new species based on speculation. Recent research found ecological restoration plantings benefit native fauna but they do not necessarily provide conservation values for non-planted aspects of the flora (Munro, et al, 2009). It would be presumptive to assume the

current assemblage requires augmentation. It would be more appropriate to allow the flora to develop naturally, without the re-introductions by restoration specialists. The experience of the specialist should concentrate on size of the individual mosaic components and invasive species issues.

Instituting the management plan would implement a few basic tasks to ensure continuity between land managers. A first step on the path to Red Hill's management would be to determine the target vegetation and create a site map reflecting the limits selected for the various cover types. The scene visible on the 1995 can be translated into an onsite boundary using identifying land features. Components such as walking paths, signage and access points need to be incorporated at this stage. The site needs map space to show Red Hill details. The plan should to be displayed at a dimension scale of no greater than 1" = 50' (1:600 scale).

The second stage would be applying ecological restoration methods. This would begin with the eradication of invasive plants. Periodic invasive species maintenance would slowly rid the site of non-natives, creating an island of native Coastal Plain flora in a region otherwise dominated by Piedmont species. Old field and shrub dominated restoration could be accomplished by hand cutting trees within areas designated as herbaceous or shrub cover. Volunteer restoration managers could slowly complete the cutting task when time and conditions dictate. This would help define the ecological boundaries or ecotone between shrub dominated and the old field. This would help define the desired vegetation communities providing a clear visible boundary for future restoration work. Long term restoration would require a continued disturbance to maintain the early succession cover types, old field and shrub areas alike. The use of dormant season mowing would help eliminate the larger woody plants in the old field. Periodic sapling removal would perpetuate the shrub dominated areas. Another tool to set the vegetation back to an earlier stage is fire. A low intensity winter control burn could be applied by the local fire company to kill above ground woody tissue. There are downfalls with the use of fire. There is a reluctance to use fire within urban areas. Smoke and the fear of spreading flames would make the use of fire difficult. It would also provide a smoke plume that may impact aviation at Newark-Elizabeth International Airport. Its use would also require a plow line to contain the flames. This would scar the hill and defeat the preservation efforts. Based on the comparison between fire and hand cutting, the latter is the preferred technique. It would provide desired disturbance necessary to maintain the old field and succession habitats as they exist today.

Part V: Invasive Species Management

Managing Red Hill's Invasive Species

One of Red Hill's old field habitat restoration tools is the management of invasive species. The elimination of non-native plants that compete for space and nutrients is a major part of the management strategy and a great deal of the volunteer efforts applied to the Red Hill management would be dedicated to the eradication of species not native to the Coastal Plain old field vegetation. Invasive species control has become a science in its own right. Major governmental and non-profit foundations have dedicated considerable time and effort to solving the problems associated with invasive organisms. The Red Hill management plan adopts a seven goal-oriented plan, focusing on management, coordination, planning and implementation. This plan follows a logical sequence by setting up a management team made of interested stakeholders, supported by a repeating volunteer effort to provide the Red Hill detection and response team. The management team would provide guidance or permission, when necessary, while the volunteer effort would provide the man power to implement the plan.

Goal #1: Establish a Red Hill Natural Resource Management Team

The first step in the management of Red Hill is the establishment of its management team. The National Invasive Species Management Plan (2008) and EXECUTIVE SUMMARY – NJ STRATEGIC MANAGEMENT PLAN FOR INVASIVE SPECIES (2009) acknowledge the need to set goals and objectives to achieve any degree of invasive species management. Coordination between those who manage and those that implement would be needed to sort out work assignments, ownership and regulatory issues. The management of Red Hill's resources is no different, and requires coordination with stakeholders. Red Hill stakeholders are individuals and organizations with interests in the Union County natural resources. Red Hill's stakeholders include Union County Freeholder as landowners, the Union County Parks personnel that are responsible for Ash Brook Reservation; and interested groups such as the Rahway River Association, the regional Natural Resource Conservation Service personnel, the adjacent citizens of Scotch Plains, interested Union County / State of New Jersey citizens, and natural resource conservation institutions. Stakeholder representatives would form a management team and decide the best course and techniques to successfully eliminate invasive species while managing the Red Hill native resources. Therefore, the Red Hill management plan's first objective would be to request stakeholder participation and form a management team from interested organizations and individuals. The team would meet infrequently on an "as needed" basis. The team would act as an advisory board, providing guidance and permission for the tasks outlined in this plan. The management team should have representatives that have some responsibility to act independently to address permit issues or funding requests. A suggested team would be 5 members represented by Union County administration and Park officials (2), with a single representative from the State resource conservation service and two local conservation organizations.

Table 2: Suggested Red Hill Stakeholder List

Stakeholder	Contact	Position	E-Mail Address
<i>Governmental</i>			
Union Co. Board of Freeholders	Alexander Mirabella	Chair	www.ucnj.org
Union Co. Parks and Community Renewal	Ken Fellner	Recreation	
	Alex Chappottin	Maintenance Supervisors	
Union Co. Horticulture and Forestry	Theodore Edzek	Chief	
Union Co. Trailside Nature & Science Center	Patricia Bertsch	Director	
USDA Natural Resource Conservation Service Out Reach Program	Barbara Phillips	Coordinator	http://www.nj.nrcs.usda.gov/programs/
<i>Non-Governmental Organizations</i>			
Rahway River Association	Dennis Miranda	Executive Director	www.rahwayriverassociation@Verizon.net
New Jersey Conservation Foundation	Michele Byers	Executive Director	www.njcf.org
New Jersey Audubon Society	Thomas Gilmore	President	www.njaudobon.org
Native Plant Society of New Jersey	Kathleen V. Salisbury	President	President@npsnj.org
Total = 8			

Source: Union County and individual non-profit organization websites

Goal #2: Management Team Collaboration

This goal calls for maximizing organization skills. Time and funding are always limiting factors and increasing cooperation among the stakeholders will insure best use of volunteers and funds to assist the eradication and management efforts. Red Hill is within the Union County park system and any active management will require permission from the Ash Brook Reservation site manager. This applies to any restoration activities involving vegetation removal or application of herbicides. The Red Hill management issues are relatively simple at this time and would require minimum coordination efforts. An objective of

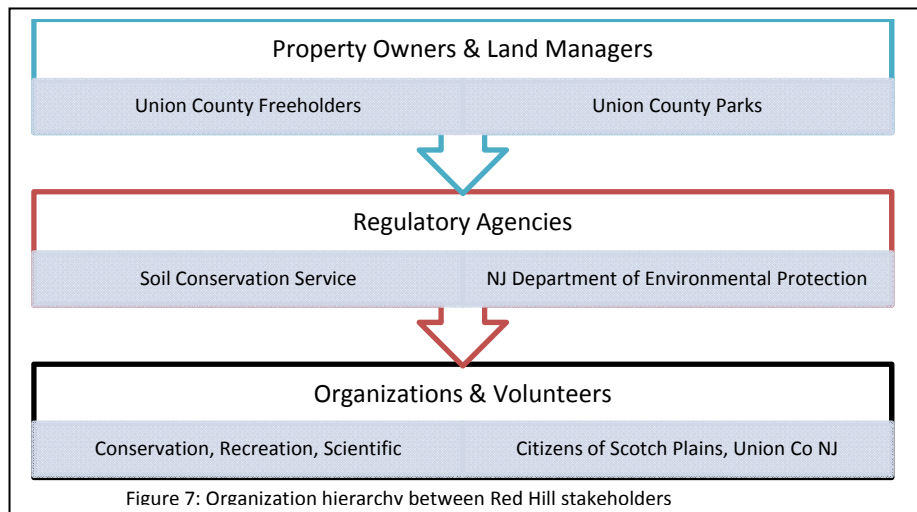
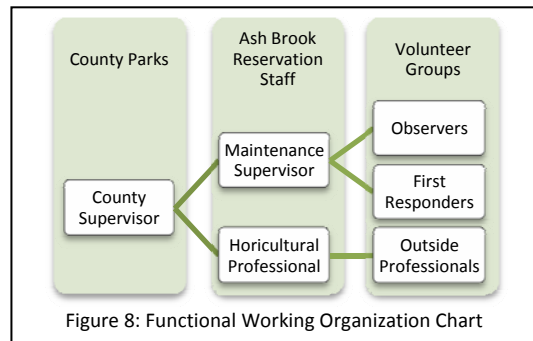


Figure 7: Organization hierarchy between Red Hill stakeholders

the management team identified by Goal #1 should dedicate a point of contact for each anticipated activity. If these activities are located within wetlands or wetland buffers, State regulatory approvals may be required. Any formal application would require County approval, necessitating task assignment to stakeholders. Applications and formal approvals would be handled by the property owners and land managers. Implementation of regulated tasks would be handled by volunteer stakeholders such as the conservation organizations and citizen volunteers. Figure 7 shows the organization hierarchy formed between the various levels of stakeholders. Property owners and land managers decide appropriate

action. The regulatory agencies provide the legal permission when appropriate. Finally the tasks needed to achieve the selected management action would be applied by the organizations and volunteers. The identification of a single point of contact would achieve the objective and create the simple chain of command.

A second collaborative objective would be to decide when a decision by the chain of command is needed to accomplish a task. Most of Red Hill's invasive species do not require substantial expensive or destructive removal strategies. Species such as Scotch pine can be managed by hand cutting mature specimens to eliminate the seed source. The seedlings can be hand pulled or cut to eliminate the next generation of seed production. Neither activity requires permits or waivers. Simple non-destructive tasks only require approval by the land owners and managers. This would be verbal permission from the Reservation Manager. A similar sequence can be applied to the other notable invasive species.



The funding of Red Hill is also a management team responsibility. One of this goal's objectives would appoint a single team member as the contact for funding. An example of this is shown in Figure 8. This would maximize efforts to request grants from governmental and philanthropic groups. The simple budget provided in this report's appendix identifies some of the obvious costs and their impacts on certain activities. Most costs are associated with the initial target species elimination. Most of the eradication effort and associated costs would be in-kind dedication of person hours with simple hand tools. A moderate dedication of team coordination would maximize the volunteer's physical labor, and reduce regulatory conflicts needed to achieve species elimination. The team funding coordinator could assure a better dedication of the limited finances for expenditures for items such as herbicide, one time purchase of cutting and digging tools, and any professional hourly compensation. Once the invasive species problem is under control, costs would be low and would be dedicated to ecological restoration goals. Funding for invasive species eradication is available from a variety of sources. A major first step searching for funds is the United State Department of Agriculture. This agency provides multiple grant opportunities for invasive species control and management. Requests for in-kind consultation from governmental and independent research groups can help reduce costs by recommending the most appropriate techniques to control and eradicate newly emerging species. Agencies such as New Jersey's Department of Agriculture can be a valuable asset. The Department supervises cutting edge research and in-field application of techniques specifically for insect control. The County Agricultural agents can provide recommendations for plant control and management. All opportunities to obtain grants and free consultation to fund Red Hill's management would be an objective that is strongly recommended.

The Red Hill Invasive Species Management plan applies a synthesis of basic concepts outlined in the National and State's invasive species plans adapted to address specific Red Hill problems. The plan would be staged so the obvious problems are addressed first, followed by an implementation the

seasonal observation, detection and maintenance goals. Coordination within the management team can provide a clear vision and provide specific task approvals so the problems are solved in order. The invasive species issues on Red Hill at this time are relatively small. A few plants require small scale eradication. The recommended goal to maintain the old field vegetation type needs management. The Red Hill ecological management tasks are small and require little dedicated effort. The invasive plant eradication can be accomplished by one of the volunteer stakeholders. What is needed is a clear management direction and coordination. Figure 9 simply illustrates the steps needed to manage Red Hill. A management team coordination objective can simply assure this sequence is followed.



Figure 9: Red Hill Management Components in Order of Importance.

Goal #3: Invasive Species Control and Management

Invasive species eradication and control requires the use of standard methods. Species specific eradication methods have been developed for all Red Hill invasive plants. Research institutions, governmental, and conservation organizations as well as the chemical industry have developed appropriate procedures to eradicate nuisance plants. The use of the appropriate eradication method and following the same decision procedure provides a repeatable framework that can be applied to the management of all invasive plants or animals. Figure 10 is a representation of the suggested repeatable steps. The flow chart provides three basic protocols to help determine the “what species”, “what method” and “when to use” answers needed to address Red Hill’s invasive species problems. The procedures include low impact manual removal as well as treatments with various chemical herbicides. Red Hill’s approach should focus on the low impact and low cost manual removal methods before electing to apply herbicides.

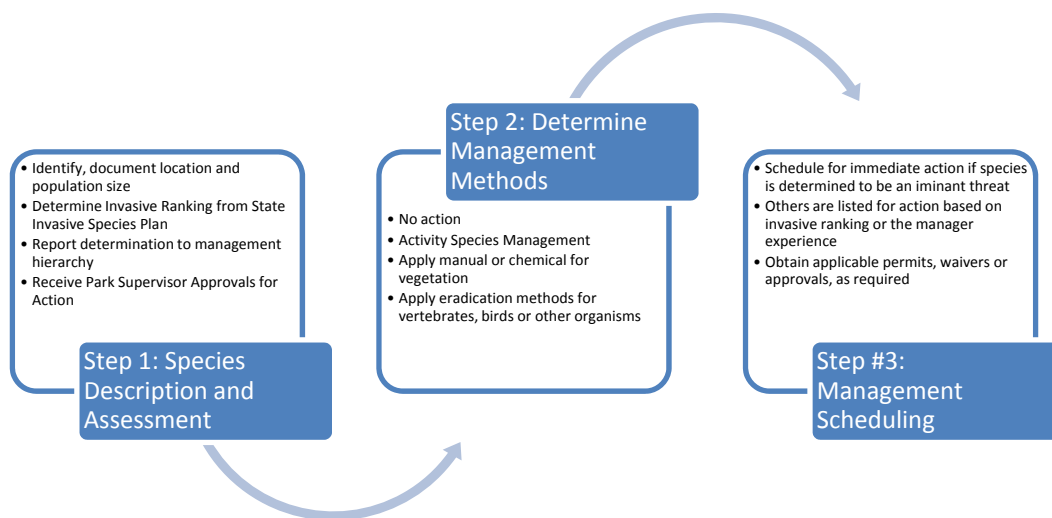


Figure 10: Control and Management Flow Chart linking Early Detection/Rapid Response and maintenance actions

The management team or shareholder assigned the detection task would be to apply the steps needed to identify threats to Red Hill, alert management team members and implement the appropriate control methods. Initially, these tasks would apply only to 5 plants chosen for immediate eradication. The this report's fieldwork completed step #1's species identification, site documentation, and task ranking, and determined the eradication methods for step #2. Only step #3 requires a management team action. Selective hand pulling is suggested initially as a low impact method that is aimed to eliminate all species except Scotch pine. Scotch pine requires cutting to remove mature specimens from the Red Hill landscape.

The same procedures apply to for any newly discovered invasive species. Repeating the steps 1 through 3 for each newly discovered invasive plant or animal would insure the management team is informed and all proposed actions are in compliance with applicable township, county and state land use rules.

Goal #4: Early Detection/Rapid Response

Early detection and rapid response is an object common to all invasive species management plans. It combines the collaborative effort of the management team with the individual assignments dedicated to volunteer stakeholders. The combined effort provides a site history for the long term management description needed to maintain the native Red Hill Coastal Plain vegetation. The acronym ED/RR represents the crucial 1st line of defense when monitoring for new invasive species. Regular field inspections by Red Hill observers would attempt to identify new invasive species before they gain a foothold. Early detection is many times a chance event. The chances are improved with repeated site inspections. Periodic surveys, at a minimum of once per growing season, improve the chance for invasive species identification. Repeating this step provides an opportunity to catch new species invasions. The goal is early detection providing time to select the suitable response. The process would assign volunteer stakeholder groups to periodically visit Red Hill and report the findings to the management team.

The Natural Resource Conservation Service provides invasive species education in the form of classes and seminars. Volunteers and interested stakeholders could use this resource to assist the eradication and restoration effort. Reporting the results of a site visit would include completion of a simple one page form (see example in appendix) describing basic information such as the visit date, volunteer name and issues discovered on or near Red Hill. The data sheets could be kept by the stakeholder team assigned the inspection tasks, made available for review and publication as requested by the management team. Records provided from the site visits would develop a site history, and be useful for future site management.

The first objective in the ED/RR protocol is to assign a stakeholder the responsibility to make regular visits to Red Hill. The visits would document observable changes and report new species. New information collected on the visits would follow the monitoring flow chart for invasive plants or animals early detection.

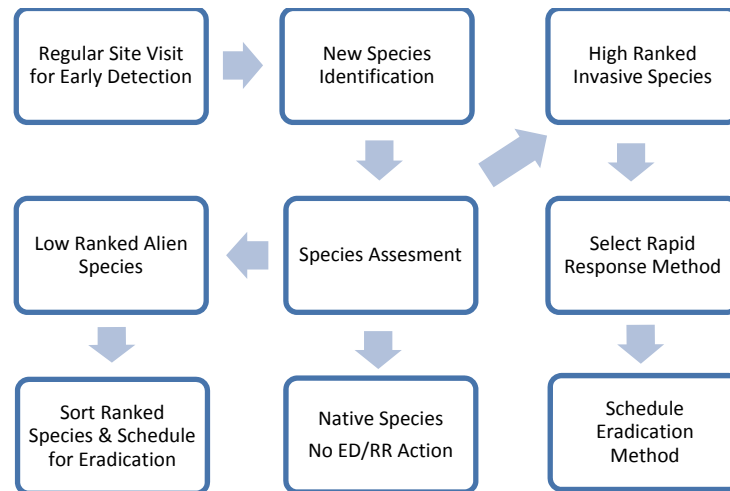


Figure 11: Early Detection and Rapid Response Flow Chart

Monitoring visits completed in the 2009 growing season found the site supports a flora with 14 non-native species, of which 5 have been determined are high ranked. The methods for eradication have been suggested and only require a scheduled date to complete the process.

One function of the ED/RR is the species assessment. Once a new species has been identified by the seasonal visit, it can be determined how to address its management by answering the following 6 questions.

1. **What species?** The official State invasive species lists (Invasive Species Council @ <http://www.nj.gov/dep/njisc/index.htm>) in conjunction with federal agencies would provide baseline to determine if a species is non-native and describe invasive qualities. Some species would require immediate attention. Plants such as Nepalese stilt grass or Japanese honeysuckle fit this immediate action description. Non-native species such as the hawkweeds or speedwell do not.
2. **Where is it?** Red Hill site information can be translated into mapped geographical information using software such as Arc-Gis®. This mapping software allows a layered demonstration of the field collected data. Hand held Global Positioning System (GPS) should be the standard method to collect a reported new invasive species occurrence. This allows volunteers to determine if a newly identified plant is unique or if it has changed its Red Hill distribution.
3. **What harm?** Once a plant has been identified, it can be determined if the species has the invasive capabilities to harm to the Red Hill native vegetation. Some species, such as Japanese knotweed, can exclude native species with its dense monotypic colonies, while others have allelopathic affects, reducing the health of native species. Plants such as garlic mustard modify the surrounding soil chemistry, negatively affecting many native herbs.
4. **What action?** Invasive species literature is available from a variety of resources. The Nature Conservancy and the US Department of Agriculture have extensive web pages dedicated to this topic. Tapping into this readily available data would help decide the appropriate method for invasive plant eradication. The site management team would decide an action based on species rank and potential for invasion.

5. **Who has authority?** The pre-determined hierarchy identified by Figure 7, ranks the stakeholders. The land owners and site managers would determine thresholds needed to allow volunteers to act alone or require approvals to implement an eradication effort. An example involves the eradication of invasive species in a wetland transition area. The State regulations allow limited property management, whereas the same rules requires a formal application if the eradication process uses mechanical or chemical methods. The decision would be the responsibility of the management team.
6. **How will eradication or other efforts be funded?** Some eradication efforts will incur a cost. Notable examples include common reed grass and Japanese knotweed. Neither exists on the Red Hill, but if they did eradication of both species would require repeated applications of herbicides. An invasive species early detection would provide time to determine its invasive qualities and if needed obtain grants to address the invasive species problem. State Department of Agriculture, Natural Resource Conservation Service or private philanthropic organizations could be sources for funds.

Information dissemination between researchers and land managers has been one of the foundations for invasive species management. It provides the documentation needed to inform the stakeholders of progress and possible actions. Publicly funded efforts frequently require disclosure to show how the appropriated funds were spent. A possible method to provide this information to the public would be to publish the results of monitoring and eradication efforts. The best way to distribute data in the internet age is to post the information on a web page. This could be done using one of the stakeholder's web presences or a unique page could be developed and dedicated to Red Hill. Basic information about the site could be included. The management plan, funding sources and dedication, a species list, vegetation map, ED/RR results and eradication efforts would populate the site and fulfill basic public notification requirements.

Goal #5: Invasive Species Prevention

The sports adage "*the best defense is a good offensive*" wasn't meant for invasive species protection, but it is a statement that is directly applicable toward this effort. The best way to protect Red Hill's vegetation from an alien species invasion is to prevent plants with those attributes from ever getting a foothold. Prevention is the rationale behind the early detection and rapid response goal. The ED/RR visits are a preventive prescription in an attempt to eliminate establishment of undesirable plants or animals. Successful prevention depends of knowledge of the site, the ports of entry and species circulating in the region that could be problems if transported to Red Hill. Off road vehicles such as ATV and motorcycles may occasionally use the site. Other users may also transport unwanted plants as seeds stuck to shoes and tires. Animals and wind are also modes of transport for seeds with windblown seeds or sticky surfaces. Red Hill's deer and bird populations are the most likely animal sources of transportation. Reducing the deer herd and its associated pressures will help prevent new species introductions as well as reduce damage to all levels of vegetation. Preventing invasive species from establishing on Red Hill can be achieved by determining the points of entry most likely to provide access for invasive species. This will help determine the best use of ED/RR visits by concentrating search efforts where plants or animals are most likely. Reducing access will help prevent introductions of invasive species. Access is not denied, only redirected to well worn paths and keeping introductions from

“walking” into the old field. Prevention must also incorporate an educational component. As time passes, other species will become problematic. It will be important for the Red Hill team be kept informed of local invasive species issues. Plants and animal currently not on site but are present regionally should be familiar to ED/RR personnel. Newly emerging species likely to harm Red Hill can be provided by State Department of Agriculture or federal web sites. Currently insects such as Asian long horned beetle, plants like Japanese holly and systemic diseases such as bacteria leaf scorch are new pests invading New Jersey. ED/RR teams will be better prepared if they understand and can identify the new threats as they emerge.

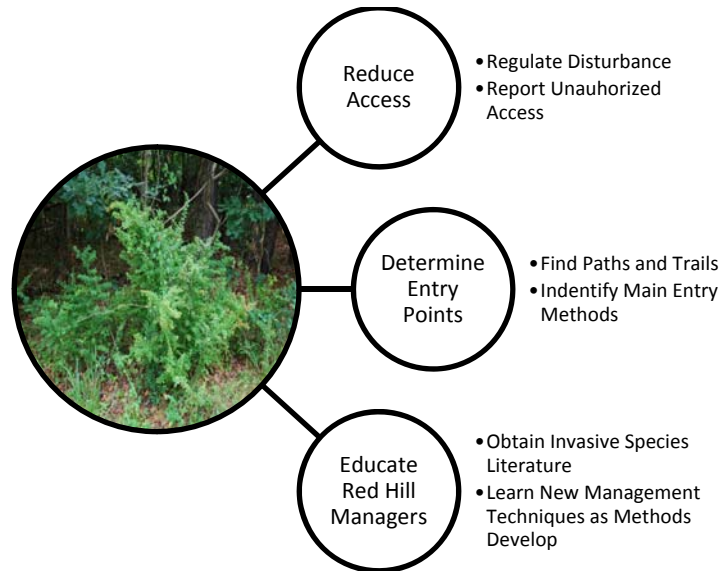


Figure 12: Invasive Species Introduction Prevention Relationships

Goal #6: Recommend Species for Immediate Eradication

It is this plan’s recommendation, once the management team and volunteer assignments have been developed, to begin Red Hill management by eliminating aggressive invasive plants. Each species has control methods based on species-specific growth strategies and sensitivity to various techniques. Invasive species management by eradication is not a novel approach. There are many sources of information describing the methods manage each of these invasive plants. Both public and private organizations offer a wide array of accepted techniques with clear and accurate descriptions to implement any suggested methods. Sources such as the United State Department of Agriculture (<http://plants.usda.gov>) and the Natural Resource Conservation Service (<http://www.nrcs.usda.gov>) offer excellent suggestions on species identification, distribution, and methods to control when a plant is considered invasive. The recently adopted New Jersey Invasive Species Management Plan (www.state.nj.us/dep/njisc.htm) provides additional protocol details and species management descriptions. The Nature Conservancy (<http://www.nature.org/initiatives/invasivespecies/>) is a private, non-profit organization that is in the forefront of this issue. This organization manages thousands of acres of wild lands throughout the world. With this kind of exposure, the Nature Conservancy’s staff of

scientists developed species monographs and management strategies to confront many invasive species problems common to Red Hill.

Red Hill invasive species management would begin with the eradication of a select set of plants identified by recent field investigations. Invasive species do not currently have a significant foothold on Red Hill. The sandy soil has benefited the native flora, reducing invasive species to a small group with manageable populations. Of the non-native species recorded for Red Hill, only 5 species rise to the level requiring immediate eradication efforts. Common mugwort, garlic mustard, Nepalese Silt grass, Japanese honeysuckle and Scotch pine are the non-native plants worthy of immediate control.

Garlic mustard and stilt grass are both species with reproductive strategies that favors high seeds production. Garlic mustard is a biennial. Nepalese stilt grass is an annual. Both are shade tolerant species, somewhat intolerant of open drought prone conditions. Mugwort and Japanese honeysuckle, on the other hand, are perennials. Mugwort is a composite with viable seed production and rhizomatous vegetative reproduction. Its vegetative strategy allows this species to expand even when seed bed conditions are less than desirable. Honeysuckle is a woody vine with multiple growth strategies. Not only does it possess a vegetative growth strategy that will allow each colony to expand, but it also processes a sexual reproductive tactic that provides viable seeds in an edible berry that are readily distributed by native birds. Scotch pine is a special case. Normally, this conifer is not a species commonly associated with invasive characteristics. This tree, however, has been able to exploit Red Hill's open sandy old field by occupying space critical for perpetuating the open Coastal Plain old field conditions.

The eradication techniques suggested to address these species include physically removing the plants with manual labor, followed secondarily, if needed, with herbicide application. Manual removal is always the first choice to control invasive plants. It allows for surgical accuracy and has the least impact to the surrounding vegetation. The disadvantage of manual removal is that it requires a large labor investment. It also can be futile with perennial species that use vegetative strategies involving rhizomes or stolons. Herbicide use is appropriate on a limited and controlled application to spot treat burgeoning infestations.

The following short descriptions provide basic site and treatment information for the 5 invasive species. These 5 species have been selected from the complete tally of Red Hill's 14 non-native plants because they have the highest invasive qualities with the most immediate potential to impact the native flora. The species descriptions provide specific Red Hill locations with suggested eradication solutions, sufficient to provide immediate directions to an ED/RR team.

Red Hill's Top 5 Problem Plants

❖ Garlic Mustard (#1, *Alliaria petiolata*) and Nepalese Stilt Grass (#2, *Microstegium vimineum*)

These two plants are presented together because on Red Hill they occupy the same site. A single mixed colony composed of both species exists on the north side of the Hill. Both plants are well documented as two of the most notorious invasive species in New Jersey. Their ability to tolerate shade and to equally colonize uplands and wetland, allow these plants to compete with smaller, native herbs. Specifically, both species have been documented in Ash Swamp in direct



Photo #5: NE view of Garlic mustard and Nepalese Stilt Grass stand

completion with spring woodland ephemeral flowering plants such as native Violets. Both garlic mustard and Nepalese stilt grass occupy the forest floor habitat. Both are capable of replacing desirable shade tolerant native plants such as *Danthonia spicata* and *Solidago rugosa*. These two invasive species impact the fauna as well as flora. Garlic mustard has been demonstrated to have effects on insects, such as butterflies. Nepalese stilt grass replaces palatable browse with leaves and stems shunned by most herbivores. Neither species, when present in North America, have effective predators allowing each to expand unchecked.

Garlic mustard's broad basal leaves compete with native species by shading during its entire first year. Mature specimens tower above the same native species during the plant's second spring. The plant freely flowers in the spring and it produces a bounty of viable seeds. These seeds are spread by ejection and gravity, a common mustard family trait associated with its long thin seed capsule (silique). The species can expand rapidly, occupy space in undisturbed forests.

Nepalese stilt grass affects a similar sub-canopy herbaceous flora through completion. The annual reproduction eliminates the alternate year cycle seen with garlic mustard. Unlike garlic mustard, this species matures within a single season producing large numbers of viable seeds. During the summer months, this species compete for space by forming a dense mat of leaves and stems, physically crushing other species. It branches freely and roots at the stem nodes. Both traits allow the plant to creep over surrounding shorter plants, effectively creating a monotypic cover. It flowers in the fall, spreading seeds that may last years in the local seed bank.

Red Hill's Population: The mixed stand of Garlic mustard and Nepalese silt grass exists on the northern edge of Red Hill. It occupies a narrow band under the deciduous canopy between a wet swale and the open dry sand of the dirt trail. Both species occupy a single, continuous patch. There are two

additional non-native plants, orchard grass and blue grass, in the same patch. The latter two grasses present no immediate threat to Red Hill's native Coastal Plain flora.

Both garlic mustard and Nepalese stilt grass are tolerant of low light conditions and each thrives in the shaded and moist condition (Miller, 1997). Both species are known for rapid population expansions by seed. High seed production and rapid germination require immediate attention.

Location: The center of the colony is at or near North 40°37.216', West 074°21.229'.

Population size: The mixed garlic mustard and Nepalese stilt grass colony occupies an area approximately 100' by 20', or approximately 2,000 Square Feet (SF).

Management Issues: Garlic mustard is a biennial whereas stilt grass is annual. Annual and biennial species can be managed differently. Annual species should be addressed in the spring or early in the growing season. This eliminates the plants from reaching maturity and dropping additional seeds into the seed bank. Biennial species can be handled any time before it flowers. Garlic mustard is visible throughout its first year and eradication should occur during this time. The seed bank will allow both plants to reappear for a number of years. This will require repeated actions over a number of seasons to eradicate both plants.

Garlic Mustard Eradication Techniques: Small populations of garlic mustard such as Red Hill's are appropriate for hand pulling. This has been determined to be an effective management strategy, rapidly eliminating the seed source when completed before the plants flower. This is a spring flowering species and efforts should concentrate of pulling basal rosettes and developing flowering specimens before they set seed. Once the seed is mature, harvesting should include bagging collected specimens to keep seed of the year from being spread. Any plants collected should be removed or elevated to dry the roots. The persistent seed bank will require land managers to return to the site of infestation each spring until seedlings are no longer visible. An alternate method using herbicide would apply a 2% glyphospahte in fall and early spring when most other plants are dormant.

Nepalese Stilt Grass Eradication Techniques: The garlic mustard colony includes a patch of this aggressive alien grass. Its expansion onto the open dry hilltop is not likely, but it could establish under any forest cover as the woodland matures. It is found in the wetland forest surrounding the Red Hill, providing a nearby source for repeated introduction. Like the mustard, the existing population on the Hill is small. At the current scale, hand pulling is an appropriate method. Stilt grass is a fall flowering species, so summer and early fall removal would achieve seasonal eradication before the plants mature and seeds of the year set. Yearly removal new seedlings will be required until the seed bank is exhausted. Herbicide use can be effective, but does not eliminate the seed bank. A seed pre-emergence herbicide such as Ronstar® is a possible alternative to yearly seedling removal.

❖ **Common mugwort, common wormwood, (#3, *Artemisia vulgaris*)**

A small colony of this plant occupies an open sandy clearing the western edge of the Red Hill old field. Mugwort is a perennial composite, a member of the same family as sunflowers, goldenrods and asters. The plant occupies space on Red Hill that otherwise would be supporting warm season grasses. The existing colony appears to be composed of few individual plants that are spreading by vegetative means. Mugwort's perennial reproductive strategy provides two avenues to expand. Seed for this species is spread by gravity and animals. Its primary distribution once established is by rhizomes. Like many of the wind pollinated members of this family, its pollen is armored and produces the same allergic reaction to sensitive people as ragweed. Members of the composite tribe Anthemideae also exhibit allelopathic effects (Chester et al, 2001) that exclude sensitive species. The plant's chemistry (Chaves et al, 2001) provides an adaptation to repel insect herbivores and influence other plant seedlings, favoring this species.

Location: The small population of common mugwort is found at or near North 40°37.136', West 074°21.194'.

Population Size: A dispersed colony occupies a 10' by 10'; ~100 SF space west of the dirt trail circling the old field.

Management Issues: Common mugwort originated from Europe, with introduction occurring during colonial times. The plant will occupy nutrient poor soils, forming dense mono-specific cultures devoid of competing species. The plant is an aromatic perennial composite. It possesses allelopathic biochemistry thus influencing its association with other plants. This species has the capability to spread by seed and rhizome. Its presence will eliminate space needed by native species. The plant slowly expands, propagating in a nearly imperceptible manner that lulls managers into inaction. Once established, it's very difficult to completely eradicate without mechanical removal and repeated application of herbicides.



Figure 9: Common mugwort

Mugwort Removal Techniques: The perennial nature of this plant will require the use of aggressive mechanical excavation or repeated use of herbicides. The population is small enough to attempt hand removal, using a spade to expose the subterranean rhizomes. This method is labor intensive and will undoubtedly allow small bits of the rhizome to remain. This would necessitate a repeated excavation over a period of two or three seasons. Any manual work should gather all weeded plants for proper disposal.

Alternatively, the use of herbicides applied to leaves is another approach. Products such as Roundup or Stinger can be applied as per product standards at their designated application rates to control up to 85% after the first application. Applications can occur as soon as the leaves of the season appear in the spring.

❖ **Japanese Honeysuckle, (#4, *Lonicera japonica*)**

This invasive vine is found as scattered individuals on the eastern side of Red Hill's upland. Native of East Asia, this species is one of New Jersey notorious invasive woody plants. It is tolerant of a wide array of habitats. It is able to colonize open fields and forest sub-canopies alike. It presents a unique set of adaptive features, including the ability to sustain repeated deer browse that is fatal to other woody species. It has the ability to act as a ground cover as well as climb trees and other



Photo #10: Japanese Honeysuckle, *Lonicera japonica*

upright plants on which it uses as a trellis to reach canopy branches. It is spread by seeds digested by berry eating birds. Once established it expands using its twining branches covering and suffocating surrounding vegetation. Currently, Japanese honeysuckle is a minor problem. The plant has not expanded beyond the initial seedlings and would be easily manageable at this time.

Location: Approximately North 40°37.0839, West 074°21.1668' is a center point between widely scattered colonies.

Population Size: The scattered individuals and small colonies cover a small area. Estimates of 5' x 5' or smaller patches would characterize each site.

Management Issues: Japanese honeysuckle has a bad reputation because of its success as an invasive species. This plant is an aggressive vine with the ability to invade forests and other native settings (Miller, 1997). The plant can occupy nutrient poor soils such as those found on Red Hill. It prefers areas enriched by farming or other similar nutrient rich uses. Red Hill's farming history provides a nutrient source for this species. Once established, it's very difficult to completely eradicate without substantial mechanical removal and repeated herbicide applications. One disadvantage is its palatability to white tailed deer. Deer thrive on Japanese honeysuckle during the winter. Often deer will repeatedly browse the plant into small disfigured specimens. This can have a secondary impact to Red Hill, providing a food source differentially attracting deer due to the presence of Japanese honeysuckle.

Japanese Honeysuckle Removal Techniques: The perennial nature of this plant will require an aggressive manual eradication effort or repeated use of herbicides. Red Hill's small population composed of small stature specimens lends itself to the manual removal method. This would require repeated pulling above ground tissue and excavation into the roots over a period of two or three seasons. Alternatively, the use of foliar applied herbicides, such as Roundup or Stinger, can reduce this plant by up to 85% after the first application. Applications can occur as soon as the leaves appear in spring.

❖ **Scotch Pine, (#5, *Pinus sylvestris*)**

Photo #11: Scotch pine at Red Hill

Red Hill supports a small population of this non-native pine. This European tree species is found as scattered mature specimens surrounded by seedlings and saplings. The tree was once widely planted as a landscape specimen and it was frequently used as a Christmas tree. The species has a record of expanding from planted settings. Scotch pine has similar exposed seed bed requirements making Red Hill's old field ideal for expansion. Its presence reflects the proximity of Red Hill to the surrounding developed landscape where this tree has been used for ornamental reasons. The seed is spread by wind with its source probably somewhere north and west of Red Hill.

Location: The tree is found on the west and south sides of the Red Hill old field surrounding North 40°37.084', West 074°21.173'. This point identifies the main patch of mature specimens. Seedlings and saplings are scattered throughout.

Population Size: Main patch of mature specimens occupies a ~75' by 20' area, proving a canopy of ~1500 SF. The seedlings as scattered individuals and are most prevalent leeward of the mature trees.

Management Issues: Like most pines, this species responds to sandy soils and is capable of occupying open areas such as Red Hill. The tree is spread by seed cast in the fall by mature specimens. The plant is capable of invading plantations and open woodlands. Unlike other invasive species, Scotch pine is susceptible to a variety of pathogens. Two are already attacking the Red Hill colony. The U.S. Department of Agriculture (1994) identifies this pine is susceptible to saw fly, pine needle scale, Zimmerman Pine moth larvae, Pine weevils and Pine shoot beetle. The Red Hill infestation is infected by insects causing bark damage and branch tip damage. Both infections are substantial, affecting the majority of seedlings.



Photo #12: Scotch pine tip damage

Scotch Pine Removal Techniques: The control of this species is relatively simple: manual removal of both mature specimens and seedlings. Cutting the mature specimens is the most effective method to remove this species and the on-site seed source. Seedlings can be hand pulled until the seed bank is exhausted. Branches with mature cones should be removed. The remaining branches and trunks can be used to create brush piles along Red Hill's periphery.

Conclusion

Red Hill's geologic and land use history have provided an opportunity for an unusual landscape setting. This setting, with its sandy soil and isolated prominent position in Ash Swamp, supports vegetation reminiscent of New Jersey Coastal Plain. This is not only unusual for Ash Brook Reservation it is also unusual for Union County. Coastal Plain conditions formally end many miles south of Scotch Plains, on the south edge of the Piedmont Physiographic region. North of that intersection geologic boundary were, at one time, remnants of similar vegetation that also colonized glacial deltaic sands. Now, nearly all of those similar conditions are developed. The few that remain have naturally moved beyond the old field conditions and the other early succession cover types, losing the southern herbaceous flora that made this habitat unique. This unique natural feature becomes even more important when it is evaluated in the ecological web connected between the Hill and the surrounding wetland ecosystem. All sorts of vertebrates and invertebrates depend on the open sandy conditions to maintain their populations. Red Hill is an integral part of the life cycles for birds, reptiles, insect such as Lepidoptera, and is a stop on the foraging trail for many of Ash Brook Reservation's mammals. Red Hill provides diversity to the swamp, both in species richness and in habitat complexity and detail. Physically, Red Hill's sand provide valuable storm water functions that would cost figuratively and physically to Union County residents. Without Red Hill, Union County would lose a suite of biological and physical functions and become undifferentiated for the surrounding urban-developed Piedmont region.

Immediate physical threats to Red Hill are few. There are no points of erosion or readily observable pathology with native species. What do threaten Red Hill are changes to its flora, altering its Coastal Plain ecology. These threats are from two sources: natural forest development and introduction of invasive plants. Red Hill forest development is just beginning. Unlike the remaining Dunellen sandy loam soil deposits in the Ash Brook Reservation, those on Red Hill have maintained an open canopy. This open canopy presents one the Northern Piedmont-Plains wildlife most scarce habitats, old field and early succession habitats. Red Hill presents nearly 5 acres of open old field and shrub dominated habitat, representing nearly a full percentage of the regions similar habitat. Maintaining this open habitat will benefit many levels in the local trophic system. Native old field birds will benefit from this habitat maintenance. Maintenance of the open field will include natural occurring openings, which will provide nesting sites for reptiles such as wood turtle and grooming sites for birds.

Invasive species are the other threat to Red Hill. The unusual sandy conditions have worked in the Hill's favor, repelling most regional invasive plants. Those that have arrived are limited in size and numbers, and are readily manageable. There are less than 20 identified species of alien plants on Red Hill. Of those only 5 have risen to the level deemed necessary to manage. The plants deemed immediate threats are 4 herbs and one tree. All are in the early stages of site colonization and are readily susceptible to manual eradication efforts. They can be kept in check by an initial purge followed by regular monitoring and regular suppression maintenance.

Tasks such as eradication and regular monitoring will not happen unless there is a proposal for formal management. Red Hill management would require a relatively simple structured system based on a team created by interested stakeholders and the dedication of time and effort by volunteers to

implement the tasks outlined in this report. Coordination with stakeholders will provide a legitimate process to accomplish the long term goal, keeping Red Hill's Coastal Plain ecology intact. Early detection and rapid response would be the process to keep Red Hill's upland ecosystem free of aliens, resulting in the perpetual presence of the desired coastal plain flora. Volunteer monitoring would identify problems as they develop, allowing the managing team to address new invasions as they occur.

Without this or similar effort, Red Hill will slowly succumb to the effects of succession, gradually changing from the mosaic of open habitats now present, to a closed hardwood forest. It would be nearly indistinguishable from the surrounding Ash Brook Reservation. The unique Coastal connection would be initially replaced with a forest dominated by species capable of occupying open spaces, wet or dry. Sweet gum, pin oak, black cherry, sassafras, green ash and red maple will eventually create a closed canopy, excluding most old field species. Lost would be the one of Union County's only old field sites with *Andropogon virginicum*, *Bartonia virginica*, *Dichanthelium spaerocarpon*, *Dichanthelium villosissium*, *Eupatorium hyssopifolium*, *Eupatorium pilosum*, and *Euthamia tenuifolia*. *Solidago patula*, a regionally restricted mesic species, would be affected. Also lost would be the ideal nesting site for the threatened wood turtle, as well as 5-acres of critical wildlife habitat distinctly identified in the State's wildlife management plan. Each, if lost, represents some of Union County's only natural history representatives of this Coastal Plain affinity.

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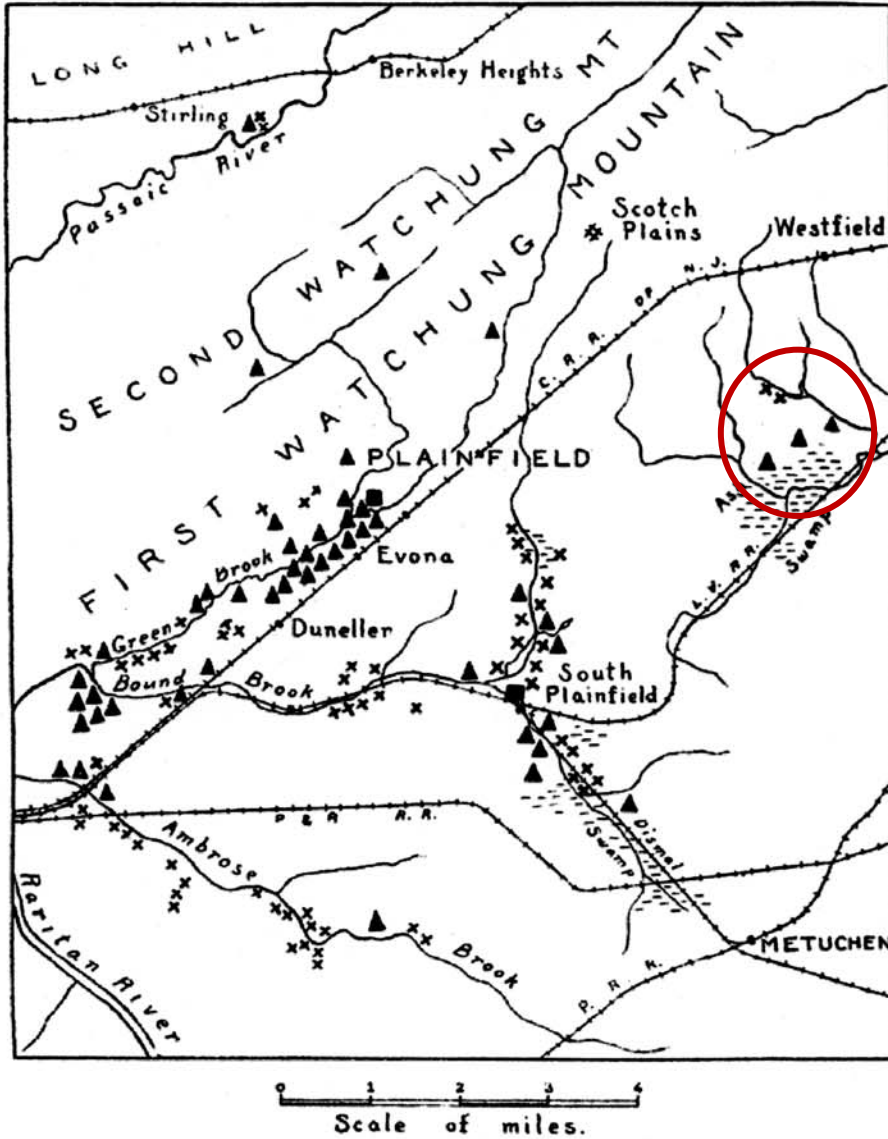
Appendix

Literature, Historic Maps, Photos and Miscellaneous Documents

- 2 Pages from 1915 Archaeological Document describing Red Hill
- Species List from Field Observations
- Historic Maps
- Site Photographs

INDIAN REMAINS.

Scattered relics are found hereabout, chiefly arrow points. (25-23-6-9-9.)



LEGEND— ▲ Camp sites ■ Burial grounds. x Scattered finds

FIG. 5.—Indian Remains Near Plainfield.

Watchung.—One mile northeast of Watchung there is a small camp site on a hillock. There were formerly a number of springs here, now dried up. Arrow points, several celts, and chips were

Willow Grove.—East of the road from Lambert's Mills to Rahway at the end of Ash Swamp, is a camp site, the débris of which extends fore one-quarter of a mile north and south. Axes, hammer stones and arrow points of all materials common to this region are found here. (25-35-1-2-9.)

The fields adjacent to this site also show evidence of occupation by the finds of scattered relics.

Implements have been found scattered about Lambert's Pond northwest of this site.

A small camp was situated on a hillock north of Ash Swamp on the farm of Anthony Wahl, one-half mile from Willow Grove. A number of grooved axes were taken from this site. Arrow points and chips made in the process of flaking are fairly abundant. Few argillite objects have been found. (25-35-1-5-4.)

A large sandy hill on the northern edge of Ash Swamp 1 mile southwest of Willow Grove is the site of a camp. Including the camp proper and the scattered débris from it the site is one of several acres. A large number of arrow points, one or two stone drills, and several pitted hammer stones were collected here. Stone flakes are very abundant on this site. Dr. Buchanan believes that the position of objects found here indicates that they have been ploughed up or washed out from a considerable depth. (25-35-1-4-5.)

THE LOWER DELAWARE VALLEY GROUP.

Woodbury.—Many scattered finds have been made in the fields adjacent to Woodbury Creek on both sides from its mouth to its source, as well as along Mathew's Brook. Objects, although not abundant, are more plentiful on the south side of the creek. (31-11-4, 5, 8.)

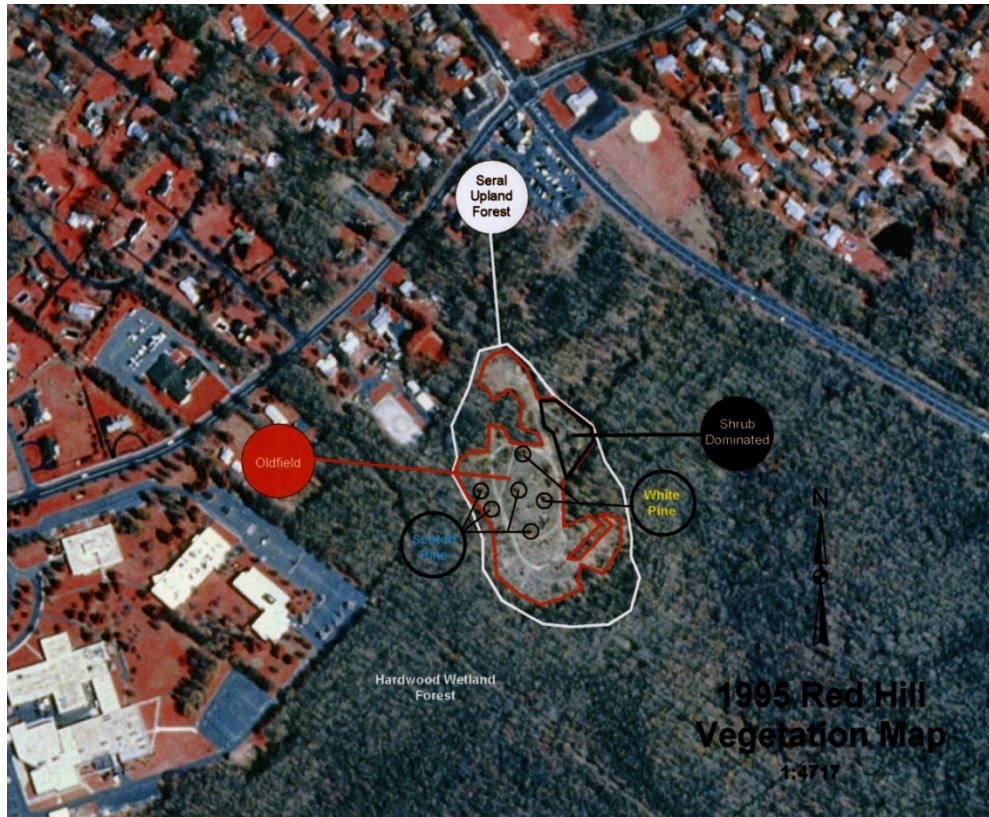
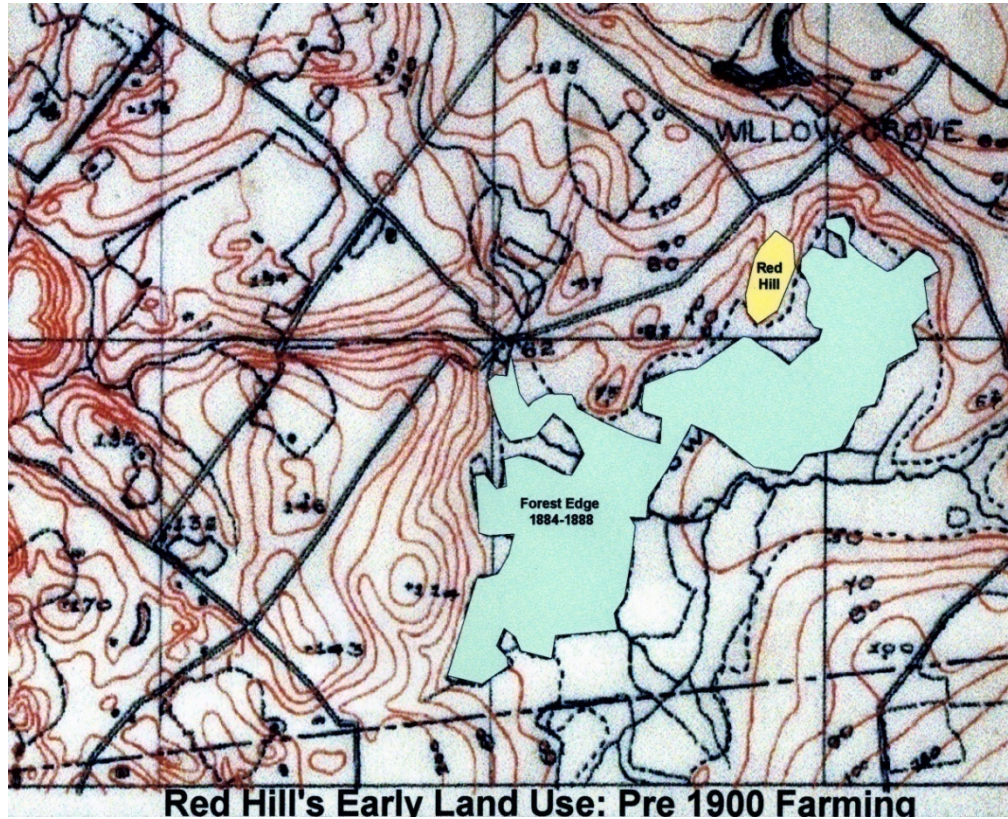
Mantua Creek.—Along Mantua Creek, on the bluffs on both sides, from Mt. Royal to Hee's Branch and along Monongehela Brook, relics have been found. These are chiefly arrow points, occasionally a grooved axe is found. It is probable, however, that all the sites on this creek have not yet been reported. (31-11-7, 8; 31-21-1, 2, 3.)

Red Hill Vegetation and Species List

Vegetation: The upland is dominated by old field. This cover occupies the highest parts of the hill. Little blue stem and other common warm season grasses are the most common herbs in this cover type. Young forest composed of pin oak, sweet gum, gray birch, and sassafras occupies the lower slopes of Red Hill. Shrub dominant areas support northern bayberry, high bush and low bush blueberry, and arrowwood. Refer to the 1995 Vegetation Map on page 43. The symbol * refers to non-native plants. The ** symbolizes aggressive invasive plants. Italicized names are species with Coastal Plain affinities.

Species List (68 count)

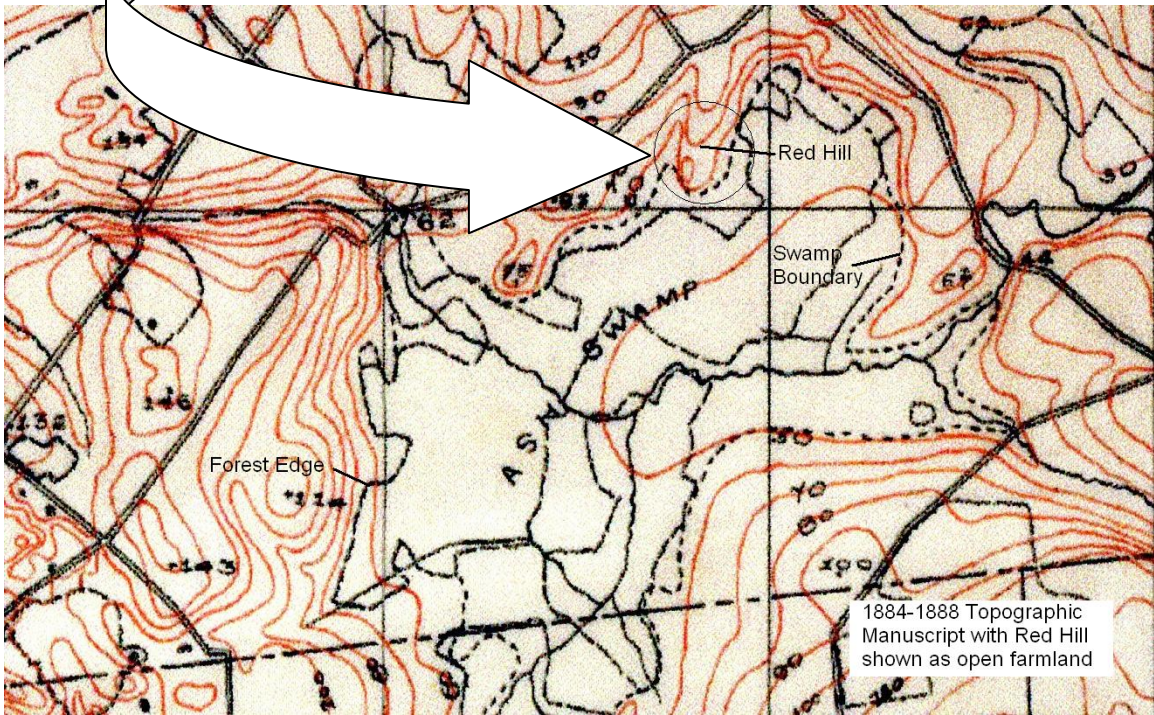
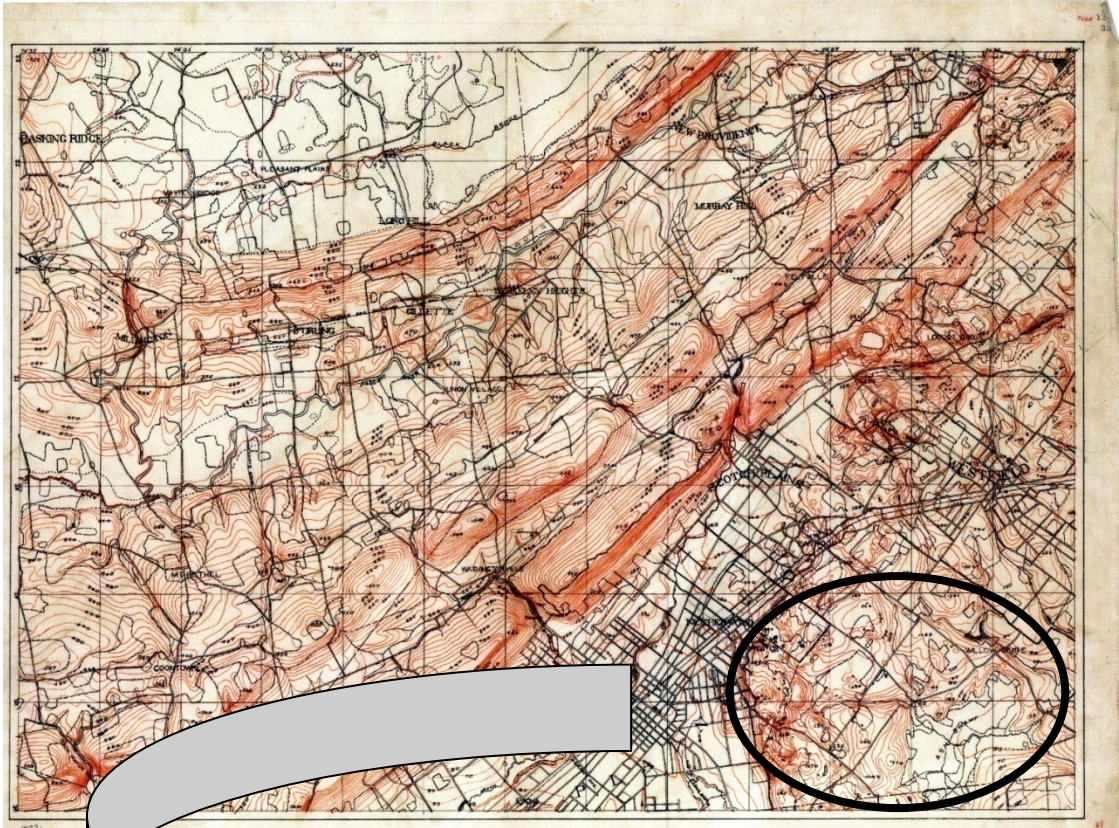
<i>Achillea millefolium</i> *	<i>Microstegium vimineum</i> **
<i>Agrostis perennans</i>	<i>Monotropa uniflora</i>
<i>Alliaria petiolata</i> **	<i>Morella pensylvanica</i>
<i>Andropogon virginicus</i>	<i>Morus rubra</i>
<i>Anthoxanthum odoratum</i> *	<i>Paspalum setaceum</i>
<i>Apocynum cannabinum</i>	<i>Pinus strobus</i>
<i>Aristida dichotoma v. dichotoma</i>	<i>Pinus sylvestris</i> *
<i>Artemisia vulgaris</i> **	<i>Polygonatum biflorum</i>
<i>Asclepias amplexicaulis</i>	<i>Populus gradidentata</i>
<i>Bartonia virginica</i>	<i>Populus tremuloides</i>
<i>Betula lenta</i>	<i>Potentilla simplex</i>
<i>Betula nigra</i>	<i>Prunus serotina</i>
<i>Betula populifolia</i>	<i>Pseudognaphalium obtusifolium</i>
<i>Carex swanii</i>	<i>Quercus bicolor</i>
<i>Chimaphila maculata</i>	<i>Quercus palustris</i>
<i>Danthonia spicata</i>	<i>Quercus velutina</i>
<i>Desmodium cilare</i>	<i>Rhamnus frangula</i> *
<i>Desmodium paniculatum</i>	<i>Rubus</i> spp. (including <i>flagelaris</i>)
<i>Dichantherium acuminatum</i>	<i>Rumex acetosella</i> *
<i>Dichantherium sphaerocarpon</i>	<i>Sassafras albidum</i>
<i>Dichantherium villosissimum</i>	<i>Schizachyrium scoparium</i>
<i>Eupatoirum rugosum</i>	<i>Smilax glauca</i>
<i>Eupatorium pilosum</i>	<i>Solidago patula</i>
<i>Euthamia graminifolia</i>	<i>Solidago rugosa</i>
<i>Euthamia tenuifolia</i>	<i>Sorghastrum nutans</i>
<i>Galium aparine</i> *	<i>Taraxacum officinale</i> *
<i>Hieracium paniculatum</i> *	<i>Toxiodendron radicans</i>
<i>Hieracium pilosella</i> *	<i>Ulmus</i> sp.
<i>Ilex opaca</i>	<i>Vaccinium fuscatum</i>
<i>Juncus tenuis</i>	<i>Vaccinium pallidum</i>
<i>Juniperus virginiana</i>	<i>Veronica officinalis</i> *
<i>Krigia virginica</i>	<i>Viburnum dentatum</i>
<i>Lonicera japonica</i> **	<i>Viola lanceolata</i>
<i>Lysimachia quadrifolia</i>	



1884-88 Vermeule Manuscript (top) with forest highlighted; 1995 Vegetation Map (bottom)



Red Hill on 1930 Air Plane Mosaic Photo: Regional view (top); low altitude (bottom). The photos exhibit a long established landscape: rural, small plot subsistence farming.



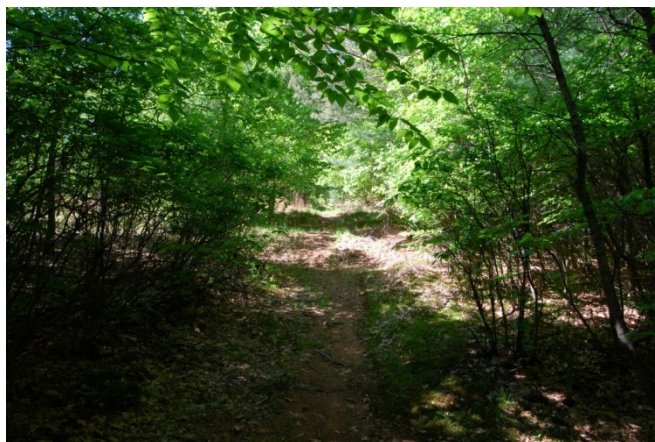
Scotch Plains Topographic NJ DEP-Geological Survey Manuscript: Full manuscript (top) and close view of Red Hill (Bottom). This source shows Red Hill was cleared farmland in the late 1880's.



Scotch pine seedlings, notice tip / shoot damage



Young native upland woodlands on Red Hill's lower slope



Dirt path provides access to Red Hill



A hardwood forest, Ash Swamp, surrounds Red Hill



This boulder shows surface use possibly from Native Americans



Broken crypto-crystalline projectile from Red Hill's dirt path

Invasive Species Control Documentation

Anticipated Red Hill Invasive Budget

Early Detection / Rapid Response Site Visit Form

Specific Data for the 5 plants Identified of Eradication

- Garlic Mustard
- Common Mugwort
- Japanese Honeysuckle
- Japanese Stilt grass
- Scotch Pine

Anticipated Invasive Species Control Budget: Immediate and Yearly Costs

1st Year Eradication Budget

Problem Species Estimated Eradication Costs: Assumes use of professional crew in lieu of volunteers. Equipment for project would assume a backpack sprayer for liquid herbicide application and hand tools such as shovels, rakes and hand saws. Foreman - \$51.79/hr; Laborer - \$43.51 Union Co rates.

Problem Species/ Area SF	Method	Product / Use Per 1000 SF	Product Cost	Est. Time Foreman 2 Laborer Crew	Est. Crew Cost	Equip. Costs¹	Total Eradication Cost
Garlic Mustard 2000	Herbicide and Manual	Glyphosphate 0.5-1.0 oz.	\$35 / Gallon; use 2.0 oz	3 hours hand pull and spray	\$416.63	0	\$451.43
Common Mugwort 100	Herbicide	Stinger 0.0003 oz. use < 1 oz.	\$132.60/ quart;	0.25 hrs	\$34.70	0	\$167.30
Japanese Honey-suckle 1000	Herbicide and manual	Glyphosphate 0.5-1.0 oz.	\$35 / Gallon; Use < 2.0 oz.	3.5 hrs hand pull and spray	\$485.84	0	\$486.38
Nepalese Stiltgrass 2000	Herbicide and Manual	Ronstar 2.25 – 4.5 lb	\$106 / 50lb. bag	Incorporated with Garlic Mustard	-	0	\$9.54 Ronstar
Scotch Pine 5000	Manual	-	-	8 hrs Cut and stack	\$1110.48	-	\$1,110.48
5 Species	H & M	3 Herbicides	\$273.60	14.75 Hrs	\$2,047.65		\$2,321.25 ²

Subsequent Yearly Costs

Volunteer Site Visits to determine early detection / rapid response efforts.

Yearly Visits	Person Hours			Totals
	Field	Correspondence	Response/Meetings	
Spring Visit	3	1	1	5
Late Summer Visit	3	1	1	5
Totals: 2 Visits	6 Field Hours	2 Hrs Correspondence	2 Hrs Response/Meetings	10 hrs yearly total

Based on Laborer costs of \$43.51/hr – Class C Journeyman, 10 hrs would cost \$435.10

Web Page Development and Maintenance

Market prices for pages range wildly, yet most private services cost \$400 to \$1000 per page setup; up keep would cost ~\$50/hour for page maintenance and updates; hosting costs \$6.25 to \$15.00 per month.

¹ Equipment used beyond the use of tools in landscape profession tool bag.

² Total Cost incorporates the cost to purchase smallest quantity of herbicide, not the amount of herbicide dedicated to the total eradication cost per species.