Highlands Council
New Jersey

Ecosystem Management

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Prepared by State of New Jersey Highlands Water Protection and Planning Council in Support of the Highlands Regional Master Plan

Technical Report

HIGHLANDS REGIONAL MASTER PLAN

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The Ecosystem Management element of the Highlands Regional Master Plan evaluates the effect of land development and other stresses on the ecological resources of the Highlands Region, and establishes the overall strategies necessary to maintain and enhance their value. These resources include:

- Highlands Open Waters
- Riparian Areas
- Steep Slopes
- Forest Resources
- Critical Habitats

The purpose of the Ecosystem Management element is to highlight areas of the Highlands Region with exceptionally high ecological values that should be conserved, those with lesser value that may be restored, and those previously impaired by past human activity that may be appropriate to support growth. These are each presented in an integrated ecosystem protection and management framework.

HIGHLANDS OPEN WATERS AND RIPARIAN AREAS

The protection, enhancement and restoration of water resources is a fundamental goal of the Highlands Act. A primary mechanism to meet this goal is the assessment of surface waters and wetlands, known as Highlands Open Waters, and lands adjacent to these waters, known as Riparian Areas. Highlands Open Waters are a critical public trust resource and an essential source of drinking water for the State of New Jersey. These surface waters and the associated riparian areas provide protection against floods and help to ameliorate the affects of prolonged droughts. They are also important habitat for numerous plant and animal species including many rare, threatened, endangered species in the State. Highlands Open Waters and Riparian Areas provide a wealth of agricultural, recreational, and aesthetic uses for both residents and visitors alike, helping to contribute to a vibrant regional economy.

Highlands Open Waters include all springs, wetlands, intermittent or ephemeral streams, perennial streams, and bodies of surface water, whether natural or artificial, located wholly or partially within the boundaries of the Highlands Region. The protection area necessary to maintain the quality and ecological integrity of streams was evaluated. The Highlands Regional Master Plan includes a recommendation for a 300 foot protection area buffer around all streams and wetlands.

Riparian Areas are areas adjacent to, and hydrologically interconnected with, rivers and streams. They are areas that exhibit periodic inundation or saturation of soils, are subject to periodic flooding, and include wildlife corridors within 300 feet of a surface water feature. Riparian Areas serve as an interface between surface water bodies and terrestrial ecosystems and play a critical role in maintaining the quality and ecological integrity of Highlands Open Waters.

The Highlands Region contains an extensive network of surface waters and associated riparian lands. The Highlands Council completed an inventory of the Highlands Open Waters within the Highlands Region. The total stream length mapped in the Highlands is 3,605 miles and the extent of mapped streams and lakes acreage is 32,214 acres. The total for mapped wetlands in the Highlands Region is 90,091 acres. The mapped Riparian Area is 367,988 acres, representing over 42% of the Highlands Region.

The Highlands Council utilized a watershed-based assessment to evaluate the integrity and protection needs of Highlands Open Waters at the HUC14 subwatershed level. There are 183 HUC14 subwatersheds that are located partially or entirely within the Highlands Region accounting for over 1 million acres. The watershed indicators that were selected to evaluate each of the HUC14s of the Highlands Region are as follows:

- Percent Developed Lands - the percentage of the HUC14 that is developed, with developed defined as lands that have been altered for residential, industrial or commercial uses.

- Habitat Quality – the percentage of the HUC14 that contains habitat for species of concern including rare, threatened, or endangered species.
- Percent Total Forest – the percentage of the HUC14 that is forested, with forested defined as all mature and successional upland and wetland forested.
- Percent Core Forest – the percentage of the HUC14 that contains forest areas greater than 300 feet in distance from an altered edge.
- Proportion of Total Forest – the percentage of the HUC14 that contains forest within a fixed search radius.

The Highlands Council assigned a watershed value class to each HUC14 in the Highlands Region based on a cumulative assessment of all the watershed indicators. These value classes are:

- High Resource Value Watershed – these areas exhibit predominantly forested lands and includes a significant portion of the watershed that is high quality habitat.
- Moderate Resource Value Watershed – these areas contain forest lands and some habitat suitable for rare, threatened, or endangered species, but typically also contains developed lands.
- Low Resource Value Watershed – these areas contain a low proportion of forest lands or suitable habitat suitable, and typically consists of higher levels of developed lands.

The Highlands Council analyzed the relative resource value for each of the 183 subwatersheds and determined that the total acreage of High Resource Value Watersheds is 586,534 acres or 68% of the Highlands Region. The total acreage of Moderate Resource Value Watersheds includes 137,118 acres, or 16% of the Region, and the total acreage of Low Resource Value Watersheds includes 135,706 acres, or 16% of the Region.

The integrity of Riparian Areas within that portion of a subwatershed that is immediately adjacent to and hydrologically interconnected with surface waters, serves as an indicator of that area's ability to provide water protection and ecological function including nutrient and sediment filtration, stream bank stabilization, wildlife migration corridors and habitat, storm water and flood water storage, and stream water quality protection. Characterizing Riparian Area integrity entailed the examination of existing land use conditions within the Riparian Area and expressed at the HUC14 subwatershed level.

The Highlands Council selected the following integrity indicators to evaluate each of the 183 subwatersheds:

- Impervious Coverage – the percentage of the riparian area that includes impervious surfaces.
- Agriculture Land Use - the percentage of the riparian area that is in agricultural use.
- Number of Road Crossings per Linear Stream Mile – the number of road crossing per linear stream mile.
- Vegetation Condition – the percentage of the riparian area that features urban and agricultural lands (as a means to determine the percent of natural vegetation).
- Water/Wetland Dependent Species Habitat - the amount of habitat suitable for one or more water/wetland dependent species of concern including rare, threatened or endangered species.

A Riparian Area integrity value class was assigned to each subwatershed based on a cumulative assessment of all the indicators as follows:

- High Integrity Riparian Area – these areas exhibit predominantly natural vegetation including high quality habitat for water/wetland dependent species, and a generally low incidence of impervious area, agricultural uses, and/or road crossings.
- Moderate Integrity Riparian Area - these areas contain a higher incidence of impervious area, agricultural uses, and road crossings and a reduced proportion of natural vegetation including high quality habitat for water/wetland dependent species.
- Low Integrity Riparian Area - these areas contain a high proportion of impervious area, agricultural uses, and road crossings and minimal natural vegetation including high quality habitat for water/wetland dependent species.

The Highlands Council analyzed the relative resource value for each of the 183 subwatersheds and determined

that the total acreage of High Resource Value Riparian Areas includes 419,253 acres or 49% of the Highlands Region. The total acreage of Moderate Resource Value Riparian Areas includes 333,041 acres or 39% of the Region and Low Resource Value Riparian Areas include 107,063 acres or 12% of the Region.

The classification of watersheds with respect to resource value and riparian integrity has been utilized by the Highlands Council to develop the Land Use Capability Map and will also be used to evaluate site specific protection requirements.

STEEP SLOPES

Slope is a measurement of the steepness of terrain and is defined as the vertical change in elevation over a given horizontal distance. Disturbance of areas containing steep slopes can trigger erosion and sedimentation, resulting in the loss of topsoil. It can also result in the disturbance of habitats, degradation of surface water quality, silting of wetlands, and alteration of drainage patterns. The Highlands Region contains extensive areas of steep slopes which offer a variety of recreation, aesthetic, and ecologic functions and values. The identification and classification of steep slopes is important in order to effectively manage critical natural resources in the Highlands Region.

The Highlands Council classified and mapped steep slopes within the Highlands Region to identify areas that are significantly constrained by steep slopes and to ensure that the level of protection for these areas is appropriate. The Highlands Council spatially examined slopes in the Highlands Region using the 10-meter Digital Elevation Grids generated from the United States Geological Survey's (USGS) Digital Elevation Model. The Council examined areas of slope in the Highlands Region that encompassed a minimum of 5,000 square feet and that exhibited one of the following grade classifications and these grades were established as steep slope protection areas:

- grades of slopes of 20% or greater
- grades of slope between 15% and 20%
- grades of slope between 10% and 15% that occur within the Riparian Area

For slopes that exhibited grades between 10% and 15%, the Highlands Council differentiated between those within and outside Riparian Areas. Alteration of slopes of 10% or greater within a Riparian Area have a greater potential of impacting adjacent water bodies through soil erosion (thereby causing degradation of surface water quality, silting of wetlands, and alteration of drainage patterns). Thus, in order to meet the protection needs of Highlands Open Waters, slopes with a grade of 10% or greater in the Riparian Area were identified and mapped as steep slope protection areas.

FOREST RESOURCES

The forests of the Highlands Region provide essential ecosystem functions, including surface water filtration, which is important to protecting essential drinking water supplies for the Highlands Region, and air filtration, which helps to reduce the effects of global warming through carbon sequestration. Forests also serve as habitat for animal and plant species and are critically important to maintenance of biodiversity in the Highlands Region. In addition, properly managed, they provide an important renewable source of wood products.

Historically, forests were the predominant land cover of the Highlands. Today, more than half of the Highlands Region consists of upland and wetland forested communities (approximately 464,200 acres or 54% of the total of land area). Despite increasing forest loss due to land development patterns, the Highlands Region still includes extensive areas of relatively intact forested tracts. More than half of the existing forests in the Highlands Region consist of contiguous forested tracts greater than 500 acres in size.

Protecting the integrity of Highlands forests is dependent on the maintaining large contiguous forested areas and healthy forest stands. Large contiguous forest tracts have a higher degree of interior, or core, forest. Interior or core forest provides important ecological values. Core forest habitat is defined as a forest located more than 300 feet from altered land or a road. Approximately 44% of the total Highlands Region forest area is core forest habitat. It is important to note, however, that even these large contiguous areas may consist of

many smaller parcels under individual ownership. In 2002, the average woodland under a single ownership was 10-20 acres. This presents a significant challenge in efforts to manage forest for sustained ecological and water quality benefits.

Increased fragmentation of forest tracts is occurring due to land use alterations. This fragmentation results in quantifiable landscape level changes which include increased edge, reduced forest interior, increased number of patches, forest patch isolation, and reduced habitat area. Historical and current forest losses due to changes in land development patterns and poor management activities threaten the protection of the region's wildlife, water quality, air quality, and overall ecosystem health.

Sustainable forestry becomes more difficult as woodlot sizes decrease, particularly with increased suburbanization occurring around larger properties. Deer overabundance and introduction of non-native pest species are of significant threat to the region's forest. An overabundance of white tailed deer, in particular, is detrimental to forest health and regeneration due to over-browsing.

The Highlands Council assessed the ecological integrity of forests through the examination of landscape level characteristics at both the forest patch and subwatershed (HUC14) level, utilizing measures of forest fragmentation, to identify where regionally significant forests are located in the Highlands Region. These are the forests that are most suited to support ecological processes. The result of this assessment is the spatial delineation of the Forest Resource Area within the Highlands Region. The Forest Resource Area includes high ecological value forest areas including those forested areas that exhibit the least fragmentation and are vital for the maintenance of ecological processes. The Highlands Council spatially delineated the Forest Resource Area by including those forested areas that express one or more of the following indicators – a contiguous forest patch of equal to or greater than 500 acres in size, an area consisting of >250 acres of core forest area greater than 300 feet from an altered edge, or areas that include >45% of mean total forest cover, and mean distance to nearest patch (HUC14 only).

In addition, the Highlands Council assessed forest cover integrity in the Highlands Region at the watershed level. Forests are important for the protection of water quality and quantity. To assess forest cover integrity at a subwatershed level, the Highlands Council assigned a value class to each of the 183 HUC14 subwatersheds in the Highlands Region as follows:

- High Integrity Forest Area – predominantly forested, including a high proportion of forest cover consisting of high core area, large patch size, and a low distance to nearest patch.
- Moderate Integrity Forest Area – predominantly forested, but do not exhibit a high proportion of forest cover, core area or patch size and an increase in distance to nearest patch.
- Low Integrity Forest Area – predominantly non-forested or include low values for proportion of forest cover and patch size, or a high distance to nearest patch.

Each subwatershed within the Highlands Region was evaluated, using these indicators of forest watershed integrity to identify forested subwatersheds that provide important water quality benefits. The Forest Resource Area and the Forest Integrity Indicators are used in the Highlands Regional Master Plan to achieve the protection of forest areas in the Highlands Region.

CRITICAL HABITAT

Biodiversity is the variety of plant species, animal species, and all other organisms found in a particular environment and is a critical indicator of ecological viability. The protection of habitats that are critical to maintaining biodiversity contributes to the protection of rare, threatened, or endangered plant and animal species of the Highlands Region. There are three categories of Critical Habitat Areas in the Highlands Region: 1) Critical Wildlife Habitat (habitat for rare, threatened or endangered species); 2) Significant Natural Areas (regionally significant ecological communities); and 3) Vernal Pools (confined, ephemeral wet depressions that support distinctive, and often endangered, species that are specially adapted to periodic extremes in water pool levels). Critical Wildlife Habitat and Significant Natural Areas are designated based on the presence of species of concern. Vernal pools are certified by the NJDEP, and to protect and promote the biodiversity of Vernal

Pools, the Highlands Council has determined that a terrestrial habitat protection buffer of 1,000 feet around Vernal Pools will generally address the habitat requirements of vernal pool-breeding wildlife.

The Highlands Council utilized NJDEP's Endangered and Nongame Species Program Landscape Project data to delineate suitable habitat for species of concern within the Highlands Region. A Landscape model (Version 3) was developed for the Highlands Region to identify areas of habitat based upon documented occurrences of rare, threatened, or endangered species.

Of the Highlands Region's 860,000 acres, the Council identified approximately 536,000 acres or over 62% of the Region as potential habitat for rare, threatened, or endangered species. Of these 536,000 acres of potential habitat within the Region, approximately 320,000 acres are in the Preservation Area and approximately 215,000 acres are in the Planning Area. For each species, a Highlands Conservation Rank was assigned indicating the significance of the Highlands Region to the continued survival of the species within the State.

Ecological communities represent a higher level of biodiversity than species. Ecological communities include assemblages of co-existing, interacting species; may be natural or the result of human activities; are inclusive of the physical environment, including climate, topography, geology, soils, hydrology; and include the dynamic ecological processes, such as fire, flooding, drought, that may effect them. The Highlands Council utilized NJDEP's Natural Heritage Program Natural Heritage Priority Sites and unique ecological community information as a preliminary list of significant natural areas within the Highlands Region. A total of 95 Significant Natural Areas were designated.

Vernal Pools are unique ecosystems that provide important breeding habitat and are critical to the survival of many species of amphibians. These pools either dry out completely or draw down to very shallow levels unsuitable for sustaining fish. Lands adjoining Vernal Pools are also important to protect the ecological integrity of these sites and provide for the life requisites of amphibians during the breeding and non-breeding season. The Highlands Council utilized the list of certified vernal pools provided by NJDEP.

An index of relative conservation rank was developed for all habitat that is important to the continued survival of a species of concern in the Highlands Region. This Highlands Rank index includes: 1) a Critically Significant ranking which applies to species whose existence in the State is critically dependent upon Highlands Region habitat; and 2) a Significant ranking which applies to species in which Highlands Region habitats play a significant role for that species' existence in the State.

INTRODUCTION

The New Jersey Highlands Region (Highlands Region) includes 859,358 acres comprised of two areas, the Preservation Area and the Planning Area (See figure Highlands Region). It is located in the northwest part of the State encompassing eighty-eight municipalities in seven counties. A region noted for its scenic beauty and environmental significance, it stretches from Phillipsburg, Warren County in the southwest to Mahwah, Bergen County in the northeast. It is the source of drinking water for nearly 5 million people.

The Highlands Water Protection and Planning Act (Highlands Act) was enacted on August 10, 2004. In adopting the Highlands Act, the Legislature "found and proclaimed that the New Jersey Highlands is an essential source of drinking water . . . for one-half of the State's population, . . . that . . . [it] contains other exceptional natural resources such as clean air, contiguous forest lands, wetlands, pristine watersheds, and habitat for fauna and flora, [and that it] includes many sites of historic significance, and provides abundant recreational opportunities for the citizens of the State." (Highlands Water Protection and Planning Act (Highlands Act), Section 2).

The Legislature also recognized that the resources of the Highlands Region are a vital part of the public trust. It declared that the measures of the Highlands Act "should be guided, in heart, mind, and spirit, by an abiding and generously given commitment to protecting the incomparable water resources and natural beauty of the New Jersey Highlands so as to preserve them intact, in trust, forever for the pleasure, enjoyment, and use of future generations . . . ." The statutory mechanism imposed by the Highlands Act to protect the Region's public trust resources includes the State's commitment to provide state funds for land preservation along with a reorganization of land use powers to emphasize regional planning.

Through passage of the Highlands Water Protection and Planning Act ("Act"), the New Jersey Highlands Water Protection and Planning Council (Highlands Council) was charged with the important task of developing a Regional Master Plan to protect the critical natural resources and other significant values of the Highlands Region. The Act specifically emphasizes the protection of water resources for both potable supply and ecosystem viability but also includes goals relating to the protection of agricultural viability, ecosystems, species and communities, as well as scenic and historic resources.

The New Jersey Highlands supports the greatest diversity of natural resources of any region of the State, with 70% of its lands classified as environmentally sensitive (Highlands Task Force Action Plan, 2004). The biological diversity of the Highlands Region is exemplified by an assemblage and linkages of diverse wetlands, streams and rivers, forests, wildlife habitats, and ridges and valleys. These features collectively comprise the Highlands Region *ecosystem*. An ecosystem is the dynamic and interrelating complex of plant and animal communities and their associated non-living environment.

The Ecosystem Management Technical Report provides an inventory of ecological resources within the Highlands Region. The resources addressed in this report include Highlands Open Waters, Riparian Areas, Steep Slopes, Forests, and Critical Habitat Areas. The report evaluates the affect of land development and other stresses on these resources, and establishes the overall strategies necessary to maintain and enhance their value. The data analysis and conclusions contained in this technical report, and in concert with other technical reports, provides the basis to conduct a resource assessment component of the Regional Master Plan and forms the basis for the Land Use Capability Map (LUCM).

Ecosystem management is the "integration of ecological, economic, and social principles to manage biological and physical systems in a manner safeguarding the long-term ecological sustainability, natural diversity, and productivity of the landscape" (US Department of the Interior, Bureau of Land Management 1994). The primary goal of ecosystem management is to develop and implement management that conserves, restores, and maintains ecosystem integrity, productivity, and biological diversity. Sustainable ecosystems provide many benefits for wildlife and humans such as habitat for fish and wildlife, clean drinking water for communities, wood, fiber, forage, recreational, and economic opportunities (US Department of the Interior, Bureau of Land Management 1994).

The Ecosystem Management Technical Report evaluates the affect of land development and other stresses on the natural and ecological resources of the Highlands Region, and it establishes the overall strategies necessary to maintain and enhance their value, including:

- Highlands Open Waters
- Riparian Areas
- Steep Slopes
- Forest Resources
- Critical Habitat

These are each interrelated and interdependent systems and they are presented in an integrated ecosystem protection and management framework. The purpose of the Ecosystem Management element of the Regional Master Plan is to spotlight areas of the Highlands Region with exceptionally high ecological values that should be conserved, and those previously impaired by past human activity that may be may be restored in concert with appropriate patterns of economic growth.

HIGHLANDS ACT REQUIREMENTS

In accordance with Section 10 of the Highlands Act, the overarching goal of the Regional Master Plan "with respect to the entire Highlands Region shall be to protect and enhance the significant values of the resources thereof in a manner which is consistent with the purposes and provisions of this act." Section 10.a.

The Highlands Act establishes specific goals relating to protection of Highlands Open Waters and Ecological Resources. Those goals with respect to the Preservation Area shall be to:

- protect, restore, and enhance the quality and quantity of surface and ground waters. Section 10.b.(1).
- preserve extensive and, to the maximum extent possible, contiguous areas of land in its natural state, thereby ensuring the continuation of a Highlands environment which contains the unique and significant natural, scenic, and other resources representative of the Highlands Region. Section 10.b.(2).
- protect the natural, scenic, and other resources of the Highlands Region, including but not limited to contiguous forests, wetlands, vegetated stream corridors, steep slopes, and critical habitat for fauna and flora. Section 10.b.(3).

In addition, the goals relating to protection of Highlands Open Waters and Ecological Resources with respect to the Planning Area shall be to:

- protect, restore, and enhance the quality and quantity of surface and ground waters. Section 10.c.(1).
- preserve to the maximum extent possible any environmentally sensitive lands and other lands needed for recreation and conservation purposes. Section 10.c.(2).
- protect and maintain the essential character of the Highlands environment. Section 10.c.(3).

The Highlands Act includes specific requirements relating to protection of Highlands Open Waters and other ecological resources requiring the development of a Resource Assessment for the Highlands Region which "(a) determines the amount and type of human development and activity which the ecosystem of the Highlands Region can sustain while still maintaining the overall ecological values thereof, with special reference to **surface and ground water quality and supply; contiguous forests and woodlands; endangered and threatened animals, plants, and biotic communities**; ecological factors relating to the protection and enhancement of agricultural or horticultural production or activity; air quality; and **other appropriate considerations affecting the ecological integrity of the Highlands Region.**" Section 11.a.(1)(a)(emphasis added).

The Highlands Act also includes specific requirements relating to protection of open waters and other ecological resources that require the development of a Smart Growth component that includes "an assessment, based upon the resource assessment prepared pursuant to paragraph (1) of subsection a. of this section, of opportunities for appropriate development, redevelopment, and economic growth, and a transfer of development rights program…. In preparing this component, the council shall:

(a) prepare **a land use capability map**;
(g) identify **special critical environmental areas and other critical natural resource lands** where development should be limited. Section 11.a.(6)"(emphasis added).

For the Preservation Area, Section 12 of the Highlands Act requires "a **land use capability map** and a comprehensive statement of policies for planning and managing the development and use of land in the preservation area, which shall be based upon, comply with, and implement the **environmental standards" adopted by NJDEP** and the **Resource Assessment prepared the Highlands Council** under Section 11. Section 12.(emphasis added).

Section 12 specifically requires implementation "that will ensure the continued, uniform, and consistent protection of the Highlands Region in accordance with the goals, purposes, policies, and provisions of this act, and shall include:

(a) a preservation zone element that **identifies zones within the preservation area where development shall not occur** in order to protect water resources and environmentally sensitive lands and which shall be permanently preserved through use of a variety of tools, including but not limited to land acquisition and the transfer of development rights; and
(b) minimum standards governing municipal and county master planning, development regulations, and other regulations concerning the development and use of land in the preservation area, including, but not limited to, standards for minimum lot sizes and **stream setbacks**, construction on steep slopes, maximum appropriate population densities, and **regulated or prohibited uses** for specific portions of the preservation area. Section 12.(emphasis added).

The NJDEP's rules at N.J.A.C. 7:38-3.6 requires a 300-foot buffer adjacent to Highlands **open waters** in which no disturbance is permitted with the exception of linear development, which shall be permitted provided that there is no feasible alternative for the linear development outside the Highlands open water or Highlands open water buffer. See N.J.A.C. 7:38-3.6(b). This rule implements the 300 foot requirement in the Preservation Area pursuant to Section 34.a.

(a) a prohibition on major Highlands development within **300 feet of any Highlands open waters**, and the establishment of a 300-foot buffer adjacent to all Highlands open waters; provided, however, that this buffer shall not extend into the planning area.

Section 34.b. requires "measures to ensure that existing **water quality** shall be maintained, restored, or enhanced, as required pursuant to the "Water Pollution Control Act," P.L.1977, c. 74 (C.58:10A-1 et seq.) or the "Water Quality Planning Act," P.L.1977, c. 75 (C.58:11A-1 et seq.), or any rule or regulation adopted pursuant thereto, in all Highlands open waters and waters of the Highlands." Similarly, Section 34.g. requires that the "antidegradation provisions of the surface water quality standards and the stormwater regulations applicable to category one waters to be applied to Highlands open waters."

The NJDEP's rules at N.J.A.C. 7:38-3.7 prohibits any net displacement of **flood storage volume within a flood plain**. There shall be no displacement of flood storage volume onsite or the proposed activities, both individually and cumulatively, displace no more than 20 percent of the flood storage volume onsite as long as an equal or greater volume of flood storage is created offsite. N.J.A.C. 7:38-3.7(b). This rule implements the zero net fill requirement in the Preservation Area pursuant to Section 34.f.

The NJDEP's rules at N.J.A.C. 7:38-3.5(a) prohibits development or activity if it will result in **impervious surface** of greater than three percent of the land area of a lot. This rule implements the impervious surface requirements in the Preservation Area pursuant to Section 34.h.

The NJDEP's rules at N.J.A.C. 7:38-3.9 protect **upland forested areas**. In accordance with N.J.A.C. 7:38-3.9(e), the NJDEP will "identify as upland forest area any other area so identified by the Highlands Council, using an alternate method of identification." The Highlands Council provided NJDEP with an alternative method of identification in September of 2005.

This rule implements the forest protection requirements in the Preservation Area pursuant to Section 34.k: including the "prohibition on development that disturbs **upland forested areas**, in order to prevent soil

erosion and sedimentation, protect **water quality**, prevent **stormwater runoff**, and protect **threatened and endangered animal and plant species** sites and designated habitats; and standards to protect upland forested areas that require all appropriate measures be taken to avoid impacts or disturbance to upland forested areas, and where avoidance is not possible that all appropriate measures have been taken to minimize and mitigate impacts to upland forested areas and to prevent soil erosion and sedimentation, protect water quality, prevent stormwater runoff, and protect threatened and endangered animal and plant species sites and designated habitats." Section 34.k.

The following activities are exempt from the Highlands Act: "an activity conducted in accordance with an approved **woodland management plan** pursuant to section 3 of P.L.1964, c. 48 (C.54:4-23.3) or the normal harvesting of forest products in accordance with a forest management plan approved by the State Forester." Section 30.a.(7).

In addition, Section 31 of the Highlands Act includes restrictions on "**agricultural or horticultural development** in the preservation area that would result in the increase, after the date of enactment of this act either individually or cumulatively, of agricultural impervious cover by three percent or more of the total land area of **a farm management unit**." The Department of Agriculture has adopted regulations, at N.J.A.C. 2:92, to implement this provision requiring the review and approval by the local soil conservation district of a farm conservation plan.

Section 31 also includes restrictions on "agricultural **or horticultural development** in the preservation area that would result in the increase, after the date of enactment of this act either individually or cumulatively, of agricultural impervious cover by nine percent or more of the total land area of a **farm management unit**." Where there is a nine percent increase, there is a requirement for the review and approval by the local soil conservation district and NJDEP of a resource management systems plan which shall be prepared and submitted by the owner or operator of the farm management unit.

The NJDEP's rules at N.J.A.C. 7:38-3.11 prohibits development or activity if it will jeopardize the continued existence of species listed pursuant to "The **Endangered and Nongame Species** Conservation Act," P.L.1973, c. 309 (C.23:2A-1 et seq.) or the "Endangered Plant Species List Act," P.L.1989, c. 56 (C.13:1B-15.151 et seq.), or which appear on the federal endangered or threatened species list, and will not result in the likelihood of the destruction or adverse modification of habitat for any **rare, threatened, or endangered species of animal or plant.** This rule implements the species protection requirements in the Preservation Area pursuant to Section 36.a(4).

In addition, Section 36 of the Highlands Act requires that NJDEP's permitting review approval without a waiver may be issued only upon a finding that the proposed major Highlands development:

(1) would have a **de minimis impact on water resources** and would not cause or contribute to a significant degradation of surface or ground waters. In making this determination, the commissioner shall consider the extent of any impacts on water resources resulting from the proposed major Highlands development, including, but not limited to, the regenerative capacity of aquifers or other surface or ground water supplies, increases in stormwater generated, increases in impervious surface, increases in stormwater pollutant loading, changes in land use, and changes in vegetative cover;

(2) would cause **minimal feasible interference with the natural functioning of animal, plant, and other natural resources** at the site and within the surrounding area, and **minimal feasible individual and cumulative adverse impacts to the environment** both onsite and offsite of the major Highlands development;

(3) will result in **minimum feasible alteration or impairment of the aquatic ecosystem** including existing contour, vegetation, fish and wildlife resources, and aquatic circulation of a freshwater wetland;

(4) will **not jeopardize the continued existence of species** listed pursuant to "The Endangered and Nongame Species Conservation Act," P.L.1973, c. 309 (C.23:2A-1 et seq.) or the "Endangered Plant Species List Act," P.L.1989, c. 56 (C.13:1B-15.151 et seq.), or which appear on the federal endangered or threatened species list, and will not result in the likelihood of the destruction or adverse modification of habitat for any rare, threatened, or endangered species of animal or plant;

(5) is located or constructed so as to neither endanger human life or property nor otherwise impair the public health, safety, and welfare;
(6) would result in minimal practicable degradation of unique or irreplaceable land types, historical or archeological areas, and existing public scenic attributes at the site and within the surrounding area; and
(7) meets all other applicable department standards, rules, and regulations and State laws." Section 36.

HIGHLANDS OPEN WATERS

The protection, enhancement, and restoration of water resources are a fundamental goal of the Highlands Act. A primary mechanism to meet this goal is the assessment of surface waters and wetlands, known as Highlands Open Waters, and lands adjacent to these waters, known as Riparian Areas. Highlands Open Waters are a critical public trust resource and an essential source of drinking water for the State of New Jersey. These waters and the associated riparian areas provide protection against floods and help to ameliorate the affects of prolonged droughts. They are also important habitat for numerous plant and animal species including many endangered and threatened in the State. Highlands Open Waters also provide a wealth of agricultural, recreational and aesthetic uses for both residents and visitors alike, helping to contribute to a vibrant regional economy.

Highlands Open Waters include all springs, wetlands, intermittent or ephemeral streams, perennial streams, and bodies of surface water, whether natural or artificial, located wholly or partially within the boundaries of the Highlands Region. Specific definitions for the various types of Highlands Open Waters follow, based on State regulatory definitions where they exist:

- **Stream** – A surface water drainage channel with definite bed and banks. A stream can be either perennial, intermittent, or ephemeral. Perennial streams have a permanent flow of water. Many perennial streams are shown as "blue line" watercourses on United States Geological Survey Quadrangle Maps. Intermittent and ephemeral streams do not have a permanent flow of surface water. Surface water flow in an intermittent stream generally occurs for several weeks or months, due to seasonal precipitation and/or ground water discharge to the channel. Surface water flow in an ephemeral stream generally occurs after rain events, and typically lasts a few hours to days following the rain event.
- **Lake/Pond** - Any impoundment of water, whether naturally occurring, or created in whole or in part, by the building of structures for the retention of surface water.
- **Seep** – The natural movement of water from below ground to the surface, many times forming a pool.
- **Spring** – A point where ground water flows from the ground to the surface, representing the point where an aquifer meets the ground surface. Springs may be ephemeral or perennial.
- **Vernal Pool** – NJDEP defines vernal habitat as the following (N.J.A.C. 7:7A-1.4): 1) occurs in a defined basin depression without a permanent flowing outlet; 2) features evidence of breeding by one or more species of fauna adapted to reproduce in ephemeral aquatic conditions as identified in N.J.A.C. 7:7A; 3) maintains ponded water for at least two continuous months between March and September of a normal rainfall year; and 4) is free of fish throughout the year, or dries up at some time during a normal rainfall year.
- **Wetland** – NJDEP defines a freshwater wetland as an area that is inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated soil conditions, commonly known as hydrophytic vegetation; provided, however, that the Department, in designating a wetland, shall use the three-parameter approach (that is, hydrology, soils, and vegetation) enumerated in the 1989 Federal Manual as defined in this (N.J.A.C. 7:7A-1.4) section. Definitions of wetland hydrology, hydric soil and hydrophytic vegetation are as follows:
    1. Wetlands hydrology - an area has wetland hydrology when saturated to the surface or inundated at some point in time during an average rainfall year, or is inundated at some time if ponded or frequently flooded with surface water for one week or more during the growing season.
    2. Hydric soil - a soil that in its undrained condition is saturated, flooded, or ponded long enough

during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation.

3. Hydrophytic vegetation - plant life adapted to growth and reproduction under periodically saturated root zone conditions during at least a portion of the growing season.

Wetlands provide many functions and values as described in Mitsch and Gosselink (1993) and summarized below:

- **Water flow** – Wetlands can discharge water to serve as the headwaters of surface water streams. Wetlands also can receive surface flow from streams, episodic flow from flood events, or overland flow during precipitation events. Ground water influences some wetlands, depending on hydrogeology and soils. Ground water inflow to wetlands results when surface water levels in a wetland are lower than the water table of the surrounding land (i.e., discharge wetland). When water level within a wetland is higher than the surrounding water table, ground water will flow out of the wetland (i.e., recharge wetland). Wetlands influenced by ground water are typically buffered against dramatic seasonal flow changes. Wetlands not predominantly influenced by ground water are influenced primarily by surface water runoff, and transport water by surface outflows or evapotranspiration. These wetlands often have fluctuating hydroperiods and intermittent flooding (Mitsch and Gosselink,1993).

- **Water quality** – Wetlands serve as deposition sites for nutrients and pollutants in surface water runoff and ground water discharge. Wetlands can function as filters and provide areas where water movement is slowed. This reduction in water movement allows suspended sediments to settle out to the wetland substrate.

- **Fish and wildlife habitat** – Wetlands are home to a variety of animals including rare, threatened, and endangered species that utilize wetlands for nesting, food sources, and reproduction. Wetlands provide migratory stopover and over-wintering habitats for a diversity of wildlife, provide breeding and spawning grounds and nursery habitat and food for fish and amphibians, and provide areas of high plant productivity, which support significant wildlife diversity and abundance.

- **Flood control** – Wetlands can alleviate flooding problems through storage of overland precipitation runoff and flood waters. Wetlands have the capacity to capture flood waters and temporarily store and slowly release excess water.

- **Recreation, aesthetics and education** – Wetlands are an important part of outdoor recreation. They provide areas for hunting and fishing as well as other types of activities such as bird watching. Many local, state, and national parks contain large wetland areas that allow visitors to enjoy their scenic beauty. Wetlands serve as living classrooms for the study of biology, ecology, and natural history at many age levels.

Numerous existing state regulatory programs protect State open waters and adjacent buffers in order to maintain the integrity of aquatic systems, as described below.

Surface Water Quality Standards at N.J.A.C. 7:9B – Implemented by NJDEP-Division of Water Quality, these rules establish the water quality goals and policies for managing the State's surface water quality. These standards designate the uses of the water and establish narrative and numerical criteria to protect those uses. The surface water quality standards also incorporate anti-degradation policies intended to protect and enhance the quality of surface waters. The following anti-degradation and water quality classifications are defined according to N.J.A.C. 7:9B:

- Outstanding National Resource Waters are high quality waters that constitute an outstanding national resource (e.g., waters of National/State Parks and Wildlife Refuges and waters of exceptional recreational or ecological significance). In the Highlands, waters classified as Freshwater 1 (FW1) are Outstanding National Resource Waters (refer to FW1 definition below).

- Category One (C1) waters are those waters designated for purposes of implementing the anti-degradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality characteristics because of their clarity, color, scenic setting, other characteristics of aesthetic value, exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resources. These waters may include, but are not limited to:

1. Waters originating wholly within Federal, interstate, State, county, or municipal parks, forests, fish and wildlife lands, and other special holdings;
2. Waters classified at N.J.A.C. 7:9B-1.15(b) through (g) as Freshwater 2 (FW2)-trout production (TP) waters and their tributaries. TP waters are those that are designated at N.J.A.C. 7:9B-1.15(b) through (g) for use by trout for spawning or nursery purposes during their first summer;
3. Surface waters classified in this subchapter as FW2-trout maintenance (TM) or FW2-non-trout (NT) that are upstream of waters classified in this subchapter as FW2 trout production. TM are waters designated at N.J.A.C. 7:9B-1.15(b) through (g) for the support of trout throughout the year. NT waters are freshwaters that have not been designated in N.J.A.C. 7:9B-1.15(b) through (g) as TP or TM waters. NT waters are generally not suitable for trout because of their physical, chemical, or biological characteristics, but are suitable for a variety of other fish species;
4. Shellfish waters of exceptional resource value; or
5. Other waters and their tributaries that flow through, or border, Federal, State, county or municipal parks, forests, fish and wildlife lands, and other special holdings.

- Category Two (C2) waters are those waters that are not designated as C1 for purposes of implementing the anti-degradation policies set forth at N.J.A.C. 7:9 B-1.5(d). For C2 waters, water quality characteristics that are generally better than, or equal to, the water quality standards shall be maintained within a range of quality that shall protect existing uses. Water quality shall be protected from changes that might be detrimental to the attainment of the designated uses. Water quality characteristics that are generally worse than the water quality criteria shall be improved to meet the water quality criteria.
- Freshwater 1 (FW1) means those fresh waters that are to be maintained in their natural state of quality (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).
- Freshwater 2 (FW2) means the general surface water classification applied to those freshwaters that are not designated as FW1. The include the following sub-classifications:
  1. FW2-TM: Trout maintenance water for the support of trout throughout the year.
  2. FW2-NT: Non-trout waters, not considered suitable for trout production or maintenance, but may be suitable for other fish species.

Stormwater Management Rules at N.J.A.C. 7:8 – Implemented by NJDEP-Land Use Regulation Program, these rules set forth the required components of regional and municipal stormwater management plans, and establish the stormwater management design and performance standards for new (proposed) development. The design and performance standards for new development include ground water recharge, runoff quantity controls, runoff quality controls, and protection area buffers for C1 waters. These rules provide for special protection area buffers for C1 waters and their immediate tributaries referred to as "Special Water Resource Protection Areas". A 300-foot special water resource protection area is provided on each side of the waterway, and is intended as a buffer between development and these special waters in order to protect both water quality and the uses and attributes for which the waters have been designated.

Flood Hazard Area Control Act Rules at N.J.A.C. 7:13 – Implemented by NJDEP-Land Use Regulation Program, these rules originally were intended "to minimize potential on and off site damage to public or private property caused by development which, at times of flood, subject structures to flooding and increase flood heights and/or velocities both upstream and downstream." These rules also were intended to safeguard the public from the dangers and damages caused by materials being swept onto nearby or downstream lands, to protect and enhance the public's health and welfare by minimizing the degradation of water quality from point and nonpoint pollution sources, and to protect wildlife and fisheries by preserving and enhancing water quality and the environment associated with the flood plain and the watercourses that create them.

In November 2007, the NJDEP adopted new flood hazard rules, which expanded the regulated area to 300 feet along C1 waters and all upstream tributaries within the same HUC14 subwatershed; 150 feet along all upstream

tributaries to trout production waters, trout maintenance waters, and tributaries within one mile upstream, waters flowing through areas that support certain threatened or endangered species and tributaries within one mile upstream, and waters that flow through areas that contain acid producing soils; and 50 feet along all other waters. Also, there is a 0 % net fill requirement on all non-tidal flood hazard areas, and a permitted 20% net fill on site with required off site mitigation in the same flood hazard area and same watershed within which the filling within a flood hazard area is proposed.

Freshwater Wetlands Protection Act Rules at N.J.A.C. 7:7 – Implemented by NJDEP-Land Use Regulation Program these rules regulate certain activities within and adjacent to freshwater wetlands, including the discharge of dredged or fill material into State open waters and wetlands. The rules also impose buffer or transition areas, ranging from zero to 150 feet, adjacent to a freshwater wetland. The width of the transition area varies according to the resource value classification of the wetland. Certain activities are regulated within a transition area.

Highlands Rules – Section 34(a) of the Highlands Act and the Highlands Rules at N.J.A.C. 7:38-3.6 mandate the establishment of a 300-foot buffer adjacent to all Highlands Open Waters in the Preservation Area; provided that this buffer shall not extend into the Planning Area. As part of the continued development of the Regional Master Plan, all Highlands Open Waters within the Preservation Area are to be assigned a 300-foot Highlands Waters buffer. This buffer will be contained within the limits of the Preservation Area. Section 34(g) of the Highlands Act requires that the anti-degradation provisions of the Surface Water Quality Standards (N.J.A.C. 7:9B) and Stormwater Management Rules (N.J.A.C. 7:8) applicable to C1 waters be applied to Highlands Open Waters within the Preservation Area.

INVENTORY OF HIGHLANDS OPEN WATERS

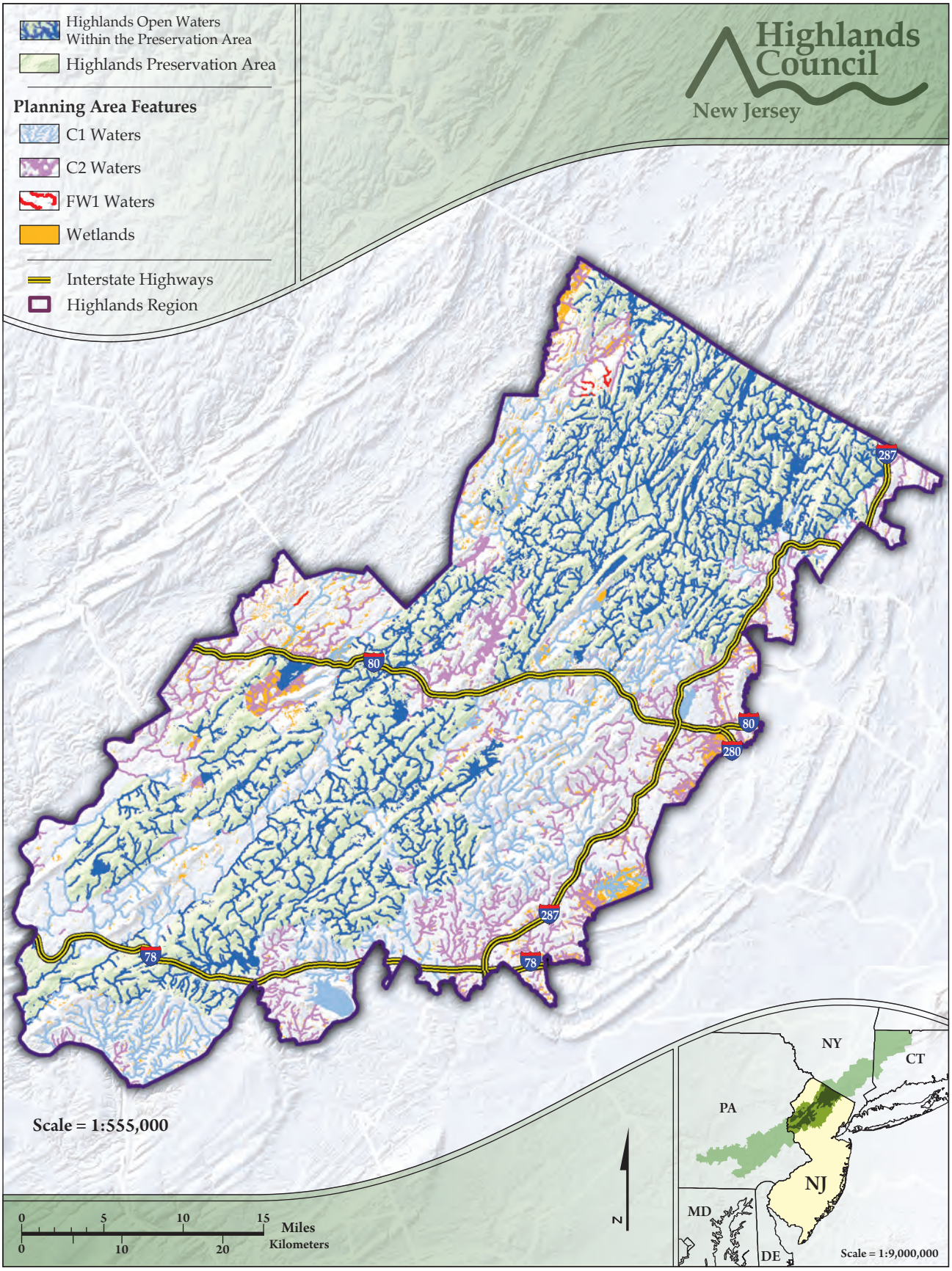
The Highlands Open Waters Inventory includes mapping of rivers, streams, lakes and wetlands (see figure *Highlands Open Waters*).

Three primary Geographic Information System (GIS)-based spatial data sets were used to derive a preliminary inventory of Highlands Open Waters. These data sets include the NJDEP 2002 Land Use/Land Cover (LU/LC), NJDEP 2002 Hydrography Draft (HYDRO) mapping and the Highlands Council Supplemental Headwater Stream Delineation. Each data set is briefly described below.

NJDEP 2002 Land Use/Land Cover – The 2002 Land Use/Land Cover dataset is the third iteration conducted by the NJDEP to capture the state of the land use and natural land cover statewide in a digital GIS file (NJDEP 2002). The initial land use/land cover GIS file was based on aerial photography captured in the spring of 1986. The second iteration of the land use data was based on photography captured in 1995, with this latest series based on photography captured in the spring of 2002. The significance of a land use/land cover classification scheme is that it provides information not only about the land cover characteristics of an area, but also about the specific human uses of that area.

As with both previous layers, the 2002 data were produced by visually interpreting color infrared photography. Through this process, photo-interpreters examine each image, and based on their knowledge of photo signatures, classify the image into various land use/land cover categories using a modified Anderson Classification System (Anderson et. al, 1976), as described below. The classifications are converted into a land use/land cover GIS digital file, with each delineated polygon representing a distinct land use/land cover type.

HIGHLANDS OPEN WATERS



The Anderson Classification System is a hierarchical, four-digit system. The four digits represent one to four levels of land use classification: Level 1 – general, Level II – descriptive, Level III – detailed and Level 4 – most detailed. For example, the code 6251 represents the following:

- 6 - Wetlands
- 62 - Wetlands, Interior Wetlands
- 625 - Wetlands, Interior Wetlands, Mixed Forest
- 6251 - Wetlands, Interior Wetlands, Mixed Forest, Deciduous Dominant

The Land Use Land Cover dataset identifies open waters that visually exceed 30 feet in width from bank to bank (the NJDEP's Hydrography mapping, as described below, captures waters less than 30 feet in width). For the Highlands Open Waters inventory, streams, lakes, and ponds were extracted from the 2002 Land Use Land Cover data based on the following Anderson classification system codes:

- (5100) Streams and Canals
- (5200) Natural Lakes
- (5300) Artificial Lakes

Wetlands were extracted from the NJDEP 2002 Land Use Land Cover data based on the following Anderson classification system codes:

- (1461) Wetland Rights-of-Way (Modified)
- (1711) Cemetery on Wetland
- (1750) Managed Wetland in Maintained Lawn Greenspace
- (1850) Managed Wetland in a Built-up, Maintained Recreation Area
- (2140) Modified Agricultural Wetlands
- (6120) Freshwater Marshes
- (6210) Deciduous Wooded Wetlands
- (6220) Coniferous Wooded Wetlands
- (6221) Atlantic White Cedar Wetlands
- (6231) Deciduous Scrub/Shrub Wetlands
- (6232) Coniferous Scrub/Shrub Wetlands
- (6233) Mixed Scrub/Shrub Wetlands with Deciduous Dominant
- (6234) Mixed Brush and Bog Wetlands with Coniferous Dominant
- (6240) Herbaceous Wetlands
- (6241) *Phragmites* Dominate Interior Wetlands
- (6251) Mixed Forested Wetlands with Deciduous Dominant
- (6252) Mixed Forested Wetlands with Coniferous Dominant
- (7430) Modified Disturbed Wetlands

It should be noted that there are numerous situations where an accurate identification and mapping of wetlands can not be made through visual interpretation of aerial imagery alone. In those cases, supplemental field surveys are necessary to accurately map the full extent of wetlands.

NJDEP 2002 Hydrography Draft (HYDRO) – The 2002 Hydrography Draft Update was created by the NJDEP by digitizing stream locations from the 2002 color infrared orthophotos (NJDEP, 2005). The HYDRO data layer was completed by NJDEP in conjunction with the Land Use/Land Cover update for 2002. Streams greater than 10 feet are delineated as a single line (representing the center-line of the stream). Linear artificial

connectors (e.g., culverts) were digitized to provide connectivity of the stream network.

Supplemental Headwater Stream Delineation – The Highlands Council conducted supplemental identification and mapping of headwater streams. In mapping water features at a regional scale (versus a local or site-specific scale), many headwater or intermittent streams are often omitted. They are therefore overlooked from a planning and protection standpoint, despite the fact that headwater streams play a significant role in protecting stream health. Small headwater streams are the initial collection point for routing surface water across the landscape and as such, act as a key interface between the land and surface water system. Headwater streams are especially sensitive to ground water fluctuations, soil erosion, and to both point and non-point source pollution (State of Ohio EPA, 2003).

This subsection provides an overview of the data and methods that were used for the supplemental headwater stream delineation. The Center for Remote Sensing and Spatial Analysis (CRSSA) at Rutgers University, in New Brunswick, New Jersey worked with Highlands Council staff to spatially delineate and map additional headwater and intermittent streams.

The 2002 NJDEP orthorectified color infrared mapping served as the base map. The 2002 NJDEP HYDRO file was then overlain on the infrared mapping to identify potential locations of headwater and intermittent streams. The United States Department of Agriculture Natural Resource Conservation Service (NRCS) soil maps for New Jersey, which contain detailed soil and hydrography data, were then reviewed to identify areas with hydrological indicators of headwater and intermittent streams (e.g., presence of hydric soils). In this manner, the soils maps served as the primary independent reference data for the HYDRO data.

The NJDEP 10-meter Digital Elevation Grids were used to model the terrain to determine stream flow direction. The Digital Elevation Grids are raster grids generated from the United States Geological Survey's (USGS's) Digital Elevation Models (DEM). These types of data sets are powerful analytical tools, as they can be used as source data to create other layers which require elevation information (e.g., hillside, slope and flow direction). From the DEM elevation data, stream flow direction was derived using the Hydrology Modeling Tool in the ArcGIS software package. The stream flow network generated from the 10-meter DEM was used as a guide when digitizing streams that appeared in the soil maps, but were not delineated in the 2002 HYDRO file.

It should be noted that there are numerous situations where an accurate identification and mapping of headwater and intermittent streams could not be made through visual interpretation of aerial imagery alone or in concert with the terrain modeling data. In those cases, supplemental field surveys are necessary to accurately map the full extent of a headwater stream.

Data Integration and Results – A single Highlands Open Waters coverage was created by joining: 1) the open waters data extracted from the 2002 Land Use Land Cover data set; 2) the 2002 Hydrography Draft Update; and 3) the supplemental headwater stream delineation to create a combined Highlands Open Waters GIS map (see figure *Highlands Open Waters*).

Following is a breakdown of stream lengths and area of Highlands Open Waters in the Highlands Region:

- Total stream length = 3,605 miles
- Total streams and lakes = 32,214 acres
- Total wetlands = 90,091 acres

Appendix A provides a summary of the Highlands Open Water Inventory for each HUC14 subwatershed. Table A-1 presents total stream length (in river miles) for each HUC14. Table A-2 depicts the area (in acres) of open water (excluding wetlands) for each HUC14. Table A-3 presents the total wetlands acreage for each HUC14. Table A-4 presents the total protection area buffer within each HUC14. The total protection area buffer in the Highlands Region (total of all 183 HUC14s) is over 398,000 acres (see Appendix A, Table A-4).

Data Limitations - The 2002 Land Use Land Cover data set, the 2002 Hydrography Draft Update, and the supplemental headwater stream delineation that were collectively used to identify Highlands Open Waters, are the best available information for identification of these waters at a landscape level. However, the mapping is

primarily based on remote sensing using high resolution aerial photography and has not been field verified. Similarly, it should be noted that for the mapping of wetlands or headwater streams, there were numerous situations where an accurate identification and mapping of these streams could not be made without field verification. Therefore, supplemental field surveys will be required to verify and delineate the boundaries of Highlands Open Waters subject to protection under the RMP and the inventory of Highlands Open Waters will need to be periodically updated.

The Highlands Council will be maintaining an on-going inventory that can be updated to track changes in Highlands Open Waters coverage. The Council will continue the development and refinement of the inventory with an emphasis of identifying headwater streams and headwater seeps and springs as new information becomes available.

ESTABLISHING PROTECTION AREAS REQUIREMENTS FOR HIGHLANDS OPEN WATERS

The vegetated corridors adjacent to lakes, streams, rivers and wetlands are effective and important tools to protect water quality and stream health both in rural and urban environments. By filtering sediments and transforming nutrients so they are less damaging to the water bodies, buffers safeguard Highlands Open Waters from the impacts of adjacent land use practices. The Highlands Regional Master Plan includes a Highlands Open Water Protection Area necessary to maintain the quality and ecological integrity of streams. *The Highlands Regional Master Plan includes a recommendation for a 300 foot protection area buffer around all streams and wetlands.*

Appropriate buffer widths are generally correlated to existing open waters functions, values and significance, adjacent upland characteristics, desired buffer functions and land use impacts. A detailed review of the scientific literature that references over 150 studies published within the last 30 years was conducted by Seth Wenger for the Office of Public Service & Outreach Institute of Ecology at the University of Georgia (Wenger 1999). The literature review included a summary of Cooper et al (1988) and Lowrance et al (1988) which suggests that the buffer width for effective long term sediment retention (e.g., 98-328 feet) may be substantially wider than those indicated in effective short term experiments (e.g., 50-197 feet).

Buffer widths for removal of nutrients (e.g., phosphorus and nitrogen) from surface and subsurface water in riparian areas were typically shorter (e.g., 50-328 feet), although many studies reported increasing effectiveness with increasing buffer width (Dillaha et al 1989; Magette et al 1987, 1989; Desbonnet et al 1993; Sorrano et al 1996; Peterjohn and Correll 1985; Hanson 1994; Jordan et al 1993; Mander et al 1997; Hubbard and Lowrance 1994; Lowrance 1992). Osborne and Kovacic (1993) reported that buffers of 33-98 feet can effectively maintain stream water temperature. Buffer widths ranging from 45 feet to more than 2,500 feet were reported for the protection of terrestrial habitat important to riparian-dependent species (Keller et al 1993; Spackman and Hughes 1995; Kinley and Newhouse 1997; Cross 1985; Gomez and Anthony 1996; Burbrink et al 1998).

In his summary of recommended stream buffers widths for the protection of wildlife habitat Wegner (1999) noted that "while narrow buffers offer considerable habitat benefits to many species, protecting diverse terrestrial riparian wildlife communities requires buffers of at least 300 feet." He also recommended that at least a few wide (300 to 1,000 feet) riparian corridors and large blocks of upland forest should be identified and targeted for preservation. Specifically, preservation and/or creation of 300-foot riparian corridors (from each stream bank) have been shown to be protective of forest interior species habitat and movement corridors (MDFS 2006; Castelle et al. 1994; MDFWELE 1997).

ASSIGNING WATERSHED VALUE CLASSES

A subwatershed-based assessment was utilized to evaluate the integrity and protection needs of Highlands Open Waters. The subwatershed boundaries used for this analysis were 14-digit Hydrologic Units. There are 183 HUC14 subwatersheds that are located partially or entirely within the Highlands Region.

A watershed describes an area of land that drains downslope to the lowest point. Water moves through a network of drainage pathways, both underground and on the surface, and these pathways converge into streams and rivers, which become progressively larger (i.e., higher order) as the water moves downstream and

the size of the contributing drainage area increases. The connectivity of the stream system is the primary reason for conducting aquatic assessments at the watershed level. Because water moves downstream, any activity that affects the water quality, quantity, or rate of movement at one location can affect locations downstream.

Watersheds are widely accepted as an appropriate geographic unit for managing water resources (Schueler 1995). The condition of a watershed greatly influences the functions and integrity of its wetlands and streams. Land use disturbances in watersheds can have significant negative impacts on wetland or stream morphology, vegetation, flood abatement, water chemistry, and aquatic biota (Tiner 2004).

Watershed-based planning and zoning begins with the notion that the level of impairment of a watershed (e.g., the percent developed lands versus undeveloped forested lands) largely determines the quality of streams and therefore, the attainability of stream protection goals. This, in turn, strongly influences the nature of the stream protection strategy for a given watershed (i.e., the selection of land use standards, stream corridor management plans, implementation of best management practices, and instituting land acquisition or other protection strategies) (Schueler 1995). The extent of forest, in particular, is an important indicator of watershed condition due to its strong association with water quality and as an indicator of the extent of alteration of a watershed due to past human activity (Russell 1988).

Peer-reviewed scientific literature was reviewed (FitzHugh 2001; Tiner 2004; Snyder, et. al. 2005) to identify defensible indicators of watershed condition for the Highlands Region. From the suite of indicators identified in the literature, an interdisciplinary team of scientists at the Highlands Council selected the following to evaluate each of the HUC14s of the Highlands Region including: 1) Percent Developed Lands; 2) Habitat Quality; 3) Forest Cover.

Percent Developed Lands is the percentage of a subwatershed that is developed, with developed defined as lands that have been altered for residential and/or commercial use. Developed lands include areas with impervious cover as well as those with non-impervious cover (e.g., lawns, golf courses). The source of this data is the 2002 LU/LC data set developed by the NJDEP.

Percent developed land is an indicator of watershed impairment (i.e., in general, the higher the percentage, the lower the watershed quality). FitzHugh (2001) identified a series of research articles that documented a negative relationship between developed land use and aquatic habitat integrity. The US Geological Survey National Water Quality Assessment study compared aquatic community indicators of selected watersheds to the proportion of urban land use in the watershed. It was found that as natural vegetation communities are replaced by developed land, downstream water quality declines due to combined impacts of point and non-point source pollution and soil erosion (Ayers et. al., 2000).

Habitat Quality represents the percentage of a subwatershed that contains habitat for species of concern including rare, threatened or endangered species. The source of this data is the NJDEP's Endangered and Nongame Species Program (ENSP) Landscape Project (described in detail in the *Critical Habitat* section of this report). Habitat quality is used as an indicator of the biological diversity of a watershed (i.e., the more habitat that supports a species of concern, the higher the quality of habitat within a watershed). Given the importance of the Act in protecting rare, threatened, and endangered species they are considered to be excellent indicator of watershed protection needs. Often a rare, threatened and endangered species serve as an indicator species and are the first to show the effects of environmental alteration and degradation because they are often sensitive to biological changes within their habitat.

Forest Cover provides a reliable indicator of essential ecosystem functions of surface water filtration and ground water recharge. Connection between forest and water quality has been acknowledged for more than one hundred years, as is evidenced in the 1899 New Jersey State Geologist's Report on the forests of New Jersey (Russell 1988). Further, as previously noted, forests are an indicator of the extent of alteration of a watershed due to past human activity. Three distinct forest cover metrics were utilized to characterize watershed condition, as briefly described below and described in greater detail in the *Forest Integrity and Sustainable Forestry* section of this report and in the *Ecosystem Management* Technical Report:

- **Percent Total Forest** is the percentage of a subwatershed that is forested, with forested defined as all mature and successional upland and wetland forested communities (excluding old fields) . The source of

this data is the 2002 LU/LC data set developed by the NJDEP.

- **Percent Core Forest** represents the percentage of a subwatershed that contains forest areas greater than 300 feet in distance from an altered edge (i.e., disturbed land). The source of this data is the 2002 LU/LC data set developed by the NJDEP.
- **Proportion of Total Forest** is the amount of forest cover within a given geographic area. A 3-kilometer search area was used to calculate this metric. The source of this data is the 2002 LU/LC data set developed by the NJDEP.

Watershed Value Classes

Each of the watershed indicators discussed above are expressed as a percent of a HUC14. For the purpose of ranking the condition of the subwatershed based on the indicators, it was useful to establish a range of value classes. For each watershed indicator, four (4) value classes were established ranging from 4 (highest watershed quality) to 1 (lowest watershed quality). The value classes were established using the natural breaks option in the ArcView software. The natural break formula is called Jenks optimization, which identifies breakpoints between data classes using a statistical formula to facilitate the identification of groupings and patterns inherent in the data (Conservation Biology Institute, 1999). The natural breakpoints were then adjusted slightly to round to whole numbers and/or when available, to conform to approximate value class breakpoints in the scientific literature.

This methodology can best be understood by looking at a specific example. Once again using percent developed land as the example, the four approximate natural breakpoints in the data are: 1) 0-15%; 2) 15-30%; 3) 30-45%; and 4) greater than 45%. These breakpoints are generally consistent with what is presented in the scientific literature regarding value class breaks for developed/urban land and levels of watershed impairment (FitzHugh 2001). Because developed land is an indicator of impairment, the higher the percentage of developed land, in general, the lower the watershed quality, while the lower the percentage, the higher the watershed quality. Thus, for percent developed land, the values classes (ranging from highest value class = 4 to lowest value class = 1) are as follows:

- 0-15% - Value Class 4
- 15-30% - Value Class 3
- 30-45% - Value Class 2
- >45% - Value Class 1

The following table summarizes the watershed indicator values for each assigned value class.

Data Value Breaks and Value Classes for each Watershed Indicator

Watershed Indicator	Calculated Value (expressed as percent by HUC14)			
Developed Lands	0-15%	15-30%	30-45%	>45%
Habitat Quality	>60%	40-60%	20-40%	0-20%
Total Forest	>45%	30-45%	15-30%	0-15%
Core Forest	>30%	20-30%	10-20%	0-10%
Proportion of Forest	>45%	30-45%	15-30%	0-15%
Assigned Value Class	**4**	**3**	**2**	**1**

The value classes were then scored for each HUC14 subwatershed to arrive at a total score for each subwatershed. The scores were calculated using an equation designed to balance those positive indicators of watershed integrity (forest cover and habitat quality) with the indicator of watershed impairment (developed lands), as illustrated in the following text box:

HUC14 Watershed Value = (Total Forest Value Class + Core Forest Value Class + Proportion of Forest Value Class + Habitat Quality Value Class)/4) + Developed Lands Value Class

Using this equation, the highest achievable watershed value for each HUC14 subwatershed is 8 and the lowest is 2. The total HUC14 watershed value was used to designate High, Moderate or Low Resource Value Watersheds according to the following criteria:

High Resource Value Watershed includes all HUC14 subwatersheds that contain predominantly forest lands and includes a significant portion of the watershed that is high quality habitat. A high value watershed typically consists of limited pre-existing developed land within the watershed. A High Resource Value Watershed includes the following HUC14s:

- Total Watershed Value = 7 or greater
- Total Watershed Value = 5 - 6 AND Habitat Quality Value Class = 4
- Total Watershed Value = 5 - 6 AND sum of Forest Cover Value Class (Total Forest + Core Forest + Proportion of Forest) $\geq$ 10

Moderate Resource Value Watershed contains forest lands and some habitat suitable for rare, threatened or endangered species, but typically also contains developed lands. A Moderate Resource Value Watershed shall include the following HUC14s:

- Total Watershed Value = 5-6 excluding those watersheds that exhibit a Habitat Quality Value Class = 4, sum of Forest Cover Value Class (Total Forest + Core Forest + Proportion of Forest) $\geq$ 10, Developed Lands Value Class = 1 and Habitat Quality Value Class $\leq$ 2

Low Resource Value Watershed contains a low proportion of forest lands, a low proportion of habitat suitable for rare, threatened or endangered species, and typically consists of higher levels of developed lands. A Low Resource Value Watershed shall include the following HUC14s:

- Total Watershed Value $\leq$ 4
- Total Watershed Value = 5 - 6 AND Developed Lands Value Class = 1
- Total Watershed Value = 5 - 6 AND Habitat Quality Value Class $\leq$ 2

The Watershed Resource Value mapping depicts the watershed resource value class (High, Moderate or Low) assigned to each of the 183 HUC14s in the Highlands Region (see figure *Watershed Value by HUC14*).

The table below presents the total acreage of each watershed resource value class in the Highlands Region, as well as the percent of the region each value class comprises. As can be seen from the table *Highlands Watershed Resource Value Classes*, High Resource Value Watersheds encompass over 586,000 acres, or greater than 68% of the Highlands Region. Moderate and Low Resource Value Watersheds each comprise approximately 16% of the Region.

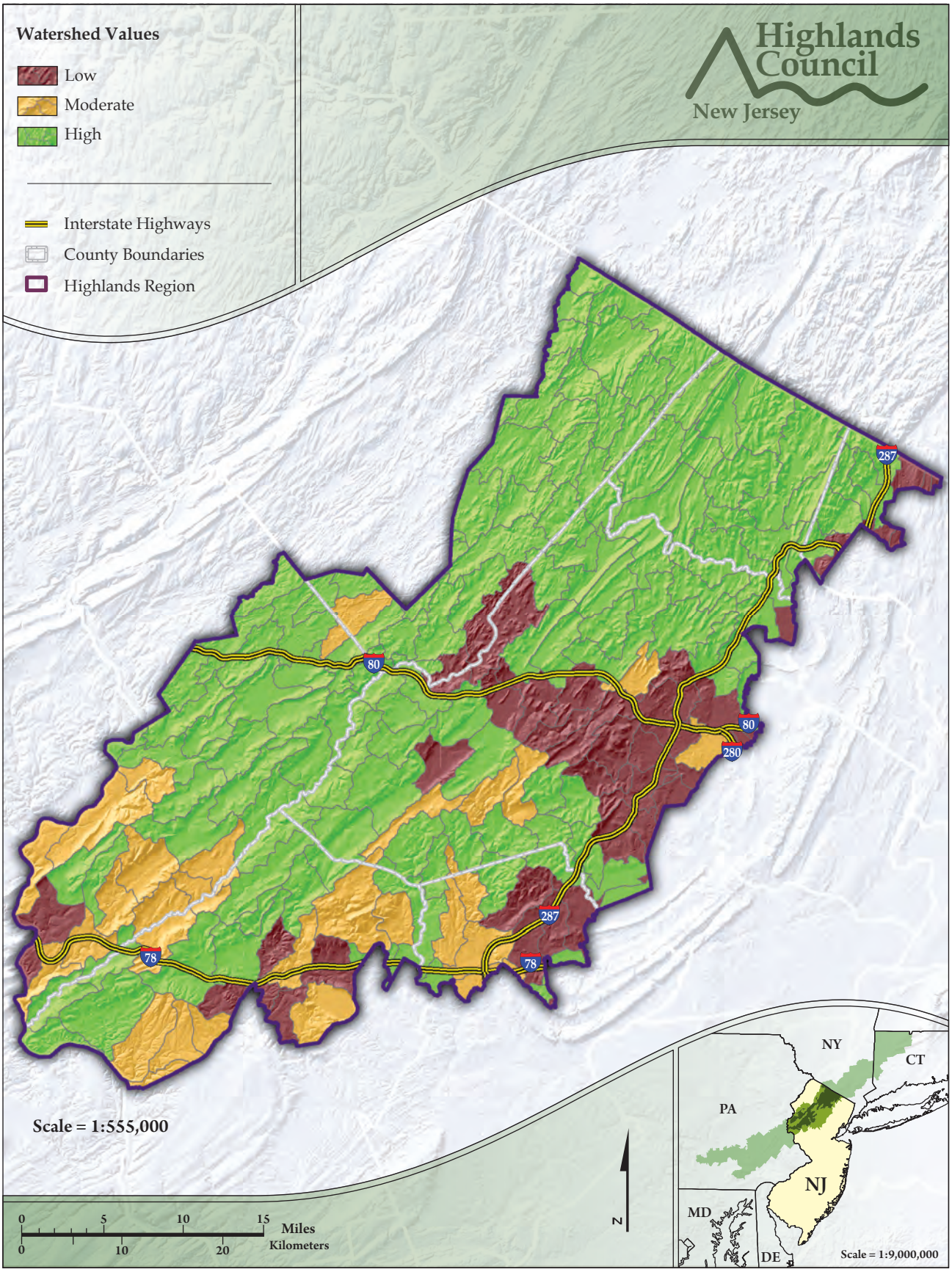
Highlands Watershed Resource Value Classes

Watershed Value Class	Total Acres	Percent of Highlands Region
High Resource Value Watershed	586,534	68%
Moderate Resource Value Watershed	137,118	16%
Low Resource Value Watershed	135,706	16%

ALTERNATIVE METHODS FOR EVALUATING STREAM INTEGRITY

The Highlands Council examined a variety of alternative approaches to assess the protection needs of Highlands Open Waters based on the biological and water quality characteristics and structural integrity of a stream that: 1) could be applied at a regional scale, 2) be based on available information, and 3) could

WATERSHED VALUES BY HUC 14



incorporate key concepts of generally accepted indicators of stream integrity. However, given limitations in available data, the Highlands Council utilized a watershed-based approach using regional land use and land cover information to assess watershed and stream corridor condition. As part of the long term goals to ensure continued refinement and development of the Regional Master Plan, the Highlands Council will continue development of a Regional Stream Integrity model at a subwatershed level to further refine protection requirements of Highlands Open Waters based on biological and water quality indicators.

There are a variety of approaches that are used to assess stream integrity at the reach-specific level or site-specific level that often have limited utility at the regional level due to limitations in data availability. Many approaches to stream integrity couple an assessment of stream corridor condition with water quality and biological data (e.g., fish, macroinvertebrates, algae, etc.). Biological data are synthesized into indices of biological integrity that change predictably when impairment of water quality or disturbance of aquatic habitat occurs (Horowitz and Flinders 2006). With respect to fish, there is the Index of Biologic Integrity (IBI) which uses the number of fish species, feeding habitats, fish abundance and health to evaluate the biological integrity of streams (Ayers 2000). Other approaches utilize the presence or absence of specific indicator species to evaluate the integrity of streams. For example, freshwater mussels, which are macroinvertebrates that spend their entire lives in the aquatic environment, have a low tolerance for water-borne pollutants and are especially useful as water quality indicators. Algal communities are also typically used as biological indicators because of their sensitivity to nutrients (Horowitz and Flinders 2006).

The Natural Resources Conservation Service (NRCS website, 2006) uses the Stream Visual Assessment Protocol, which utilizes a variety of structural, biological, hydrologic, and water quality components to value or "score" specific stream reaches. They include:

- **Channel condition** – the level of stream disturbance/alteration – a determination if a stream channel is natural or has been altered. Alteration of a natural stream channel impacts its natural functions (e.g., sediment transport, maintenance of fish habitat).
- **Hydrologic alteration** – the level of alteration of the natural flooding characteristics of a stream. Water withdrawals, dams, dikes, and other structures affect stream flow and associated aquatic habitat
- **Riparian zone** – the width of the natural vegetation zone from the edge of the active channel out onto the floodplain. A healthy riparian vegetation zone is a critical element in a stream ecosystem.
- **Bank stability** – a measurement of the existence of, or potential for soils to erode from stream banks into a stream, which can impact the stream's water and habitat quality. High elevation and steep banks are more susceptible to erosion or collapse than low elevation, gently sloping stream banks.
- **Water appearance** – a measurement of the turbidity (water clarity), color, and other visual characteristics of a stream as compared to a healthy or reference stream.
- **Nutrient enrichment** – a measure of the level of nutrients in a stream, which is reflected by the types and amounts of aquatic vegetation in the stream. Excess nutrients cause excess growth of algae and other plants. Plant respiration and decomposition consume dissolved oxygen in the water, which is critical to aquatic life.
- **Barrier to fish movement** – an assessment of the presence of barriers in a stream. Barriers such as dams may prevent the movement or migration of fish, deny access to important breeding and foraging habitats, and isolate populations of fish and other aquatic animals.
- **Instream fish cover** – a measurement of the variety and abundance of suitable habitat and cover available to fish. These habitats/cover types are features such as logs, woody debris, overhanging vegetation, boulders and cobbles.
- **Pools** – a measure of the number of pool areas in a stream. Pool areas serve as important resting and feeding sites for fish.
- **Insect/invertebrate habitat** – a measure of the suitability of the stream habitat to allow insect/invertebrate colonization. Stable, undisturbed sediments that feature varied covered types (e.g., fine woody debris, submerged logs, coarse gravel) provide quality insect/invertebrate habitat.

- **Canopy cover** – a measure of the shading of streams by vegetation. Shading of the streams is important because it keeps water cool and limits algal growth. Cool water has a greater oxygen holding capacity than warm water.
- **Manure presence** – an assessment for the potential for manure to enter a stream. Manure can reduce dissolved oxygen levels and increase the loading of nutrients.
- **Riffle embeddedness** – a measure of the percentage of the stream that contains riffle areas. Riffles are areas, often downstream of a pool, where the water is breaking over rocks or natural debris. Riffles can maintain high species diversity and abundance of insects and provide spawning habitats and feeding rounds for certain fish species.
- **Macroinvertebrates observed** – a measure of the ability of a stream to support aquatic invertebrates. The presence of species known to be intolerant to pollution stress indicates a healthy stream condition. An abundance of individuals of species that are known to be tolerant of pollution stress, coupled with the absence of intolerant species, indicates a degraded stream condition.

Benthic macroinvertebrates are commonly used to assess stream integrity. In addition to the presence and absence of species known to be tolerant or intolerant to pollution stress, benthic community structure can be indicative of prevailing stream conditions. Communities with few species but high abundance of individuals typically reflect degraded conditions, while communities that feature many species with relatively low abundance of individuals typically reflect a healthy stream condition. The NJDEP implements the Ambient Biomonitoring Network (AMNET), with approximately 200 sites in each of five major drainage basins (upper and lower Delaware, Northeast, Raritan, and Atlantic) sampled once every five years to determine the composition of macroinvertebrates within the sampled stream reach.

There are approximately 200 AMNET stations that exist in the Highlands Region. The Highlands Council (in cooperation with Rutgers-Center for Remote Sensing and Spatial Analysis and the New Jersey Water Supply Authority) performed statistical analyses to assess correlations between key watershed characteristics and AMNET scores for Highlands Region streams. The intent was to determine whether the correlations were strong enough to use available AMNET scores to estimate stream integrity for streams that lacked AMNET data.

Some correlations (e.g., between AMNET scores and a group of land cover factors such as agriculture and urban lands) were strong enough to provide limited insight into watershed conditions of the streams where the AMNET sites are actually located. Forest cover was the strongest predictor of high AMNET scores. However, the AMNET analysis did not yield sufficiently strong statistical correlations for assigning scores to non-assessed watersheds.

RIPARIAN AREAS

This section describes the approach and findings of the Highlands Riparian Area element of the Regional Master Plan. Riparian areas are hydrologically connected to surface water through overland surface runoff, hydric soils, wetlands, or subsurface flow. They serve as an interface between surface water bodies (e.g., streams, rivers, lakes, or reservoirs) and terrestrial ecosystems.

Riparian areas moderate fluctuations in water temperature, help maintain ground water recharge and stream base flow, stabilize stream banks, and provide flood storage areas. During high flow or overland runoff events, riparian areas reduce erosion and sediment loads to surface water and remove excess nutrients and contaminants from flood water. Riparian areas also provide habitat and for a variety of animal species and support terrestrial and aquatic food webs through deposition of woody debris (NRCS 2006; NJWSA 2000).

The effectiveness of a riparian area is influenced by its size, intensity, type of land use, and riparian corridor condition (e.g., soils, slope, vegetation, wetlands, and floodplain). Anthropogenic (i.e., human-induced) disturbance to riparian areas often significantly alter the movement and storage of water that is critical to ecological functions (NRCS 2006). Land use changes, impervious (i.e., paved) surfaces, and riparian vegetation removal decrease infiltration rates within riparian areas and increase overland storm or flood water runoff.

Overland surface or flood water runoff within disturbed riparian areas may negatively affect downstream aquatic ecosystem health. Thus, functional values of riparian areas are lost as anthropogenic disturbances increase.

This subsection describes the technical approach for identifying Highlands Riparian Areas. The approach entails two distinct components: 1) identification of Riparian Areas; and 2) evaluating Riparian Area integrity.

IDENTIFICATION OF RIPARIAN AREAS

Riparian areas in the Highlands Region were defined and mapped using hydrologic properties of land cover, soil, and evidence of periodic inundation or saturation. Riparian areas include the integration of flood prone areas, riparian soils, Highlands Open Waters, and wildlife corridors. A single riparian GIS coverage was created by joining flood prone area, riparian soil, wetland and stream, and wildlife corridor coverages to create a combined riparian area map (see figure *Identification of Riparian Areas in the Highlands*). Each is described in more detail below.

- **Flood Prone Areas** – defined as NJDEP documented and undocumented flood prone areas and Federal Emergency Management Agency (FEMA) 100-year floodplain (NJDEP 1996; FEMA 1996).
- **Riparian Soils** – defined as a hydric soil, a soil exhibiting a shallow depth to seasonal high water table, or alluvial soil (NRCS 2004).
- **Highlands Open Waters** – defined as all mapped rivers, lakes, streams and wetlands that are adjacent to and hydraulically interconnected with a river or stream as identified in the Highlands Open Water Inventory (NJDEP 2002a; NJDEP 2002b).
- **Wildlife Corridors** – defined as a 300-foot corridor on each mapped stream bank or from the stream centerline if no stream bank is mapped.

Flood Prone Areas

Flood prone areas were delineated using both NJDEP flood prone and FEMA Q3 flood area (NJDEP 1996; FEMA 1996). NJDEP flood prone areas were derived from USGS 100-year floodplain coverage and include USGS documented and undocumented flood prone areas (NJDEP 1996). NJDEP flood prone areas were delineated by readily available information on past floods rather than from detailed surveys and inspections. Delineated areas were for natural conditions and did not take into consideration the possible effects of existing or proposed flood control structures except where those effects could be evaluated. Flood areas were identified for urban areas where the upstream drainage basin exceeds 25 square miles, rural areas in humid regions where the upstream drainage basin exceeds 250 square miles, and smaller drainage basins, depending on topography and potential use of the floodplains (NJDEP 1996).

The FEMA Q3 flood coverage includes the 100-year floodplain. The FEMA 100-year floodplain is defined as:

- **Flood** Insurance **Risk Zone A** - Areas subject to inundation by the 1-percent-annual-chance flood event. Because detailed hydraulic analyses have not been performed, no base flood elevation or depths are shown.
- **Flood Insurance Risk Zone AE** - Areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. Base flood elevations are shown within these zones.

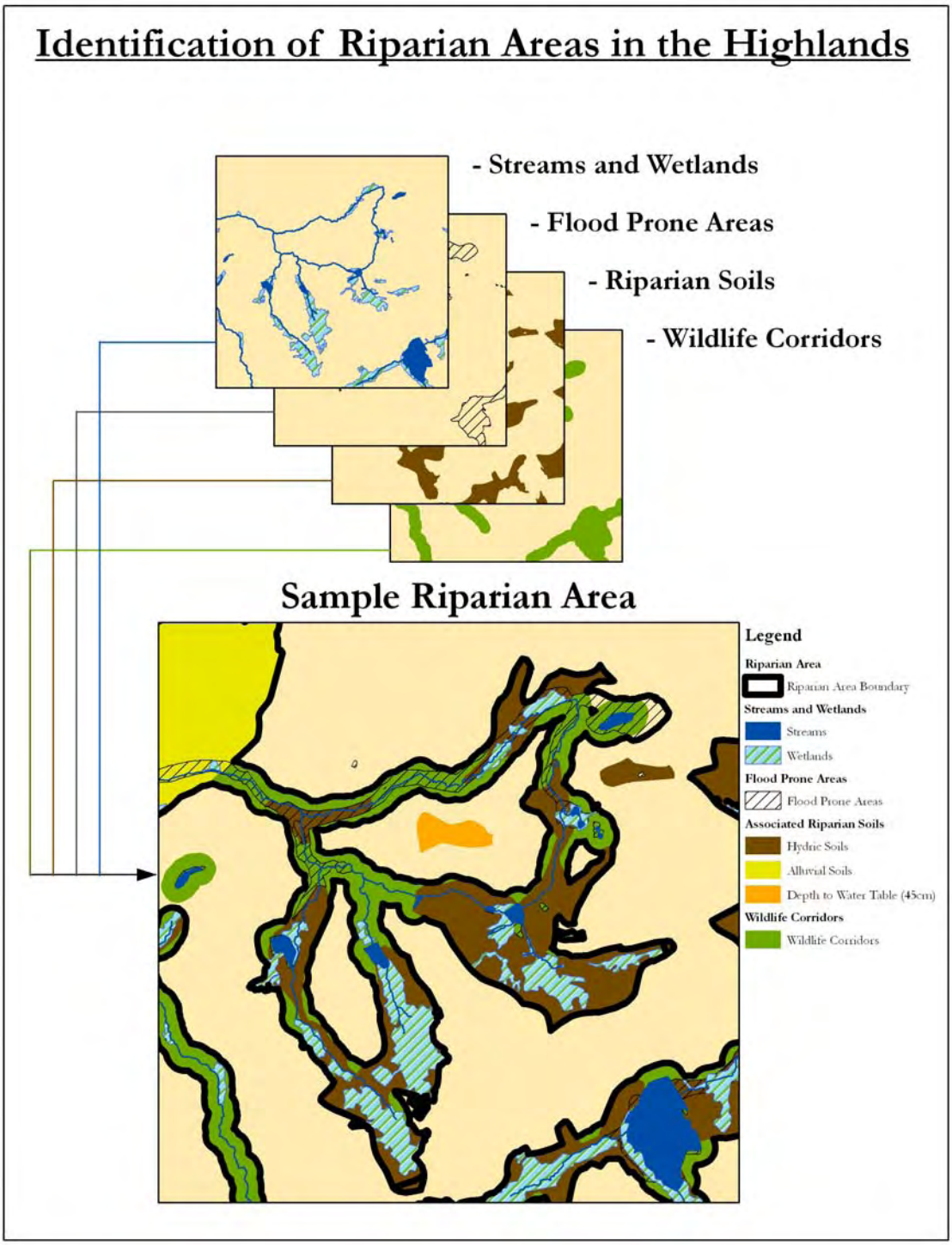
The digital Q3 Flood Data are designed to serve FEMA's needs for disaster response activities, National Flood Insurance Program activities, risk assessment, and floodplain management. The data are expected to be used for a variety of planning applications including broad-based review for floodplain management, land-use planning, commercial siting analysis, insurance target marketing, natural resource/environmental analyses, and real estate development and targeting (FEMA 1996).

Riparian Soils

For the purpose of identifying Highlands Riparian Areas, riparian soils have been defined as hydric soils, soils exhibiting a depth to seasonal high water table $\leq$ 18 inches, and alluvial soils.

Riparian soils mapping is based on the Natural Resources Conservation Service (NRCS) Soil Survey

Geographic (SSURGO) digital soils coverage (NRCS 2004). The map extent for a SSURGO data set is a soil survey area, which may consist of a county, multiple counties, or parts of multiple counties. A SSURGO data set consists of map data, attribute data, and metadata.



Hydric soils are partial and full hydric classified soils; as defined in the SSURGO hydric component information (HYDCOMP) GIS soil attribute table (NRCS 2004). The soil series presented in the table below are classified as entirely or partially hydric and/or as containing hydric soil inclusions. Soils exhibiting a depth to seasonal high water table ≤18 inches are derived from the SSURGO HYDCOMP GIS soil attribute table. All soil series listed in the *Hydric Soil Series within the Highlands Region* table exhibited or partially exhibited a shallow depth to seasonal high water table.

Hydric Soil Series within the Highlands Region			
Abbottstown	Dunellen variant	Mount Lucas	Rowland
Adrian	Elkton	Norwich	Transquaking
Alden	Ellington variant	Palms	Turbotville
Amwell	Fluvaquents	Parsippany	Udifluvents
Annandale	Fredon	Parsippany variant	Udorthents
Atherton	Haledon	Pascack	Urban land
Bartley	Halsey	Pattenburg	Venango
Biddeford	Hasbrouck	Penn	Wallkill
Bowmansville	Hero	Pits	Watchung
Braceville	Hibernia	Pompton	Water (>40 acres)
Califon	Keyport	Preakness	Water (<40 acres)
Califon variant	Lamington	Preakness variant	Wayland
Carlisle	Lansdowne	Quakertown	Whippany
Catden	Lawrenceville	Raritan	Whitman
Chalfont	Lehigh	Readington	Willette
Chippewa	Lyons	Reaville	Wurtsboro
Cokesbury	Middlebury	Reaville variant	
Croton	Minoa	Ridgebury	

Alluvial soils include soils taxonomically classified as fluvents, udifluvents, or fluvaquents (personal communication, Chris Smith, - NRCS) (see table *Alluvial Soil Series within the Highlands Region*).

Alluvial Soil Series within the Highlands Region
Middlebury
Pope
Rowland
Bowmansville
Wayland
Wallkill
Fluvaquents
Udifluvents

Highlands Open Waters

Wetland mapping is based on the NJDEP 2002 Land Use/Land Cover mapping (NJDEP 2002a). All wetlands mapped adjacent to water bodies or through which water bodies flow were considered part of the riparian area. Stream coverage is based on a combination of the Highlands Open Water Inventory, NJDEP Land Use/Land Cover mapping, and NJDEP 2002 Hydrography mapping (NJDEP 2002b). All mapped streams were included in the analysis, including headwater streams.

Wildlife Corridors

A wildlife corridor was established, including all mapped streams and intersecting surface water features (e.g., lakes) extending 300 feet on each stream bank or from the stream centerline if no stream bank is mapped. Narrow riparian corridors may provide suitable wildlife habitat; however, wider corridors have been documented to support a greater diversity of species, including interior species. In addition to narrow riparian corridors, scientific literature recommends preservation and/or creation of 300-foot riparian corridors (from each bank) for protection of forest interior species habitat and movement corridors (Wenger 1999; MDFS 2006).

Approximately 367,988 acres of Riparian Area (or 43% of total land area) were mapped in the Highlands Region (see figure *Riparian Area*) and are summarized by HUC 14 in Appendix B.

EVALUATING RIPARIAN AREA INTEGRITY

Riparian area integrity may be defined by an area's ability to provide water protection and ecological function. These functions include nutrient and sediment filtration, stream bank stabilization, wildlife migration corridors and habitat, storm water and flood water storage, and stream water quality protection (NJWSA 2000). Evaluating riparian area integrity includes an assessment of existing land use and land cover condition within the Riparian Area as a measure of the quality and condition of the stream corridor.

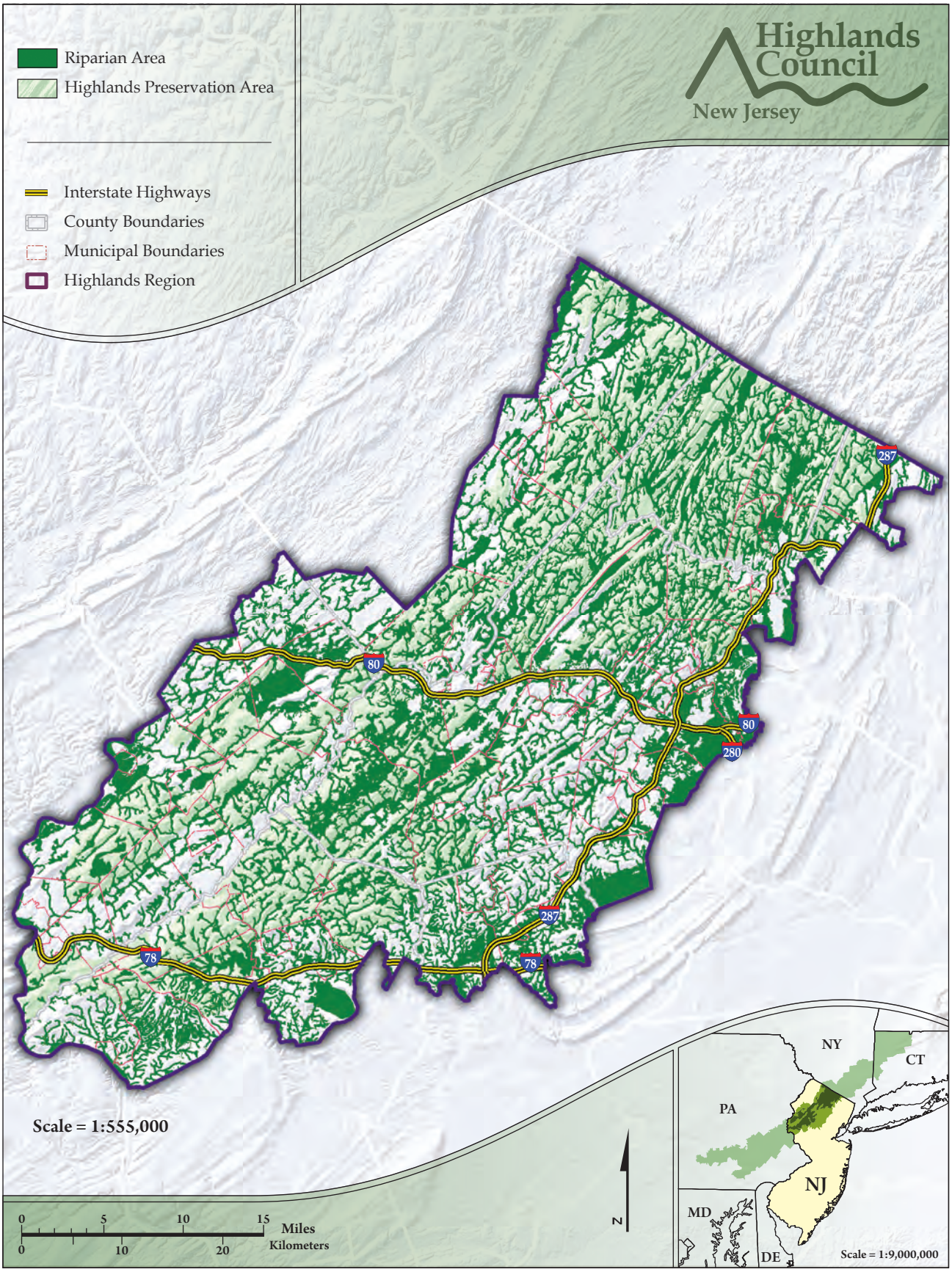
As was done for the watershed value classes for Highlands Open Waters land use characteristics and land cover condition were analyzed within the riparian areas. Peer-reviewed scientific literature (Castelle et.al., 1994; NRCS 2006; Phillips 1989; and Wegner 1999) was reviewed to identify indicators of riparian area integrity. From the suite of indicators identified in the literature, the following were selected including:

- Amount of Impervious Coverage
- Degree of Agriculture Land Use
- Frequency of Road Crossings
- Condition of Vegetation Cover
- Habitat for Water/Wetland Dependent Species

Impervious Coverage is the percentage of the riparian area that is covered in impervious surfaces. The source of this data is the 2002 Land Use/Land Cover data set developed by the NJDEP.

There are strong correlations between increases in impervious cover and impacts to stream hydrology and water quality (Booth et al., 2002). Impervious surface is any surface that cannot be effectively penetrated by water, thereby resulting in runoff. Examples are pavement (asphalt, concrete, etc.), buildings and structures, driveways and roadways, parking lots, and sidewalks. Unlike *pervious* areas where soil and vegetation absorb rainwater, impervious surfaces are areas that water cannot permeate. Land cover that is impervious prevents rainwater from entering into the soil and forces it to run off the land and pick up pollutants before getting deposited into waterways. Impervious surfaces are so associated with urban water pollution that they are commonly used as an indicator of overall stream quality (Arnold and Gibbons 1996). The Stormwater Manager's Resource Center website (at www.stormwatercenter.net) indicates that streams with 0-10% impervious cover in their drainage areas are unimpacted, streams with 11-25% are somewhat impacted, and streams with 26%+ impervious cover are heavily impacted. As such, increases in the amount of impervious surface can be used as an indicator of impairment of the integrity of a riparian area.

RIPARIAN AREA



Agriculture Land Use is the percentage of the HUC14 that is in agricultural use. The source of this data is the 2002 Land Use/Land Cover data set developed by the NJDEP.

The percent of agricultural use is an indicator of impairment of riparian area integrity (i.e., in general, the higher the percentage, the lower the riparian integrity). Lands in agricultural use are typically associated with water quality impairments. Soil disturbance associated with land cultivation activities can increase the rate of sedimentation to adjoining waterways. This can result in increases in the amount of phosphorous and pesticides entering surface waters. Roth et al (1996) found that stream biotic integrity was negatively correlated to the percent agricultural land use and positively correlated with the percent of wetlands and forests. Lammert and Allan (1999) found that stream indicators of biologic integrity were negatively related to riparian agriculture, and positively related to riparian forest land.

Frequency of Road Crossings is the number of road crossing per linear stream mile. The source of the data is the NJDOT 2002 Roads data. This is an indicator of impairment of riparian area integrity (the higher the number of crossings, the lower the riparian integrity) (Daniels et al., no date).

Vegetation Condition is the percent of the HUC14 that features urban and agricultural lands (as a means to determine the percent of natural vegetation within the HUC14). The source of this data is the 2002 LU/LC data set developed by the NJDEP.

Vegetation condition is an indicator of impairment of riparian integrity (i.e., in general, the higher the percentage of urban and agricultural land means the less natural vegetation; this results in lower riparian integrity). FitzHugh (2001) identified a series of research articles that documented a negative relationship between developed land use and aquatic habitat integrity. The US Geological Survey National Water Quality Assessment study compared aquatic community indicators of a selected watershed to the proportion of urban land use in the watershed. It was found that as natural vegetation communities are replaced by developed land, downstream water quality declines due to combined impacts of point and non-point source pollution and soil erosion (Ayers et. al., 2000). Steedman (1988) found positive correlation between high stream biological integrity score and the percent of riparian forest (versus percent urban lands).

Water/Wetland Dependent Species includes a measure of the percentage of the riparian area that contains habitat for water/wetland dependent species of concern including rare, threatened or endangered species. The source of this data is the NJDEP's Endangered and Nongame Species Program (ENSP) Landscape Project (described in detail in Section 7 of this report).

This is an indicator of riparian area integrity (i.e., in general, the higher the percentage, the higher the riparian integrity). Rare, threatened, and endangered species that are dependent upon open water and/or wetland habitats rely on intact riparian habitats for their survival. Thus, the loss and modification of riparian habitat would result in direct impacts to these species.

Riparian Area Integrity Classes

Each of the five indicators of riparian integrity were calculated within the corresponding riparian area and expressed at the HUC14 level. A range of percentages (with the exception of stream/road crossings, which is expressed as the actual number per stream mile) have been generated for each indicator. For the purpose of ranking the integrity of the riparian area within a HUC14 based on the indicators, it was useful to establish a range of value classes.

For riparian area integrity, five value classes were established ranging from 5 (highest integrity) to 1 (lowest integrity) for each of the five indicators. The value classes were established using the natural breaks option in the ArcView software. The natural break formula is called Jenks optimization, which identifies breakpoints between data classes using a statistical formula to facilitate the identification of groupings and patterns inherent in the data (Conservation Biology Institute, 1999). The natural breakpoints were then adjusted slightly to round to whole numbers (and in the case of impervious surface, the breakpoints were adjusted to conform to approximate value class break points in the scientific literature regarding the relationship between riparian area condition and stream health).

This methodology can best be understood by looking at a specific example. Using percent impervious surface as the example, the five approximate natural breakpoints in the data are: 1) 0-5%; 2) 5-10%; 3) 10-15%; 4) 15-20%; and 5) >20%. These breakpoints are generally consistent with what is presented in the scientific literature regarding value class breaks for percent impervious surface and relative stream health (Snyder, et. al, 2005; Cianfrani, et. al, 2005; and Tiner 2004). Because impervious surface is an indicator of impairment, the higher the percentage of impervious surface, the greater the potential disturbance to riparian integrity, while the lower the percentage the less potential disturbance to riparian integrity. Thus, for impervious surface, the values classes (ranging from the highest integrity value – 5, to the lowest integrity value – 4) are as follows:

- 0-5% - Value Class 5
- 5-10% - Value Class 4
- 10-15% - Value Class 3
- 15-20% - Value Class 2
- >20% - Value Class 1

The following table presents the value breaks and assigned value classes for each of the five watershed indicators.

Data Value Breaks and Value Classes for each Riparian Integrity Indicator

Riparian Indicator	Value Breaks (expressed as percent of HUC14)				
Percent Impervious	0-5%	5-10%	10-15%	15-20%	>20%
Percent Agriculture	0-3%	3-10%	10-20%	20-30%	>30%
Road Crossings/Stream Mile	0-0.25	0.25-0.5	0.5-1.0	1-1.5	>1.5
Vegetation Condition (% urban/agricultural lands)	0-5%	5-15%	15-30%	30-50%	>50%
Percent Wetland/Water Species	>80%	60-80%	40-60%	20-40%	0-20%
Assigned Value Class	**5**	**4**	**3**	**2**	**1**

A logic-decision matrix was developed that integrated watershed riparian indicator scores to classify a watershed as being of high integrity, moderate integrity, or low integrity. Following is a summary definition of each of the riparian integrity indicator value classes of the Highlands Region:

- **High Integrity Riparian Area** – These areas include watersheds with Riparian Areas that exhibit predominantly natural vegetation including high quality habitat for rare, threatened, and endangered water/wetland dependent species, and a generally low incidence of impervious area, agricultural uses and/or road crossings.
- **Moderate Integrity Riparian Area** - These areas include watersheds with Riparian Areas that contain a higher incidence of impervious area, agricultural uses and/or road crossings and a reduced proportion of natural vegetation including high quality habitat for rare, threatened, and endangered water/wetland dependent species.
- **Low Integrity Riparian Area** - These areas include watersheds with Riparian Areas that contain a high proportion of impervious area, agricultural uses and/or road crossings and minimal natural vegetation including high quality habitat for rare, threatened, and endangered water/wetland dependent species.

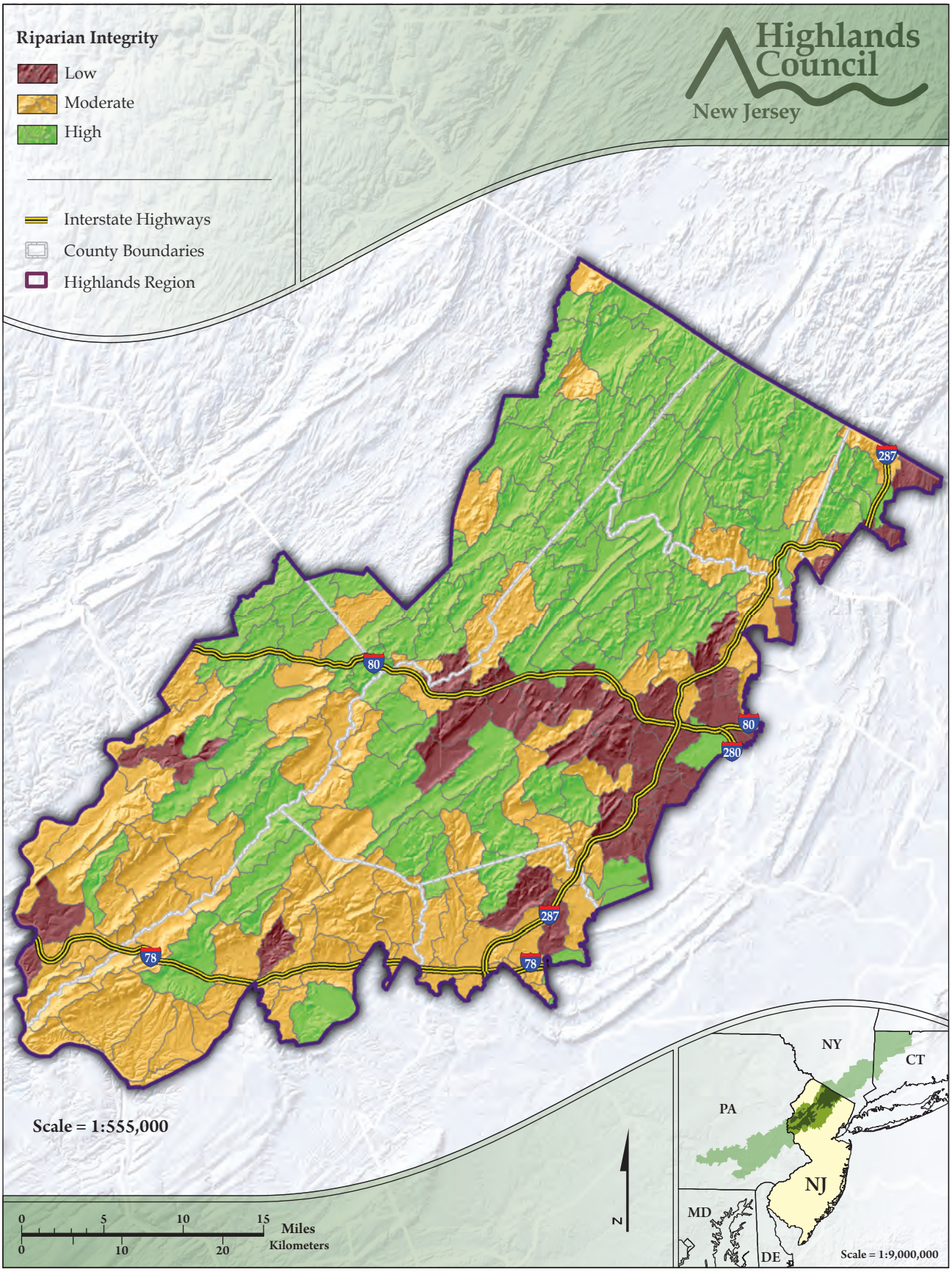
The Highlands Riparian Area Integrity Value Classes mapping depicts the riparian area integrity class (High, Moderate or Low) assigned to each of the 183 HUC14s in the Highlands Region (see figure *Riparian Integrity Value by HUC14*).

The total acreage of each watershed resource and riparian integrity value class in the Highlands Region, as well as the percent of the region each value class comprises is presented in the table *Highlands Riparian Integrity Value Classes*. High Integrity Riparian Area Watersheds encompass over 419,000 acres, or about 49% of the Region. Moderate and Low Integrity Riparian Areas Watersheds comprise about 39% and 12%, respectively.

Highlands Riparian Integrity Value Classes by HUC14

Value Class	Total Acres	Percent of Highlands Region
Watershed Riparian Area Integrity		
High Integrity Riparian Area	419,253	49%
Moderate Integrity Riparian Area	333,041	39%
Low Integrity Riparian Area	107,063	12%

RIPARIAN INTEGRITY BY HUC 14



STEEP SLOPE PROTECTION

Slope is a measurement of the steepness of terrain and is defined as the vertical change in elevation over a given horizontal distance. Disturbance of areas containing steep slopes can trigger erosion problems, resulting in the loss of topsoil and the sedimentation of water bodies. It can also result in the disturbance of habitats, degradation of surface water quality, silting of wetlands, and alteration of drainage patterns. These processes, when severe, can also result in land slumping and landslides that can damage both developed property and ecosystems. The identification and classification of steep slopes is important in order to effectively manage critical natural resources in the Highlands Region.

The Highlands Region contains extensive areas of steep slopes which offer a variety of recreation, aesthetic, and ecologic functions and values. Areas of steep slope can provide popular recreation opportunities including hiking, climbing, and wildlife observation. Ridgelines, hillsides, and steep slopes provide scenic views and vistas, which contribute significance to the enjoyment of the rural character inherent to many areas of the Highlands Region.

There are a variety of factors that influence the severity of potential impacts that may occur as a result of steep slope disturbance. In addition to the percent slope (i.e., the vertical change in elevation over a given horizontal distance), these factors include:

- **Soil Erodibility** – represents both susceptibility of soil to erosion and the rate of runoff. The Natural Resources Conservation Service Soil Survey Geographic (SSURGO) data set includes data on soil erodibility. Understanding the erodibility properties of soils in areas of slope is important as the combination of even a moderate slope and highly erodible soils can pose an erosion hazard.
- **Land Cover** – the type, health, density and extent of vegetative land cover is an important consideration in a steep slope analysis because the cover type influences the stability of the soil and thus, its erodibility. Soil erosion potential is increased if the soil has no or very little vegetative cover. Conversely, soil erosion potential is low in areas with dense cover, leaf litter and organic material such as forested areas, where that land cover is not disturbed.
- **Sediment Delivery** – represents the potential for direct delivery of sediments (the potential for soil detachment, transport and deposition of soil particles) from a steep slope to a water body.
- **Soil Capability Class** – a ranking system which identifies limitations in soils for agricultural usage. The SSURGO data set includes these soils capability classes as determined by the Natural Resources Conservation Service.
- **Depth to Bedrock** – soils with a shallow depth to bedrock are adversely affected by erosion.

To protect natural resources from the damages of soil erosion, the State of New Jersey adopted the Soil Erosion and Sediment Control Act (Chapter 251 of the New Jersey Public Laws). The Act establishes and implements, through the State Soil Conservation Committee and the Soil Conservation Districts, a comprehensive and coordinated erosion and sediment control program. The "Standards for Soil Erosion and Sediment Control" (N.J.A.C 2:90-1) promulgated by the New Jersey State Soil Committee provide guidance to assure that soil, water, and related natural resources are managed during development in a manner that prevents or minimizes soil loss and related environmental damage.

Pursuant to the Act, certification of a soil erosion and sediment control plan by the local Soil Conservation District is required for any project involving the disturbance of greater than 5,000 square feet of land (unless such land is used for agricultural, silvicultural or horticultural purposes). In certifying soil erosion and sediment control plans, the soil conservation districts ensure that plans meets the standards promulgated by the State Soil Committee, which include standards for land disturbing activities for various categories of slopes. Thus, development of steep slopes is governed by the provisions of the Soil Erosion and Sediment Control Act.

In order to address the requirements and goals of the Highlands Act, the Highlands Council classified and mapped areas of steep slopes within the Highlands Region to identify areas that are significantly constrained by steep slopes and to ensure that the level of protection for these areas is appropriate. The development of steep

slope protection requirements is intended to ensure the protection of the natural, scenic, and other resources of the Highlands Region.

The Highlands Council spatially examined slopes in the Highlands Region using the 10-meter Digital Elevation Grids generated from the United States Geological Survey's (USGS) Digital Elevation Model. The Digital Elevation Model includes digital records of terrain elevations for ground positions at regularly spaced horizontal intervals, which are derived from USGS quadrangle maps. The Council examined areas of slope in the Highlands Region that encompassed a minimum of 5,000 square feet and that exhibited one of the following grade classifications, and these grades were established as steep slope protection areas:

- grades of slopes of 20% or greater;
- grades of slope between 15% and 20%; and
- grades of slope between 10% and 15% that occur within the Riparian Area.

The table *Acreage of Steep Slope Protection Areas in Undeveloped and Developed Lands* presents the acreage of undeveloped and developed lands in the Highlands Region by steep slope class.

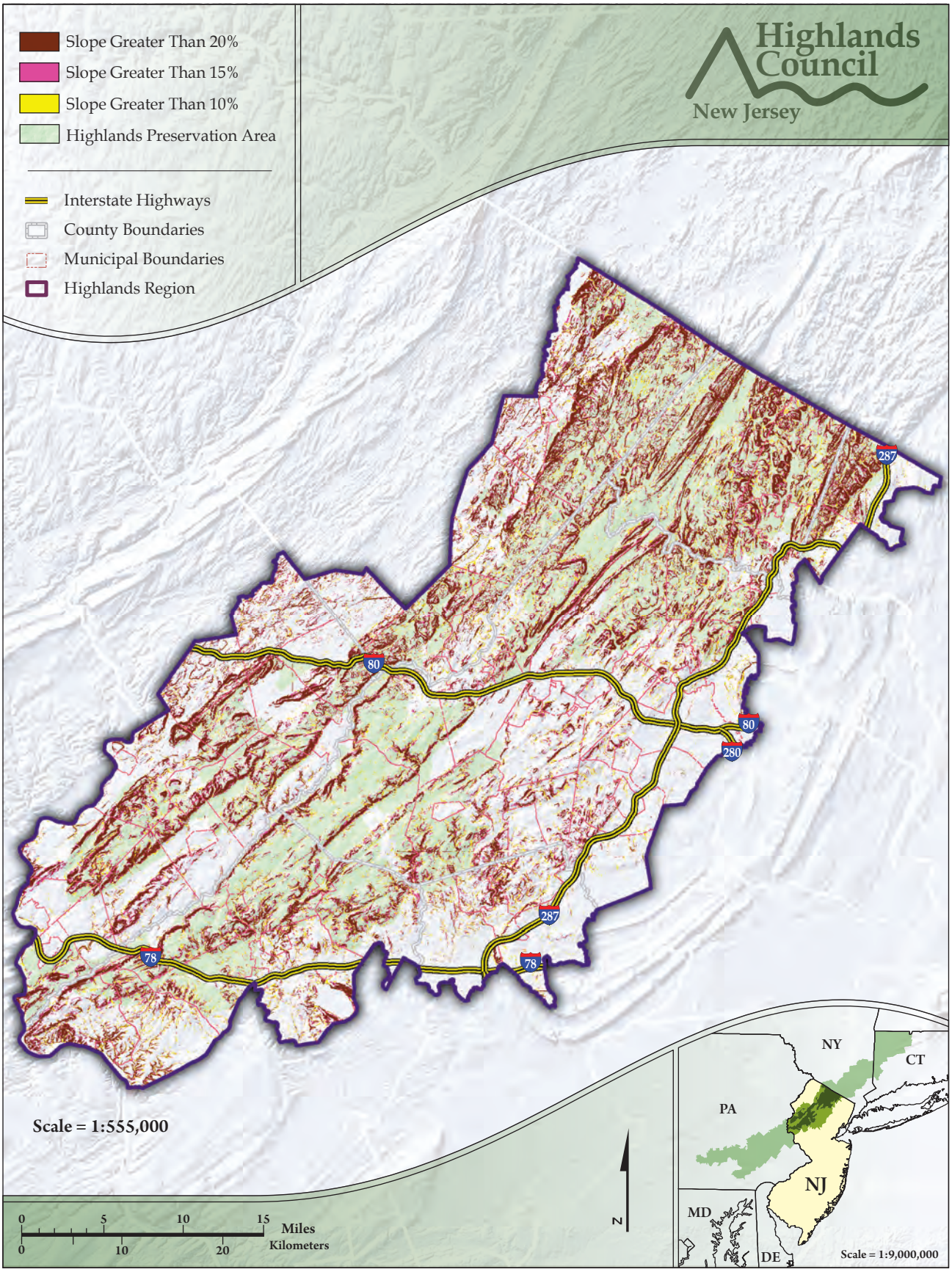
Acreage of Steep Slope Protection Areas in Undeveloped and Developed Lands

Steep Slope Class	Undeveloped	Developed	Totals
10 to 15 pct within Riparian	32,660	8,309	40,969
15 to 20 pct	64,897	14,359	79,257
Greater Than 20 pct	113,154	12,909	126,063
TOTALS (Acres)	210,711	35,577	246,289

For slopes that exhibited grades between 10% and 15%, the Highlands Council differentiated between those within and outside Riparian Areas. Alteration of slopes of 10% or greater within a Riparian Area have a greater potential of impacting adjacent water bodies through soil erosion (thereby causing degradation of surface water quality, silting of wetlands, and alteration of drainage patterns). Thus, in order to meet the protection needs of Highlands Open Waters, slopes with a grade of 10% or greater in the Riparian Area were identified and mapped as steep slope protection areas (see figure *Steep Slopes Protection Area*).

The Highlands Council recognized the need for more refined information on steep slopes in the Highlands Region and is in the process of developing accurate slope data using laser technology. Aerial flyovers of the entire Highlands Region, using Light Detection and Ranging (LiDAR) technology, occurred in late 2006 to prepare an updated and accurate digital model of the Region. The result will be a highly accurate Digital Elevation Model that will provide 2-foot contour interval mapping of the entire Highlands Region. This model will be a valuable tool to assist municipalities and counties during site plan review and will provide important information for the further development of the Highlands Regional Master Plan.

STEEP SLOPE PROTECTION AREA



FOREST INTEGRITY AND SUSTAINABLE FORESTRY PRACTICES

Forests within the Highlands Region provide essential ecosystem functions, including surface water filtration, which is important to protecting drinking water supplies for the Highlands Region, and air filtration, which helps to reduce the effects of global warming through carbon sequestration. Forests also serve as habitat for animal and plant species and are critically important to maintenance of biodiversity in the Highlands Region. In addition, properly managed, they provide an important renewable source of wood products. However, historical and current forest losses due to changes in land development patterns and poor management activities threaten the protection of the region's wildlife, water quality, air quality, and overall ecosystem health (Heilman, et al., 2002; Ritters, et al., 2003). The forests of the Highlands Region represent regrowth of the resource from the late 1800's and early 1900's, when most forests had been cut for charcoal production, agriculture, etc. As with most of New Jersey, few if any of the Highlands forest lands were never cut.

Total forest area was extracted from the NJDEP 2002 Land Use Land Cover data. Forest was defined as including all upland and wetland forest and scrub/shrub categories (excluding old field). Appendix C provides a discussion of the methods for field identification and delineation of Highlands Forest. The GIS data were extended beyond the Highlands Region borders to the HUC14 level in order to eliminate possible border artifacts that may result as a function of clipping the data by the Highlands Region boundary. To address this issue for the New York/New Jersey State borders, the best available GIS data from the USFS 2002 Highlands Regional Assessment was used.

Despite increasing forest loss due to land development patterns, the Highlands Region still includes extensive areas of relatively intact forested tracts. More than half of the Highlands Region consists of upland and wetland forested communities (approximately 464,200 acres or 54% of the total of land area). More than half of the existing forests in the Highlands Region consist of contiguous forested tracts greater than 500 acres in size. These large contiguous forested tracts primarily occur within the northern portion of the Highlands Region (25 tracts of forest >2,500 acres in size). It is important to note, however, that even these large contiguous areas may consist of many smaller parcels under individual ownership. In 2002, the average woodland under a single ownership was 10-20 acres.

Even with the extensive forest areas contained within the Highlands Region, increased fragmentation of forest tracts is occurring due to land use alterations. This fragmentation results in quantifiable landscape level changes which include increased edge, reduced forest interior, increased number of patches, forest patch isolation, and reduced habitat area.

DOMINANT FOREST TYPES IN THE HIGHLANDS REGION

The ridges and uplands of the Highlands are noted for rich and diverse forests with the exception of major farming areas in lower river valleys of the Delaware, Musconetcong/Pohatcong, and Wallkill Rivers. These forests provide watershed protection services as also can serve as a timber resource.

The USFS New York-New Jersey (NY-New Jersey) *Highlands Regional Study* assessed forest and timber resources of the NY-New Jersey Highlands study region based on USFS Forest Inventory and Analysis (FIA) data (see table *Forest Inventory and Analysis Data for New Jersey Highlands Counties: Dominant Forest Types*). FIA data were analyzed for counties included in the New Jersey Highlands study region (Bergen, Hunterdon, Morris, Passaic, Somerset, Sussex, and Warren). Reports for New Jersey were available for 1987 and 1999 (DiGiovanni and Scott 1990; Griffith and Widmann 2001).

Mixed oak hardwood forests are the dominant forest variety in the Highlands Region. Three oak species: black, white and red oak, occur most frequently. Other species, including sugar maple, red maple, hickories, tulip tree, American beech, white ash, elm and birch, are interspersed throughout the forests. The Eastern hemlock is intermixed with other species in cool, moist areas.

Forest Inventory and Analysis Data for New Jersey Highlands Counties:

Dominant Forest Types

	Forest Type in Thousands of acres				
County	Oak/Pine	Oak/Hickory	Elm/Ash/ Red Maple	Northern Hardwoods	Totals
Hunterdon		56.4	17.2	24.5	120.8
Morris		68.9	6.1	46.5	121.5
Sussex	5.8	109.4	29.0	44.8	193.5
Warren	4.1	50.4	13.3	29.1	97.0
Passaic/ Bergen		74.6	4.5	12.7	91.9
Somerset (including Middlesex/Mercer)		78.4	32.8	20.4	155.6
Totals	9.9	438.1	102.9	178.0	780.3
% of New Jersey	1.3%	56.1%	13.2%	22.8%	

Note: These FIA values are for the entire county area and not specific to the county area within the New Jersey Highlands boundary.

UNUSUAL FOREST TYPES WITHIN THE HIGHLANDS REGION

Atlantic White Cedar Bogs - Atlantic white cedar swamps make up <1% of the Highlands Region. These unique habitats are typically found at or near sea level, near the coast and along streams on the coastal plain. Highlands Region Atlantic white cedar stands are found in acidic bogs and at much higher elevations than other Atlantic white cedar forests.

These forests include associations with red maple, yellow birch, Eastern hemlock and black gum. Associated shrubs include mountain laurel, great rhododendron, common winterberry and highbush blueberry. Common herbaceous species includes cinnamon fern, starflower, eastern teaberry, and sedge species.

Pitch Pine Ridges - This forest type contains mixed woodlands of bedrock ledges. The canopy is usually dominated by pitch pine with scarlet oak, black oak, white oak, chestnut oak and white pine in association. Shrubs include black huckleberry and lowbush blueberry. Herbaceous species include little bluestem, Pennsylvania sedge, and hairy pinweed.

Red Cedar Glades - This traprock ridge community is found on mountainous sites. Most of these sites have minimal soil development. Tree cover is sparse ranging from 5-30% cover. Red cedar is the most common tree. Other associated species include white ash, red oak, pignut hickory and hornbeam. Shrub layer associates include Carolina rose, chestnut oak, lowbush blueberry, shortstalk arrowwood and staghorn sumac. Herb layers are dominated by little bluestem and poverty oatgrass.

Black Spruce Swamps - Black Spruce swamps are a rare occurrence in New Jersey. These bogs are located in well-defined topographic depressions (e.g. kettle hole basins) and are characterized by relatively deep peat accumulation. Black Spruce are the dominant tree with associates including tamarack and balsam fir. Shrubs include highbush blueberry and mountain holly as well as leatherleaf, black huckleberry, and sheep laurel. Herb layer includes sedge species, three-leaf Solomon's seal, white beaksedge, roundleaf sundew, purple pitcherplant, three-leafed goldthread, and tawny cottongrass.

ROLE OF FORESTS IN PROTECTING BIODIVERSITY

Conservation of large tracts of contiguous forest habitat and minimization of fragmentation were identified as major issues of concern in the New Jersey Highlands study region by the USDA Forest Service study (USDA,

2002). Large contiguous tracts of forest that are not fragmented by human development are valuable for wildlife habitat, recreational open space, and watershed protection. When considered from a landscape perspective the spatial pattern of these forest remnant parcels plays an important role in maintaining connectivity across a watershed, thereby facilitating ecological processes such as species dispersal (Gardner et al. 1987; With and Crist 1995). In highly fragmented landscapes, habitat quality of the intervening matrix (i.e., developed or agricultural lands) can also be important in determining how well species disperse across a landscape (as they try to traverse between forest remnants or other habitat patches) (Franklin 1993; Malanson 2003).

Paved roads and residential and commercial development often serve as a barrier, or hazard, to wildlife movement and native plant dispersal, as well as altering natural disturbance regimes. Human development also has an indirect impact by creating different intrusions of varying impact into adjacent natural habitat and recreational open spaces. These intrusions include increased air, water, noise and light pollution; changes in microclimatic conditions due to increased sunlight and wind; increased populations of invasive weed species; and increased frequency of disturbance due to direct contact with humans, human pets, and associated rural/suburban pest species. The border area affected by these disturbances is labeled *edge* as compared to the undisturbed *core* or interior forest habitat (Zipperer 1993).

In addition to critical habitat for rare, threatened and endangered wildlife and plant species, the region's forest exists within a major bird migratory flyway, connecting wintering habitat in Central and South America with breeding grounds in northern latitudes. One-quarter of all neotropical bird species found in the United States are found in the Highlands and half of the total number of species that breed in the Highlands are neotropical migrants. Many of these species are forest-interior breeding species. Interior forests in the Highlands provide critical habitat for species including red-eyed vireo (*Vireo olivaceus*), American redstart (*Setophaga ruticilla*) and Eastern pee-wee (*Contopus virens*). Two-thirds of migrant birds that use eastern migratory flyways are believed to be in serious decline. Several species, including northeastern populations of wood thrush (*Hylocichla mustelina*), Kentucky warbler (*Oporornis formosus*), black-throated blue warbler (*Dendroica caerulescens*), and cerulean warbler (*Dendroica cerulea*) are in rapid decline (www.audobon.org/bird/watch).

One reason for migratory bird species decline is loss of habitat through forest fragmentation and development pressure (Robinson et al. 1995, Villard et al. 1995, DeCalesta 1994). Fragmentation has lead to isolation of interior forest habitat (Whitcomb 1977; Butcher et al. 1981; Blake and Karr 1984) and increased pressure by nest predators (Wilcove 1985). Brood parasitism by cowbirds shows higher frequency closer to forest edges (Brittingham and Temple 1983). Area-sensitive species depend on large tracts of undisturbed interior habitat to maintain viable populations. Large raptors such as red-shouldered hawks (*Buteo lineatus*) and barred owls (*Strix varia*) are area-sensitive species that require large blocks of mature forested wetlands and adjacent upland forest (Niles et al. 1999).

Many Highlands amphibian and reptiles are sensitive to habitat fragmentation and human disturbance. Slow-moving amphibians and reptiles are susceptible to road-kill and are negatively affected by increasing road densities and traffic volumes (Mitchell 1992). Timber rattlesnakes (*Crotalus horridus*), a New Jersey endangered species of particular concern in the Highlands, are considered restricted range species because they rely on winter denning (hibernation) sites in rocky talus areas. During periods before and after hibernation, the snakes congregate around these sites, making them susceptible to human disturbance (Brown 1993). A number of area-sensitive mammal species, such as bobcats (a state threatened species in New Jersey) require large areas of relatively intact forest (Niles et al. 1999) for breeding, hunting, and rearing young.

ROLE OF FOREST INTEGRITY IN PROTECTING WATER QUALITY

Clean, high quality water is one of the Highlands most important natural resources. Undisturbed forests provide essential ecosystem functions of surface water filtration and ground water recharge.

Urban and suburban areas generate significant pollution loading from street litter deposition, atmospheric fallout, road traffic, soil erosion and soil-adsorbed pollutants (Novotny and Chesters 1981). Impervious surfaces (e.g., asphalt, concrete, buildings, road surfaces) closely correlate with water quality degradation and

altered runoff patterns in urban and urbanizing areas (Novotny and Chesters 1981; Driver and Troutman 1989; Arnold and Gibbons 1996; Bolstad and Swank 1997; Charbeneau and Barrett 1998; Wang 2001). As development accelerates forest loss, ground water recharge decreases, surface runoff and soil erosion increases, and storm flow volume peaks result in increases to downstream flooding (Brown 1988; Ferguson and Suckling 1990).

There is a clear connection between land use/land cover and integrity of Highlands water sources (USFS 2002). Aquatic communities, such as benthic macroinvertebrates and algae, are used as biological indicators of stream health due to their varying tolerance of human influences on the environment (USGS 2002). The USGS National Water Quality Assessment (NAWQA) study compared aquatic community indicators of water quality of selected watersheds to the proportion of urban land use in the watershed (Ayers et al. 2000). As forest and wetlands are replaced by developed and agricultural land, downstream water quality declines due to combined impacts of point and non-point source pollution and soil erosion. Connection between forest and water quality has been acknowledged for more than one hundred years, as is evidenced in the 1899 New Jersey State Geologist's Report on the forests of New Jersey (Russell 1988).

EFFECTS OF FOREST FRAGMENTATION

Protecting the integrity of Highlands forests is dependent on the maintenance of large contiguous forested areas and healthy forest stands. Land use change within the Highlands Region has resulted in forest loss and reduction in important forest ecosystem functions and societal benefits.

Forest fragmentation results in the separation of forest tracts from each other and from larger blocks of forest. Many species are especially vulnerable to the reduction in habitat area caused by forest fragmentation, and they may disappear entirely from forest patches because food or other resources are inadequate to support them. The reduction in species diversity within a forest can profoundly affect the ecosystem viability of the remaining forest. Fragmentation also reduces the movement of species that are reluctant or unable to cross non-forest areas and for those that depend on such species for dispersal. Reduced movement and dispersal increases the chance of local extinction of individual species. In order to control further degradation of the Highlands forest ecosystem, effective forest protection mechanisms and sustainable management policies are essential.

Large contiguous forest tracts have a higher degree of interior, or core, forest. Interior or core forests provide important ecological values. Core forest habitat is defined as a forest located more than 300 feet from altered land or a road. Approximately 44% of the total Highlands Region forest area is core forest habitat.

Literature suggests that effects of forest fragmentation can be classified into three major categories: area effects, edge effects and isolation effects.

- **Area Effect** - Fragmentation is likely the largest threat to Highlands forests. Forest fragmentation is the process by which larger, contiguous forests are broken into smaller, more isolated fragments. Ecological implications resulting from fragmentation include, but are not limited to, decrease in native biodiversity, irreversible loss or degradation of habitat, changes in stream conditions, decreased food availability to the system, changes in microclimate, increased nuisance wildlife, reduced water quality, and increased flooding.
- **Edge Effect** - Large contiguous forests contain less edge than several patches of smaller fragmented forests. Fragmented forests exhibit a high percentage of edge habitat, subject to greater sunlight and wind than core forest. This changes forest habitat structure, allowing for introduction of invasive species and increase in predation pressure. These intrusions include increased air, water, noise and light pollution; changes in microclimatic conditions due to higher sunlight and wind levels; increased populations of invasive species; and increased frequency of disturbance due to direct contact with humans, human pets and associated rural/suburban pest species (Zipperer 1993). Edge can promote overall biological diversity at a local scale by providing habitat for species dependent upon two or more land cover types. Conversely, creation of edge conditions often occurs at the expense of interior conditions thereby reducing biodiversity on a larger, regional scale.
- **Isolation Effect** - From a landscape perspective, spatial pattern of forest patches plays an important role in maintaining connectivity across a watershed and facilitating ecological processes such as species dispersal

(Gardner et al. 1987; With and Crist 1995). Nearest neighbor indices quantify landscape configuration. This indicator of forest fragmentation is related to the ability of species to move from forest patch to forest patch, particularly important in the event of a local extirpation of species. Recolonization from a nearby patch may minimize this event. The farther a forest patch is from another forest patch, the more likely such extirpation will occur and the more difficult recolonization will be. Significant distances between forest patches can interfere with pollination, seed dispersal, wildlife migration, and breeding. Ultimately these changes may result in the loss of species and overall decline in forest health.

While percolation theory (the study of plausible paths between different points in a multidimensional lattice network or grid) suggests an organism can move freely if its critical resource or habitat occupies approximately 60% of the landscape (O'Neill et al. 1989), other researchers have suggested significant transitions in forest connectivity can occur at much lower levels of conversion to non-forest cover. Wickham et al. (1999) found a transition in forest fragmentation in the Mid-Atlantic as the amount of altered land use increased above 20%. Vogelmann (1995) found a similar threshold for forest fragmentation in New England. These findings imply that a species' ability move or percolate within an even mildly fragmented forest landscape may be severely compromised.

In a continental scale fragmentation study of U.S. forests, Riitters et al. (2002) found that 43.5% of forest was located within approximately 300 feet of a forest edge. Riitters and Wickham (2003) suggested that regions with more than 60% of land area within 1,253 ft of a road may be at greater risk of cumulative ecological impacts. Using Riitters and Wickham's criteria, the New Jersey Highlands have an increased risk of ecological impacts due to fragmentation from roads.

FOREST INTEGRITY METRICS

A number of metrics were utilized to evaluate the effects of forest fragmentation across the Highlands Region landscape. Core forest area as well as patch area statistics (number and size frequency distribution) for total and core forest patches were determined across the entire study area as well as at the individual HUC14 basin-level. The HUC14 subwatershed was used as the landscape reporting unit because it provided a convenient and hydrologic geographic unit that recognizes the importance of forest cover to watershed characteristics and downstream water quality and quantity.

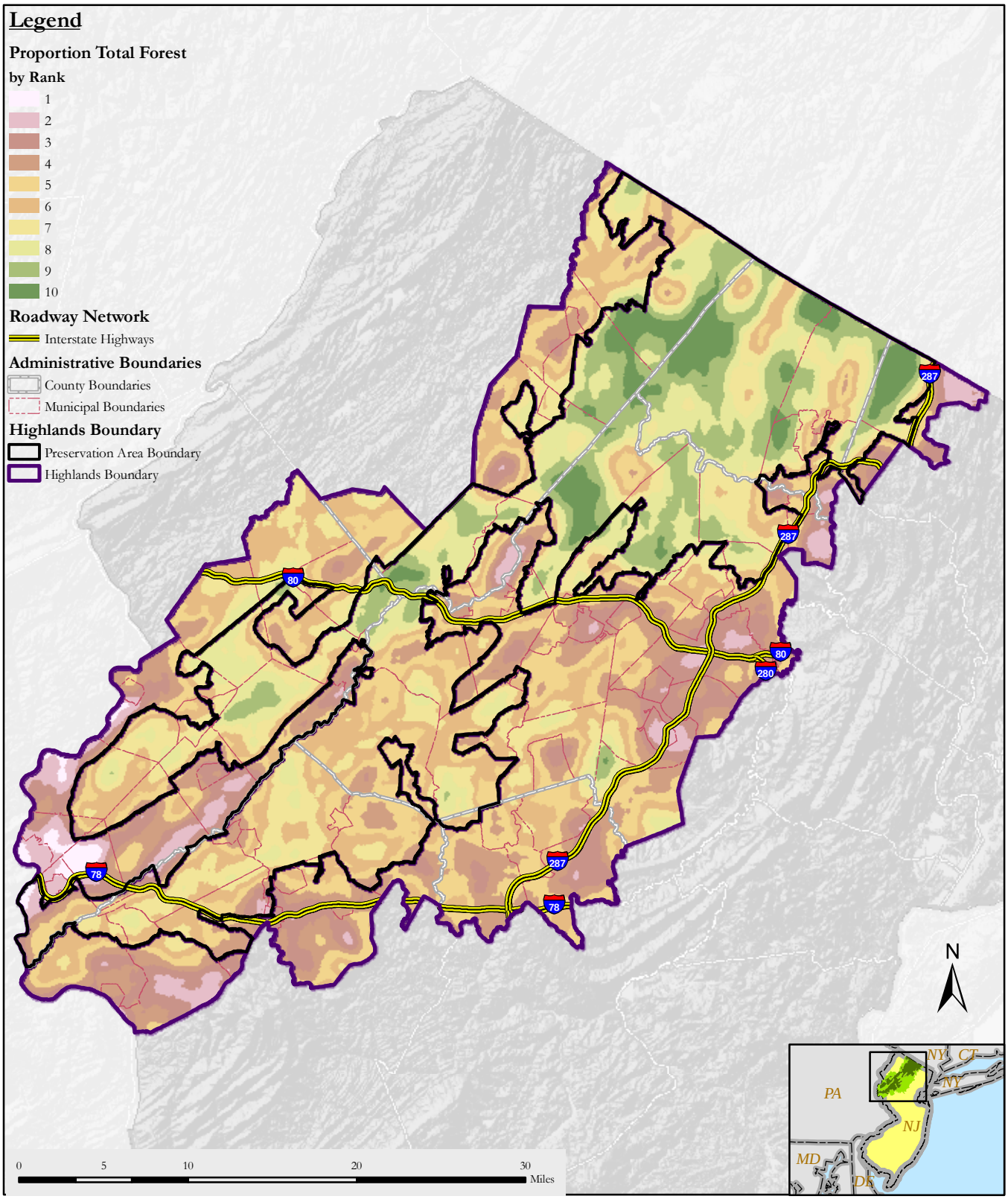
The following metrics were calculated using forest patch and individual HUC14 basins as the landscape reporting units:

- Forest Patch Size – the size of a contiguous forest stand
- Total Forest Area – the percentage of area that is covered in forest
- Core Forest – the area and percent of a forest patch that is greater than 300 feet from a forest edge
- Mean Distance to Closest Patch (MDCP) - the shortest edge-to-edge distance between distinct patches within a 1000 foot search radius. The MDCP provides a measure of forest patch isolation within the landscape area of interest.
- Proportion of Total Forest Area – the proportion of forest cover within a 3 square Kilometer search area to provide a landscape level view of the Highlands forest landscape was also used to simulate habitat requirements of Highlands wide-ranging wildlife species (figure *Proportion Total Forest by HUC14*).

The Highlands Council also assessed forest cover integrity in the Highlands Region at the watershed level because forests are important for the protection of water quality and quantity. The Highlands Council assigned a value class to each of the 183 HUC14 subwatersheds in the Highlands Region based on the following classes:

- High Integrity Forest Area – predominantly forested, including a high proportion of forest cover consisting of high core area, large patch size, and a low distance to nearest patch.
- Moderate Integrity Forest Area – predominantly forested, but do not exhibit a high proportion of forest cover, core area or patch size and an increase in distance to nearest patch.

Proportion Total Forest



Regional Master Plan, July 2008

Highlands Council
New Jersey

Sources:
New Jersey Highlands Council, 2006
New Jersey Department of Environmental Protection, 2006
New Jersey Department of Transportation, 2004

- Low Integrity Forest Area – predominantly non-forested or include low values for proportion of forest cover and patch size, or a high distance to nearest patch.

Each subwatershed within the Highlands Region was evaluated, using these indicators of forest watershed integrity to identify forested subwatersheds that provide important water quality benefits (figure *Forest Integrity Indicators by HUC14*).

The New Jersey Highlands study area is comprised of approximately 464,200 acres of forest (or 54% of the total land area) (see table *Acreage of Core vs. Edge Forest for the New Jersey Highlands Region*). Approximately 205,785 acres of forest (or approximately 44% of the total forest area or 24% of the total land area) represents core (interior) forest habitat. While there are large tracts of unbroken forest extending greater than one mile from the nearest road or altered land, the median distance to a forest edge is 226 feet (i.e., 50% of the forest area was within 226 feet of an edge) (see table *Area Statistics for Distance to Edge for all Forest Areas in the New Jersey Highlands Region*).

Acreage of Core vs. Edge Forest for the New Jersey Highlands Region

	NEAR EDGE<100 FT (ACRES)	FAR EDGE 100-300 FT (ACRES)	CORE > 300 FT (ACRES)	TOTAL FOREST (ACRES)
With Roads	138,284	120,137	205,785	464,206
No Roads	131,621	119,140	215,064	465,825

Note:
"With Roads" implies that the altered edge that created the patch was a road feature.
"No Roads" implies that the patch's altered edge was not a road feature

Area Statistics for Distance to Edge for all Forest Areas in the New Jersey Highlands Region

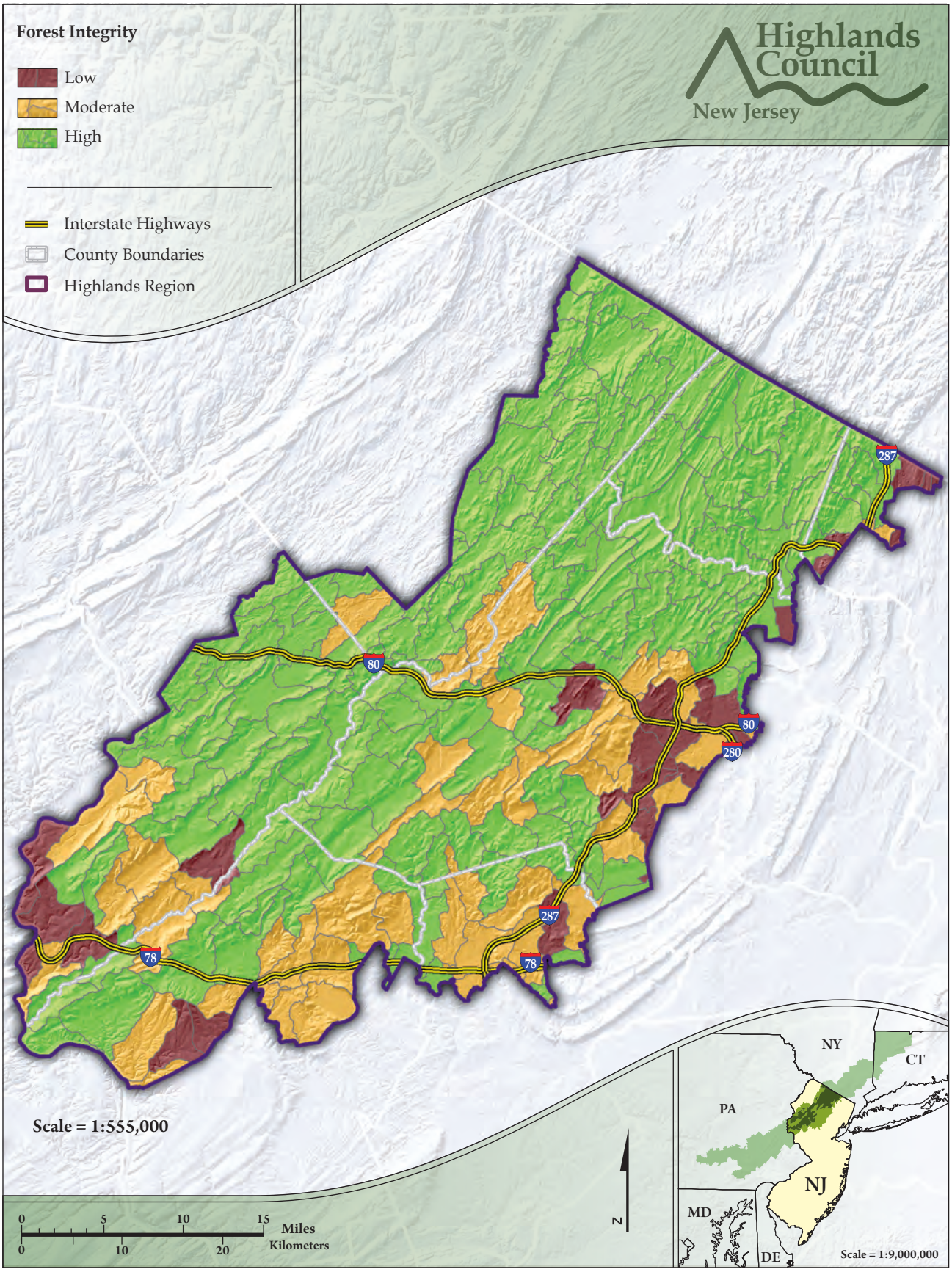
	Mean Distance	Median Distance	Maximum Distance
With Roads	543 ft	226 ft	6,530 ft
No Roads	594 ft	241 ft	7,790 ft

Notes:
"With Roads" implies that the altered edge that created the patch was a road feature.
"No Roads" implies that the patch's altered edge was not a road feature

Examination of patch size distribution (see table *Patch Size Distribution and Core Forest Area*) indicates a large number of forest patch parcels less than 2.5 acres in size (>15,000 small tracts). As patch size decreases, fragmentation increases. However, greater than 50% (or nearly 254,293 acres of 464,206 acres) of total Highlands forest area is comprised of unbroken tracts of forest greater than 500 acres in size. The largest tracts of unfragmented forest (25 tracts of forest > 2,500 acres in size) are largely located in the northern portions of the Highlands (i.e., north of Interstate Route 80 and to a lesser extent along the ridges in the southern Highlands). These largest tracts comprise approximately 24% (112,801 acres) of total forest area and 43% percent (88,050 acres out of 205,785) of core forest area).

The 3-km roving window analysis produced a regional level analysis of forest cover across the Highlands. North of Route 80 has been identified as a large contiguous area of relatively intact forest (i.e. greater than 60% proportion of forest area) with a few isolated pockets of zero or minimal forest cover. In the southern Highlands, intact forest splits into a two-forked prong following the ridgelines of Scotts-Jenny Jump-Pohatcong-Allamuchy Mountains (northern prong) and Musconetcong-Schooleys Mountains (southern prong) with a few isolated tracts of relatively intact forest (e.g., Jockey Hollow).

FOREST INTEGRITY INDICATORS BY HUC 14



Patch Size Distribution and Core Forest Area

PATCH SIZE (ACRES)	TOTAL FOREST WITH ROADS	TOTAL FOREST NO ROADS	CORE ONLY WITH ROADS	CORE ONLY NO ROADS
0-2.5	15,461	4,025	3,442	3,444
2.5-5	1,701	1,186	340	330
5-10	1,198	736	283	260
10-25	1,029	546	338	307
25-50	525	240	216	181
50-100	383	161	127	112
100-250	383	116	151	104
250-500	188	32	69	54
500-1,000	121	31	43	28
1,000-2,500	41	27	26	15
2,500-5,000	17	11	8	3
5,000-10,000	8	5	5	4
10,0000-25,000	--	4	--	3
>25,000	--	4	--	1
Total # of patches	21,055	7,124	5,048	4,846
Mean Size	22.0 ac	65.4 ac	40.8 ac	44.4 ac

A majority (approximately 56%) of the Highlands study area was comprised of more than 50% proportion of total forest cover within a 3x3km neighborhood (see table *Acreage and Percent of Total and Core Forest Cover within 3-km Search Area*). However, only 15% of the Highlands study area was comprised of grid cells with more than 50% core forest cover within a 3x3km neighborhood.

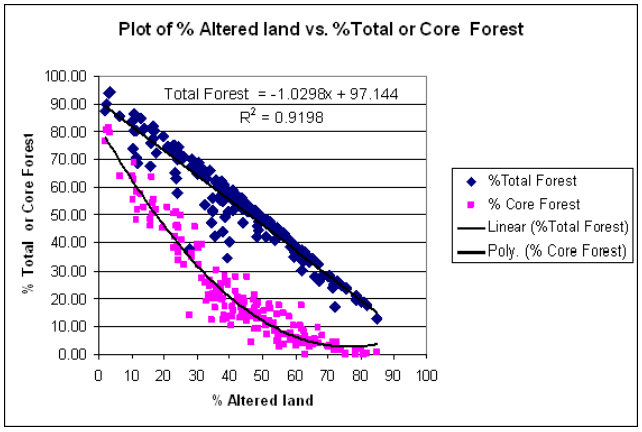
Acreage and Percent of Total and Core Forest Cover within 3-km Search Area

PROPORTION OF FOREST COVER (%)	TOTAL FOREST ACRES	% WITHIN 3KM WINDOW	CORE FOREST ACRES	% WITHIN 3KM WINDOW
0-9	5,787ac	0.7%	255,230 ac	33.5%
10-19	29,901 ac	3.5%	205,846 ac	24.0%
20-29	75,512 ac	8.8%	116,837 ac	13.6%
30-39	117,525 ac	13.7%	67,132 ac	7.8%
40-49	148,129 ac	17.2%	55,066 ac	6.4%
50-59	158,545 ac	18.4%	50,784 ac	5.9%
60-69	125,711 ac	14.6%	33,208 ac	3.9%
70-79	97,604 ac	11.4%	22,530 ac	2.6%
80-89	69,624 ac	8.1%	14,267 ac	1.7%
90-99	30,687 ac	3.6%	5,750 ac	0.7%

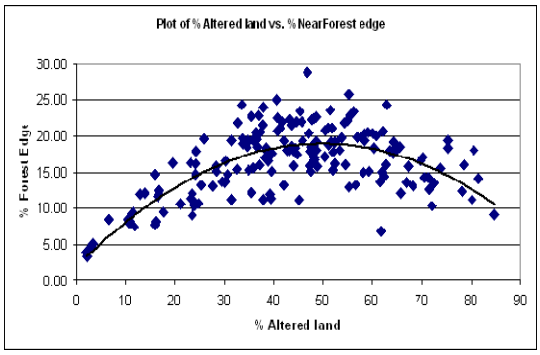
Amount or percent of core forest in a HUC14 basin provides a useful index of forest integrity. The chart below (see figure *Plot of % Altered Land vs. % Total Forest and % Core Forest on a HUC14 Basis*) illustrates that

percent total forest cover is strongly related to the amount of altered land (e.g., urban, barren/transitional, agriculture land uses) in a HUC14 basin. Those basins that diverge from the best-fit line, and have lower than expected percent total forest cover, are primarily basins with large water bodies (i.e., lakes or reservoirs). The relationship between percent altered land and percent core forest is not a simple linear relationship.

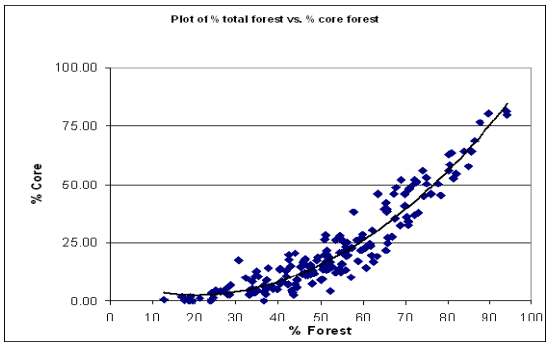
Plot of % Altered Land vs. % Total Forest and % Core Forest on a HUC14 Basis



As the percent of total forest in a HUC14 increases, the percent of core forest increases, but in a non-linear fashion (see figure *Plot of Total Forest vs. Core Forest*) with an inflection point near approximately 60% total forest. As the amount of altered land increases in a watershed, the amount of forest edge (% near edge) forest increases. The amount of forest edge (% near edge) starts to level off between 30% and 40% altered land, reaches a peak near 50% altered land, and then decreases (see figure *Plot of % Altered Land vs. % Near Edge*) as altered land dominates the basin. The results of the forest metric analysis also indicate that as percent core forest in a HUC14 increases, distance to forest edge increases. This type of relationship is similar to forest timber clear-cutting patterns (Franklin and Forman 1987).



Plot of % Altered Land vs. Near Edge
Note that % Near Edge forest increases as Altered Land increases and reaches a peak near 50% altered land and then decreases.



Plot of Total Forest vs. Core Forest
Note that as the % of total forest in a HUC14 increases, the % of core forest increases, but not in a perfectly linear fashion.

The Mean Distance to Closest Forest Patch (MDCP) provides a measure of how isolated forest patches are within the landscape area of interest. A negative relationship between percent core forest and MDCP occurs. Forest patches in HUC14s with high percent core forest are typically close to neighboring forest patches. In most New Jersey Highlands HUC14 basins, forest represents dominant land cover and the MDCP is relatively low. In portions of the southern or eastern Highlands HUC14 basins, where forest cover is not dominant, forest patches may be more isolated and MDCP is higher.

FOREST RESOURCE AREA

To identify important contiguous forest resources that should be maintained, the Highlands Council spatially delineated a Forest Resource Area (see figure *Forest Resource Area*) for incorporation into the Land Use Capability Map of the Regional Master Plan. The Forest Resource Area represents the application of landscape metrics on a forest patch basis to identify those forests that include criteria most suited to support ecological processes. The Forest Resource Protection Area includes high ecological integrity forest areas including those forested areas that express one or more of the following forest integrity indicators:

- a contiguous forest patch of equal to or greater than 500 acres in size;
- an area consisting of 250+ acres of Core forest; and
- areas that account for 45% or greater of proportion of total forest cover

The evaluation of forest ecological integrity, as a measure of fragmentation, provides guidance for where contiguous forests are located in the Highlands Region.

SUSTAINABLE FOREST MANAGEMENT PRACTICES

Sustainable forestry practices rely on strong land stewardship that integrates the management, regeneration, growing, and nurturing of forests, while harvesting trees for useful products, in a manner that both maintains or improves the biological, physical, and aesthetics values of forest and conserves soil, air, water quality, and wildlife and fish habitat.

Active forest management is important to address issues such as forest health, invasive species, fire risk, and wildlife habitat management. Invasive species and white-tailed deer are altering the forest ecosystem, and management of these threats is critical to protect threatened and endangered wildlife, water quality, and overall forest ecosystem health. Fire control and other management practices have in places resulted in forests with insufficient variation in forest community succession and tree age, posing the potential for catastrophic canopy loss through disease, fire and other factors.

Silviculture is an applied science which deals with the growth and development of trees and other forest biota as well as of the whole forest ecosystem. Silviculture is designed to create and maintain the types of forest that will best fulfill a particular management objective.

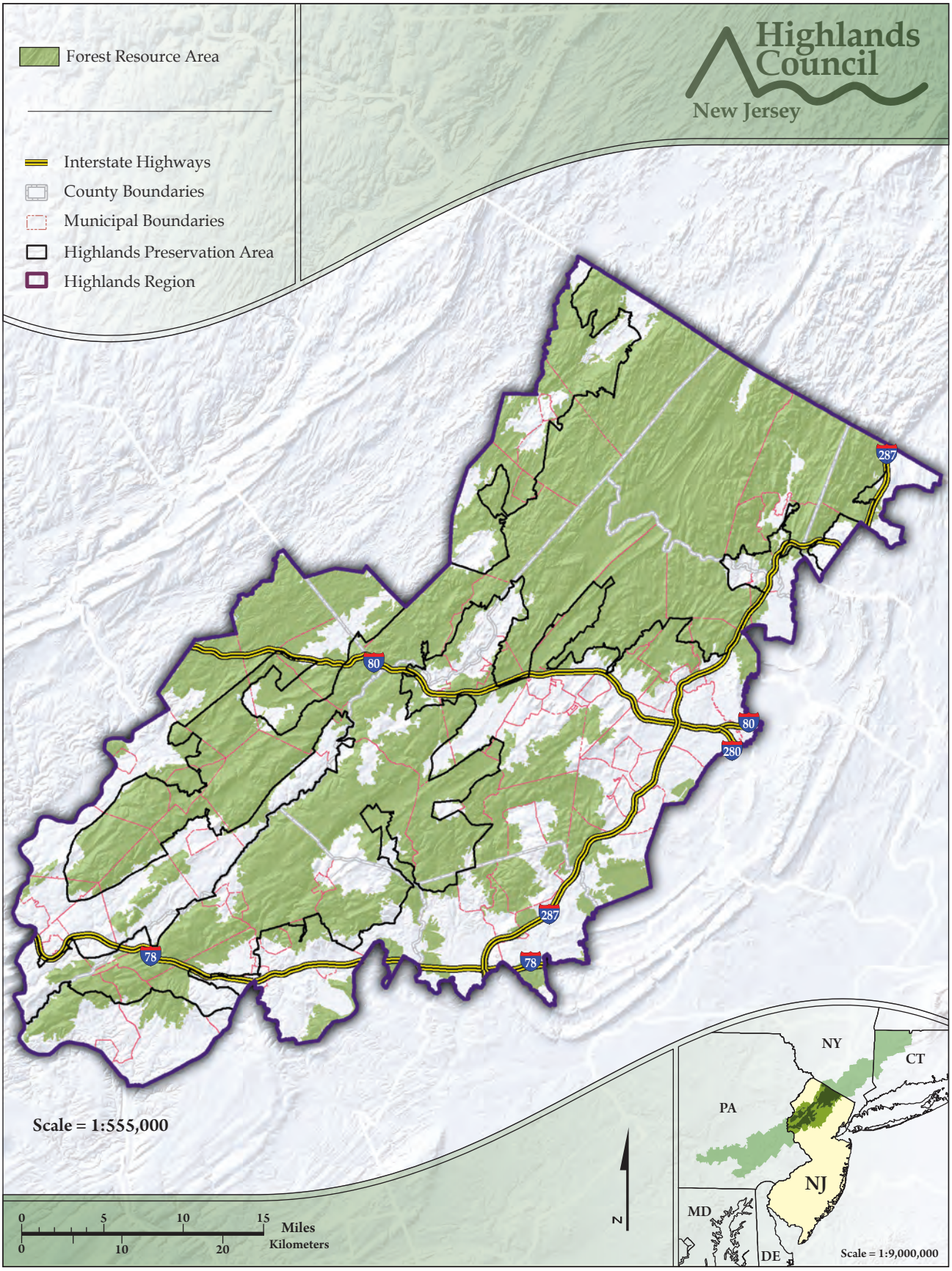
Existing Forestry Practices

A majority of all forestry operations occur on private land within the Highlands. Limited management occurs on land owned by the federal government, the State and non-profit land trusts. (Personal communication with NJFS June 2006). The majority of forest management occurring on private land is linked to qualifying for property tax reduction under the Farmland Assessment Act.

Under current practices, harvesting of timber is typically done under an approved forest management plan. However, under the Farmland Assessment rules, farmers with less than half of their land in forest cover are not required to complete a forest management plan.

Currently there are no criteria in place for management of non-timber forest products. Non-timber forest products can include medicinal and herbal products, decorative products, specialty wood products, aromatics, and edible products. Examples include ginseng goldenseal, wreaths, floral arrangements, baskets or bowls, black walnuts, berries and wild fruit, mushrooms, maple syrup, beeswax, or tree and shrub seeds. Much like

FOREST RESOURCE AREA



timber products, a major concern with non-timber products is over–harvesting or other unsustainable management practices.

In the Highlands Region, most private land under active forest management is conducted under the requirements of the Farmland Assessment Act of 1964, which is based upon commodity production and income. Under current Farmland Assessment rules, ancillary benefits, such as water quality protection, recreation and wildlife management, are not recognized as providing a financial benefit to the landowner, but several landowners do include these benefits as objectives within their management plans.

For small woodland owners, it may be difficult to sustainably manage woodlots due to the yearly income requirement while managing the land strictly for traditional forest products such as timber or firewood. Under the Farmland Assessment, gross sales of products from the land must average at least $500 per year for the first five acres plus, and average of $0.50 per acre for any acreage over five.

Although a landowner qualifying for farmland assessment requires a woodland management plan, requirements are different for appurtenant woodland. Appurtenant woodland acreage is part of a crop or livestock farm which may or may not contribute income to the farm. These forests do not require an approved forest management plan.

Under the Farmland Assessment Act, if required, a Woodland Management Plan must be completed by a Forester approved by the New Jersey Forest Service pursuant to N.J.A.C. 7:3-2. Plans are typically written to cover a 10-year planning period with specific yearly activities laid out to meet the landowners' objectives and the requirements of the Farmland Assessment Regulations.

Forest management activities conducted on private land under an approved management plan are not subject to State inspection to verify that the work was completed in accordance with the approved plan. Currently, few data are collected, recorded, and maintained for the Farmland Assessment program. Under the current reporting methods, information on the location of forested lands being managed under an approved plan, and the volumes of materials removed from a given property or from the region, is limited, though private foresters under contract to the woodland owners may have records of activities.

Forest management activities on appurtenant woodlands are not subject to review or oversight by the New Jersey Forest Service. In the Highlands Region, there are approximately 33,000 acres of appurtenant woodland located primarily in Hunterdon and Warren County.

In 2002, only about 5,600 acres were managed through a Forest Stewardship Plan (of landowners that wanted to qualify for Farmland Assessment). This represents less than one percent of New Jerseys Highlands Region forests. A Forest Stewardship Plan, through New Jersey's Forest Stewardship Program, includes all of the planning criteria included in a Forest Management Plan but also includes a discussion of stewardship goals pertaining to soil, water, wildlife and fish habitats, riparian areas and wetlands, recreation, aesthetics, timber resources, and potential alternate forest products.

Sustainable Forest Management Practices Data and Policy Gaps

The following policy and practice gaps need to be addressed to have a better understanding of current forest management practices in the Highlands Region and assist in promoting sustainable forestry practices in the future. The location of lands being managed under Forest Management and Stewardship Plans needs to be tracked. This can be important to maintain the existence of the wood products industry in the Highlands Region. Location of these properties can help to guide forest management strategies in the Region and promote sustainable forest management practices under the Farmland Assessment Act. These strategies include highlighting areas where active management is not occurring, providing valuable data on fragmentation, parcelization and land ownership trends over time, and analyzing forest ecosystem health and vitality, biodiversity, and contributions to carbon sequestration. Once properties with approved management plans are located, it would be possible to better monitor forest harvesting practices and view them on a regional or landscape basis.

Water and other ecological resources are arguably the most important and valuable forest product produced in the Highlands Region. Raw water has a real value to society for human use and consumption and ecological services. Persons who own "vacant land" are producing water for the benefit of society.

State law would require amendment to allow landowners to receive benefits for ancillary values based on water and ecological resource benefits derived from an approved forest management plan. These values can only be claimed if the forest management activities are being completed according to the recommendations and schedule laid out in the approved forest management plan. The ability to submit resource protection benefits in meeting income requirements can help promote sustainable forestry for small landowners who are over-cutting in order to meet financial requirements (burdens) placed on them by the law. In a similar manner, landowners of appurtenant woodlands could receive such benefits by preparing and implementing a forest management plan for such properties to facilitate better management, sustainable resource extraction, improved ecologic integrity, and improved water quality.

In addition to resource protection benefits, forest landowners who hunt on their land or lease the land to hunters could be eligible to receive benefits under State law. The sale of hunting leases could also be credited towards benefit requirements for the landowner as it is an income derived from the management of the land and its resources. Doing so would help address the excessive deer populations that are harming forest health and regeneration. Income credit could also be provided for invasive species control based on a per acre credit. Landowners could be credited for invasive species removal conducted under the guidance of a forest management and stewardship plan and discussed in stand descriptions and laid out in the yearly management recommendations.

In order to determine whether Highlands Region forests are being managed in a sustainable fashion, removal of forest products needs to be recorded and compiled so it can be accurately compared to analysis of growth rates within the Region using US Forest Service Forest Inventory and Analysis data.

Completion of a Forest Stewardship Plan should be encouraged, but not required, for approval of a Forest Management Plan. Currently, preparation of a forest stewardship plan can be funded by the New Jersey Forest Service through the Forest Stewardship Program if the property is within the Highlands Area. Under the Forest Land Enhancement Program, forest management activities in an approved plan are eligible for cost-share funds to implement recommendations made in the plan. As part of a stewardship plan, foresters can field-verify the location of streams, including intermittent streams and associated riparian areas, wetlands including vernal pools, seeps, and springs on lands that they manage. Conducting these activities along with implementing best management practices will protect soils from erosion and loss of productivity and will protect water quality.

Low impact logging practices should be incorporated into approved forest management plans, where not already in use. Low impact logging practices may include some of the following:

- Establish designated and protected refueling areas to avoid potential for incidental spills.
- Outfit heavy equipment with spill kits which may include sorbent pads or other material.
- Attempt to avoid harvest during the time of year that forests serve as critical habitat for wildlife species, such as neotropical bird breeding season or reptile and amphibian breeding season. Ideally, harvest during times when the ground is frozen.
- Harvesting should be discouraged during the spring thaw when the ground and soils are saturated. Heavy equipment use at this time will compact soils and injure roots.
- Access logging roads should be minimized, properly located to avoid sensitive resource areas, and identified in a forest management plan. Restoration and maintenance of access roads should be a required element of a stewardship plan.
- Avoid road building practices that block or reroute natural drainage.
- Reduce travel using heavy equipment over forest soils particularly during the thinning process.
- Encourage the use of draft horses for salvage operations where possible and practical.

Additional steps could be taken to improve the sustainability of both forests and forestry, including:

- Promoting through forest management plans the formation of a cooperative that will allow small landowners to pool resources and coordinate harvesting activities in order to improve efficiency and forest industry viability in New Jersey.
- Completing timber harvesting under the supervision of an approved Forester under the auspices of an approved forest management plan by an approved logger. Forest management plans could further benefit forests by including recommendations for dealing with regeneration failure, deer management, and control of invasive plant species.
- Inspect forest harvesting sites both prior to, and post harvest to ensure that best management practices are sufficient for water quality protection.
- Provide a cutting plan and notification letter to the New Jersey Forest Service prior to commencement of the harvesting operation within the Region, and also upon completion of the harvesting operation, which denotes the amount of material removed in thousand board feet. These data would, over time, demonstrate that forest products removed from the Highlands Region are removed on a sustainable basis and may lay the groundwork for third-party certification of forest products from the Region.
- Include information on material removed by landowners or, sales that were not conducted under the supervision of an approved Forester, in the biennial accomplishment report required from Approved Foresters. This report is required as part of remaining on the State's Approved Forester list. Also specify the property that was harvested so it could be determined whether it was harvested from within the Highlands Region or from areas outside of the Highlands Region.
- Visit any timber sale upon completion to evaluate the effectiveness of best management practices. Further, advanced forest regeneration should be a primary concern following such a harvest. When a timber sale is completed, whether under the supervision of an Approved Forester or not, conduct a follow up site visit in order to ensure that best management practice protocols are being followed and implemented. At the time of the inspection, the amount of timber can be recorded into a database to confirm sustainability. Valuable information can be collected concerning conservation of soil and water resources, forest successional stages, associated wildlife, invasive species, and effectiveness of best management practices.

Benefits of Urban and Community Forestry Planning

A community forest is the sum of all woody and associated vegetation in and around human development. This would include trees found on streets, parks, municipally-owned land, utility right of ways, and transportation corridors. Community forests are important to the character of Highland's communities.

Many municipalities have tree protection ordinances. In some cases municipal ordinances may hinder active forest management and implementation of an approved forest management plan. However, most of these ordinances exempt forest management activities conducted under an approved forest management plan or under the Farmland Assessment Regulations.

The New Jersey Shade Tree and Community Forestry Assistance Act allows New Jersey communities to obtain liability protection under the New Jersey Tort Claims Act for shade tree programs. However, in order to qualify for this protection, shade tree commissioners or other community representatives must develop a community forestry plan for their community, as well as attend the state's training skills and accreditation program. These plans serve as a blueprint for a community to actively and efficiently manage forest resources for numerous ecologic and social benefits.

The New Jersey Forest Service provided the Highlands Council a Community Forestry Planning Status list for the 88 municipalities in the Highlands Region as of August 2006. As of August 2006, 17 had approved Community Forestry Plans and 10 were in the process of developing a plan. The table *Community Forestry*

Planning Status in the Highlands Region provides a list of communities within the Highlands Region that have adopted, or have obtained a state grant, and are in the process of working toward adopting, a Community Forestry Plan.

Improved community forest planning in the Highlands can provide long term benefits to water quality, air quality, and livable communities.

Community Forestry Planning Status in the Highlands Region

MUNICIPALITY	Plan Completed	Plan Approved	In Progress
BEDMINSTER TOWNSHIP			✓
BELVIDERE TOWN	October-99	✓	
BERNARDS TOWNSHIP	January-03	✓	
BERNARDSVILLE BOROUGH	August-01	✓	
BLOOMSBURY BOROUGH			✓
CHESTER BOROUGH	March-03	✓	
DOVER TOWN	December-04	✓	
FRANKLIN BOROUGH	July-01	✓	
HARDING TOWNSHIP			✓
HIGH BRIDGE BOROUGH			✓
LEBANON BOROUGH	February-05	✓	
LEBANON TOWNSHIP			✓
LOPATCONG TOWNSHIP	November-01	✓	
MENDHAM BOROUGH	June-02	✓	
MONTVILLE TOWNSHIP	December-03		✓
MORRIS TOWNSHIP	July-99	✓	
MOUNT OLIVE TOWNSHIP	August-99		
MOUNTAIN LAKES BOROUGH	November-00	✓	
PEAPACK GLADSTONE BOROUGH	November-01	✓	
PEQUANNOCK TOWNSHIP	April-04	✓	
PHILLIPSBURG TOWN	June-05		✓
ROCKAWAY TOWNSHIP			✓
ROXBURY TOWNSHIP			✓
STANHOPE BOROUGH	March-06	✓	
TEWKSBURY TOWNSHIP	October-03	✓	
WANAQUE BOROUGH			✓
WHARTON BOROUGH	April-04	✓	
WHITE TOWNSHIP	August-05	✓	

Supplied by NJFS Community Forestry Program August 2006

Community Forestry Plans can be easily implemented through coordination with the New Jersey Forest Service. The New Jersey Forest Service Community Forestry Program maintains a list of foresters who have completed a course required for eligibility. The program also provides Green Community grants for up to $3,000, which provides funding for the completion of a Community Forestry Plan. The plan is typically written by a Consultant Forester who is hired by the Municipality and works with a Shade Tree or Environmental Commission.

Community Forestry plans set the groundwork for a successful Community Forestry Program by setting out yearly goals for the program, typically in five-year cycles, which include educational, planting, and planning components as well as an Arbor Day celebration. It may recommend tree protection ordinances, hazard tree planning, a community forest inventory, reforestation and restoration efforts, implementation of a pruning

program, and education.

Education should be a key to the Highlands Forest Management Initiative to provide residents, visitors, and elected officials with an understanding of the importance of this valuable resource, the benefits provided by forests, and the need for proactive management. Educational topics may include managing for invasive plants, insects, and diseases and there control methods, the ecological benefits of natural resource management, benefits of forest cover to the Highlands Region, low impact and best management practices, developing an effective forest protection program, etc.

Municipal forest management ordinances can include provisions for roll back of Farmland Assessment when land is converted from forest to another land use. If Forest Stewardship or Forest Land Enhancement Program funds were used to pay for the plan or activities on the land, these funds should be recovered.

Small niche industries that utilize wood products being harvested from local sources should be encouraged. A niche market may allow owners of small and portable sawmills the ability to fill a service area gap as a result of the loss of established wood processing facilities. Small portable sawmills may allow for small scale forest harvesting operations to be more practical for small landowners.

Funding Assistance

In New Jersey, the management and stewardship of privately owned forests is encouraged through a number of New Jersey Forest Service Programs. These programs have been instituted to provide technical and cost share assistance. These programs and others that are administered by federal agencies to encourage forest stewardship and management, can be encouraged and leveraged using Highlands Region municipal grant funds. These and other funding initiatives for land stewardship programs are discussed in the Technical Report entitled *Land Preservation and Stewardship*.

CRITICAL HABITAT AREAS

Biodiversity is the variety of species, both plant and animal, that is important to maintaining the ecological viability of natural systems. The protection of critical habitat areas contributes to the protection of the Region's biodiversity. This section provides baseline information regarding these environmentally sensitive areas. Its intent is to lay the groundwork for future management and long-term sustainability of those habitat areas that are critical for the survival of rare, threatened or endangered plant and wildlife species and significant natural areas of the Highlands Region.

For the purpose of this Technical Report, there are three types of critical habitat areas incorporated into the Regional Master Plan, including:

- **Critical Wildlife Habitat** - habitats of animal species identified as endangered, threatened, of special concern, or of regional conservation priority in the Highlands Region.
- **Significant Natural Areas** - regionally significant ecological communities.
- **Vernal pools** – confined, ephemeral wet depressions that support distinctive, and often endangered, species that are specially adapted to periodic extremes in water pool levels.

NJDEP LANDSCAPE PROJECT

The Regional Master Plan utilized an updated version of the NJDEP-Endangered and Nongame Species Program (ENSP) Landscape Project (Version 3) data set to identify critical wildlife habitat in the Highlands Region. This data set was chosen for use because it represents a landscape level approach to identify habitat that is important to endangered and threatened species, as well as species of special concern within the Region. It identifies the locations and types of habitat that are critically important to maintaining biological diversity in the Highlands Region.

In previous versions of the Landscape Project the main source of species data was from the Natural Heritage Program's (NHP's) Biological Conservation Database (BCD). ENSP staff reviewed all animal records for

acceptability/reliability and subsequently accepted or rejected records for inclusion in the BCD, but maintenance of the database was the responsibility of the NHP staff. Species occurrences were exported from the BCD database to ArcView shapefile format for use in the Landscape Project. Buffers were applied to each species occurrence based on either:

1. The animal species' spatial requirements for obtaining food for themselves and/or their offspring and average home range size as reported in peer-reviewed literature, or;
2. In cases where that information was not available, a default buffer size (~70 meter radius) was applied to take into account locational uncertainty.

The occurrences, with their associated buffers, were used to value patches of habitat. Species occurrences in the BCD were derived from a variety of sources including ENSP surveys, NJDEP staff reports, private consultant reports and those reports from the general public that were reviewed and accepted by ENSP biologists.

In 2005, species distribution data was upgraded from the BCD to an Oracle-based database called Biotics. Biotics is the new standardized data management system used for tracking rare species occurrences. While making the conversion to Biotics, ENSP reviewed all rare animal occurrences and supplied new standards for how occurrences would be reviewed and used for the Landscape Project.

In previous versions of the Landscape Project, ENSP used all occurrences dated 1970 or later for which there existed precise location information (70 meters). The 1970 cut-off date and high precision requirements are still being used, but all records were reviewed to verify that suitable habitat remains in the immediate vicinity of the occurrence. If suitable habitat no longer exists in the vicinity of the occurrence, the occurrence was not used to value patches in the Landscape Project. All occurrences received a 'feature label' as well as a 'location use class.' Both of these were used to record more information about the occurrence. A 'feature label' described the type of occurrence, i.e. nest, den, etc., while a 'location use class' was specified for migratory species and indicated the season or behavior that was associated with the occurrence.

The ENSP defined a buffer for every feature label/species combination used to value habitat patches in the Landscape Project. The buffers represented the species' approximate spatial requirements for obtaining food for themselves and/or their offspring, and were typically based on the average home range size, as reported in peer-reviewed literature.

ENSP utilized the NJDEP 2002 aerial photo-based Land/Use Land Cover (LU/LC) data layer to delineate potential rare species habitat within the Highlands Region. The 2002 imagery includes 69 unique LU/LC classes within the Highlands Region described in Anderson et al. (1976). The LU/LC classifications provide flexibility and potential for an accurate representation of potential rare species habitat based on individual species habitat associations. New Jersey DOT Major Roadway (2004) centerlines (county level 500 and above) were used to create a polygon file to bisect LU/LC classifications and serve as a boundary between contiguous areas of habitat.

The 2002 Landscape Project was also updated to include species of special concern within the Highlands Region. A Highlands Conservation Rank index was developed for those species whose survival in New Jersey is highly dependent upon Highlands Region habitats.

The Landscape Project ranks habitat according to the status and distribution of species of concern. Landscape Ranks include the following:

- **Federally Listed (5)** – a species listed by USFWS as threatened or endangered.
- **State Endangered (4)** - a species listed on the official endangered wildlife list that the NJDEP promulgates pursuant to the Endangered and Nongame Species of Wildlife Conservation Act of 1973 (ENSCA).
- **State Threatened (3)** - a species designated as "threatened" on the list of nongame wildlife species that the NJDEP promulgates pursuant to ENSCA.
- **Special Concern (S3) (2)** – nongame wildlife that are considered by the NJDEP to be species of special concern as determined by a panel of experts or S3 according to NatureServe methodology.

- **Suitable (1)** – meets minimum habitat suitability requirements.

A Highlands Conservation Rank index was also assigned to each species occurrence based upon how critical the Highlands Region is to the continued existence of the species within the state. Following are the Highlands Conservation Ranks that were used:

- **Critically Significant** – if habitats in the Highlands Region were lost, that species would not exist in the state.
- **Significant** – Highlands Region habitats play a significant role for that species' existence in the state.
- **Low Significance** – Highland Region habitats do not play an important role for that species' existence in the state.

A list of Rare, Threatened and Endangered animal species that occur within the Highlands Region including their associated Landscape and Highlands Conservation Ranks are provided in Appendix D.

CRITICAL WILDLIFE HABITAT

The Highlands Council delineated critical wildlife habitat by utilizing Landscape Project Version 3 (see figure *Critical Wildlife Habitat*). The table *Critical Wildlife Habitat in the Highlands Region* provides a breakdown of the acreage of rare, threatened, and endangered species habitat (Landscape Rank 2 through 5 in the Preservation Area; Landscape Rank 3 through 5, and Rank 2 with a Highlands Conservation Rank of 2 or 3 in the Planning Area) in the Region Of the Highlands Region's approximately 860,000 acres, the Highlands Council identified approximately 522,067 acres or 61% of the Region as potential habitat for rare, threatened, or endangered species. With respect to Highlands Rank, there are approximately 492,000 acres of habitat in the Region (approximately 57%) that are considered Critically Significant or Significant to the continued existence of specific species in the State.

Critical Wildlife Habitat in the Highlands Region

Region	Critical Wildlife Habitat Acres
Highlands Planning Area	201,550
Highlands Preservation Area	320,517

SIGNIFICANT NATURAL AREAS

The Highlands Council worked in cooperation with the NHP to identify Natural Heritage Priority sites that are appropriate for inclusion as Significant Natural Areas within the Regional Master Plan. Natural Heritage Priority sites include areas that are regionally significant due either to the presence of rare or endangered plant species (see Appendix E), or unusual or exemplary natural ecological communities within the Highlands Region.

The NHP Priority Sites were delineated based on field surveys and the expertise of staff of the NHP. Priority Sites were defined as the full extent of habitat occupied by a precisely documented occurrence of a rare plant species or ecological community. In many cases sites also included adjoining (buffer) lands which were needed to ensure protection of the occurrence(s).

Buffer lands consisted of those lands needed to protect the element's habitat and the ecosystem processes that sustain it. The buffer for an occurrence may, by necessity, be small because little of the habitat required to sustain it remains. Many factors, such as habitat elimination or alteration, hydrological changes, browsing by deer or other herbivores, competition from invasive species, habitat succession, collection, etc. can extirpate or threaten the survival of these occurrences. Some of these factors can be eliminated or mitigated through proper land management.

The Highlands Council reviewed Priority Site boundaries using 2002 color orthophotography and the 2002 Land Use/Land Cover data to identify land use and land cover within and adjacent to NHP delineated Priority

Sites. Where land use or land cover indicated a habitat disturbance or feature constraint, boundary lines were revised. Final revised boundaries of Priority Sites were identified as Highlands Significant Natural Areas (see figure *Significant Natural Areas*). A total of 95 Significant Natural Areas were designated accounting for a total of 33,963 acres in the Highlands Region. A list of Significant Natural Areas in the Highlands is provided in Appendix F.

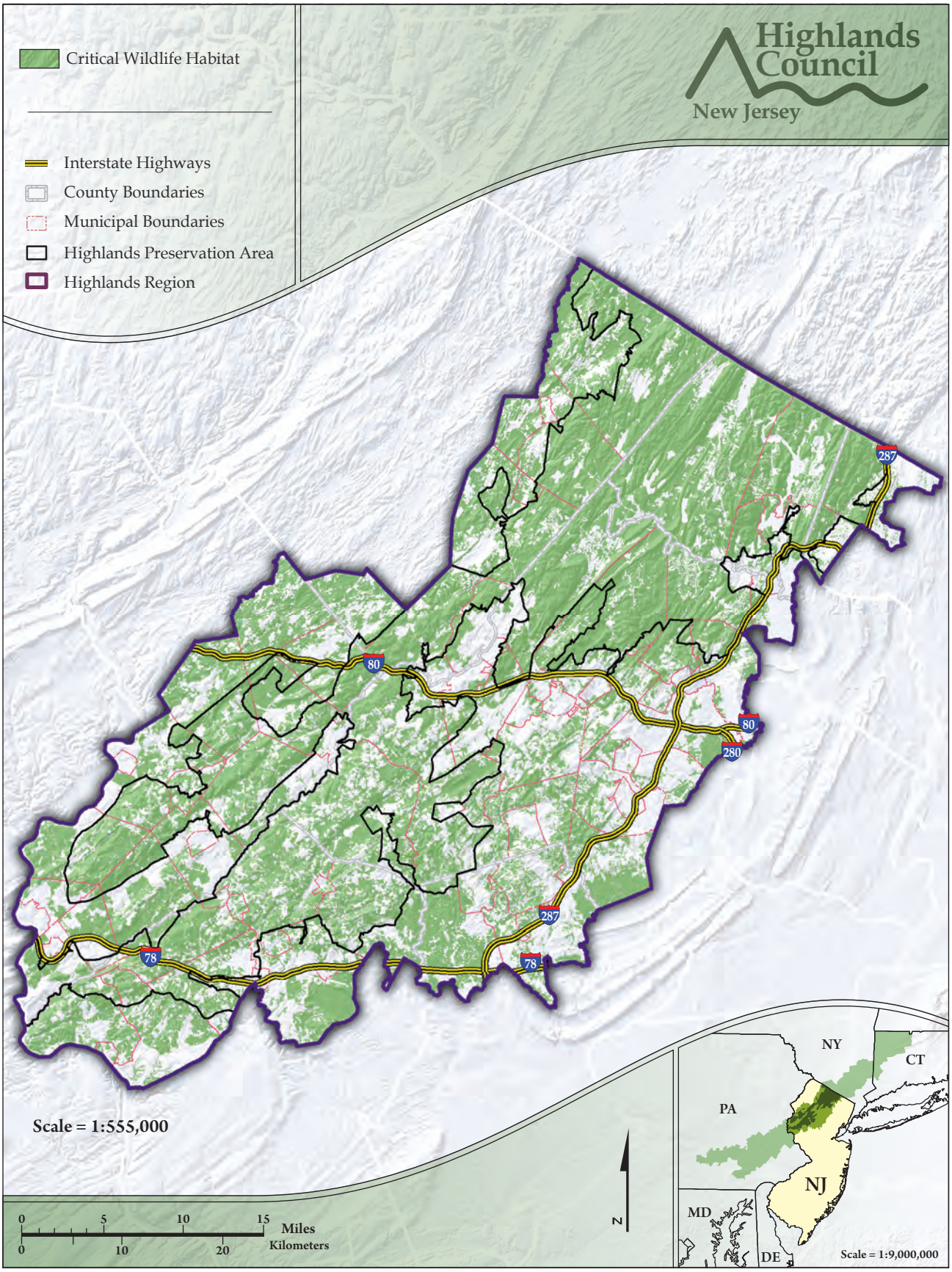
Significant Natural Areas include the Priority Site ranking information. Priority Sites were ranked according to their significance for biological diversity on both a global and state level. The ranks are based on the quality of the individual element occurrence(s) at the site, as well as the rarity of the species or community on a global and statewide level.

The Nature Conservancy and NatureServe have developed a ranking system for use in identifying elements of natural diversity (rare species and ecological communities) most endangered with extinction. Each element is ranked according to its global, national, and state rarity. These global ranks (GRANKS) and state ranks (SRANKS) are used to prioritize conservation work so that the most endangered elements receive attention first. Definitions for element ranks are after The Nature Conservancy (1982).

Global and state element ranks are then considered along with additional information about the quality of the species and ecological community occurrences at each Priority Site to develop a global biodiversity rank for each Highlands Significant Natural Area. The global biodiversity rank is then combined with a state biodiversity rank for each Highlands Significant Natural Area site in order to provide information about the significance of the site on a state and regional level. Global and state biodiversity significance ranks range from B1 to B5 and V1 to V5, respectively.

These ranks are based on the quality of the element occurrence(s) at the site, as well as the rarity of the species or ecological community on a global and statewide level. Similar to the element rank, the global and state biodiversity ranks are used to establish conservation priorities. Complete definitions of global and state biodiversity ranks can be found in Appendix F.

CRITICAL WILDLIFE HABITAT



VERNAL POOLS

Vernal pools are unique ecosystems that:

- Provide critical breeding habitat for a variety of amphibian and invertebrate species;
- Contribute significantly to local biodiversity by supporting plants, animals, and invertebrates that would otherwise not occur in the landscape; and
- Contribute significant amounts of food to adjacent habitats.

Protecting vernal pools and adjacent habitat are important for maintaining ecological integrity and providing amphibian and invertebrate breeding habitat (Semlitsch 1998, Gibbons 2003). For pool-breeding amphibian species, studies indicate amphibian species travel distances ranging from 400 to 4,000 feet from vernal pools to surrounding terrestrial habitat (Faccio 2003; Petranka 1998; Calhoun and deMaynadier, 2004).

NJDEP currently regulates vernal habitat through the Freshwater Wetlands Act Rules at N.J.A.C. 7:7. The NJDEP Land Use Regulation Program utilizes a protocol to determine whether an area potentially identified as a vernal habitat meets the regulatory definition of vernal habitat. If the application of this protocol results in a confirmation that an area meets the definition, the area is place on the list of certified vernal habitats maintained by the NJDEP. The definition of a certified (i.e., confirmed) vernal habitat includes four criteria that must be satisfied:

- Occurs in a confined basin depression without a permanently flowing outlet.
- Provides documented habitat for obligate or facultative vernal habitat species.
- Maintains ponded water for at least two continuous months between March and September of a normal rainfall year.
- Is free of fish populations throughout the year, or dries up at some time during a normal rainfall year.

Unless threatened/endangered (T&E) species habitat is present within the vernal habitat, the Freshwater Wetlands Act Rules classify vernal habitat as intermediate value wetlands. The Freshwater Wetlands Act Rules prescribe a 50-foot transition area adjacent to intermediate value wetlands unless T&E species are identified, at which point the Rules provide for a 150-foot transition area. These protective areas do not provide adequate habitat protection for species dependent upon ephemeral vernal pools.

Lands adjoining Vernal Pools are also important to protect the ecological integrity of these sites and provide for the life requisites of amphibians during the breeding and non-breeding season. Because of their complicated lifecycle, many amphibian species require open access to both terrestrial and aquatic environments. Adequate terrestrial habitat around vernal ponds and spring seeps is required for adult salamanders (Semlitsch 1998, Gibbons 2003). For certain species of salamanders, it has been recommended that a protected area or buffer zone extend to greater than 500 feet from vernal ponds (Faccio 2003). Because some salamanders (such as the Jefferson salamander, which is known to occur in the Highlands Region and is a State Species of Concern) appear to move farther from ponds, occasionally in excess of 1,900 feet (Petranka 1998), an even larger protected area or buffer zone around vernal pools would be necessary to protect these species. The Highlands Regional Master Plan utilizes a buffer of 1,000 feet adjacent to a vernal pool.

Semlitsch (1998) summarized the use of terrestrial habitat by pond-breeding salamanders and evaluated whether current laws (as of publication date) adequately protect salamander populations. The author summarized average migration distances for adults of six species (411 feet), and juveniles of two of these species (228 feet) of pond-breeding salamanders respectively. An average migration distance represents a distance encompassing only 50% of the studied populations. A terrestrial buffer encompassing the majority (i.e., upper 95% confidence limits) of the populations would have to encompass the terrestrial habitat 534 feet from a wetland's edge. Semlitsch noted that literature results state that adult and juvenile salamanders were found up to 2,051 feet and 810 feet from the edge of wetlands, respectively. The author stated that all studied salamander migration occurred well beyond federal wetland protection boundaries and that 76% of studied

salamanders were found beyond the extended terrestrial buffers provided through Massachusetts and Florida state regulations.

It should be noted that the studied populations occurred well beyond the vernal pool transition areas provided by New Jersey's Freshwater Wetlands Act Rules. Results from Semlitsch (1998) indicate that New Jersey's transition areas are inadequate to protect the salamander species potentially utilizing these habitats. The author recommends that the 534 foot buffer encompassing 95% of the studied populations is scientifically defendable and is an appropriate general starting point for initiating legislative change regarding wetland buffers for pond-breeding amphibians.

Rittenhouse and Semlitsch (2007) applied a univariate kernel density estimation to a series of data sets about amphibian migration to reflect an aggregate distribution from wetland breeding habitat to non-breeding upland habitat for all amphibians. Results from the study found that 95% of amphibians occur within 2,179 feet from the wetland edge, and 50% of amphibians occur within 305 feet. Species data included: California tiger salamander, spotted salamander, mole salamander, tiger salamander, great crested newts, Western toad, Japanese common toad, spotted frog, wood frog, and dusky gopher frog.

Semlitsch and Bodie (2003) reviewed literature related to amphibian and reptile terrestrial habitat requirements around wetlands. They distinguish between core habitat and wetland/riparian buffer zones for amphibians and reptiles. Core habitat is defined as the amount of terrestrial habitat used by a population during migrations to and from wetlands and for foraging. Wetland/riparian buffer zones are typically applied to promote water quality protection, and are often significantly smaller in size than core habitat required by local amphibian and reptile populations.

Using extensive, species-specific data for migration distances from wetlands, the authors compiled a table of mean minimum and maximum core terrestrial habitat for each taxa (see table *Core Terrestrial Habitat for Amphibians and Reptiles*).

Core Terrestrial Habitat for Amphibians and Reptiles*

Group	Mean minimum (ft)*	Mean maximum (ft)*
Frogs	673	1207
Salamanders	384	715
Amphibians	522	951
Snakes	551	997
Turtles	404	941
Reptiles	417	948
Herptofauna	466	948

*Table reproduced from Semlitsch and Bodie (2003)

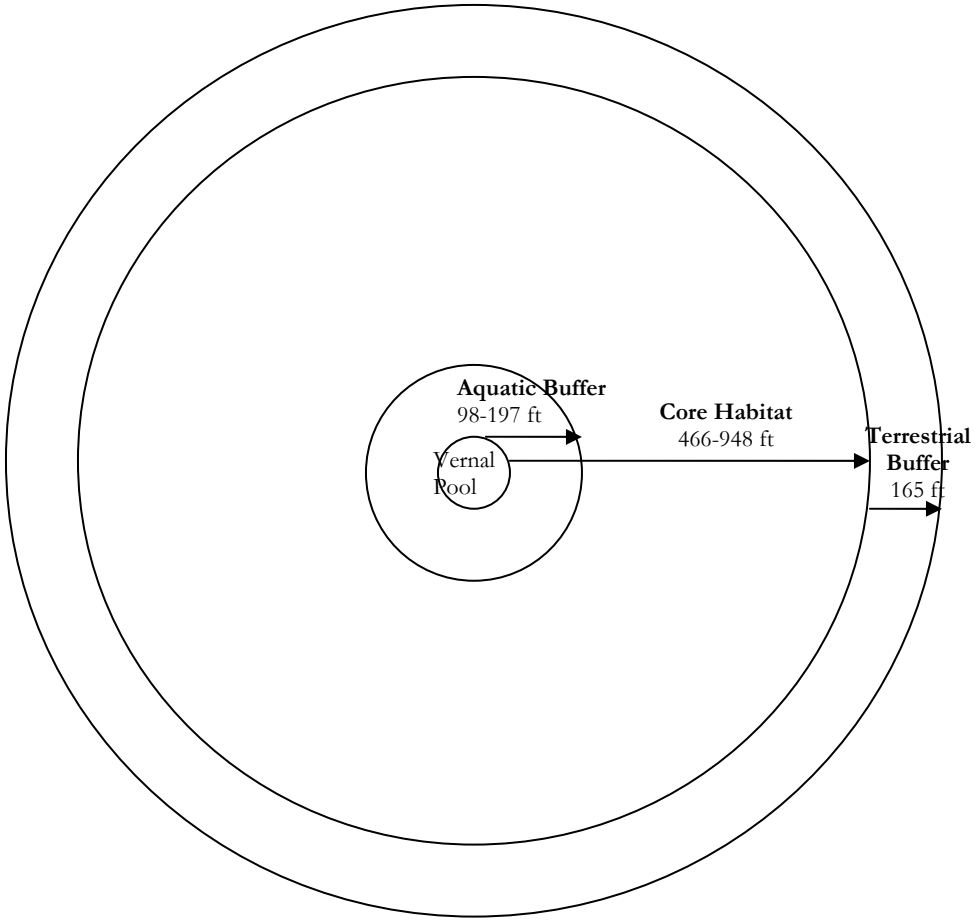
**Values represent mean linear radii extending outward from the edge of aquatic habitats from summary data.

The data suggest that an appropriate core habitat value could be derived from the maximum value generated by the local taxon with the largest core habitat requirements. It is assumed that utilizing the largest habitat area would encompass all other taxa core habitat requirements. The authors suggest that the maximum value is appropriate for application to public lands, where conserving biodiversity is often a high priority. They state that, on private lands, where sustainable land use is the priority, a tiered protection zone system could minimize impacts to wildlife and support private land uses. The authors propose a tiered system of three terrestrial zones adjacent to core aquatic and wetland habitat (see figure *Proposed Zones of Protection of a Vernal Pond*).

1. **Aquatic Buffer** - a first terrestrial zone immediately adjacent to the aquatic habitat which is restricted from use and designed to buffer the aquatic habitat and protect water resources.
2. **Core Habitat** - a second terrestrial zone that starts at the aquatic habitat edge, overlaps the first terrestrial zone, and extends to encompass the core terrestrial habitat defined by the local taxon.

3. **Terrestrial Buffer** - a third terrestrial zone that extends from the edge of the second terrestrial zone outward to serve as a buffer to protect the core terrestrial habitat from edge effects of surrounding land use.

Proposed Zones of Protection of a Vernal Pool (reproduced from Semlitsch and Bodie [2003])



The Highlands Council performed a literature review of migration distances from vernal pools to upland habitat for the species listed by NJDEP as obligate (i.e., dependent upon for survival) and facultative (utilizes for habitat requirements) vernal pool-breeding species in the state. Results from the literature review are included in the table *New Jersey's Vernal Pool-breeding Amphibians.*

New Jersey's Vernal Pool-breeding Amphibians

Species	Vernal Class	State Status	Migration Distance (in feet)**	Literature**
Marbled salamander	Obligate	Special Concern	637 (mean) 0-1,476 (range); 98	Williams (1973) in Semlitsch and Bodie (2003); Douglas and Monroe (1981) in Semlitsch (1998)
Eastern tiger salamander	Obligate	Endangered	197 (mean) 0-938 (range); 532;	Maddison and Farrand (1998) in Semlitsch and Bodie (2003); Semlitsch (1983) in Semlitsch (1998)
Spotted salamander	Obligate		387 (mean) 49-689 (range); 656; 220; 339; 211; 492; 630	Madison (1997) in Semlitsch and Bodie (2003); Windmiller, B.S. (1996); In Semlitsch (1998): Wacasey (1961); Wacasey (1961); Williams (1973); Douglas and Monroe (1981); Kleeberger & Werner (1983)
Jefferson salamander	Obligate	Special Concern	827 (mean) 65-2,051 (range); 820; 303	Williams (1973) in Semlitsch and Bodie (2003); Douglass & Monroe (1981) in Semlitsch (1998); Wacasey (1961) in Semlitsch (1998)
Blue-spotted salamander	Obligate	Endangered	570 (mean); 656 (max); >820; impacts occur at 82-114 from an edge	Homan and Windmiller (1999) in MNHESP (2006); Windmiller (1996) in MNHESP (2006); Regosin et al. (in press) in MNHESP (2006); Lannoo (2005)
Wood frog	Obligate		6,561	Berven, and Grudzien (1990)
Eastern spadefoot frog	Obligate		3,000 (max)	Dodd (1996) in Lannoo (2005)
Green frog	Facultative		397 (mean) 1,181 (max)	Lamoureux & Madison (1999) in Semlitsch and Bodie (2003)
Bullfrog	Facultative		1,332(mean)	Ingram & Raney (1943) in Semlitsch and Bodie (2003)
Pickerel frog	Facultative		None found	
Southern leopard frog	Facultative		None found	
Carpenter frog	Facultative	Special Concern	None found	
Northern cricket frog	Facultative		26-72 (range)	O'Neil (2001) in Semlitsch and Bodie (2003)
Northern spring peeper	Facultative		1,000 (max)	Davis (1999)
NJ chorus frog	Facultative		None found	
Upland chorus frog	Facultative		None found	
Northern gray treefrog	Facultative		None found	
Southern gray treefrog	Facultative	Endangered	None found	
Pine Barrens treefrog	Facultative	Threatened	230 (mean) 348 (max); (344)	Freda & Gonzalez (1986) in Semlitsch and Bodie (2003); Freda and Gonzalez (1986) in Lannoo (2005)
Four-toed salamander	Facultative		None found	
Long-tailed salamander	Facultative	Threatened	100 (max)	Anderson & Martino (1966) in Semlitsch and Bodie (2003)
American toad	Facultative		76-1,575 (range)	Oldham (1966) in Semlitsch and Bodie (2003)
Fowler's toad	Facultative	Special Concern	None found	

*Table reproduced from NJDEP-DFW (2007)

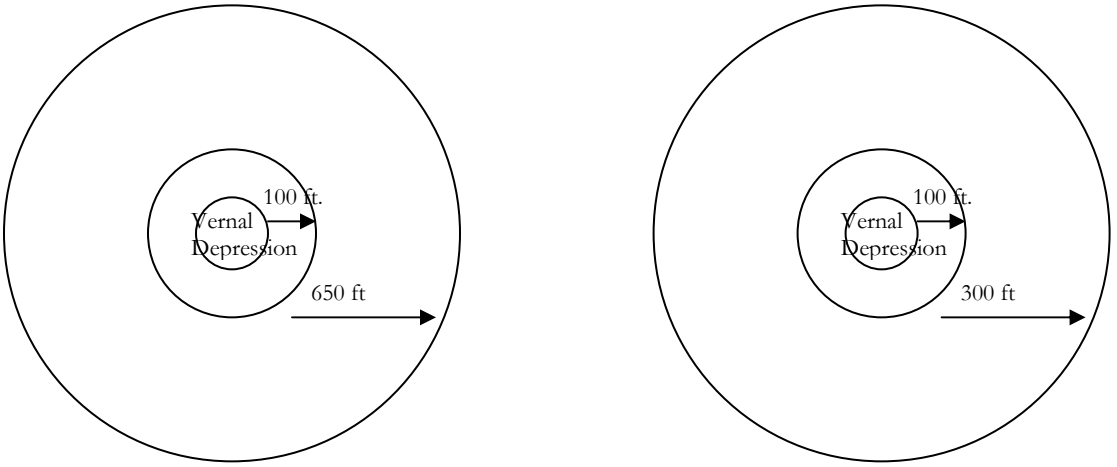
**Migration distance added through literature review

For vernal pools located on privately-owned, small parcels of land, the Metropolitan Conservation Alliance (Calhoun and Klemens, 2002) recommends three rings of buffers (vernal pool depression, 100-foot protection zone, 750-foot amphibian life zone) around vernal pools in which differing degrees of management activities are recommended (see figure *Proposed Zones of Protection around Vernal Pools on 1) Privately-Owned, Small Land Parcels*.) It should be noted that the authors do not reference literature to support the specific recommended distances for either the 100-foot protection zone or the 750-foot life zone.

The authors include a recommendation allowing disturbance of up to 25% of the amphibian life zone in the Management Goals and Recommendations Section. This recommendation appears to be based on data from one unpublished study in Massachusetts in which the researcher compared amphibian populations at two vernal pool breeding sites for five years. One site was undisturbed and the other site lost 25% of surrounding forest to residential development within 1,000 feet of the pool. Data from the disturbed site showed a 53% decline in spotted salamander population, a 40% decline in wood frog population, and a 2-year decline in blue-spotted salamander numbers, that recovered the following two years. The authors state that this study indicates that development that removes 25% of surrounding critical terrestrial habitat can harm vernal pool-breeding wildlife. They then recommend that future development footprints be limited to <25% of the area surrounding vernal pools. This recommendation is not scientifically defensible as it assumes that limiting development footprints to <25% will protect vernal pool-breeding wildlife. However, in the one study in which 25% of the surrounding forest was cleared for development, the data shows fairly dramatic declines in amphibian populations at that site.

It would seem that more extensive research would be needed to support a recommendation for a percentage of land that may be disturbed without harming existing vernal pool-breeding wildlife populations. In the Specific Issues and Recommendations Section, the authors include literature citations relating to Conservation Issues for amphibians but include very few sources relating to their Management Recommendations.

Similarly, the Metropolitan Conservation Alliance (Calhoun and deMaynadier, 2004) recommends three rings of buffers (vernal pool depression, 100-foot protection zone, 400-foot amphibian life zone) around vernal pools located in "managed" forests (i.e., forest canopy disturbance followed by renewed forest growth and not subject to permanent conversion to development, roads, and associated impervious surfaces) in which differing degrees of management activities are recommended (see figure *Proposed Zones of Protection around Vernal Pools on 2) Managed Forests).* It should be noted that the authors do not reference literature to support the specific recommended distances for either the 100-foot protection zone or the 400-foot life zone nor for the management goals and recommendations within those zones. They do cite literature sources presenting data for vernal pool-breeding wildlife migration distances away from vernal habitat, and all reported data are larger than the 400-foot life zone recommendation.



Proposed Zones of Protection around Vernal Pools on 1) Privately-Owned, Small Land Parcels and 2) Managed Forests Respectively (reproduced from Calhoun and Klemens [2002] and Calhoun, A. J. K. and P. deMaynadier [2004]).

Given the lack of scientific defensibility of the management recommendations for activities allowed within the amphibian life zone outlined by Calhoun and Klemens (2002), the Highlands Council is not proposing their tiered management approach for undisturbed vernal pools. Instead, the Council is proposing that a 1,000-foot protective buffer be applied to Highlands Region vernal pools. This size buffer is scientifically robust as evidenced by data in Tables 1 and 2. It also accounts for the three protective buffers recommended by Semlitsch and Bodie (2003) for: 1) water quality protection around the vernal pool, 2) core terrestrial habitat, and 3) terrestrial habitat. The Council is proposing a nomination procedure to increase vernal pool protection buffers if an applicant can demonstrate, in coordination with the Highlands Council and NJDEP's Endangered and Nongame Species Program, that:

- Existing vernal pool-breeding wildlife require a larger protective buffer.

Similarly, the Council is proposing a procedure to permit decreased vernal pool protection buffers if an applicant can demonstrate, in coordination with the Highlands Council and NJDEP's Endangered and Nongame Species Program, that:

- In an undisturbed wetland, existing vernal pool-breeding wildlife require a smaller protective buffer;
- Existing land uses present a human, natural, or development barrier to vernal pool-breeding wildlife; or
- A need to protect public health and safety, or to provide for minimum practical use with required mitigation, (including a habitat protection buffer in addition to mitigation), in the absence of any alternative through issuance of a waiver by NJDEP.

If an applicant successfully demonstrates the first item listed above (in concert with the Highlands Council and NJDEP's Endangered and Nongame Species Program), migration distances for the specific species identified at the site would dictate the protection buffer size, and that protection buffer will remain intact.

If an applicant successfully demonstrates the second item listed above, in concert with the Highlands Council and NJDEP's Endangered and Nongame Species Program**,** then the vernal pool is classified as disturbed. For disturbed vernal pools, the Council proposes implementation of a variety of the best management practices (BMPs) for land use outlined in Calhoun and Klemens (2002) that maintain a majority of vernal pool-breeding wildlife habitat.

If an applicant successfully obtains a Highlands Preservation Area Approval with a waiver from NJDEP, the Council recommends a requirement for in-kind mitigation with additional terrestrial habitat protection buffers.

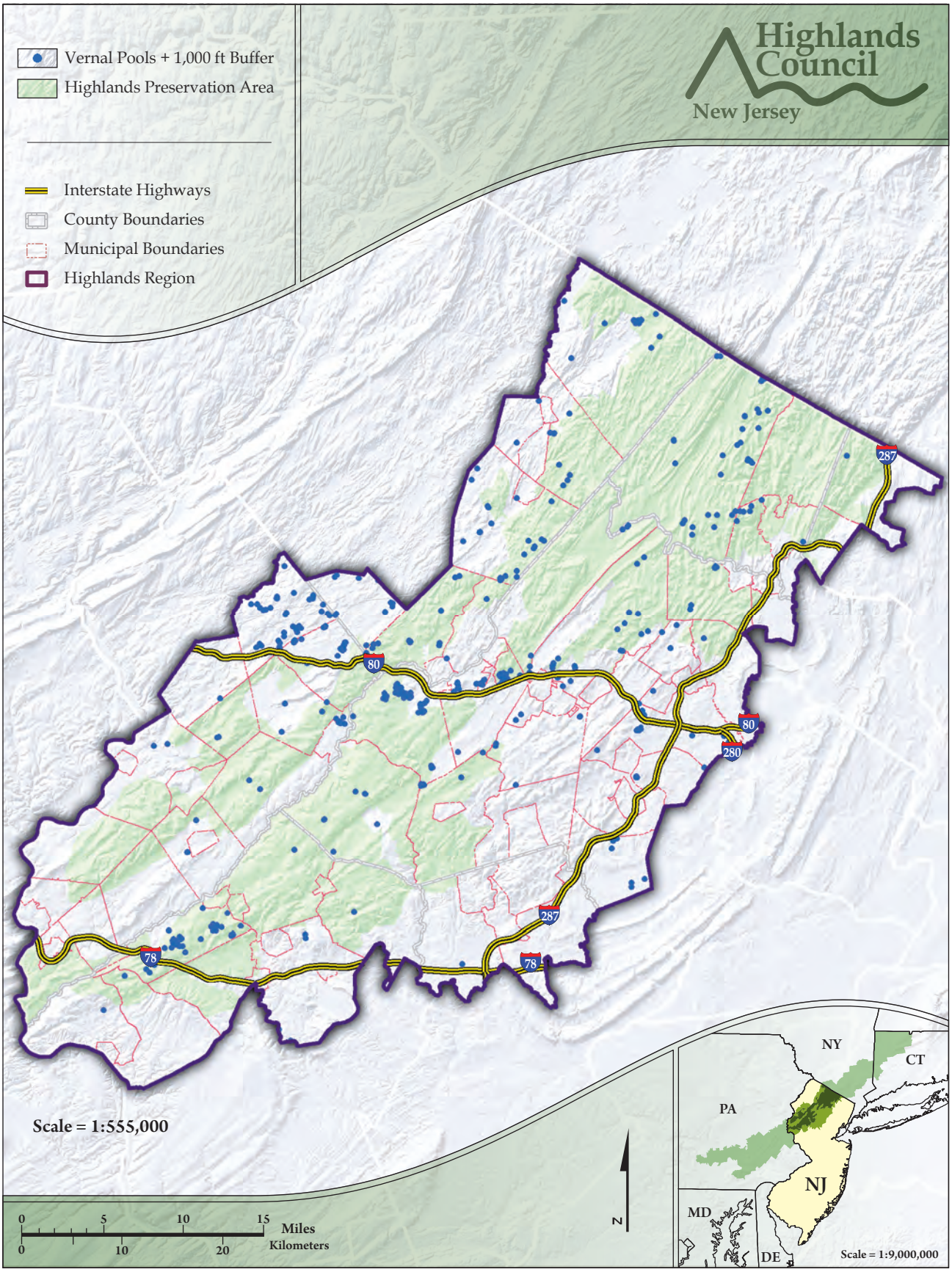
There are 466 locations of NJDEP certified pools in the Highlands Region that account for a total area, including adjacent buffers of 20,015 acres (see figure Certified *Vernal Pools*).

WATER/WETLAND DEPENDENT SPECIES HABITAT

Rare, threatened, and endangered species that are dependent upon open water and/or wetland habitats rely on intact riparian habitats for their survival. The Highlands Council selected 34 rare, threatened, and endangered species for which dependence upon water bodies or wetlands is critical to their survival to serve as indicator species for high quality aquatic ecosystems (see table *Water/Wetland Dependent Indicator Species in the Highlands Region*).

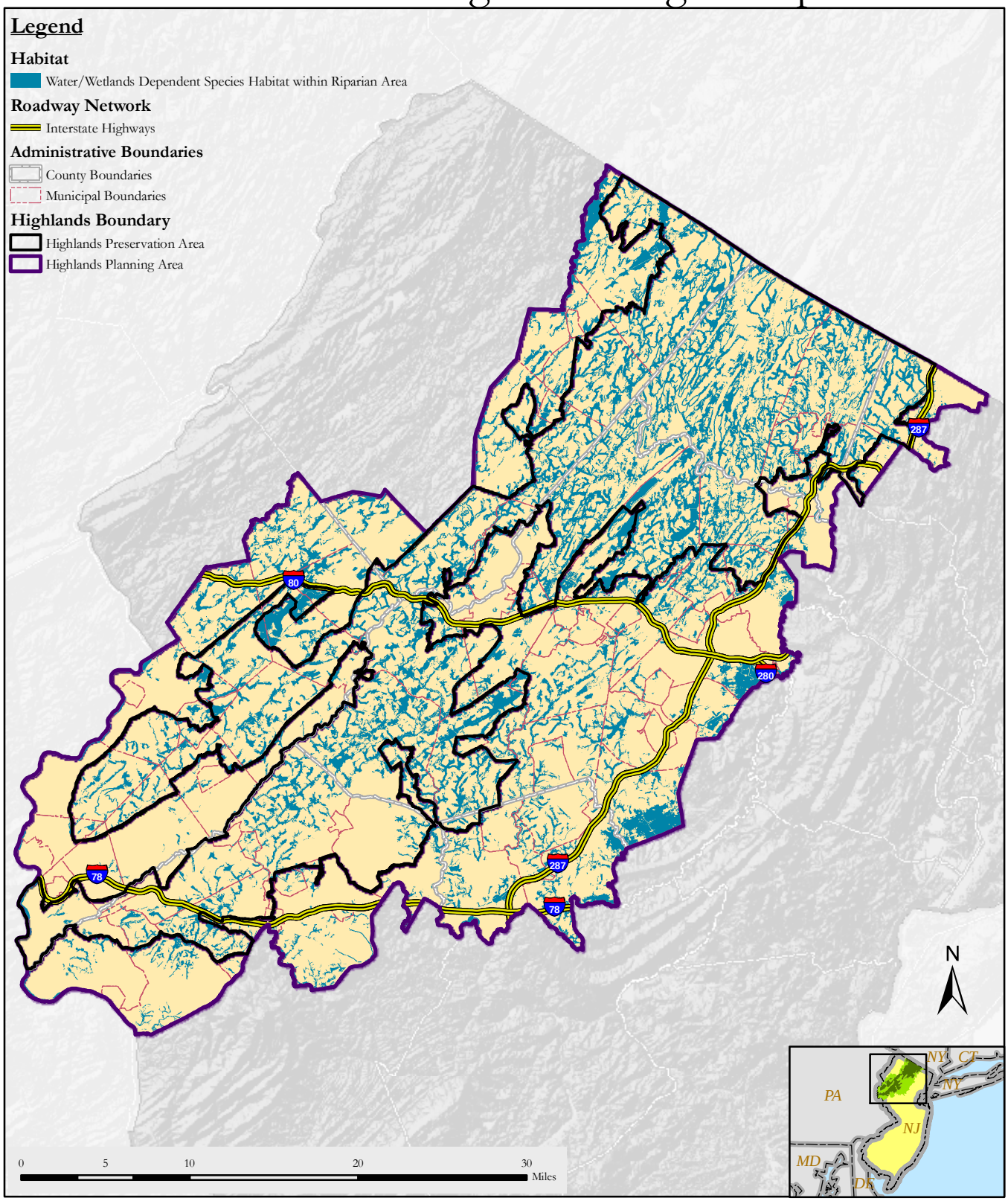
The list of Water/Wetlands Dependent Indicator Species includes native freshwater mussels of special concern in the Region. Freshwater mussels are water-dependent species which function as important indicators of high quality aquatic ecosystems. Mussels have a low tolerance for water-borne pollutants, and as such are effective indicators of water quality. New Jersey is home to twelve native species of freshwater mussels, including seven species of concern in the Highlands Region. These include the federally endangered dwarf wedgemussel (*Alasmidonta heterodon*); the state endangered brook floater (*Alasmidonta varicosa*); four state listed threatened species eastern lampmussel (*Lampsilis radiate*), eastern pondmussel (*Ligumia nasuta*), triangle floater (*Alasmidonta undulate*), and the yellow lampmussel (*Lampsilis cariosa*); and one species of special concern the creeper **(***Strophitus undulates***)**

NJDEP CERTIFIED VERNAL POOLS



Habitat for Water/Wetland Dependent Indicator Species was used to identify high quality wetland and aquatic habitat within the Highlands Region that are important to maintain biological diversity, and to develop an indicator for riparian area integrity (see the *Riparian Areas* section of this report). Species habitat identified from NJDEP Landscape Project was used to identify important water/wetland dependent species habitat for the Highlands Region. The Highlands Council mapped all habitat for water/wetland dependent indicator species for the Highlands Region within the Highlands Riparian Area (see figure *Water/Wetland Dependent Species Habitat within Highlands Region Riparian Area).* There are 179,398 acres of Riparian Area in the Highlands Region that provide habitat for a water/wetland indicator species.

Water/Wetland Dependent Species Habitat within Highlands Region Riparian Area



Regional Master Plan, July 2008

Highlands Council
New Jersey

Sources:
New Jersey Highlands Council, 2006

Water/Wetland Dependent Indicator Species in the Highlands Region

Group	Common Name	Scientific Name	Landscape Rank/Status	Indicator Status
Amphibian	Blue-spotted Salamander	*Ambystoma laterale*	4	OB
Amphibian	Jefferson Salamander	*Ambystoma jeffersonianum*	2	OB
Amphibian	Longtail Salamander	*Eurycea longicauda longicauda*	2	OB
Bird	American Bittern	*Botaurus lentiginosus*	4	OB
Bird	Barred Owl	*Strix varia*	3	FA
Bird	Henslow's Sparrow	*Ammodramus henslowii*	5	FA
Bird	King Rail	*Rallus elegans*	3	OB
Bird	Red-shouldered Hawk	*Buteo lineatus*	2	OB
Bird	Sedge Wren	*Cistothorus platensis*	2	OB
Mammal	Indiana Bat	*Myotis sodalis*	2	FA
Odonate	Arrowhead Spiketail	*Cordulegaster obliqua*	2	OB
Odonate	Brook Snaketail	*Ophiogomphus aspersus*	2	OB
Odonate	Brush-tipped Emerald	*Somatochlora walshii*	2	OB
Odonate	Harpoon Clubtail	*Gomphus descriptus*	4	OB
Odonate	Maine Snaketail	*Ophiogomphus mainensis*	2	OB
Odonate	Midland Clubtail	*Gomphus fraternus*	2	OB
Odonate	New England Bluet	*Enallagma laterale*	2	OB
Odonate	Rapids Clubtail	*Gomphus quadricolor*	4	OB
Odonate	Sable Clubtail	*Gomphus rogersi*	4	OB
Odonate	Ski-tailed Emerald	*Somatochlora elongata*	2	OB
Odonate	Spatterdock Darner	*Rhionaeschna mutata*	2	OB
Odonate	Tiger Spiketail	*Cordulegaster erronea*	4	OB
Odonate	Williamson's Emerald	*Somatochlora williamsoni*	3	OB
Odonate	Zebra Clubtail	*Stylurus scudderi*	2	OB
Reptile	Bog Turtle	*Clemmys muhlenbergii*	5	OB
Reptile	Timber Rattlesnake	*Crotalus horridus horridus*	2	FA
Reptile	Wood Turtle	*Glyptemys insculpta*	2	OB
Mussel	Brook Floater	*Alasmidonta varicosa*	State Endangered	OB
Mussel	Creeper	*Strophitus undulatus*	Special Concern	OB
Mussel	Dwarf Wedgemussel	*Alasmidonta heterodon*	Federally Listed	OB
Mussel	Eastern Lampmussel	*Lampsilis radiata*	State Threatened	OB
Mussel	Eastern Pondmussel	*Ligumia nasuta*	State Threatened	OB
Mussel	Triangle Floater	*Alasmidonta undulata*	State Threatened	OB
Mussel	Yellow Lampmussel	*Lampsilis cariosa*	State Threatened	OB

Note:
FA = a facultative species is frequently associated with a wetland or aquatic habitat to meet part or all of its life cycle requirements
OB = an obligate species is a species that is dependent on wetland or aquatic habitat for its survival

SUPPORTING INFORMATION

Acknowledgments
Glossary
References
Appendix

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New Jersey Department of Transportation
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New Jersey Economic Development Authority
New Jersey Environmental Infrastructure Trust
New Jersey Meadowlands Commission
New Jersey Pinelands Commission
New Jersey Redevelopment Authority
New Jersey State Agriculture Development Committee
New Jersey Transit
New Jersey Water Supply Authority
North Jersey District Water Supply Commission
North Jersey Transportation Planning Authority
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Land Preservation
Land Use Planning
Regional Development and Design
Sustainable Agriculture
Sustainable Forestry
Transfer of Development Rights
Transportation
Utility Capacity
Water Resource Management

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GLOSSARY

Agricultural Uses – Existing uses of land for agricultural or horticultural activities for the purpose of the production of crops or raising of livestock.

Altered Edge – The spatial delineation of the geographic boundary (i.e., edge) between forest and non-forest land.

Biodiversity - The variety of species, both plant and animal, that is collectively important to maintaining the ecological viability of natural systems. Biodiversity serves as a barometer of ecological health and the ability of natural systems to provide for human need – food, water, wood products, recreational opportunities, and aesthetic enjoyment.

Category One Waters – Category One (C1) waters are those waters designated in the tables in N.J.A.C. 7:9B-1.15(c) through (h), for purposes of implementing the antidegradation policies set forth at N.J.A.C. 7:9B-1.5(d), for protection from measurable changes in water quality characteristics because of their clarity, color, scenic setting, other characteristics of aesthetic value, exceptional ecological significance, exceptional recreational significance, exceptional water supply significance, or exceptional fisheries resource(s).

Core Forest - Forest patches greater than 300 feet in distance to an altered edge.

Critical Habitat - Critical habitat may be defined as the full extent of habitat occupied by a precisely documented occurrence of a rare plant species or ecological community.

Developed Lands – Previously developed lands including residential, commercial, industrial and public service uses and attendant features.

Ecological Community - Defined as an assemblage of interacting plant and animal species that recur in predictable patterns across the landscape under similar physical conditions. Ecological communities include assemblages of co-existing, interacting species; may be natural or the result of human activities; are inclusive of the physical environment, including climate, topography, geology, soils, hydrology; and include the dynamic ecological processes, such as fire, flooding, drought, that may effect them.

Endangered Species - Endangered species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination.

Forest – A biological community as described in *Highlands Council Alternate Method for Identifying Upland Forest Areas in the Highlands.*

Forest Integrity – An expression of the application of landscape metrics to evaluate the effects of forest fragmentation across the Highlands landscape thereby recognizing the ability of Highlands forests to provide essential ecosystem functions.

Forest Management Plan – A site specific plan which prescribes needed land treatment and related conservation and natural resource management measures deemed to be practical and reasonable for the conservation and protection of forest productivity and the control and prevention of nonpoint source pollution.

Forest Patch – A forest patch represents a contiguous tract of forest bordered by either altered land or a road.

Forest Resource Area – A Forest Resource Area includes high ecological integrity forest areas including those forested areas that express one or more of the following forest integrity indicators – a contiguous forest patch of equal to or greater than 500 acres in size, an area consisting of 250+ acres of Core forest greater than 300 feet from an altered edge, or areas that account for 45% or greater of mean total forest cover.

High Resource Value Watershed – A watershed that consists of indicators suggesting high resource value including significant forest cover, high quality habitat, low development and agricultural activity as determined by the Highlands Council.

Highlands Open Waters – all springs, streams including intermittent streams, wetlands and bodies of surface water, whether natural or artificial, located wholly or partially within the boundaries of the Highlands Region, but shall not mean swimming pools.

Highlands Open Water Protection Area Buffer – The area adjacent to a Highlands Open Water feature necessary to protect the value and integrity of the resource as determined by the Highlands Council.

Hydrologic Unit Code – Hydrologic Unit Code (HUC) means an area within which water drains to a particular receiving surface-water body, which is identified by a specific digit number, or "hydrologic unit code." The HUC codes were developed by the U.S. Geological Survey. *N.J.A.C. 7:38-1.4.*

HUC14 - An area within which water drains to a particular receiving surface-water body, which is identified by a fourteen-digit number, or "hydrologic unit code." In New Jersey, a HUC14 correlates to a subwatershed. *N.J.A.C. 7:38-1.4.*

Habitat Quality - The degree to which habitat is suitable for one or more species designated as rare, threatened or endangered in New Jersey.

Low Impact Development (LID) Best Management Practices – Low Impact Development is an environmentally sensitive approach to storm water management that emphasizes conservation and the use of existing natural site features integrated with distributed, small scale storm water controls to more closely mimic natural hydrologic patterns in residential, commercial and industrial settings. LID best management practices involve comprehensive land planning and engineering design to maintain and enhance the hydrologic regime of urban lands and development within watersheds. LID standards and best management practices are supported by the New Jersey Stormwater Management Rules, N.J.A.C. 7:8 and the "New Jersey Stormwater Best Management Practices Manual" developed by the New Jersey Department of Environmental Protection, in coordination with the New Jersey Department of Agriculture, the New Jersey Department of Community Affairs, the New Jersey Department of Transportation, municipal engineers, county engineers, consulting firms, contractors, and environmental organizations.

Low Resource Value Watershed – A watershed that consists of indicators suggesting significant levels of impairment due to past human development activity as determined by the Highlands Council.

Moderate Resource Value Watershed – A watershed that consists of indicators suggesting moderate resource value due to past development and agricultural uses as determined by the Highlands Council.

Proportion of Total Forest - Proportion of total forest cover within a 3-km radius.

Priority Sites – Priority Sites are delineated to encompass the critical habitat for occurrences of rare plant species and ecological communities.

Resource Management System Plan - A site specific conservation system plan that (1) prescribes needed land treatment and related conservation and natural resource management measures, including forest management practices, for the conservation, protection, and development of natural resources, the maintenance and enhancement of agricultural or horticultural productivity, and the control and prevention of nonpoint source pollution, and (2) establishes criteria for resources sustainability of soil, water, air, plants, and animals.

Riparian Area – Areas adjacent to and hydrologically interconnected with rivers and streams that exhibit period inundation or saturation of soils, are subject to periodic flooding and include wildlife corridors within 300 feet of a surface water feature.

Rare Species – Those species which may be widely distributed in the state, but consist of restricted distribution and/or population levels and have experienced recent declines in populations that may jeopardize their continued survival in the state if current trends continue.

Regional Watershed Indicator – Includes characteristics of watershed condition that are indicators of the quality and ecological integrity of Highlands Open Waters including Forest Resource Value, Habitat Quality, and Developed Lands.

Significant Natural Area – Significant Natural Areas represent a site or area, typically with unusual or exemplary floristic qualities, that constitutes an outstanding example of that particular resource type (such as bog, forest or geological feature).

Slope - Slope is a measurement of the steepness of terrain. It is the ratio of vertical rise to horizontal distance expressed as a percentage.

Threatened Species - Threatened species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

Trout Production (TP) Waters – Surface waters in New Jersey that are designated at N.J.A.C. 7:9B-1.15(b) through (g) as trout production waters for use by trout for spawning or nursery purposes during their first summer.

Vernal Pools - Confined, ephemeral wet depressions that support distinctive, and often endangered, species that are specially adapted to periodic extremes in water pool levels.

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APPENDIX

APPENDIX A

Summary Statistics of Highlands Open Water Inventory and Classification

Table A-1. Stream Lengths (in miles) by HUC14

HUC14	Subwatershed Name	WMA	Total Waters
02020007010010	Wallkill R/Lake Mohawk(above Sparta Sta)	02	28.13
02020007010020	Wallkill R (Ogdensburg to SpartaStation)	02	24.87
02020007010030	Franklin Pond Creek	02	20.22
02020007010040	Wallkill R(Hamburg SW Bdy to Ogdensburg)	02	31.68
02020007010050	Hardistonville tribs	02	12.79
02020007010060	Beaver Run	02	4.77
02020007010070	Wallkill R(Martins Rd to Hamburg SW Bdy)	02	18.27
02020007020070	Papakating Creek (below Pellettown)	02	0.01
02020007030010	Wallkill R(41d13m30s to Martins Road)	02	14.91
02020007030030	Wallkill River(Owens gage to 41d13m30s)	02	5.93
02020007030040	Wallkill River(stateline to Owens gage)	02	11.90
02020007040010	Black Ck(above/incl G.Gorge Resort trib)	02	14.66
02020007040020	Black Creek (below G. Gorge Resort trib)	02	47.27
02020007040030	Pochuck Ck/Glenwood Lk & northern trib	02	16.20
02020007040040	Highland Lake/Wawayanda Lake	02	16.97
02020007040050	Wawayanda Creek & tribs	02	37.17
02020007040060	Long House Creek/Upper Greenwood Lake	02	19.54
02030103010010	Passaic R Upr (above Osborn Mills)	06	27.65
02030103010020	Primrose Brook	06	14.57
02030103010030	Great Brook (above Green Village Rd)	06	19.79
02030103010040	Loantaka Brook	06	7.91
02030103010050	Great Brook (below Green Village Rd)	06	23.47
02030103010060	Black Brook (Great Swamp NWR)	06	11.89
02030103010070	Passaic R Upr (Dead R to Osborn Mills)	06	29.65
02030103010080	Dead River (above Harrisons Brook)	06	24.91
02030103010090	Harrisons Brook	06	15.93
02030103010100	Dead River (below Harrisons Brook)	06	10.34
02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	06	0.00
02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	06	0.90
02030103020010	Whippany R (above road at 74d 33m)	06	14.58
02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	06	17.75
02030103020030	Greystone / Watnong Mtn tribs	06	17.33
02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	06	14.34
02030103020050	Whippany R (Malapardis to Lk Pocahontas)	06	10.88
02030103020060	Malapardis Brook	06	11.14
02030103020070	Black Brook (Hanover)	06	12.26
02030103020080	Troy Brook (above Reynolds Ave)	06	22.29
02030103020090	Troy Brook (below Reynolds Ave)	06	26.87
02030103020100	Whippany R (Rockaway R to Malapardis Bk)	06	8.49
02030103030010	Russia Brook (above Milton)	06	21.92
02030103030020	Russia Brook (below Milton)	06	15.12
02030103030030	Rockaway R (above Longwood Lake outlet)	06	17.84
02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	06	23.07
02030103030050	Green Pond Brook (above Burnt Meadow Bk)	06	15.10
02030103030060	Green Pond Brook (below Burnt Meadow Bk)	06	18.26
02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	06	20.87
02030103030080	Mill Brook (Morris Co)	06	15.44
02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	06	11.76
02030103030100	Hibernia Brook	06	20.96
02030103030110	Beaver Brook (Morris County)	06	43.19
02030103030120	Den Brook	06	19.68
02030103030130	Stony Brook (Boonton)	06	40.26
02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	06	18.06
02030103030150	Rockaway R (Boonton dam to Stony Brook)	06	17.29
02030103030160	Montville tribs.	06	23.53
02030103030170	Rockaway R (Passaic R to Boonton dam)	06	24.14
02030103040010	Passaic R Upr (Pompton R to Pine Bk)	06	7.66
02030103050010	Pequannock R (above Stockholm/Vernon Rd)	03	15.87
02030103050020	Pacock Brook	03	18.10
02030103050030	Pequannock R (above OakRidge Res outlet)	03	26.22
02030103050040	Clinton Reservior/Mossmans Brook	03	33.87
02030103050050	Pequannock R (Charlotteburg to OakRidge)	03	43.31
02030103050060	Pequannock R(Macopin gage to Charl'brg)	03	25.68
02030103050070	Stone House Brook	03	19.42
02030103050080	Pequannock R (below Macopin gage)	03	51.83
02030103070010	Belcher Creek (above Pinecliff Lake)	03	16.51
02030103070020	Belcher Creek (Pinecliff Lake & below)	03	24.16
02030103070030	Wanaque R/Greenwood Lk(aboveMonks gage)	03	34.41
02030103070040	West Brook/Burnt Meadow Brook	03	38.05
02030103070050	Wanaque Reservior (below Monks gage)	03	65.80
02030103070060	Meadow Brook/High Mountain Brook	03	18.97
02030103070070	Wanaque R/Posts Bk (below reservior)	03	36.27
02030103100010	Ramapo R (above 74d 11m 00s)	03	16.19
02030103100020	Masonicus Brook	03	7.31
02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	03	20.28
02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	03	11.44

Table A-1. Stream Lengths (in miles) by HUC14

HUC14	Subwatershed Name	WMA	Total Waters
02030103100050	Ramapo R (Crystal Lk br to BearSwamp Bk)	03	21.13
02030103100060	Crystal Lake/Pond Brook	03	6.64
02030103100070	Ramapo R (below Crystal Lake bridge)	03	19.33
02030103110010	Lincoln Park tribs (Pompton River)	03	25.52
02030103110020	Pompton River	03	4.88
02030103140010	Hohokus Bk (above Godwin Ave)	04	3.74
02030103140020	Hohokus Bk(Pennington Ave to Godwin Ave)	04	4.08
02030103140040	Saddle River (above Rt 17)	04	0.78
02030105010010	Drakes Brook (above Eyland Ave)	08	25.89
02030105010020	Drakes Brook (below Eyland Ave)	08	22.26
02030105010030	Raritan River SB(above Rt 46)	08	11.63
02030105010040	Raritan River SB(74d 44m 15s to Rt 46)	08	17.40
02030105010050	Raritan R SB(LongValley br to 74d44m15s)	08	44.54
02030105010060	Raritan R SB(Califon br to Long Valley)	08	37.02
02030105010070	Raritan R SB(StoneMill gage to Califon)	08	20.58
02030105010080	Raritan R SB(Spruce Run-StoneMill gage)	08	12.90
02030105020010	Spruce Run (above Glen Gardner)	08	30.76
02030105020020	Spruce Run (Reservior to Glen Gardner)	08	8.21
02030105020030	Mulhockaway Creek	08	42.60
02030105020040	Spruce Run Reservior / Willoughby Brook	08	24.09
02030105020050	Beaver Brook (Clinton)	08	21.04
02030105020060	Cakepoulin Creek	08	11.22
02030105020070	Raritan R SB(River Rd to Spruce Run)	08	20.67
02030105020080	Raritan R SB(Prescott Bk to River Rd)	08	16.43
02030105020090	Prescott Brook / Round Valley Reservior	08	22.65
02030105040020	Pleasant Run	08	0.00
02030105040030	Holland Brook	08	0.00
02030105050010	Lamington R (above Rt 10)	08	14.76
02030105050020	Lamington R (Hillside Rd to Rt 10)	08	40.96
02030105050030	Lamington R (Furnace Rd to Hillside Rd)	08	17.97
02030105050040	Lamington R(Pottersville gage-FurnaceRd)	08	30.79
02030105050050	Pottersville trib (Lamington River)	08	17.80
02030105050060	Cold Brook	08	16.67
02030105050070	Lamington R(HallsBrRd-Pottersville gage)	08	51.63
02030105050080	Rockaway Ck (above McCrea Mills)	08	51.42
02030105050090	Rockaway Ck (RockawaySB to McCrea Mills)	08	6.04
02030105050100	Rockaway Ck SB	08	26.37
02030105050110	Lamington R (below Halls Bridge Rd)	08	7.83
02030105060010	Raritan R NB (above/incl India Bk)	08	19.20
02030105060020	Burnett Brook (above Old Mill Rd)	08	20.46
02030105060030	Raritan R NB(incl McVickers to India Bk)	08	25.85
02030105060040	Raritan R NB(Peapack Bk to McVickers Bk)	08	27.21
02030105060050	Peapack Brook (above/incl Gladstone Bk)	08	19.03
02030105060060	Peapack Brook (below Gladstone Brook)	08	17.45
02030105060070	Raritan R NB(incl Mine Bk to Peapack Bk)	08	26.47
02030105060080	Middle Brook (NB Raritan River)	08	27.94
02030105060090	Raritan R NB (Lamington R to Mine Bk)	08	34.65
02030105070010	Raritan R NB (Rt 28 to Lamington R)	08	14.32
02030105120050	Middle Brook EB	09	0.40
02030105120060	Middle Brook WB	09	2.26
02040105040040	Lafayette Swamp tribs	01	0.10
02040105040050	Sparta Junction tribs	01	17.05
02040105040060	Paulins Kill (above Rt 15)	01	0.00
02040105050010	Paulins Kill (Blairstown to Stillwater)	01	14.25
02040105060020	Delawanna Creek (incl UDRV)	01	5.66
02040105070010	Lake Lenape trib	01	3.45
02040105070020	New Wawayanda Lake/Andover Pond trib	01	4.82
02040105070030	Pequest River (above Brighton)	01	10.16
02040105070040	Pequest River (Trout Brook to Brighton)	01	19.01
02040105070050	Trout Brook/Lake Tranquility	01	30.14
02040105070060	Pequest R (below Bear Swamp to Trout Bk)	01	21.54
02040105080010	Bear Brook (Sussex/Warren Co)	01	9.49
02040105080020	Bear Creek	01	24.36
02040105090010	Pequest R (Drag Strip--below Bear Swamp)	01	26.84
02040105090020	Pequest R (Cemetary Road to Drag Strip)	01	12.73
02040105090030	Pequest R (Furnace Bk to Cemetary Road)	01	13.02
02040105090040	Mountain Lake Brook	01	11.46
02040105090050	Furnace Brook	01	19.45
02040105090060	Pequest R (below Furnace Brook)	01	13.92
02040105100010	Union Church trib	01	18.02
02040105100020	Honey Run	01	20.39
02040105100030	Beaver Brook (above Hope Village)	01	13.73
02040105100040	Beaver Brook (below Hope Village)	01	21.04
02040105110010	Pophandusing Brook	01	9.70
02040105110020	Buckhorn Creek (incl UDRV)	01	21.92
02040105110030	UDRV tribs (Rt 22 to Buckhorn Ck)	01	8.88

Table A-1. Stream Lengths (in miles) by HUC14

HUC14	Subwatershed Name	WMA	Total Waters
02040105120010	Lopatcong Creek (above Rt 57)	01	11.82
02040105120020	Lopatcong Creek (below Rt 57) incl UDRV	01	14.52
02040105140010	Pohatcong Creek (above Rt 31)	01	20.67
02040105140020	Pohatcong Ck (Brass Castle Ck to Rt 31)	01	23.86
02040105140030	Pohatcong Ck (Edison Rd-Brass Castle Ck)	01	23.53
02040105140040	Merrill Creek	01	10.89
02040105140050	Pohatcong Ck (Merrill Ck to Edison Rd)	01	14.86
02040105140060	Pohatcong Ck (Springtown to Merrill Ck)	01	15.21
02040105140070	Pohatcong Ck(below Springtown) incl UDRV	01	8.38
02040105150010	Weldon Brook/Beaver Brook	01	18.94
02040105150020	Lake Hopatcong	01	47.49
02040105150030	Musconetcong R (Wills Bk to LkHopatcong)	01	18.01
02040105150040	Lubbers Run (above/incl Dallis Pond)	01	25.13
02040105150050	Lubbers Run (below Dallis Pond)	01	29.61
02040105150060	Cranberry Lake / Jefferson Lake & tribs	01	15.15
02040105150070	Musconetcong R(Waterloo to/incl WillsBk)	01	28.15
02040105150080	Musconetcong R (SaxtonFalls to Waterloo)	01	24.62
02040105150090	Mine Brook (Morris Co)	01	11.26
02040105150100	Musconetcong R (Trout Bk to SaxtonFalls)	01	19.48
02040105160010	Musconetcong R (Hances Bk thru Trout Bk)	01	35.10
02040105160020	Musconetcong R (Changewater to HancesBk)	01	45.29
02040105160030	Musconetcong R (Rt 31 to Changewater)	01	9.46
02040105160040	Musconetcong R (75d 00m to Rt 31)	01	4.81
02040105160050	Musconetcong R (I-78 to 75d 00m)	01	31.90
02040105160060	Musconetcong R (Warren Glen to I-78)	01	10.89
02040105160070	Musconetcong R (below Warren Glen)	01	15.89
02040105170010	Holland Twp (Hakihokake to Musconetcong)	11	14.18
02040105170020	Hakihokake Creek	11	52.18
02040105170030	Harihokake Creek (and to Hakihokake Ck)	11	43.42
02040105170040	Nishisakawick Creek (above 40d 33m)	11	20.12
02040105170050	Nishisakawick Creek (below 40d 33m)	11	9.24
Totals			**3,604.77**

Table A-2. Acreage of Streams and Lakes by HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02020007010010	Wallkill R/Lake Mohawk(above Sparta Sta)	02	7,341.86	990.66
02020007010020	Wallkill R (Ogdensburg to SpartaStation)	02	4,595.95	98.06
02020007010030	Franklin Pond Creek	02	4,589.24	364.82
02020007010040	Wallkill R(Hamburg SW Bdy to Ogdensburg)	02	9,032.92	184.49
02020007010050	Hardistonville tribs	02	3,504.13	89.16
02020007010060	Beaver Run	02	4,143.80	1.01
02020007010070	Wallkill R(Martins Rd to Hamburg SW Bdy)	02	5,845.96	53.73
02020007020070	Papakating Creek (below Pellettown)	02	8,498.43	0.03
02020007030010	Wallkill R(41d13m30s to Martins Road)	02	5,859.71	98.58
02020007030030	Wallkill River(Owens gage to 41d13m30s)	02	3,324.69	61.96
02020007030040	Wallkill River(stateline to Owens gage)	02	4,103.80	47.65
02020007040010	Black Ck(above/incl G.Gorge Resort trib)	02	3,467.01	72.69
02020007040020	Black Creek (below G. Gorge Resort trib)	02	9,574.86	185.90
02020007040030	Pochuck Ck/Glenwood Lk & northern trib	02	3,570.78	58.73
02020007040040	Highland Lake/Wawayanda Lake	02	3,954.14	695.56
02020007040050	Wawayanda Creek & tribs	02	9,181.46	189.25
02020007040060	Long House Creek/Upper Greenwood Lake	02	5,025.98	487.46
02030103010010	Passaic R Upr (above Osborn Mills)	06	6,486.32	53.99
02030103010020	Primrose Brook	06	3,354.25	18.84
02030103010030	Great Brook (above Green Village Rd)	06	5,071.45	50.84
02030103010040	Loantaka Brook	06	3,238.15	19.17
02030103010050	Great Brook (below Green Village Rd)	06	3,296.08	31.71
02030103010060	Black Brook (Great Swamp NWR)	06	9,089.77	25.39
02030103010070	Passaic R Upr (Dead R to Osborn Mills)	06	5,694.00	52.10
02030103010080	Dead River (above Harrisons Brook)	06	4,864.65	20.80
02030103010090	Harrisons Brook	06	3,485.21	10.06
02030103010100	Dead River (below Harrisons Brook)	06	4,949.85	13.26
02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	06	4,278.68	0.00
02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	06	3,417.36	5.71
02030103020010	Whippany R (above road at 74d 33m)	06	3,875.69	62.63
02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	06	4,015.26	17.13
02030103020030	Greystone / Watnong Mtn tribs	06	4,972.41	35.31
02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	06	3,594.46	62.39
02030103020050	Whippany R (Malapardis to Lk Pocahontas)	06	4,305.74	49.81
02030103020060	Malapardis Brook	06	3,256.36	51.03
02030103020070	Black Brook (Hanover)	06	6,644.31	9.81
02030103020080	Troy Brook (above Reynolds Ave)	06	6,439.19	386.70
02030103020090	Troy Brook (below Reynolds Ave)	06	3,870.59	54.21
02030103020100	Whippany R (Rockaway R to Malapardis Bk)	06	3,594.69	21.77
02030103030010	Russia Brook (above Milton)	06	5,478.66	121.06
02030103030020	Russia Brook (below Milton)	06	3,099.37	91.49
02030103030030	Rockaway R (above Longwood Lake outlet)	06	4,288.83	185.95
02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	06	5,100.62	52.17
02030103030050	Green Pond Brook (above Burnt Meadow Bk)	06	4,721.31	784.24
02030103030060	Green Pond Brook (below Burnt Meadow Bk)	06	5,055.75	168.25
02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	06	5,825.17	66.52
02030103030080	Mill Brook (Morris Co)	06	3,130.27	7.30
02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	06	4,692.53	47.93
02030103030100	Hibernia Brook	06	5,074.74	66.26
02030103030110	Beaver Brook (Morris County)	06	9,453.21	1,007.39
02030103030120	Den Brook	06	5,769.40	297.90
02030103030130	Stony Brook (Boonton)	06	7,864.43	351.97
02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	06	3,382.24	213.61
02030103030150	Rockaway R (Boonton dam to Stony Brook)	06	4,417.55	867.15
02030103030160	Montville tribs.	06	5,065.54	126.22
02030103030170	Rockaway R (Passaic R to Boonton dam)	06	5,138.44	99.27
02030103040010	Passaic R Upr (Pompton R to Pine Bk)	06	7,602.04	56.56
02030103050010	Pequannock R (above Stockholm/Vernon Rd)	03	3,464.16	81.99
02030103050020	Pacock Brook	03	4,590.79	340.51
02030103050030	Pequannock R (above OakRidge Res outlet)	03	6,710.17	511.96
02030103050040	Clinton Reservior/Mossmans Brook	03	8,486.56	820.77
02030103050050	Pequannock R (Charlotteburg to OakRidge)	03	11,761.05	439.28
02030103050060	Pequannock R(Macopin gage to Charl'brg)	03	5,047.69	357.32
02030103050070	Stone House Brook	03	4,677.03	336.84
02030103050080	Pequannock R (below Macopin gage)	03	10,835.76	402.95
02030103070010	Belcher Creek (above Pinecliff Lake)	03	3,480.08	28.17
02030103070020	Belcher Creek (Pinecliff Lake & below)	03	5,782.36	210.56
02030103070030	Wanaque R/Greenwood Lk(aboveMonks gage)	03	9,360.28	1,410.29
02030103070040	West Brook/Burnt Meadow Brook	03	7,569.99	146.97
02030103070050	Wanaque Reservior (below Monks gage)	03	13,749.41	2,618.36
02030103070060	Meadow Brook/High Mountain Brook	03	3,837.47	59.08
02030103070070	Wanaque R/Posts Bk (below reservior)	03	6,915.88	378.80
02030103100010	Ramapo R (above 74d 11m 00s)	03	3,720.96	120.85
02030103100020	Masonicus Brook	03	2,783.22	11.54
02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	03	4,305.47	113.44
02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	03	3,018.09	80.66

Table A-2. Acreage of Streams and Lakes by HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02030103100050	Ramapo R (Crystal Lk br to BearSwamp Bk)	03	4,041.21	64.90
02030103100060	Crystal Lake/Pond Brook	03	5,509.00	45.76
02030103100070	Ramapo R (below Crystal Lake bridge)	03	7,224.00	303.59
02030103110010	Lincoln Park tribs (Pompton River)	03	8,394.39	35.19
02030103110020	Pompton River	03	6,963.19	132.53
02030103140010	Hohokus Bk (above Godwin Ave)	04	3,394.92	16.96
02030103140020	Hohokus Bk(Pennington Ave to Godwin Ave)	04	6,001.09	7.96
02030103140040	Saddle River (above Rt 17)	04	8,729.99	1.65
02030105010010	Drakes Brook (above Eyland Ave)	08	5,935.72	46.05
02030105010020	Drakes Brook (below Eyland Ave)	08	4,684.13	30.33
02030105010030	Raritan River SB(above Rt 46)	08	3,218.56	391.66
02030105010040	Raritan River SB(74d 44m 15s to Rt 46)	08	4,264.73	26.30
02030105010050	Raritan R SB(LongValley br to 74d44m15s)	08	9,766.20	67.84
02030105010060	Raritan R SB(Califon br to Long Valley)	08	9,530.62	74.49
02030105010070	Raritan R SB(StoneMill gage to Califon)	08	5,050.33	49.58
02030105010080	Raritan R SB(Spruce Run-StoneMill gage)	08	2,961.24	57.64
02030105020010	Spruce Run (above Glen Gardner)	08	7,868.14	53.33
02030105020020	Spruce Run (Reservior to Glen Gardner)	08	2,056.53	4.74
02030105020030	Mulhockaway Creek	08	9,413.78	27.93
02030105020040	Spruce Run Reservior / Willoughby Brook	08	7,808.14	1,388.74
02030105020050	Beaver Brook (Clinton)	08	4,437.97	12.62
02030105020060	Cakepoulin Creek	08	9,105.34	8.20
02030105020070	Raritan R SB(River Rd to Spruce Run)	08	5,262.95	59.55
02030105020080	Raritan R SB(Prescott Bk to River Rd)	08	4,720.69	33.06
02030105020090	Prescott Brook / Round Valley Reservior	08	7,218.25	2,306.05
02030105040020	Pleasant Run	08	6,919.04	0.00
02030105040030	Holland Brook	08	7,965.60	0.00
02030105050010	Lamington R (above Rt 10)	08	4,014.95	253.21
02030105050020	Lamington R (Hillside Rd to Rt 10)	08	7,065.70	52.20
02030105050030	Lamington R (Furnace Rd to Hillside Rd)	08	3,843.04	19.81
02030105050040	Lamington R(Pottersville gage-FurnaceRd)	08	5,702.56	49.10
02030105050050	Pottersville trib (Lamington River)	08	3,147.93	2.63
02030105050060	Cold Brook	08	3,988.01	17.34
02030105050070	Lamington R(HallsBrRd-Pottersville gage)	08	8,948.04	82.99
02030105050080	Rockaway Ck (above McCrea Mills)	08	10,840.33	34.50
02030105050090	Rockaway Ck (RockawaySB to McCrea Mills)	08	3,262.54	6.34
02030105050100	Rockaway Ck SB	08	7,910.01	15.70
02030105050110	Lamington R (below Halls Bridge Rd)	08	4,833.29	22.02
02030105060010	Raritan R NB (above/incl India Bk)	08	4,282.20	28.21
02030105060020	Burnett Brook (above Old Mill Rd)	08	4,253.69	30.24
02030105060030	Raritan R NB(incl McVickers to India Bk)	08	4,897.15	44.92
02030105060040	Raritan R NB(Peapack Bk to McVickers Bk)	08	4,804.73	81.11
02030105060050	Peapack Brook (above/incl Gladstone Bk)	08	4,228.28	8.27
02030105060060	Peapack Brook (below Gladstone Brook)	08	3,247.97	12.97
02030105060070	Raritan R NB(incl Mine Bk to Peapack Bk)	08	5,380.10	43.59
02030105060080	Middle Brook (NB Raritan River)	08	4,279.21	19.08
02030105060090	Raritan R NB (Lamington R to Mine Bk)	08	5,562.47	56.48
02030105070010	Raritan R NB (Rt 28 to Lamington R)	08	5,967.47	31.46
02030105120050	Middle Brook EB	09	6,131.20	0.74
02030105120060	Middle Brook WB	09	4,188.04	1.22
02040105040040	Lafayette Swamp tribs	01	3,530.47	0.38
02040105040050	Sparta Junction tribs	01	8,620.85	135.39
02040105040060	Paulins Kill (above Rt 15)	01	8,851.12	0.47
02040105050010	Paulins Kill (Blairstown to Stillwater)	01	12,136.81	52.46
02040105060020	Delawanna Creek (incl UDRV)	01	7,861.74	191.05
02040105070010	Lake Lenape trib	01	3,436.28	2.84
02040105070020	New Wawayanda Lake/Andover Pond trib	01	7,347.31	110.63
02040105070030	Pequest River (above Brighton)	01	8,611.28	19.31
02040105070040	Pequest River (Trout Brook to Brighton)	01	5,523.92	66.95
02040105070050	Trout Brook/Lake Tranquility	01	6,032.98	136.69
02040105070060	Pequest R (below Bear Swamp to Trout Bk)	01	4,033.60	40.94
02040105080010	Bear Brook (Sussex/Warren Co)	01	4,816.15	26.50
02040105080020	Bear Creek	01	6,912.71	83.17
02040105090010	Pequest R (Drag Strip--below Bear Swamp)	01	6,079.08	72.13
02040105090020	Pequest R (Cemetary Road to Drag Strip)	01	4,891.06	17.95
02040105090030	Pequest R (Furnace Bk to Cemetary Road)	01	5,270.06	50.43
02040105090040	Mountain Lake Brook	01	3,874.30	133.04
02040105090050	Furnace Brook	01	4,939.04	72.30
02040105090060	Pequest R (below Furnace Brook)	01	5,294.86	91.16
02040105100010	Union Church trib	01	5,325.10	44.93
02040105100020	Honey Run	01	6,601.74	64.66
02040105100030	Beaver Brook (above Hope Village)	01	5,750.44	109.99
02040105100040	Beaver Brook (below Hope Village)	01	5,802.77	50.11
02040105110010	Pophandusing Brook	01	3,598.89	19.28
02040105110020	Buckhorn Creek (incl UDRV)	01	9,430.25	158.88
02040105110030	UDRV tribs (Rt 22 to Buckhorn Ck)	01	5,039.73	273.54

Table A-2. Acreage of Streams and Lakes by HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02040105120010	Lopatcong Creek (above Rt 57)	01	4,963.90	5.61
02040105120020	Lopatcong Creek (below Rt 57) incl UDRV	01	7,680.89	159.00
02040105140010	Pohatcong Creek (above Rt 31)	01	6,455.37	32.90
02040105140020	Pohatcong Ck (Brass Castle Ck to Rt 31)	01	7,999.11	32.43
02040105140030	Pohatcong Ck (Edison Rd-Brass Castle Ck)	01	6,893.10	26.36
02040105140040	Merrill Creek	01	3,604.05	650.39
02040105140050	Pohatcong Ck (Merrill Ck to Edison Rd)	01	4,453.41	58.68
02040105140060	Pohatcong Ck (Springtown to Merrill Ck)	01	4,053.88	26.73
02040105140070	Pohatcong Ck(below Springtown) incl UDRV	01	3,752.62	128.01
02040105150010	Weldon Brook/Beaver Brook	01	4,124.24	79.02
02040105150020	Lake Hopatcong	01	12,091.50	2,613.63
02040105150030	Musconetcong R (Wills Bk to LkHopatcong)	01	3,586.05	337.04
02040105150040	Lubbers Run (above/incl Dallis Pond)	01	5,123.13	128.65
02040105150050	Lubbers Run (below Dallis Pond)	01	6,445.85	335.14
02040105150060	Cranberry Lake / Jefferson Lake & tribs	01	3,357.11	281.71
02040105150070	Musconetcong R(Waterloo to/incl WillsBk)	01	4,451.71	67.71
02040105150080	Musconetcong R (SaxtonFalls to Waterloo)	01	4,954.31	275.30
02040105150090	Mine Brook (Morris Co)	01	3,171.95	21.46
02040105150100	Musconetcong R (Trout Bk to SaxtonFalls)	01	4,942.91	74.56
02040105160010	Musconetcong R (Hances Bk thru Trout Bk)	01	9,284.65	94.39
02040105160020	Musconetcong R (Changewater to HancesBk)	01	11,379.98	81.30
02040105160030	Musconetcong R (Rt 31 to Changewater)	01	4,974.57	37.44
02040105160040	Musconetcong R (75d 00m to Rt 31)	01	3,266.41	21.04
02040105160050	Musconetcong R (I-78 to 75d 00m)	01	9,280.75	58.88
02040105160060	Musconetcong R (Warren Glen to I-78)	01	4,331.27	58.76
02040105160070	Musconetcong R (below Warren Glen)	01	4,788.86	63.47
02040105170010	Holland Twp (Hakihokake to Musconetcong)	11	3,859.25	259.51
02040105170020	Hakihokake Creek	11	11,233.15	38.47
02040105170030	Harihokake Creek (and to Hakihokake Ck)	11	7,576.80	93.86
02040105170040	Nishisakawick Creek (above 40d 33m)	11	4,307.58	32.89
02040105170050	Nishisakawick Creek (below 40d 33m)	11	5,439.90	39.16
Totals			**1,043,331.06**	**32,213.46**

Table A-3. Wetlands Acreage By HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02020007010010	Wallkill R/Lake Mohawk(above Sparta Sta)	02	7,341.86	511.28
02020007010020	Wallkill R (Ogdensburg to SpartaStation)	02	4,595.95	793.77
02020007010030	Franklin Pond Creek	02	4,589.24	448.74
02020007010040	Wallkill R(Hamburg SW Bdy to Ogdensburg)	02	9,032.92	1,413.03
02020007010050	Hardistonville tribs	02	3,504.13	489.21
02020007010060	Beaver Run	02	4,143.80	141.54
02020007010070	Wallkill R(Martins Rd to Hamburg SW Bdy)	02	5,845.96	744.45
02020007020070	Papakating Creek (below Pellettown)	02	8,498.43	0.00
02020007030010	Wallkill R(41d13m30s to Martins Road)	02	5,859.71	700.96
02020007030030	Wallkill River(Owens gage to 41d13m30s)	02	3,324.69	855.24
02020007030040	Wallkill River(stateline to Owens gage)	02	4,103.80	927.29
02020007040010	Black Ck(above/incl G.Gorge Resort trib)	02	3,467.01	247.65
02020007040020	Black Creek (below G. Gorge Resort trib)	02	9,574.86	1,653.25
02020007040030	Pochuck Ck/Glenwood Lk & northern trib	02	3,570.78	830.84
02020007040040	Highland Lake/Wawayanda Lake	02	3,954.14	375.65
02020007040050	Wawayanda Creek & tribs	02	9,181.46	1,356.82
02020007040060	Long House Creek/Upper Greenwood Lake	02	5,025.98	720.62
02030103010010	Passaic R Upr (above Osborn Mills)	06	6,486.32	352.66
02030103010020	Primrose Brook	06	3,354.25	170.32
02030103010030	Great Brook (above Green Village Rd)	06	5,071.45	479.09
02030103010040	Loantaka Brook	06	3,238.15	242.66
02030103010050	Great Brook (below Green Village Rd)	06	3,296.08	1,619.95
02030103010060	Black Brook (Great Swamp NWR)	06	9,089.77	1,234.28
02030103010070	Passaic R Upr (Dead R to Osborn Mills)	06	5,694.00	1,304.65
02030103010080	Dead River (above Harrisons Brook)	06	4,864.65	794.98
02030103010090	Harrisons Brook	06	3,485.21	206.83
02030103010100	Dead River (below Harrisons Brook)	06	4,949.85	572.96
02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	06	4,278.68	0.00
02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	06	3,417.36	71.22
02030103020010	Whippany R (above road at 74d 33m)	06	3,875.69	201.98
02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	06	4,015.26	431.43
02030103020030	Greystone / Watnong Mtn tribs	06	4,972.41	196.23
02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	06	3,594.46	245.66
02030103020050	Whippany R (Malapardis to Lk Pocahontas)	06	4,305.74	216.44
02030103020060	Malapardis Brook	06	3,256.36	424.39
02030103020070	Black Brook (Hanover)	06	6,644.31	605.76
02030103020080	Troy Brook (above Reynolds Ave)	06	6,439.19	308.53
02030103020090	Troy Brook (below Reynolds Ave)	06	3,870.59	1,713.55
02030103020100	Whippany R (Rockaway R to Malapardis Bk)	06	3,594.69	414.28
02030103030010	Russia Brook (above Milton)	06	5,478.66	714.08
02030103030020	Russia Brook (below Milton)	06	3,099.37	262.41
02030103030030	Rockaway R (above Longwood Lake outlet)	06	4,288.83	287.09
02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	06	5,100.62	701.71
02030103030050	Green Pond Brook (above Burnt Meadow Bk)	06	4,721.31	689.93
02030103030060	Green Pond Brook (below Burnt Meadow Bk)	06	5,055.75	757.37
02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	06	5,825.17	510.02
02030103030080	Mill Brook (Morris Co)	06	3,130.27	292.91
02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	06	4,692.53	383.39
02030103030100	Hibernia Brook	06	5,074.74	539.83
02030103030110	Beaver Brook (Morris County)	06	9,453.21	802.00
02030103030120	Den Brook	06	5,769.40	381.75
02030103030130	Stony Brook (Boonton)	06	7,864.43	723.51
02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	06	3,382.24	337.25
02030103030150	Rockaway R (Boonton dam to Stony Brook)	06	4,417.55	208.29
02030103030160	Montville tribs.	06	5,065.54	528.32
02030103030170	Rockaway R (Passaic R to Boonton dam)	06	5,138.44	792.68
02030103040010	Passaic R Upr (Pompton R to Pine Bk)	06	7,602.04	525.54
02030103050010	Pequannock R (above Stockholm/Vernon Rd)	03	3,464.16	511.44
02030103050020	Pacock Brook	03	4,590.79	698.31
02030103050030	Pequannock R (above OakRidge Res outlet)	03	6,710.17	963.71
02030103050040	Clinton Reservior/Mossmans Brook	03	8,486.56	769.16
02030103050050	Pequannock R (Charlotteburg to OakRidge)	03	11,761.05	1,574.88
02030103050060	Pequannock R(Macopin gage to Charl'brg)	03	5,047.69	691.48
02030103050070	Stone House Brook	03	4,677.03	241.91
02030103050080	Pequannock R (below Macopin gage)	03	10,835.76	765.04
02030103070010	Belcher Creek (above Pinecliff Lake)	03	3,480.08	404.51
02030103070020	Belcher Creek (Pinecliff Lake & below)	03	5,782.36	555.96
02030103070030	Wanaque R/Greenwood Lk(aboveMonks gage)	03	9,360.28	409.36
02030103070040	West Brook/Burnt Meadow Brook	03	7,569.99	705.14
02030103070050	Wanaque Reservior (below Monks gage)	03	13,749.41	592.96
02030103070060	Meadow Brook/High Mountain Brook	03	3,837.47	224.97
02030103070070	Wanaque R/Posts Bk (below reservior)	03	6,915.88	511.35
02030103100010	Ramapo R (above 74d 11m 00s)	03	3,720.96	308.38
02030103100020	Masonicus Brook	03	2,783.22	82.49
02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	03	4,305.47	318.82
02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	03	3,018.09	217.55

Table A-3. Wetlands Acreage By HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02030103100050	Ramapo R (Crystal Lk br to BearSwamp Bk)	03	4,041.21	269.40
02030103100060	Crystal Lake/Pond Brook	03	5,509.00	56.55
02030103100070	Ramapo R (below Crystal Lake bridge)	03	7,224.00	139.67
02030103110010	Lincoln Park tribs (Pompton River)	03	8,394.39	938.76
02030103110020	Pompton River	03	6,963.19	204.20
02030103140010	Hohokus Bk (above Godwin Ave)	04	3,394.92	97.49
02030103140020	Hohokus Bk(Pennington Ave to Godwin Ave)	04	6,001.09	69.40
02030103140040	Saddle River (above Rt 17)	04	8,729.99	14.35
02030105010010	Drakes Brook (above Eyland Ave)	08	5,935.72	655.05
02030105010020	Drakes Brook (below Eyland Ave)	08	4,684.13	732.85
02030105010030	Raritan River SB(above Rt 46)	08	3,218.56	478.44
02030105010040	Raritan River SB(74d 44m 15s to Rt 46)	08	4,264.73	705.40
02030105010050	Raritan R SB(LongValley br to 74d44m15s)	08	9,766.20	1,736.21
02030105010060	Raritan R SB(Califon br to Long Valley)	08	9,530.62	1,269.90
02030105010070	Raritan R SB(StoneMill gage to Califon)	08	5,050.33	78.04
02030105010080	Raritan R SB(Spruce Run-StoneMill gage)	08	2,961.24	127.09
02030105020010	Spruce Run (above Glen Gardner)	08	7,868.14	814.97
02030105020020	Spruce Run (Reservior to Glen Gardner)	08	2,056.53	71.18
02030105020030	Mulhockaway Creek	08	9,413.78	1,015.74
02030105020040	Spruce Run Reservior / Willoughby Brook	08	7,808.14	387.23
02030105020050	Beaver Brook (Clinton)	08	4,437.97	191.66
02030105020060	Cakepoulin Creek	08	9,105.34	170.38
02030105020070	Raritan R SB(River Rd to Spruce Run)	08	5,262.95	382.39
02030105020080	Raritan R SB(Prescott Bk to River Rd)	08	4,720.69	265.86
02030105020090	Prescott Brook / Round Valley Reservior	08	7,218.25	271.20
02030105040020	Pleasant Run	08	6,919.04	0.00
02030105040030	Holland Brook	08	7,965.60	0.02
02030105050010	Lamington R (above Rt 10)	08	4,014.95	310.00
02030105050020	Lamington R (Hillside Rd to Rt 10)	08	7,065.70	1,697.37
02030105050030	Lamington R (Furnace Rd to Hillside Rd)	08	3,843.04	671.54
02030105050040	Lamington R(Pottersville gage-FurnaceRd)	08	5,702.56	442.50
02030105050050	Pottersville trib (Lamington River)	08	3,147.93	53.57
02030105050060	Cold Brook	08	3,988.01	108.32
02030105050070	Lamington R(HallsBrRd-Pottersville gage)	08	8,948.04	486.41
02030105050080	Rockaway Ck (above McCrea Mills)	08	10,840.33	505.84
02030105050090	Rockaway Ck (RockawaySB to McCrea Mills)	08	3,262.54	89.71
02030105050100	Rockaway Ck SB	08	7,910.01	193.65
02030105050110	Lamington R (below Halls Bridge Rd)	08	4,833.29	141.82
02030105060010	Raritan R NB (above/incl India Bk)	08	4,282.20	478.94
02030105060020	Burnett Brook (above Old Mill Rd)	08	4,253.69	217.07
02030105060030	Raritan R NB(incl McVickers to India Bk)	08	4,897.15	287.97
02030105060040	Raritan R NB(Peapack Bk to McVickers Bk)	08	4,804.73	166.06
02030105060050	Peapack Brook (above/incl Gladstone Bk)	08	4,228.28	197.22
02030105060060	Peapack Brook (below Gladstone Brook)	08	3,247.97	28.13
02030105060070	Raritan R NB(incl Mine Bk to Peapack Bk)	08	5,380.10	177.58
02030105060080	Middle Brook (NB Raritan River)	08	4,279.21	97.34
02030105060090	Raritan R NB (Lamington R to Mine Bk)	08	5,562.47	439.24
02030105070010	Raritan R NB (Rt 28 to Lamington R)	08	5,967.47	272.73
02030105120050	Middle Brook EB	09	6,131.20	47.94
02030105120060	Middle Brook WB	09	4,188.04	130.86
02040105040040	Lafayette Swamp tribs	01	3,530.47	5.81
02040105040050	Sparta Junction tribs	01	8,620.85	945.83
02040105040060	Paulins Kill (above Rt 15)	01	8,851.12	1.66
02040105050010	Paulins Kill (Blairstown to Stillwater)	01	12,136.81	307.78
02040105060020	Delawanna Creek (incl UDRV)	01	7,861.74	141.45
02040105070010	Lake Lenape trib	01	3,436.28	123.81
02040105070020	New Wawayanda Lake/Andover Pond trib	01	7,347.31	155.41
02040105070030	Pequest River (above Brighton)	01	8,611.28	520.76
02040105070040	Pequest River (Trout Brook to Brighton)	01	5,523.92	698.25
02040105070050	Trout Brook/Lake Tranquility	01	6,032.98	914.66
02040105070060	Pequest R (below Bear Swamp to Trout Bk)	01	4,033.60	1,901.54
02040105080010	Bear Brook (Sussex/Warren Co)	01	4,816.15	286.30
02040105080020	Bear Creek	01	6,912.71	1,676.42
02040105090010	Pequest R (Drag Strip--below Bear Swamp)	01	6,079.08	2,320.14
02040105090020	Pequest R (Cemetary Road to Drag Strip)	01	4,891.06	803.43
02040105090030	Pequest R (Furnace Bk to Cemetary Road)	01	5,270.06	244.39
02040105090040	Mountain Lake Brook	01	3,874.30	450.47
02040105090050	Furnace Brook	01	4,939.04	840.49
02040105090060	Pequest R (below Furnace Brook)	01	5,294.86	249.16
02040105100010	Union Church trib	01	5,325.10	598.38
02040105100020	Honey Run	01	6,601.74	613.48
02040105100030	Beaver Brook (above Hope Village)	01	5,750.44	554.45
02040105100040	Beaver Brook (below Hope Village)	01	5,802.77	427.60
02040105110010	Pophandusing Brook	01	3,598.89	164.50
02040105110020	Buckhorn Creek (incl UDRV)	01	9,430.25	347.66
02040105110030	UDRV tribs (Rt 22 to Buckhorn Ck)	01	5,039.73	42.45

Table A-3. Wetlands Acreage By HUC14

HUC14	Subwatershed Name	WMA	Total Acres	Total Waters
02040105120010	Lopatcong Creek (above Rt 57)	01	4,963.90	162.59
02040105120020	Lopatcong Creek (below Rt 57) incl UDRV	01	7,680.89	110.46
02040105140010	Pohatcong Creek (above Rt 31)	01	6,455.37	1,033.08
02040105140020	Pohatcong Ck (Brass Castle Ck to Rt 31)	01	7,999.11	680.57
02040105140030	Pohatcong Ck (Edison Rd-Brass Castle Ck)	01	6,893.10	454.08
02040105140040	Merrill Creek	01	3,604.05	160.34
02040105140050	Pohatcong Ck (Merrill Ck to Edison Rd)	01	4,453.41	154.64
02040105140060	Pohatcong Ck (Springtown to Merrill Ck)	01	4,053.88	40.41
02040105140070	Pohatcong Ck(below Springtown) incl UDRV	01	3,752.62	30.07
02040105150010	Weldon Brook/Beaver Brook	01	4,124.24	557.28
02040105150020	Lake Hopatcong	01	12,091.50	737.06
02040105150030	Musconetcong R (Wills Bk to LkHopatcong)	01	3,586.05	215.79
02040105150040	Lubbers Run (above/incl Dallis Pond)	01	5,123.13	705.58
02040105150050	Lubbers Run (below Dallis Pond)	01	6,445.85	561.02
02040105150060	Cranberry Lake / Jefferson Lake & tribs	01	3,357.11	312.21
02040105150070	Musconetcong R(Waterloo to/incl WillsBk)	01	4,451.71	551.68
02040105150080	Musconetcong R (SaxtonFalls to Waterloo)	01	4,954.31	275.77
02040105150090	Mine Brook (Morris Co)	01	3,171.95	231.45
02040105150100	Musconetcong R (Trout Bk to SaxtonFalls)	01	4,942.91	295.19
02040105160010	Musconetcong R (Hances Bk thru Trout Bk)	01	9,284.65	809.34
02040105160020	Musconetcong R (Changewater to HancesBk)	01	11,379.98	807.00
02040105160030	Musconetcong R (Rt 31 to Changewater)	01	4,974.57	217.08
02040105160040	Musconetcong R (75d 00m to Rt 31)	01	3,266.41	211.14
02040105160050	Musconetcong R (I-78 to 75d 00m)	01	9,280.75	346.81
02040105160060	Musconetcong R (Warren Glen to I-78)	01	4,331.27	100.00
02040105160070	Musconetcong R (below Warren Glen)	01	4,788.86	361.41
02040105170010	Holland Twp (Hakihokake to Musconetcong)	11	3,859.25	77.77
02040105170020	Hakihokake Creek	11	11,233.15	1,065.16
02040105170030	Harihokake Creek (and to Hakihokake Ck)	11	7,576.80	578.15
02040105170040	Nishisakawick Creek (above 40d 33m)	11	4,307.58	430.37
02040105170050	Nishisakawick Creek (below 40d 33m)	11	5,439.90	92.58
Totals				**90,091.25**

Table A-4. Highlands Open Waters Protection Area By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Protection Area
02020007010010	Wallkill R/Lake Mohawk(above Sparta Sta)	02	7,341.86	4,290.72
02020007010020	Wallkill R (Ogdensburg to SpartaStation)	02	4,595.95	2,809.68
02020007010030	Franklin Pond Creek	02	4,589.24	3,005.47
02020007010040	Wallkill R(Hamburg SW Bdy to Ogdensburg)	02	9,032.92	4,773.45
02020007010050	Hardistonville tribs	02	3,504.13	2,025.69
02020007010060	Beaver Run	02	4,143.80	541.96
02020007010070	Wallkill R(Martins Rd to Hamburg SW Bdy)	02	5,845.96	2,644.42
02020007020070	Papakating Creek (below Pellettown)	02	8,498.43	0.03
02020007030010	Wallkill R(41d13m30s to Martins Road)	02	5,859.71	1,988.51
02020007030030	Wallkill River(Owens gage to 41d13m30s)	02	3,324.69	1,651.91
02020007030040	Wallkill River(stateline to Owens gage)	02	4,103.80	1,731.23
02020007040010	Black Ck(above/incl G.Gorge Resort trib)	02	3,467.01	1,576.69
02020007040020	Black Creek (below G. Gorge Resort trib)	02	9,574.86	5,079.01
02020007040030	Pochuck Ck/Glenwood Lk & northern trib	02	3,570.78	2,238.52
02020007040040	Highland Lake/Wawayanda Lake	02	3,954.14	2,635.80
02020007040050	Wawayanda Creek & tribs	02	9,181.46	5,445.39
02020007040060	Long House Creek/Upper Greenwood Lake	02	5,025.98	3,338.43
02030103010010	Passaic R Upr (above Osborn Mills)	06	6,486.32	2,396.34
02030103010020	Primrose Brook	06	3,354.25	1,121.75
02030103010030	Great Brook (above Green Village Rd)	06	5,071.45	1,491.46
02030103010040	Loantaka Brook	06	3,238.15	747.78
02030103010050	Great Brook (below Green Village Rd)	06	3,296.08	2,444.40
02030103010060	Black Brook (Great Swamp NWR)	06	9,089.77	1,529.36
02030103010070	Passaic R Upr (Dead R to Osborn Mills)	06	5,694.00	2,861.92
02030103010080	Dead River (above Harrisons Brook)	06	4,864.65	3,093.24
02030103010090	Harrisons Brook	06	3,485.21	926.99
02030103010100	Dead River (below Harrisons Brook)	06	4,949.85	947.99
02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	06	4,278.68	0.08
02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	06	3,417.36	110.69
02030103020010	Whippany R (above road at 74d 33m)	06	3,875.69	1,440.69
02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	06	4,015.26	1,728.47
02030103020030	Greystone / Watnong Mtn tribs	06	4,972.41	971.21
02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	06	3,594.46	1,256.22
02030103020050	Whippany R (Malapardis to Lk Pocahontas)	06	4,305.74	904.20
02030103020060	Malapardis Brook	06	3,256.36	878.54
02030103020070	Black Brook (Hanover)	06	6,644.31	926.28
02030103020080	Troy Brook (above Reynolds Ave)	06	6,439.19	1,961.01
02030103020090	Troy Brook (below Reynolds Ave)	06	3,870.59	2,677.65
02030103020100	Whippany R (Rockaway R to Malapardis Bk)	06	3,594.69	786.68
02030103030010	Russia Brook (above Milton)	06	5,478.66	3,022.98
02030103030020	Russia Brook (below Milton)	06	3,099.37	1,577.29
02030103030030	Rockaway R (above Longwood Lake outlet)	06	4,288.83	1,996.21
02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	06	5,100.62	2,601.75
02030103030050	Green Pond Brook (above Burnt Meadow Bk)	06	4,721.31	2,997.35
02030103030060	Green Pond Brook (below Burnt Meadow Bk)	06	5,055.75	2,722.33
02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	06	5,825.17	2,449.12
02030103030080	Mill Brook (Morris Co)	06	3,130.27	1,335.98
02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	06	4,692.53	952.11
02030103030100	Hibernia Brook	06	5,074.74	2,734.05
02030103030110	Beaver Brook (Morris County)	06	9,453.21	5,489.80
02030103030120	Den Brook	06	5,769.40	1,751.47
02030103030130	Stony Brook (Boonton)	06	7,864.43	4,640.08
02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	06	3,382.24	1,999.39
02030103030150	Rockaway R (Boonton dam to Stony Brook)	06	4,417.55	2,295.28
02030103030160	Montville tribs.	06	5,065.54	2,281.52
02030103030170	Rockaway R (Passaic R to Boonton dam)	06	5,138.44	1,784.09
02030103040010	Passaic R Upr (Pompton R to Pine Bk)	06	7,602.04	911.36
02030103050010	Pequannock R (above Stockholm/Vernon Rd)	03	3,464.16	2,317.27
02030103050020	Pacock Brook	03	4,590.79	3,032.19
02030103050030	Pequannock R (above OakRidge Res outlet)	03	6,710.17	4,249.40
02030103050040	Clinton Reservior/Mossmans Brook	03	8,486.56	5,201.87
02030103050050	Pequannock R (Charlotteburg to OakRidge)	03	11,761.05	6,152.34
02030103050060	Pequannock R(Macopin gage to Charl'brg)	03	5,047.69	2,931.86
02030103050070	Stone House Brook	03	4,677.03	2,186.88
02030103050080	Pequannock R (below Macopin gage)	03	10,835.76	5,223.61
02030103070010	Belcher Creek (above Pinecliff Lake)	03	3,480.08	1,996.01
02030103070020	Belcher Creek (Pinecliff Lake & below)	03	5,782.36	3,327.01
02030103070030	Wanaque R/Greenwood Lk(aboveMonks gage)	03	9,360.28	4,914.44
02030103070040	West Brook/Burnt Meadow Brook	03	7,569.99	4,492.17
02030103070050	Wanaque Reservior (below Monks gage)	03	13,749.41	8,031.90
02030103070060	Meadow Brook/High Mountain Brook	03	3,837.47	1,785.32
02030103070070	Wanaque R/Posts Bk (below reservior)	03	6,915.88	3,729.46
02030103100010	Ramapo R (above 74d 11m 00s)	03	3,720.96	1,845.16
02030103100020	Masonicus Brook	03	2,783.22	274.88
02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	03	4,305.47	1,937.24
02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	03	3,018.09	1,470.92
02030103100050	Ramapo R (Crystal Lk br to BearSwamp Bk)	03	4,041.21	1,991.80

Table A-4. Highlands Open Waters Protection Area By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Protection Area
02030103100060	Crystal Lake/Pond Brook	03	5,509.00	615.22
02030103100070	Ramapo R (below Crystal Lake bridge)	03	7,224.00	1,762.19
02030103110010	Lincoln Park tribs (Pompton River)	03	8,394.39	2,916.73
02030103110020	Pompton River	03	6,963.19	520.63
02030103140010	Hohokus Bk (above Godwin Ave)	04	3,394.92	327.88
02030103140020	Hohokus Bk(Pennington Ave to Godwin Ave)	04	6,001.09	234.82
02030103140040	Saddle River (above Rt 17)	04	8,729.99	66.78
02030105010010	Drakes Brook (above Eyland Ave)	08	5,935.72	2,351.15
02030105010020	Drakes Brook (below Eyland Ave)	08	4,684.13	2,319.06
02030105010030	Raritan River SB(above Rt 46)	08	3,218.56	1,769.51
02030105010040	Raritan River SB(74d 44m 15s to Rt 46)	08	4,264.73	1,953.72
02030105010050	Raritan R SB(LongValley br to 74d44m15s)	08	9,766.20	4,993.52
02030105010060	Raritan R SB(Califon br to Long Valley)	08	9,530.62	4,215.39
02030105010070	Raritan R SB(StoneMill gage to Califon)	08	5,050.33	1,696.69
02030105010080	Raritan R SB(Spruce Run-StoneMill gage)	08	2,961.24	1,098.41
02030105020010	Spruce Run (above Glen Gardner)	08	7,868.14	3,236.31
02030105020020	Spruce Run (Reservior to Glen Gardner)	08	2,056.53	629.61
02030105020030	Mulhockaway Creek	08	9,413.78	4,163.19
02030105020040	Spruce Run Reservior / Willoughby Brook	08	7,808.14	3,704.17
02030105020050	Beaver Brook (Clinton)	08	4,437.97	1,865.92
02030105020060	Cakepoulin Creek	08	9,105.34	1,179.03
02030105020070	Raritan R SB(River Rd to Spruce Run)	08	5,262.95	1,998.81
02030105020080	Raritan R SB(Prescott Bk to River Rd)	08	4,720.69	1,360.04
02030105020090	Prescott Brook / Round Valley Reservior	08	7,218.25	4,421.95
02030105040020	Pleasant Run	08	6,919.04	
02030105040030	Holland Brook	08	7,965.60	0.21
02030105050010	Lamington R (above Rt 10)	08	4,014.95	1,806.28
02030105050020	Lamington R (Hillside Rd to Rt 10)	08	7,065.70	3,887.83
02030105050030	Lamington R (Furnace Rd to Hillside Rd)	08	3,843.04	1,983.66
02030105050040	Lamington R(Pottersville gage-FurnaceRd)	08	5,702.56	2,520.49
02030105050050	Pottersville trib (Lamington River)	08	3,147.93	1,205.43
02030105050060	Cold Brook	08	3,988.01	1,398.50
02030105050070	Lamington R(HallsBrRd-Pottersville gage)	08	8,948.04	3,666.17
02030105050080	Rockaway Ck (above McCrea Mills)	08	10,840.33	3,988.83
02030105050090	Rockaway Ck (RockawaySB to McCrea Mills)	08	3,262.54	612.19
02030105050100	Rockaway Ck SB	08	7,910.01	2,074.89
02030105050110	Lamington R (below Halls Bridge Rd)	08	4,833.29	737.36
02030105060010	Raritan R NB (above/incl India Bk)	08	4,282.20	1,974.12
02030105060020	Burnett Brook (above Old Mill Rd)	08	4,253.69	1,586.42
02030105060030	Raritan R NB(incl McVickers to India Bk)	08	4,897.15	1,772.81
02030105060040	Raritan R NB(Peapack Bk to McVickers Bk)	08	4,804.73	1,861.01
02030105060050	Peapack Brook (above/incl Gladstone Bk)	08	4,228.28	1,453.27
02030105060060	Peapack Brook (below Gladstone Brook)	08	3,247.97	1,158.21
02030105060070	Raritan R NB(incl Mine Bk to Peapack Bk)	08	5,380.10	1,283.87
02030105060080	Middle Brook (NB Raritan River)	08	4,279.21	1,960.21
02030105060090	Raritan R NB (Lamington R to Mine Bk)	08	5,562.47	2,813.59
02030105070010	Raritan R NB (Rt 28 to Lamington R)	08	5,967.47	767.59
02030105120050	Middle Brook EB	09	6,131.20	111.09
02030105120060	Middle Brook WB	09	4,188.04	410.60
02040105040040	Lafayette Swamp tribs	01	3,530.47	21.31
02040105040050	Sparta Junction tribs	01	8,620.85	3,434.00
02040105040060	Paulins Kill (above Rt 15)	01	8,851.12	7.70
02040105050010	Paulins Kill (Blairstown to Stillwater)	01	12,136.81	1,970.66
02040105060020	Delawanna Creek (incl UDRV)	01	7,861.74	643.69
02040105070010	Lake Lenape trib	01	3,436.28	526.99
02040105070020	New Wawayanda Lake/Andover Pond trib	01	7,347.31	803.30
02040105070030	Pequest River (above Brighton)	01	8,611.28	1,436.76
02040105070040	Pequest River (Trout Brook to Brighton)	01	5,523.92	2,208.95
02040105070050	Trout Brook/Lake Tranquility	01	6,032.98	2,885.88
02040105070060	Pequest R (below Bear Swamp to Trout Bk)	01	4,033.60	2,823.92
02040105080010	Bear Brook (Sussex/Warren Co)	01	4,816.15	1,319.19
02040105080020	Bear Creek	01	6,912.71	4,063.48
02040105090010	Pequest R (Drag Strip--below Bear Swamp)	01	6,079.08	3,723.80
02040105090020	Pequest R (Cemetary Road to Drag Strip)	01	4,891.06	2,381.05
02040105090030	Pequest R (Furnace Bk to Cemetary Road)	01	5,270.06	1,553.37
02040105090040	Mountain Lake Brook	01	3,874.30	1,678.62
02040105090050	Furnace Brook	01	4,939.04	2,096.99
02040105090060	Pequest R (below Furnace Brook)	01	5,294.86	1,145.69
02040105100010	Union Church trib	01	5,325.10	2,277.88
02040105100020	Honey Run	01	6,601.74	2,112.58
02040105100030	Beaver Brook (above Hope Village)	01	5,750.44	2,342.75
02040105100040	Beaver Brook (below Hope Village)	01	5,802.77	2,049.44
02040105110010	Pophandusing Brook	01	3,598.89	953.78
02040105110020	Buckhorn Creek (incl UDRV)	01	9,430.25	2,424.83
02040105110030	UDRV tribs (Rt 22 to Buckhorn Ck)	01	5,039.73	771.56
02040105120010	Lopatcong Creek (above Rt 57)	01	4,963.90	1,241.05

Table A-4. Highlands Open Waters Protection Area By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Protection Area
02040105120020	Lopatcong Creek (below Rt 57) incl UDRV	01	7,680.89	1,417.31
02040105140010	Pohatcong Creek (above Rt 31)	01	6,455.37	2,840.46
02040105140020	Pohatcong Ck (Brass Castle Ck to Rt 31)	01	7,999.11	2,697.24
02040105140030	Pohatcong Ck (Edison Rd-Brass Castle Ck)	01	6,893.10	2,560.24
02040105140040	Merrill Creek	01	3,604.05	1,712.64
02040105140050	Pohatcong Ck (Merrill Ck to Edison Rd)	01	4,453.41	1,368.08
02040105140060	Pohatcong Ck (Springtown to Merrill Ck)	01	4,053.88	1,126.32
02040105140070	Pohatcong Ck(below Springtown) incl UDRV	01	3,752.62	817.18
02040105150010	Weldon Brook/Beaver Brook	01	4,124.24	2,432.06
02040105150020	Lake Hopatcong	01	12,091.50	6,635.61
02040105150030	Musconetcong R (Wills Bk to LkHopatcong)	01	3,586.05	1,555.42
02040105150040	Lubbers Run (above/incl Dallis Pond)	01	5,123.13	2,983.94
02040105150050	Lubbers Run (below Dallis Pond)	01	6,445.85	3,325.47
02040105150060	Cranberry Lake / Jefferson Lake & tribs	01	3,357.11	1,915.44
02040105150070	Musconetcong R(Waterloo to/incl WillsBk)	01	4,451.71	2,638.67
02040105150080	Musconetcong R (SaxtonFalls to Waterloo)	01	4,954.31	2,572.98
02040105150090	Mine Brook (Morris Co)	01	3,171.95	1,153.06
02040105150100	Musconetcong R (Trout Bk to SaxtonFalls)	01	4,942.91	1,862.86
02040105160010	Musconetcong R (Hances Bk thru Trout Bk)	01	9,284.65	3,658.69
02040105160020	Musconetcong R (Changewater to HancesBk)	01	11,379.98	4,480.57
02040105160030	Musconetcong R (Rt 31 to Changewater)	01	4,974.57	1,351.04
02040105160040	Musconetcong R (75d 00m to Rt 31)	01	3,266.41	904.00
02040105160050	Musconetcong R (I-78 to 75d 00m)	01	9,280.75	3,040.69
02040105160060	Musconetcong R (Warren Glen to I-78)	01	4,331.27	1,042.73
02040105160070	Musconetcong R (below Warren Glen)	01	4,788.86	1,826.49
02040105170010	Holland Twp (Hakihokake to Musconetcong)	11	3,859.25	1,179.40
02040105170020	Hakihokake Creek	11	11,233.15	5,474.80
02040105170030	Harihokake Creek (and to Hakihokake Ck)	11	7,576.80	4,095.77
02040105170040	Nishisakawick Creek (above 40d 33m)	11	4,307.58	2,309.10
02040105170050	Nishisakawick Creek (below 40d 33m)	11	5,439.90	769.34
Totals			**1,043,331.06**	**398,695.94**

APPENDIX B

Extent of Riparian Area by HUC14 Subwatershed

Appendix B. Riparian Extent By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Riparian
02020007010010	Wallkill R/Lake Mohawk(above Sparta Sta)	02	7,341.86	3,348.08
02020007010020	Wallkill R (Ogdensburg to SpartaStation)	02	4,595.95	1,748.03
02020007010030	Franklin Pond Creek	02	4,589.24	2,112.04
02020007010040	Wallkill R(Hamburg SW Bdy to Ogdensburg)	02	9,032.92	2,856.13
02020007010050	Hardistonville tribs	02	3,504.13	1,158.09
02020007010060	Beaver Run	02	4,143.80	309.20
02020007010070	Wallkill R(Martins Rd to Hamburg SW Bdy)	02	5,845.96	1,447.57
02020007020070	Papakating Creek (below Pellettown)	02	8,498.43	0.03
02020007030010	Wallkill R(41d13m30s to Martins Road)	02	5,859.71	1,290.86
02020007030030	Wallkill River(Owens gage to 41d13m30s)	02	3,324.69	1,188.89
02020007030040	Wallkill River(stateline to Owens gage)	02	4,103.80	1,357.33
02020007040010	Black Ck(above/incl G.Gorge Resort trib)	02	3,467.01	1,026.26
02020007040020	Black Creek (below G. Gorge Resort trib)	02	9,574.86	3,643.05
02020007040030	Pochuck Ck/Glenwood Lk & northern trib	02	3,570.78	1,459.39
02020007040040	Highland Lake/Wawayanda Lake	02	3,954.14	2,107.38
02020007040050	Wawayanda Creek & tribs	02	9,181.46	3,661.64
02020007040060	Long House Creek/Upper Greenwood Lake	02	5,025.98	2,520.28
02030103010010	Passaic R Upr (above Osborn Mills)	06	6,486.32	2,479.10
02030103010020	Primrose Brook	06	3,354.25	1,221.18
02030103010030	Great Brook (above Green Village Rd)	06	5,071.45	2,373.79
02030103010040	Loantaka Brook	06	3,238.15	1,030.32
02030103010050	Great Brook (below Green Village Rd)	06	3,296.08	2,364.39
02030103010060	Black Brook (Great Swamp NWR)	06	9,089.77	1,531.29
02030103010070	Passaic R Upr (Dead R to Osborn Mills)	06	5,694.00	2,973.57
02030103010080	Dead River (above Harrisons Brook)	06	4,864.65	3,150.58
02030103010090	Harrisons Brook	06	3,485.21	1,618.00
02030103010100	Dead River (below Harrisons Brook)	06	4,949.85	959.06
02030103010110	Passaic R Upr (Plainfield Rd to Dead R)	06	4,278.68	0.08
02030103010180	Passaic R Upr (Pine Bk br to Rockaway)	06	3,417.36	179.79
02030103020010	Whippany R (above road at 74d 33m)	06	3,875.69	1,201.43
02030103020020	Whippany R (Wash. Valley Rd to 74d 33m)	06	4,015.26	1,516.49
02030103020030	Greystone / Watnong Mtn tribs	06	4,972.41	1,671.22
02030103020040	Whippany R(Lk Pocahontas to Wash Val Rd)	06	3,594.46	1,309.46
02030103020050	Whippany R (Malapardis to Lk Pocahontas)	06	4,305.74	1,223.39
02030103020060	Malapardis Brook	06	3,256.36	1,542.94
02030103020070	Black Brook (Hanover)	06	6,644.31	1,545.07
02030103020080	Troy Brook (above Reynolds Ave)	06	6,439.19	3,248.11
02030103020090	Troy Brook (below Reynolds Ave)	06	3,870.59	3,134.31
02030103020100	Whippany R (Rockaway R to Malapardis Bk)	06	3,594.69	1,253.89
02030103030010	Russia Brook (above Milton)	06	5,478.66	2,035.70
02030103030020	Russia Brook (below Milton)	06	3,099.37	1,399.97
02030103030030	Rockaway R (above Longwood Lake outlet)	06	4,288.83	1,660.58
02030103030040	Rockaway R (Stephens Bk to Longwood Lk)	06	5,100.62	2,014.41
02030103030050	Green Pond Brook (above Burnt Meadow Bk)	06	4,721.31	2,634.59
02030103030060	Green Pond Brook (below Burnt Meadow Bk)	06	5,055.75	1,900.37
02030103030070	Rockaway R (74d 33m 30s to Stephens Bk)	06	5,825.17	1,884.61
02030103030080	Mill Brook (Morris Co)	06	3,130.27	1,210.63
02030103030090	Rockaway R (BM 534 brdg to 74d 33m 30s)	06	4,692.53	1,502.55
02030103030100	Hibernia Brook	06	5,074.74	1,990.26
02030103030110	Beaver Brook (Morris County)	06	9,453.21	4,647.14
02030103030120	Den Brook	06	5,769.40	2,421.08
02030103030130	Stony Brook (Boonton)	06	7,864.43	3,849.02
02030103030140	Rockaway R (Stony Brook to BM 534 brdg)	06	3,382.24	1,865.73
02030103030150	Rockaway R (Boonton dam to Stony Brook)	06	4,417.55	2,168.76
02030103030160	Montville tribs.	06	5,065.54	2,633.05
02030103030170	Rockaway R (Passaic R to Boonton dam)	06	5,138.44	3,075.27
02030103040010	Passaic R Upr (Pompton R to Pine Bk)	06	7,602.04	1,056.77
02030103050010	Pequannock R (above Stockholm/Vernon Rd)	03	3,464.16	1,353.95
02030103050020	Pacock Brook	03	4,590.79	2,114.69
02030103050030	Pequannock R (above OakRidge Res outlet)	03	6,710.17	2,939.79
02030103050040	Clinton Reservior/Mossmans Brook	03	8,486.56	4,056.17
02030103050050	Pequannock R (Charlotteburg to OakRidge)	03	11,761.05	5,209.31
02030103050060	Pequannock R(Macopin gage to Charl'brg)	03	5,047.69	2,588.57
02030103050070	Stone House Brook	03	4,677.03	2,071.50
02030103050080	Pequannock R (below Macopin gage)	03	10,835.76	4,723.89
02030103070010	Belcher Creek (above Pinecliff Lake)	03	3,480.08	1,496.45
02030103070020	Belcher Creek (Pinecliff Lake & below)	03	5,782.36	2,432.98
02030103070030	Wanaque R/Greenwood Lk(aboveMonks gage)	03	9,360.28	4,349.35
02030103070040	West Brook/Burnt Meadow Brook	03	7,569.99	3,210.96
02030103070050	Wanaque Reservior (below Monks gage)	03	13,749.41	7,407.37
02030103070060	Meadow Brook/High Mountain Brook	03	3,837.47	1,608.44
02030103070070	Wanaque R/Posts Bk (below reservior)	03	6,915.88	3,432.10
02030103100010	Ramapo R (above 74d 11m 00s)	03	3,720.96	1,529.50
02030103100020	Masonicus Brook	03	2,783.22	610.87
02030103100030	Ramapo R (above Fyke Bk to 74d 11m 00s)	03	4,305.47	1,622.34
02030103100040	Ramapo R (Bear Swamp Bk thru Fyke Bk)	03	3,018.09	900.88
02030103100050	Ramapo R (Crystal Lk br to BearSwamp Bk)	03	4,041.21	1,544.48

Appendix B. Riparian Extent By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Riparian
02030103100060	Crystal Lake/Pond Brook	03	5,509.00	578.58
02030103100070	Ramapo R (below Crystal Lake bridge)	03	7,224.00	1,863.14
02030103110010	Lincoln Park tribs (Pompton River)	03	8,394.39	3,170.43
02030103110020	Pompton River	03	6,963.19	1,058.80
02030103140010	Hohokus Bk (above Godwin Ave)	04	3,394.92	468.00
02030103140020	Hohokus Bk(Pennington Ave to Godwin Ave)	04	6,001.09	450.56
02030103140040	Saddle River (above Rt 17)	04	8,729.99	100.71
02030105010010	Drakes Brook (above Eyland Ave)	08	5,935.72	2,063.13
02030105010020	Drakes Brook (below Eyland Ave)	08	4,684.13	2,977.71
02030105010030	Raritan River SB(above Rt 46)	08	3,218.56	1,713.62
02030105010040	Raritan River SB(74d 44m 15s to Rt 46)	08	4,264.73	2,708.47
02030105010050	Raritan R SB(LongValley br to 74d44m15s)	08	9,766.20	6,018.65
02030105010060	Raritan R SB(Califon br to Long Valley)	08	9,530.62	4,113.23
02030105010070	Raritan R SB(StoneMill gage to Califon)	08	5,050.33	1,717.24
02030105010080	Raritan R SB(Spruce Run-StoneMill gage)	08	2,961.24	1,197.14
02030105020010	Spruce Run (above Glen Gardner)	08	7,868.14	3,064.37
02030105020020	Spruce Run (Reservior to Glen Gardner)	08	2,056.53	595.69
02030105020030	Mulhockaway Creek	08	9,413.78	4,039.58
02030105020040	Spruce Run Reservior / Willoughby Brook	08	7,808.14	3,535.62
02030105020050	Beaver Brook (Clinton)	08	4,437.97	1,967.11
02030105020060	Cakepoulin Creek	08	9,105.34	1,215.45
02030105020070	Raritan R SB(River Rd to Spruce Run)	08	5,262.95	1,985.74
02030105020080	Raritan R SB(Prescott Bk to River Rd)	08	4,720.69	1,259.49
02030105020090	Prescott Brook / Round Valley Reservior	08	7,218.25	4,060.64
02030105040020	Pleasant Run	08	6,919.04	
02030105040030	Holland Brook	08	7,965.60	1,530.17
02030105050010	Lamington R (above Rt 10)	08	4,014.95	3,332.48
02030105050020	Lamington R (Hillside Rd to Rt 10)	08	7,065.70	1,964.92
02030105050030	Lamington R (Furnace Rd to Hillside Rd)	08	3,843.04	2,560.33
02030105050040	Lamington R(Pottersville gage-FurnaceRd)	08	5,702.56	1,473.52
02030105050050	Pottersville trib (Lamington River)	08	3,147.93	1,622.95
02030105050060	Cold Brook	08	3,988.01	4,278.66
02030105050070	Lamington R(HallsBrRd-Pottersville gage)	08	8,948.04	4,257.97
02030105050080	Rockaway Ck (above McCrea Mills)	08	10,840.33	647.38
02030105050090	Rockaway Ck (RockawaySB to McCrea Mills)	08	3,262.54	2,191.37
02030105050100	Rockaway Ck SB	08	7,910.01	981.65
02030105050110	Lamington R (below Halls Bridge Rd)	08	4,833.29	1,726.41
02030105060010	Raritan R NB (above/incl India Bk)	08	4,282.20	1,591.07
02030105060020	Burnett Brook (above Old Mill Rd)	08	4,253.69	1,777.20
02030105060030	Raritan R NB(incl McVickers to India Bk)	08	4,897.15	1,870.25
02030105060040	Raritan R NB(Peapack Bk to McVickers Bk)	08	4,804.73	1,838.44
02030105060050	Peapack Brook (above/incl Gladstone Bk)	08	4,228.28	1,251.08
02030105060060	Peapack Brook (below Gladstone Brook)	08	3,247.97	2,113.73
02030105060070	Raritan R NB(incl Mine Bk to Peapack Bk)	08	5,380.10	2,047.88
02030105060080	Middle Brook (NB Raritan River)	08	4,279.21	3,730.33
02030105060090	Raritan R NB (Lamington R to Mine Bk)	08	5,562.47	1,432.58
02030105070010	Raritan R NB (Rt 28 to Lamington R)	08	5,967.47	93.21
02030105120050	Middle Brook EB	09	6,131.20	408.30
02030105120060	Middle Brook WB	09	4,188.04	10.03
02040105040040	Lafayette Swamp tribs	01	3,530.47	1,647.52
02040105040050	Sparta Junction tribs	01	8,620.85	
02040105040060	Paulins Kill (above Rt 15)	01	8,851.12	1,307.18
02040105050010	Paulins Kill (Blairstown to Stillwater)	01	12,136.81	1,021.20
02040105060020	Delawanna Creek (incl UDRV)	01	7,861.74	260.83
02040105070010	Lake Lenape trib	01	3,436.28	539.60
02040105070020	New Wawayanda Lake/Andover Pond trib	01	7,347.31	890.74
02040105070030	Pequest River (above Brighton)	01	8,611.28	1,479.56
02040105070040	Pequest River (Trout Brook to Brighton)	01	5,523.92	2,405.40
02040105070050	Trout Brook/Lake Tranquility	01	6,032.98	2,538.78
02040105070060	Pequest R (below Bear Swamp to Trout Bk)	01	4,033.60	787.00
02040105080010	Bear Brook (Sussex/Warren Co)	01	4,816.15	2,995.73
02040105080020	Bear Creek	01	6,912.71	3,242.90
02040105090010	Pequest R (Drag Strip--below Bear Swamp)	01	6,079.08	1,861.45
02040105090020	Pequest R (Cemetary Road to Drag Strip)	01	4,891.06	1,012.02
02040105090030	Pequest R (Furnace Bk to Cemetary Road)	01	5,270.06	1,376.66
02040105090040	Mountain Lake Brook	01	3,874.30	1,777.20
02040105090050	Furnace Brook	01	4,939.04	1,971.63
02040105090060	Pequest R (below Furnace Brook)	01	5,294.86	1,543.43
02040105100010	Union Church trib	01	5,325.10	1,525.02
02040105100020	Honey Run	01	6,601.74	1,555.24
02040105100030	Beaver Brook (above Hope Village)	01	5,750.44	1,758.41
02040105100040	Beaver Brook (below Hope Village)	01	5,802.77	1,772.76
02040105110010	Pophandusing Brook	01	3,598.89	4,033.88
02040105110020	Buckhorn Creek (incl UDRV)	01	9,430.25	1,952.68
02040105110030	UDRV tribs (Rt 22 to Buckhorn Ck)	01	5,039.73	1,183.88
02040105120010	Lopatcong Creek (above Rt 57)	01	4,963.90	1,777.95

Appendix B. Riparian Extent By HUC14 Subwatershed

HUC14	Subwatershed Name	WMA	Total Acres	Total Riparian
02040105120020	Lopatcong Creek (below Rt 57) incl UDRV	01	7,680.89	2,490.83
02040105140010	Pohatcong Creek (above Rt 31)	01	6,455.37	2,505.84
02040105140020	Pohatcong Ck (Brass Castle Ck to Rt 31)	01	7,999.11	2,224.78
02040105140030	Pohatcong Ck (Edison Rd-Brass Castle Ck)	01	6,893.10	1,703.02
02040105140040	Merrill Creek	01	3,604.05	1,266.54
02040105140050	Pohatcong Ck (Merrill Ck to Edison Rd)	01	4,453.41	1,180.76
02040105140060	Pohatcong Ck (Springtown to Merrill Ck)	01	4,053.88	825.44
02040105140070	Pohatcong Ck(below Springtown) incl UDRV	01	3,752.62	1,922.93
02040105150010	Weldon Brook/Beaver Brook	01	4,124.24	6,299.62
02040105150020	Lake Hopatcong	01	12,091.50	1,332.77
02040105150030	Musconetcong R (Wills Bk to LkHopatcong)	01	3,586.05	2,101.35
02040105150040	Lubbers Run (above/incl Dallis Pond)	01	5,123.13	2,625.42
02040105150050	Lubbers Run (below Dallis Pond)	01	6,445.85	1,435.86
02040105150060	Cranberry Lake / Jefferson Lake & tribs	01	3,357.11	2,299.01
02040105150070	Musconetcong R(Waterloo to/incl WillsBk)	01	4,451.71	2,229.65
02040105150080	Musconetcong R (SaxtonFalls to Waterloo)	01	4,954.31	1,438.12
02040105150090	Mine Brook (Morris Co)	01	3,171.95	1,499.14
02040105150100	Musconetcong R (Trout Bk to SaxtonFalls)	01	4,942.91	3,817.99
02040105160010	Musconetcong R (Hances Bk thru Trout Bk)	01	9,284.65	4,320.01
02040105160020	Musconetcong R (Changewater to HancesBk)	01	11,379.98	1,191.61
02040105160030	Musconetcong R (Rt 31 to Changewater)	01	4,974.57	624.86
02040105160040	Musconetcong R (75d 00m to Rt 31)	01	3,266.41	2,893.64
02040105160050	Musconetcong R (I-78 to 75d 00m)	01	9,280.75	818.17
02040105160060	Musconetcong R (Warren Glen to I-78)	01	4,331.27	1,276.95
02040105160070	Musconetcong R (below Warren Glen)	01	4,788.86	1,604.62
02040105170010	Holland Twp (Hakihokake to Musconetcong)	11	3,859.25	4,090.02
02040105170020	Hakihokake Creek	11	11,233.15	4,122.06
02040105170030	Harihokake Creek (and to Hakihokake Ck)	11	7,576.80	2,364.01
02040105170040	Nishisakawick Creek (above 40d 33m)	11	4,307.58	654.79
02040105170050	Nishisakawick Creek (below 40d 33m)	11	5,439.90	39.16
Totals			**1,043,331.06**	**367,988.48**

APPENDIX C

Alternative Method for Identification and Delineation of Highlands Forest

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL
PROPOSED ALTERNATE METHOD FOR IDENFIFYING
UPLAND FOREST AREAS IN THE HIGHLANDS

(a) "Upland forested area" means a biological community that is a "forest" as described in items (b) through (d) below.

(b) An upland forest area shall be determined in accordance with the following method:

1. The applicant shall identify, on a site plan submitted to the Department, all forest in existence on the lot as of August 10, 2004 as well as those forest areas that have subsequently developed through regeneration.

2. The limit of the forest shall be identified using aerial photographs available from the Department free of charge at www.state.nj.us/dep/gis/.

3. If the aerial photograph contains areas of sporadic coverage that have not been identified as forest by the applicant, the applicant shall lay a one-half acre grid system over the photograph. A standard 142 $ft.^2$ grid block shall be used. Any grid block containing 33% or greater forest cover shall be included as forest for the purposes of this section, unless the applicant demonstrates otherwise using the procedure established in (c) below.

4. If an applicant has an approved forest management plan identifying forest on a site, the limit of the forest may be submitted as an additional resource, but shall not be used in lieu of aerial photographs.

(c) If the Department identifies forest areas on a lot that have not been so identified by the applicant, the Department shall require an applicant to apply the following method:

1. Select two 25-foot by 25-foot plots in every acre of the site suspected of being a forest.

    i. The plots shall be located in the portion of each acre with the highest density of trees as determined by a visual inspection.

    ii. If the tree size and density are very uniform over some or all of the site, one plot may be selected in the area of uniformity. However the point total from the one plot shall be doubled to determine the total point value.

2. In each plot, measure the diameter of each tree at four and one-half feet above ground (dbh).

3. Score each tree as follows:

Diameter of tree	Points
One to three inches	2
>Three to seven inches	4
>Seven to twelve inches	6
>Twelve inches	8

4. Add together the scores for all of the trees in both plots.

5. If the total score for both plots is equal to or greater than 16, the sampled acre is regulated as a forest under this section. For example, if the two 25-foot by 25-foot plots contain a total of three trees which are two inches in diameter, two trees which are six inches in diameter, and one tree which is 15 inches in diameter, the score for the sampled acre would be: (3x2) + (2x4) + (1x8) = 22, and the sampled acre is considered a forest.

6. If a sampled acre is a forest, the Department shall assume that a half-acre of ground surrounding all sides of the sampled acre is also forest except for the surrounding areas that are sampled by the applicant and score under 16. In that case, a sufficient number of plots in the surrounding area shall be sampled by the applicant to delineate the forest portion of the surrounding area.

7. The applicant shall submit to the Department the results of field sampling data provided in (c)1 through 6 above. The outer perimeter of all sample plots shall be flagged in the field and their locations shown on a plan.

8. For a newly planted or regenerating forest, an area shall be considered forest if there are 408 tree species seedlings or saplings per sampled acre: that is the total number of seedlings or saplings in the two sample plots is 12 or more. For the purposes of this section, a tree will be considered a seedling or sapling if it is has a caliper of less than one-inch.

9. Orchards, Christmas tree farms, nurseries, and other similar horticultural uses, acceptable to the Department, that are established shall not be regulated as forest under this section.

(d) The limit of the forest shall be the outermost edge of the canopy of the forest area identified in (b) through (c) above.

HIGHLANDS WATER PROTECTION AND PLANNING COUNCIL
BASIS FOR PROPOSED ALTERNATE METHOD FOR IDENTIFYING UPLAND FORESTED AREAS IN THE HIGHLANDS

Pursuant to the Highlands Water Protection and Planning Act, N.J.S.A. 13:20-1 et seq. ("Highlands Act"), the New Jersey Department of Environmental Protection ("NJDEP") has adopted the Highlands Water Protection and Planning Act Rules at N.J.A.C. 7:38. The rules at N.J.A.C. 7:38-3.9(b) provide a methodology to identify upland forested areas using a 16-point system to define upland forest areas. In addition, the rules at N.J.A.C. 7:38-3.9(e) enable NJDEP to identify as an upland forest area any other area so identified by the Highlands Council, using an alternate method of identification, after notice, public comment and consultation with the State Forester.

The Highlands Council has worked with NJDEP and the New Jersey State Forester to develop an alternate methodology to define upland forest areas. The alternate methodology is intended to further augment and refine the existing 16-point system for forests in the Highlands Region. This document provides the basis for the Highlands Council's proposed alternate methodology.

The proposed alternate methodology sets forth a multi-step process to verify the presence of upland forest areas by means of aerial photograph interpretation and on-site field verification. This process may also be applied to identify forested wetlands.

Step 1 - Aerial photograph interpretation: The use of a half-acre grid system overlain on an aerial photograph is a method consistent with the "New Jersey No Net Loss Reforestation Act" (N.J.S.A. 13:1L-14.1 et seq.) guidelines. Step 1 assumes that any grid block containing 33% or greater upland forest cover shall be included as an upland forest. This requirement is consistent with the New Jersey No Net Loss Reforestation Act guidelines that recognize the presence of forest in the same manner.

Step 2 - Field verification: The field method requires the establishment of two 25-foot by 25-foot plots in areas exhibiting the highest density of trees as determined by visual inspection. Field trials conducted by the Highlands Council and NJ State Forester found this requirement to be necessary since sample plots selectively located in "non-representative or sparsely vegetated" areas yielded inaccurate results.

A new category for trees one to three inches in diameter is included in the proposed alternate methodology. Without this size group, areas of forest regeneration in the Highlands Region would not be identified as forest. Young trees having a diameter at breast height (dbh) of four inches or less are categorized as an emerging forest in the New Jersey No Net Loss Reforestation Act guidelines.

The alternate methodology proposed herein is based on a 30% stocking rate calculated by the number of trees by diameter class using USFS FI data (refer to Table 5b

contained in the 2003 US Forest Service Inventory and Analysis National Core Field Guide, Volume 1: Field Data Collection Procedures for Phase 2 Plots, Version 20).[1] The tree diameter groupings have been changed to provide different ranges of tree size and to change the total number of points for each diameter category in order to achieve a 30% level of stocking (and determine the number of trees per acre according to diameter). The USFI program provides an overall analysis of tree size statewide and the percentage of such trees per acre in New Jersey's forests. The data generated for maples and oaks was used for this evaluation since these trees are representative Highlands Area forest species. Based upon this data, it was deemed necessary to adjust both the grouping of diameter categories and the point assignments for each size class in order to accurately capture trees that typically represent forests in New Jersey with the understanding that the point system would be subject to verification through field trials. The revised diameter groupings and point assignments for each class is upon data from the following sources:

Richard H. Widman. May 2005. *Forests of the Garden State*. USDA Forest Service Northeast Research Station Bulletin NE163.

Griffith, Douglas M. and Richard H. Widman. July 2001. *Forest Statistics for New Jersey 1987 and 1999.* USDA Forest Service Northeast Research Station Bulletin NE152.

USDA Forest Service. 2003. *US Forest Service Inventory and Analysis National Core Field Guide*, Volume 1: Field Data Collection Procedures for Phase 2 Plots, Version 20).

The alternate methodology requires that the scores from both 25 x 25 foot plots sampled within each acre be totaled to derive the final point value. This method is consistent with the Forest Service method which requires that the point values from both plots that were sampled within an acre of proposed forest be totaled.

Highlands Council staff and the New Jersey State Forester conducted a series of field trials on various age classes of upland forests on June 28, 2005 to test the new methodology and validated the revised approach. It was concluded that the revised approach inclusively identifies forest areas.

A representative Highlands upland forest was chosen as the study area for conducting field trials. The age class and species composition varied somewhat, as did the percent of canopy closure, corresponding understory and groundcover density. Typical forest canopy associates included white ash (*Fraxinus americana*), white oak (*Quercus alba*), black oak (*Q. velutina*), American beech (*Fagus grandifolia*), yellow birch (*Betula lutea*) and black birch (*B. lenta*). Catalpa (*Catalpa speciosa*) was abundant at one location.

[1] The USFS FI data is based on 10% stocking. The values were multiplied by 3 to yield a 30% stocking rate and equivalent number of stems/acre.

Six 25-foot by 25-foot sample plots were established within a variety of forest age classes. Four sample plots (SP#1, SP2, SP#3 and SP#4) were located in areas exhibiting the highest density of trees as determined by visual inspection. Two sample plots (SP#5A and SP#5B) were established in "non-representative/sparsely vegetated" areas to determine whether improper application of the approach would result in a non-forest determination.

In each sample plot, the diameter of every tree species at 4.5 feet above ground (dbh) and corresponding point value were recorded on a data sheet.

Tree dbh (inches)	Points
One to three	2
>Three to seven	4
>Seven to twelve	6
>Twelve	8

The results of the field trials validated the alternate approach and adequately identified Highlands upland forest areas. The State Forester and Highlands Council staff concluded that the alternate method is inclusive and protective of the resource provided the method is correctly implemented. Although the alternate methodology is inclined to provide higher point value totals for younger forests, it adequately captures the more mature forests.

The alternate methodology requires that the scores from both sample plots in each acre be totaled to derive the final point value. This requirement was found to be necessary in mature forest stands containing fewer (but larger) species. As an example, assume that the first of two sample plots located in an acre of mature forest contains two trees (6 points and 8 points respectively), yielding a score of 14. The point value derived from the first sample plot is not sufficient to qualify the acre as a forest since it falls short of 16 points. In order for the acre to qualify as a forest, the points derived from the first and second sample plots must be combined.

The alternate methodology requires that sample plots be located in areas exhibiting the highest density of trees as determined by visual inspection and the sample plots must be identified in the field and shown on a plan. We intentionally misapplied the alternate methodology to determine if the results would be skewed. Two sample plots (SP #5A and SP #5B) were established in a "non-representative and sparsely vegetated" area of a mature forest stand to determine whether the misapplication of sample plot selection would yield a nonforest determination. We found that by shifting the boundary of the plots to a sparsely wooded area, a score of less than 16 indicating a non-forest condition could be achieved. A gradual shift of the plot boundary would have included several additional mature species thereby yielding a score in excess of 16 and qualifying the area as a forest. Therefore, the provision requiring that the boundaries of the sample plot be field marked and located on the plan for subsequent review and inspection has been included in the methodology.

A**PPENDIX A**
DATA SHEETS

Field Trial Data Sheet

Sample Plot: SP #1
Date: June 28, 2005
Recorder: LBS
Score: 34
Findings: Forest

Tree Diameter (inches)	***Points***
4.8	4
5.7	4
6.5	4
6.2	4
19.9	8
4.1	4
7.6	6
	Total points 34

Notes:
Canopy species white ash, white oak, black birch. One plot was selected since it was obvious that a second plot would yield a similar score. One plot alone exceeded 16 points. Two plots would have (obviously) scored in excess of 16.

Field Trial Data Sheet

Sample Plot: SP #2
Date: June 28, 2005
Recorder: LBS
Score: 24
Findings: Forest (by doubling)

Tree Diameter (inches)	***Points***
7.2	6
9	6
	Total points 12

Notes:
Catalpa dominated canopy. Widely spaced trees with lush groundcover. Doubling this plot (which is permitted provided the forest is uniform) will yield a score greater than 16 which qualifies the area as forest.

Field Trial Data Sheet

Sample Plot: SP #3
Date: June 28, 2005
Recorder: LBS
Score: 58
Findings: Forest

Tree Diameter (inches)	***Points***
4.1	4
2.1	2
1.1	2
1.3	2
2.2	2
2.2	2
2.2	2
3.1	4
3.1	4
10.9	6
3.5	4
3.4	4
6	6
5.1	4
4.4	4
5.5	4
3.9	4
	Total points 58

Notes:
Canopy species many young yellow birch and a few black oak. One plot was selected since it was obvious that a second plot would yield a similar score. One plot alone exceeded 16 points. Two plots would have (obviously) scored in excess of 16.

Field Trial Data Sheet

Sample Plot: SP #4
Date: June 28, 2005
Recorder: LBS
Score: 48
Findings: Forest

Tree Diameter (inches)	***Points***
2.2	2
4.3	4
7.5	6
2.3	2
1.6	2
5.7	4
2.2	2
1.2	2
4.7	4
5.4	4
7.2	6
1.1	2
5.9	4
3	2
1.5	2
	Total points 48

Notes:
Canopy species – black birch, American beech and blackgum.

Field Trial Data Sheet

Sample Plot: SP #5A
Date: June 28, 2005
Recorder: LBS
Score: 8 single plot (14 combined double plot)
Findings: Nonforest (even when combined with 5B – see notes)

Tree Diameter (inches)	***Points***
13	8
	Total points 8

Notes:
The alternate methodology requires that the sample plots be located in an area exhibiting the highest density of trees as determined by visual inspection. Two sample plots (SP #5A and SP #5B) were established in "non representative/sparsely vegetated" areas to determine whether misapplication of the sample plot selection would yield inaccurate results.

Field Trial Data Sheet

Sample Plot: SP #5B
Date: June 28, 2005
Recorder: LBS
Score: 6 single plot (14 combined double plot)
Findings: Nonforest (even when combined with 5A see notes)

Tree Diameter (inches)	***Points***
9	6
	Total points 6

Notes:
The alternate methodology requires that the sample plots be located in an area exhibiting the highest density of trees as determined by visual inspection. Two sample plots (SP #5A and SP #5B) were established in "non representative/sparsely vegetated" areas to determine whether misapplication of the sample plot selection would yield inaccurate results.

APPENDIX D

List of Rare, Threatened and Endangered Animal Species in the NJ Highlands Region

Appendix D. List of Rare, Threatened, and Endangered Animal Species in the NJ Highlands Region

	GROUP	COMMON NAME	SCIENTIFIC NAME	Federal Listed	State Listed	Special Concern Rank	Landscape Rank	Highlands Rank
1	Amphibian	Jefferson Salamander	Ambystoma jeffersonianum		SC	S3	Special Concern (S3)	critically significant
2	Amphibian	Marbled Salamander	Ambystoma opacum		SC	S3	Special Concern (S3)	low significant
3	Amphibian	Spotted Salamander	Ambystoma maculatum		SC	S3	Special Concern (S3)	low significant
4	Amphibian	Blue-spotted Salamander	Ambystoma laterale		E		State Endangered	critically significant
5	Amphibian	Longtail Salamander	Eurycea longicauda longicauda		T		State Threatened	critically significant
6	Bird	Bald Eagle	Haliaeetus leucocephalus	Federally Listed			Federally Listed	low significant
7	Bird	American Kestrel	Falco sparverius		SC	S3	Special Concern (S3)	significant
8	Bird	Black-throated Green Warbler	Dendroica virens		SC	S3	Special Concern (S3)	critically significant
9	Bird	Canada Warbler	Wilsonia canadensis		SC	S3	Special Concern (S3)	critically significant
10	Bird	Cerulean Warbler	Dendroica cerulea		SC	S3	Special Concern (S3)	critically significant
11	Bird	Cliff Swallow	Petrochelidon pyrrhonota		SC	S3	Special Concern (S3)	low significant
12	Bird	Eastern Meadowlark	Sturnella magna		SC	S3	Special Concern (S3)	low significant
13	Bird	Golden-winged Warbler	Vermivora chrysoptera		SC	S3	Special Concern (S3)	critically significant
14	Bird	Great Blue Heron	Ardea herodias		SC	S3	Special Concern (S3)	low significant
15	Bird	Great Blue Heron Forage	Ardea herodias		SC	S3	Special Concern (S3)	low significant
16	Bird	King Rail	Rallus elegans		SC	S3	Special Concern (S3)	significant
17	Bird	Least Bittern	Ixobrychus exilis		SC	S3	Special Concern (S3)	low significant
18	Bird	Veery	Catharus fuscescens		SC	S3	Special Concern (S3)	significant
19	Bird	Winter Wren	Troglodytes troglodytes		SC	S3	Special Concern (S3)	critically significant
20	Bird	Worm-eating Warbler	Helmitheros vermivorus		SC	S3	Special Concern (S3)	critically significant
21	Bird	American Bittern	Botaurus lentiginosus		E		State Endangered	significant
22	Bird	Henslow's Sparrow	Ammodramus henslowii		E		State Endangered	significant
23	Bird	Migrant Loggerhead Shrike	Lanius ludovicianus migrans		E		State Endangered	significant
24	Bird	Northern Goshawk	Accipiter gentilis		E		State Endangered	critically significant
25	Bird	Northern Harrier	Circus cyaneus		E		State Endangered	low significant
26	Bird	Pied-billed Grebe	Podilymbus podiceps		E		State Endangered	low significant
27	Bird	Red-shouldered Hawk	Buteo lineatus		E		State Endangered	critically significant
28	Bird	Sedge Wren	Cistothorus platensis		E		State Endangered	significant
29	Bird	Upland Sandpiper	Bartramia longicauda		E		State Endangered	significant
30	Bird	Vesper Sparrow	Pooecetes gramineus		E		State Endangered	significant
31	Bird	Barred Owl	Strix varia		T		State Threatened	significant
32	Bird	Black Rail	Laterallus jamaicensis		T		State Threatened	low significant
33	Bird	Black-crowned Night-heron	Nycticorax nycticorax		T		State Threatened	low significant
34	Bird	Black-crowned Night-heron Forage	Nycticorax nycticorax		T		State Threatened	low significant
35	Bird	Bobolink	Dolichonyx oryzivorus		T		State Threatened	significant
36	Bird	Cooper's Hawk	Accipiter cooperii		T		State Threatened	low significant
37	Bird	Grasshopper Sparrow	Ammodramus savannarum		T		State Threatened	significant
38	Bird	Long-eared Owl	Asio otus		T		State Threatened	significant
39	Bird	Osprey	Pandion haliaetus		T		State Threatened	low significant
40	Bird	Red-headed Woodpecker	Melanerpes erythrocephalus		T		State Threatened	significant
41	Bird	Savannah Sparrow	Passerculus sandwichensis		T		State Threatened	significant
42	Bird	Yellow-crowned Night-heron	Nyctanassa violacea		T		State Threatened	low significant
43	Bird	Yellow-crowned Night-heron Forage	Nyctanassa violacea		T		State Threatened	low significant
44	Lepidoptera	Arogos Skipper	Atrytone arogos arogos		E		State Endangered	significant
45	Lepidoptera	A Silver-bordered Fritillary	Boloria selene myrina		T		State Threatened	low significant
46	Mammal	Indiana Bat	Myotis sodalis	Federally Listed			Federally Listed	critically significant
47	Mammal	Eastern Small-footed Myotis	Myotis leibii		SC	S3	Special Concern (S3)	critically significant
48	Mammal	Bobcat	Lynx rufus		E		State Endangered	critically significant
49	Mussel	Dwarf Wedgemussel	Alasmidonta heterodon	Federally Listed			Federally Listed	critically significant
50	Mussel	Creeper	Strophitus undulatus		SC	S3	Special Concern (S3)	low significant
51	Mussel	Brook Floater	Alasmidonta varicosa		E		State Endangered	significant
52	Mussel	Eastern Lampmussel	Lampsilis radiata		T		State Threatened	significant
53	Mussel	Eastern Pondmussel	Ligumia nasuta		T		State Threatened	significant
54	Mussel	Triangle Floater	Alasmidonta undulata		T		State Threatened	low significant
55	Mussel	Yellow Lampmussel	Lampsilis cariosa		T		State Threatened	significant
56	Odonate	Arrowhead Spiketail	Cordulegaster obliqua		SC	S3	Special Concern (S3)	critically significant
57	Odonate	Brook Snaketail	Ophiogomphus aspersus		SC	S3	Special Concern (S3)	critically significant
58	Odonate	Brush-tipped Emerald	Somatochlora walshii		SC	S3	Special Concern (S3)	critically significant
59	Odonate	Harpoon Clubtail	Gomphus descriptus		SC	S3	Special Concern (S3)	significant
60	Odonate	Kennedy's Emerald	Somatochlora kennedyi		SC	S3	Special Concern (S3)	critically significant
61	Odonate	Maine Snaketail	Ophiogomphus mainensis		SC	S3	Special Concern (S3)	critically significant
62	Odonate	Midland Clubtail	Gomphus fraternus		SC	S3	Special Concern (S3)	critically significant
63	Odonate	New England Bluet	Enallagma laterale		SC	S3	Special Concern (S3)	critically significant
64	Odonate	Rapids Clubtail	Gomphus quadricolor		SC	S3	Special Concern (S3)	significant
65	Odonate	Sable Clubtail	Gomphus rogersi		SC	S3	Special Concern (S3)	critically significant
66	Odonate	Ski-tailed Emerald	Somatochlora elongata		SC	S3	Special Concern (S3)	critically significant
67	Odonate	Spatterdock Darner	Rhionaeschna mutata		SC	S3	Special Concern (S3)	critically significant
68	Odonate	Tiger Spiketail	Cordulegaster erronea		SC	S3	Special Concern (S3)	critically significant
69	Odonate	Williamson's Emerald	Somatochlora williamsoni		SC	S3	Special Concern (S3)	critically significant
70	Odonate	Zebra Clubtail	Stylurus scudderi		SC	S3	Special Concern (S3)	critically significant
71	Reptile	Bog Turtle	Clemmys muhlenbergii	Federally Listed			Federally Listed	critically significant
72	Reptile	Eastern Box Turtle	Terrapene carolina carolina		SC	S3	Special Concern (S3)	low significant
73	Reptile	Northern Copperhead Snake	Agkistrodon contortrix mokasen		SC	S3	Special Concern (S3)	critically significant
74	Reptile	Timber Rattlesnake	Crotalus horridus horridus		E		State Endangered	critically significant
75	Reptile	Wood Turtle	Glyptemys insculpta		T		State Threatened	critically significant

APPENDIX E

List of Rare and Endangered Plant Species in the NJ Highlands Region

APPENDIX E

List of Rare and Endangered Plant Species in the NJ Highlands Region

	SPECIES	COMMON NAME	State Listed	Heritage State Rank
1	Sphagnum contortum	Sphagnum	E	S1
2	Alisma triviale	Large Water-plantain	E	S1
3	Andromeda glaucophylla	Bog Rosemary	E	S1
4	Aster borealis	Rush Aster	E	S1
5	Bidens beckii	Water-marigold	E	S1
6	Bouteloua curtipendula	Side-oats Grama Grass	E	S1
7	Carex brunnescens	Round-spike Brownish Sedge	E	S1
8	Carex bushii	Bush's Sedge	E	S1
9	Carex deweyana	Dewey's Sedge	E	S1
10	Carex haydenii	Cloud Sedge	E	S1
11	Carex leptonervia	Fine-nerve Sedge	E	S1
12	Carex lupuliformis	Hop-like Sedge	E	S1
13	Carex oligocarpa	Few-fruit Sedge	E	S1
14	Carex pseudocyperus	Cyperus-like Sedge	E	S1
15	Conioselinum chinense	Hemlock-parsley	E	S1
16	Cornus amomum var. schuetzeana	Pale Dogwood	E	S1
17	Crataegus calpodendron	Pear Hawthorn	E	S1
18	Crataegus succulenta	Fleshy Hawthorn	E	S1
19	Cuscuta cephalanthi	Buttonbush Dodder	E	S1
20	Eleocharis pauciflora	Few-flower Spike-rush	E	S1
21	Elymus trachycaulus	Slender Wheatgrass	E	S1
22	Equisetum variegatum	Variegated Horsetail	E	S1
23	Galium labradoricum	Labrador Marsh Bedstraw	E	S1
24	Galium trifidum	Small Bedstraw	E	S1
25	Gaultheria hispidula	Creeping-snowberry	E	S1
26	Hemicarpha micrantha	Small-flower Halfchaff Sedge	E	S1
27	Hieracium kalmii	Canada Hawkweed	E	S1
28	Hottonia inflata	Featherfoil	E	S1
29	Hybanthus concolor	Green Violet	E	S1
30	Hydrophyllum canadense	Broad-leaf Waterleaf	E	S1
31	Ilex montana	Large-leaf Holly	E	S1
32	Isanthus brachiatus	False Pennyroyal	E	S1
33	Kalmia polifolia	Pale-laurel	E	S1
34	Lechea tenuifolia	Narrow-leaf Pinweed	E	S1
35	Lonicera canadensis	American Fly-honeysuckle	E	S1
36	Melanthium virginicum	Virginia Bunchflower	E	S1
37	Muhlenbergia capillaris	Long-awn Smoke Grass	E	S1
38	Oryzopsis asperifolia	White-grained Mountain-rice Grass	E	S1
39	Panicum flexile	Wiry Panic Grass	E	S1
40	Potamogeton obtusifolius	Blunt-leaf Pondweed	E	S1
41	Potamogeton praelongus	White-stem Pondweed	E	S1
42	Pycnanthemum clinopodioides	Basil Mountain-mint	E	S1
43	Pycnanthemum torrei	Torrey's Mountain-mint	E	S1
44	Ranunculus fascicularis	Early Buttercup	E	S1
45	Rhynchospora capillacea	Capillary Beaked-rush	E	S1
46	Sagittaria cuneata	Arum-leaf Arrowhead	E	S1

APPENDIX E

List of Rare and Endangered Plant Species in the NJ Highlands Region

	SPECIES	COMMON NAME	State Listed	Heritage State Rank
47	Salix pedicellaris	Bog Willow	E	S1
48	Smilacina trifolia	Three-leaf False Solomon's-seal	E	S1
49	Sparganium minimum	Small Burr-reed	E	S1
50	Sporobolus neglectus	Small Rush-grass	E	S1
51	Stellaria borealis	Boreal Starwort	E	S1
52	Streptopus roseus	Rosy Twisted-stalk	E	S1
53	Tiarella cordifolia	Foamflower	E	S1
54	Utricularia minor	Lesser Bladderwort	E	S1
55	Viburnum alnifolium	Witch-hobble	E	S1
56	Viola septentrionalis	Northern Blue Violet	E	S1
57	Potamogeton robbinsii	Robbin's Pondweed	E	S2
58	Helonias bullata	Swamp-pink	E	S3
59	Carex disperma	Soft-leaf Sedge		S1
60	Torreyochloa pallida var. fernaldii	Fernald's False Manna Grass		S1
61	Adlumia fungosa	Climbing Fumitory		S2
62	Agastache nepetoides	Yellow Giant-hyssop		S2
63	Agrimonia microcarpa	Small-fruit Grooveburr		S2
64	Alopecurus aequalis var. aequalis	Short-awn Meadow-foxtail		S2
65	Angelica venenosa	Hairy Angelica		S2
66	Arabis hirsuta var. pycnocarpa	Western Hairy Rockcress		S2
67	Asclepias verticillata	Whorled Milkweed		S2
68	Asplenium montanum	Mountain Spleenwort		S2
69	Betula pumila var. pumila	Swamp Birch		S2
70	Boltonia asteroides var. asteroides	Aster-like Boltonia		S2
71	Botrychium oneidense	Blunt-lobe Grape Fern		S2
72	Bromus kalmii	Kalm's Brome		S2
73	Cardamine douglassii	Purple Bittercress		S2
74	Carex bicknellii var. bicknellii	Bicknell's Sedge		S2
75	Carex diandra	Lesser Panicled Sedge		S2
76	Carex eburnea	Ebony Sedge		S2
77	Carex hitchcockiana	Hitchcock's Sedge		S2
78	Carex prairea	Prairie Sedge		S2
79	Carex retrorsa	Retrorse Sedge		S2
80	Carex sterilis	Dioecious Sedge		S2
81	Carex viridula ssp. viridula	Green Sedge		S2
82	Castilleja coccinea	Scarlet Indian-paintbrush		S2
83	Celtis tenuifolia	Dwarf Hackberry		S2
84	Cheilanthes lanosa	Hairy Lipfern		S2
85	Chenopodium simplex	Maple-leaf Goosefoot		S2
86	Clematis occidentalis var. occidentalis	Purple Clematis		S2
87	Cuscuta polygonorum	Smartweed Dodder		S2
88	Dirca palustris	Leatherwood		S2
89	Doellingeria infirma	Cornel-leaf Aster		S2
90	Elatine minima	Small Waterwort		S2
91	Eleocharis quadrangulata	Angled Spike-rush		S2
92	Epilobium leptophyllum	Bog Willowherb		S2
93	Epilobium strictum	Downy Willowherb		S2
94	Gentianella quinquefolia var.	Stiff Gentian		S2
95	Geum vernum	Spring Avens		S2
96	Gymnocarpium dryopteris	Oak Fern		S2
97	Lechea intermedia var. intermedia	Large-pod Pinweed		S2
98	Lycopodiella inundata	Northern Bog Club-moss		S2

APPENDIX E

List of Rare and Endangered Plant Species in the NJ Highlands Region

	SPECIES	COMMON NAME	State Listed	Heritage State Rank
99	Mimulus moschatus var. moschatus	Muskflower		S2
100	Muhlenbergia glomerata	Eastern Smoke Grass		S2
101	Obolaria virginica	Virginia Pennywort		S2
102	Phegopteris connectilis	Northern Beech Fern		S2
103	Porteranthus trifoliatus	Indian Physic		S2
104	Ranunculus longirostris	Long-beak Water Buttercup		S2
105	Ranunculus micranthus	Rock Buttercup		S2
106	Ranunculus trichophyllus var.	Thread-leaf Water Buttercup		S2
107	Salix candida	Hoary Willow		S2
108	Salix serissima	Autumn Willow		S2
109	Scutellaria nervosa	Veined Skullcap		S2
110	Selaginella rupestris	Rock Spike-moss		S2
111	Sporobolus compositus var. compositus	Long-leaf Rush-grass		S2
112	Vaccinium oxycoccos	Small Cranberry		S2
113	Aristolochia serpentaria	Virginia Snakeroot		S3
114	Cardamine pratensis var. palustris	Meadow Cuckoo-flower		S3
115	Carex buxbaumii	Brown Sedge		S3
116	Carex frankii	Frank's Sedge		S3
117	Carex typhina	Cat-tail Sedge		S3
118	Chamaelirium luteum	Devil's-bit		S3
119	Hypericum pyramidatum	Great St. John's-wort		S3
120	Juncus brachycephalus	Fen Rush		S3
121	Lemna trisulca	Star Duckweed		S3
122	Lilium philadelphicum var.	Wood Lily		S3
123	Lysimachia thyrsiflora	Tufted Loosestrife		S3
124	Mimulus alatus	Winged Monkey-flower		S3
125	Nymphoides cordata	Floatingheart		S3
126	Pedicularis lanceolata	Swamp Lousewort		S3
127	Potentilla arguta var. arguta	Tall Cinquefoil		S3
128	Quercus muehlenbergii	Yellow Oak		S3
129	Ranunculus flabellaris	Yellow Water Buttercup		S3
130	Schoenoplectus acutus var. acutus	Hard-stem Bulrush		S3
131	Silene caroliniana var. pensylvanica	Wild-pink		S3
132	Sparganium chlorocarpum	Green-fruited Bur-reed		S3
133	Triadenum fraseri	Fraser's St. John's-wort		S3
134	Utricularia gibba	Humped Bladderwort		S3
135	Utricularia intermedia	Flat-leaf Bladderwort		S3
136	Utricularia purpurea	Purple Bladderwort		S3
137	Viburnum opulus var. americanum	Highbush-cranberry		S3

E = Endangered

S1 = Critically imperiled in New Jersey because of extreme rarity

S2 = Imperiled in New Jersey because of rarity

S3 = Rare in New Jersey

APPENDIX F

Significant Natural Areas in the NJ Highlands Region

Site ID	Site Name	Significant Natural Area	Common Name	Scientific Name	Global Rank	State Rank	State Endangered
1	Ogdensburg Meadow	Species Occurance	Swamp Birch	Betula pumila var. pumila	G5TNR	S2	NO
1	Ogdensburg Meadow	Species Occurance	Brown Sedge	Carex buxbaumii	G5	S3	NO
1	Ogdensburg Meadow	Species Occurance	Dioecious Sedge	Carex sterilis	G4	S2	NO
1	Ogdensburg Meadow	Species Occurance	Fen Rush	Juncus brachycephalus	G5	S3	NO
1	Ogdensburg Meadow	Species Occurance	Indian Physic	Porteranthus trifoliatus	G4G5	S2	NO
1	Ogdensburg Meadow	Species Occurance	Highbush-cranberry	Viburnum opulus var. americanum	G5T5	S3	NO
1	Ogdensburg Meadow	Species Occurance	Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A
1	Ogdensburg Meadow	Ecological Communities	Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A
2	Johnsonburg	Species Occurance	White-grained Mountain-rice Grass	Oryzopsis asperifolia	G5	S1	YES
2	Johnsonburg	Species Occurance	Lesser Bladderwort	Utricularia minor	G5	S1	YES
2	Johnsonburg	Species Occurance	Small Fruit Groovburr	Agrimonia microcarpa	G5	S2	NO
2	Johnsonburg	Species Occurance	Ebony Sedge	Carex eburnea	G5	S2	NO
2	Johnsonburg	Ecological Communities	Dyr-mesic Calcareous Forest	Dyr-mesic Calcareous Forest	G3G4?	S2?	No
2	Johnsonburg	Ecological Communities	Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A
3	Waywanda Swamp						

SITE ID: 1
SITE NAME: OGDENSBURG MEADOW

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Swamp Birch	Betula pumila var. pumila	G5TNR	S2	NO
Brown Sedge	Carex buxbaumii	G5	S3	NO
Dioecious Sedge	Carex sterilis	G4	S2	NO
Fen Rush	Juncus brachycephalus	G5	S3	NO
Indian Physic	Porteranthus trifoliatus	G4G5	S2	NO
Highbush-cranberry	Viburnum opulus var. americanum	G5T5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 2
SITE NAME: JOHNSONBURG

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
White-grained Mountain-rice Grass	Oryzopsis asperifolia	G5	S1	YES
Lesser Bladderwort	Utricularia minor	G5	S1	YES
Small-fruit Grooveburr	Agrimonia microcarpa	G5	S2	NO
Ebony Sedge	Carex eburnea	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Dry-mesic Calcareous	Dry-mesic calcareous forest	G3G4?	S2?	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **3**
SITE NAME: **WAYWAYANDA SWAMP**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Atlantic White-cedar / Great Rhododendron Swamp	Chamaecyparis thyoides / Rhododendron maximum Forest	G2G3	S1	NO

SITE ID: 4
SITE NAME: GREENDELL MARSH

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
White-grained Mountain-rice Grass	Oryzopsis asperifolia	G5	S1	YES
Arum-leaf Arrowhead	Sagittaria cuneata	G5	S1	YES
Short-awn Meadow-foxtail	Alopecurus aequalis var. aequalis	G5TNR	S2	NO
Virginia Snakeroot	Aristolochia serpentaria	G4	S3	NO
Aster-like Boltonia	Boltonia asteroides var. asteroides	G5T4T5	S2	NO
Green Sedge	Carex viridula ssp. viridula	G5T5	S2	NO
Devil's-bit	Chamaelirium luteum	G5	S3	NO
Angled Spike-rush	Eleocharis quadrangulata	G4	S2	NO
Yellow Water Buttercup	Ranunculus flabellaris	G5	S3	NO
Hard-stem Bulrush	Schoenoplectus acutus var. acutus	G5	S3	NO
Green-fruited Bur-reed	Sparganium chlorocarpum	G5	S3	NO

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Aster-like Boltonia - Small-headed Aster - Field Mint Herbaceous Vegetation	Boltonia asteroides var. asteroides - aster racemosus - mentha arvensis herbaceous vegetation	G1G2	S1S2	NO
Dry-mesic Calcareous Forest	Dry-mesic calcareous forest	G3G4?	S2?	NO

SITE ID: **5**

SITE NAME: **WOODRUFFS GAP**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Capillary Beaked-rush	Rhynchospora capillacea	G4G5	S1	YES
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **6**

SITE NAME: **OGDENSBURG GLADES**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Small Bedstraw	Galium trifidum	G5T5	S1	YES
Western Hairy Rockcress	Arabis hirsuta var. pycnocarpa	G5T5	S2	NO
Whorled Milkweed	Asclepias verticillata	G5	S2	NO
Swamp Birch	Betula pumila var. pumila	G5TNR	S2	NO
Bicknell's Sedge	Carex bicknellii var. bicknellii	G5T5	S2	NO
Dwarf Hackberry	Celtis tenuifolia	G5	S2	NO
Purple Clematis	Clematis occidentalis var. occidentalis	G5T5	S2	NO
Hoary Willow	Salix candida	G5	S2	NO
Autumn Willow	Salix serissima	G4	S2	NO
Humped Bladderwort	Utricularia gibba	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 7

SITE NAME: SPRINGDALE

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hop-like Sedge	Carex lupuliformis	G4	S1	YES
Arum-leaf Arrowhead	Sagittaria cuneata	G5	S1	YES
Bog Willow	Salix pedicellaris	G5	S1	YES
Lesser Bladderwort	Utricularia minor	G5	S1	YES
Short-awn Meadow-foxtail	Alopecurus aequalis var. aequalis	G5TNR	S2	NO
Aster-like Boltonia	Boltonia asteroides var. asteroides	G5T4T5	S2	NO
Bog Willowherb	Epilobium leptophyllum	G5	S2	NO
Downy Willowherb	Epilobium strictum	G5?	S2	NO
Spring Avens	Geum vernum	G5	S2	NO
Yellow Water Buttercup	Ranunculus flabellaris	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Dry-mesic Calcareous Forest	Dry-mesic calcareous forest	G3G4?	S2?	NO
Rich Red Maple - Black Ash Swamp	Fraxinus nigra - Acer rubrum – (Larix laricina)/Rhamnus alnifolia Forest	GNR	S1S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 8

SITE NAME: GLOVERS POND

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Few-flower Spike-rush	Eleocharis pauciflora	G5	S1	YES
Labrador Marsh Bedstraw	Galium labradoricum	G5	S1	YES
Small Bedstraw	Galium trifidum	G5T5	S1	YES
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **9**

SITE NAME: **MILFORD BLUFFS**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Green Violet	Hybanthus concolor	G5	S1	YES
Hairy Lipfern	Cheilanthes lanosa	G5	S2	NO

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Shale Cliff/rock Outcrop Community	Shale cliff/rock outcrop community	G3	S2?	NO

SITE ID: **10**

SITE NAME: **FRANKLIN MINE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Side-oats Grama Grass	Bouteloua curtipendula	G5T5	S1	YES
Early Buttercup	Ranunculus fascicularis	G5	S1	YES
Western Hairy Rockcress	Arabis hirsuta var. pycnocarpa	G5T5	S2	NO
Whorled Milkweed	Asclepias verticillata	G5	S2	NO
Dwarf Hackberry	Celtis tenuifolia	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 11

SITE NAME: STERLING MINE

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Side-oats Grama Grass	Bouteloua curtipendula	G5T5	S1	YES
Whorled Milkweed	Asclepias verticillata	G5	S2	NO
Devil's-bit	Chamaelirium luteum	G5	S3	NO
Purple Clematis	Clematis occidentalis var. occidentalis	G5T5	S2	NO
Long-leaf Rush-grass	Sporobolus compositus var. compositus	G5T5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 12

SITE NAME: GREAT PIECE MEADOWS

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Buttonbush Dodder	Cuscuta cephalanthi	G5	S1	YES
Cat-tail Sedge	Carex typhina	G5	S3	NO
Winged Monkey-flower	Mimulus alatus	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 13

SITE NAME: LAKE DENMARK

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Fine-nerve Sedge	Carex leptonervia	G4	S1	YES
Featherfoil	Hottonia inflata	G4	S1	YES
Robbin's Pondweed	Potamogeton robbinsii	G5	S2	YES
Small Burr-reed	Sparganium minimum	G5	S1	YES
Climbing Fumitory	Adlumia fungosa	G4	S2	NO
Wood Lily	Lilium philadelphicum var. philadelphicum	G5T4T5	S3	NO
Floatingheart	Nymphoides cordata	G5	S3	NO
Flat-leaf Bladderwort	Utricularia intermedia	G5	S3	NO
Purple Bladderwort	Utricularia purpurea	G5	S3	NO

SITE ID: **14**

SITE NAME: **GREEN POND MOUNTAIN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Featherfoil	Hottonia inflata	G4	S1	YES
Large-leaf Holly	Ilex montana	G5	S1	YES
Virginia Snakeroot	Aristolochia serpentaria	G4	S3	NO
Mountain Spleenwort	Asplenium montanum	G5	S2	NO
Purple Bittercress	Cardamine douglassii	G5	S2	NO
Soft-leaf Sedge	Carex disperma	G5	S1	NO
Tall Cinquefoil	Potentilla arguta var. arguta	G5TNR	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **15**

SITE NAME: **WAYWAYANDA LAKE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
White-stem Pondweed	Potamogeton praelongus	G5	S1	YES
Robbin's Pondweed	Potamogeton robbinsii	G5	S2	YES
Small Waterwort	Elatine minima	G5	S2	NO
Northern Bog Club-moss	Lycopodiella inundata	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **16**

SITE NAME: **Morris Lake Woods**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hop-like Sedge	Carex lupuliformis	G4	S1	YES
Rock Buttercup	Ranunculus micranthus	G5	S2	NO
Wild-pink	Silene caroliniana var. pensylvanica	G5T4	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **17**

SITE NAME: **Vernon Valley**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Cloud Sedge	Carex haydenii	G5	S1	YES
Green Violet	Hybanthus concolor	G5	S1	YES
Yellow Giant-hyssop	Agastache nepetoides	G5	S2	NO
Virginia Snakeroot	Aristolochia serpentaria	G4	S3	NO
Hitchcock's Sedge	Carex hitchcockiana	G5	S2	NO
Eastern Smoke Grass	Muhlenbergia glomerata	G5	S2	NO
Swamp Lousewort	Pedicularis lanceolata	G5	S3	NO
Yellow Oak	Quercus muehlenbergii	G5	S3	NO
Veined Skullcap	Scutellaria nervosa	G5	S2	NO

SITE ID: **18**

SITE NAME: **Black River Meadow**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Meadow Cuckoo-flower	Cardamine pratensis var. palustris	G5T5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **19**

SITE NAME: **Ironia**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Swamp-pink	Helonias bullata	G3	S3	YES
Three-leaf False Solomon's-seal	Smilacina trifolia	G5	S1	YES
Fraser's St. John's-wort	Triadenum fraseri	G4G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **20**

SITE NAME: **Cherry Ridge Ravine**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hemlock-parsley	Conioselinum chinense	G5	S1	YES
American Fly-honeysuckle	Lonicera canadensis	G5	S1	YES
Rosy Twisted-stalk	Streptopus roseus	G5T5?	S1	YES
Witch-hobble	Viburnum alnifolium	G5	S1	YES

SITE ID: **21**

SITE NAME: **Wolf Lake**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **22**

SITE NAME: **Perona Lake**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hemlock-parsley	Conioselinum chinense	G5	S1	YES
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **23**

SITE NAME: **High Rock Mountain**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **24**

SITE NAME: **Hell Mountain**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **25**

SITE NAME: **Hell Mountain**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Bog Rosemary	Andromeda glaucophylla	G5T5	S1	YES
Round-spike Brownish Sedge	Carex brunnescens	G5T5	S1	YES
Creeping-snowberry	Gaultheria hispidula	G5	S1	YES
Large-leaf Holly	Ilex montana	G5	S1	YES

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Black Spruce Woodland Bog	Picea mariana / (Vaccinium corymbosum, Gaylussacia baccata) / Sphagnum sp. Woodland	G3G5	S1	NO

SITE ID: **26**

SITE NAME: **Breakneck Mountain**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Dewey's Sedge	Carex deweyana	G5T5	S1	YES
American Fly-honeysuckle	Lonicera canadensis	G5	S1	YES
Climbing Fumitory	Adlumia fungosa	G4	S2	NO
Hitchcock's Sedge	Carex hitchcockiana	G5	S2	NO
Purple Clematis	Clematis occidentalis var. occidentalis	G5T5	S2	NO
Oak Fern	Gymnocarpium dryopteris	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **27**

SITE NAME: **Vinces Ravine**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **28**

SITE NAME: **Buckmire Pond**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Few-fruit Sedge	Carex oligocarpa	G4	S1	YES
Few-flower Spike-rush	Eleocharis pauciflora	G5	S1	YES
Wiry Panic Grass	Panicum flexile	G5	S1	YES
Capillary Beaked-rush	Rhynchospora capillacea	G4G5	S1	YES
Small Rush-grass	Sporobolus neglectus	G5	S1	YES
Climbing Fumitory	Adlumia fungosa	G4	S2	NO
Hitchcock's Sedge	Carex hitchcockiana	G5	S2	NO
Purple Clematis	Clematis occidentalis var. occidentalis	G5T5	S2	NO

SITE ID: **29**

SITE NAME: **Fyke Brook**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Sphagnum	Sphagnum contortum	G5	S1	YES

SITE ID: **30**

SITE NAME: **Sterling Hill**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hemlock-parsley	Conioselinum chinense	G5	S1	YES
Virginia Bunchflower	Melanthium virginicum	G5	S1	YES

SITE ID: **31**

SITE NAME: **Clinton Road**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Northern Blue Violet	Viola septentrionalis	G5	S1	YES

SITE ID: **32**

SITE NAME: **Bridge To Nowhere**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Meadow Cuckoo-flower	Cardamine pratensis var. palustris	G5T5	S3	NO
Leatherwood	Dirca palustris	G4	S2	NO
Star Duckweed	Lemna trisulca	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **33**

SITE NAME: **Green Pond Mountain North**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **34**

SITE NAME: **Pohatcong Mountain North**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **35**

SITE NAME: **Southtown Sinkhole**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Large Water-plantain	Alisma triviale	G5	S1	YES

SITE ID: **36**

SITE NAME: **Wrights Pond Bluffs**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Long-awn Smoke Grass	Muhlenbergia capillaris	G5TNR	S1	YES
Early Buttercup	Ranunculus fascicularis	G5	S1	YES

SITE ID: **37**
SITE NAME: **McAfee Quarry**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Cornel-leaf Aster	Doellingeria infirma	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **38**
SITE NAME: **Chester Railroad Site**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **39**
SITE NAME: **Ursus Majus Site**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **40**
SITE NAME: **JAVES ROAD SITE**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Bush's Sedge	Carex bushii	G4	S1	YES

SITE ID: **41**
SITE NAME: **HUTCHINSON**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Broad-leaf Waterleaf	Hydrophyllum canadense	G5	S1	YES

SITE ID: **42**

SITE NAME: **Splitrock Reservoir Site**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **43**

SITE NAME: **Buttermilk Bridge Site**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **44**

SITE NAME: **Sussex Mills**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Bog Willow	Salix pedicellaris	G5	S1	YES
Swamp Birch	Betula pumila var. pumila	G5TNR	S2	NO
Eastern Smoke Grass	Muhlenbergia glomerata	G5	S2	NO
Autumn Willow	Salix serissima	G4	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **45**

SITE NAME: **Sparta Pine Swamp**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Boreal Starwort	Stellaria borealis	G5T5	S1	YES
Northern Beech Fern	Phegopteris connectilis	G5	S2	NO
Fernald's False Manna Grass	Torreyochloa pallida var. fernaldii	G5?T4Q	S1	NO

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hemlock - Hardwood Swamp	Tsuga canadensis - Betula alleghaniensis / Ilex verticillata / Sphagnum spp. Forest	G5	S2	NO

SITE ID: **46**

SITE NAME: **Budd Lake Bog**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Swamp-pink	Helonias bullata	G3	S3	YES
Hairy Angelica	Angelica venenosa	G5	S2	NO

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Black Spruce Swamp	Black spruce swamp	G4	S1	NO

SITE ID: **47**

SITE NAME: **GREENDELL RIDGE**

SPECIES OCCURENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Aster-like Boltonia	Boltonia asteroides var. asteroides	G5T4T5	S2	NO
Hitchcock's Sedge	Carex hitchcockiana	G5	S2	NO
Retrorse Sedge	Carex retrorsa	G5	S2	NO
Yellow Oak	Quercus muehlenbergii	G5	S3	NO
Yellow Water Buttercup	Ranunculus flabellaris	G5	S3	NO

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Dry-mesic Calcareous Forest	Dry-mesic calcareous forest	G3G4?	S2?	NO
Yellow Water- crowfoot - Clearweed - Water Smartweed Herbaceous Vegetation	Ranunculus flabellaris - pilea pumila - polygonum amphibium herbaceous vegetation	G4	S3	NO

SITE ID: **48**

SITE NAME: **RAMAPO VALLEY**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Small-flower Halfchaff Sedge	Hemicarpha micrantha	G4	S1	YES
Cornel-leaf Aster	Doellingeria infirma	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **49**

SITE NAME: **SECOND CHANCE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Foamflower	Tiarella cordifolia	G5T5	S1	YES

SITE ID: **50**

SITE NAME: **HEATERS POND RIDGE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Slender Wheatgrass	Elymus trachycaulus	G5	S1	YES
Robbin's Pondweed	Potamogeton robbinsii	G5	S2	YES

SITE ID: **51**

SITE NAME: **MOUNTAIN LAKE BOG**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Bog Willow	Salix pedicellaris	G5	S1	YES
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Rich Red Maple – Black Ash Swamp	Fraxinus nigra - Acer rubrum – (Larix laricina)/Rhamnus alnifolia Forest	GNR	S1S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **52**

SITE NAME: **GREENDELL POWERLINE SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Kalm's Brome	Bromus kalmii	G5	S2	NO
Swamp Lousewort	Pedicularis lanceolata	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **53**

SITE NAME: **LINCOLN PARK GRAVEL PITS**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Variegated Horsetail	Equisetum variegatum	G5T5	S1	YES

SITE ID: **54**

SITE NAME: **NEW RUSSIA GRAVEL PIT SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Variegated Horsetail	Equisetum variegatum	G5T5	S1	YES
Northern Bog Club-moss	Lycopodiella inundata	G5	S2	NO

SITE ID: **55**

SITE NAME: **BELVIDERE RIVERSIDE SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Broad-leaf Waterleaf	Hydrophyllum canadense	G5	S1	S1
Spring Avens	Geum vernum	G5	S2	NO

SITE ID: **56**

SITE NAME: **WILDCAT RAVINE AND BOG**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Swamp Birch	Betula pumila var. pumila	G5TNR	S2	NO
Lesser Panicled Sedge	Carex diandra	G5	S2	NO
Prairie Sedge	Carex prairea	G5?	S2	NO
Tufted Loosestrife	Lysimachia thyrsiflora	G5	S3	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **57**

SITE NAME: **PHILLIPSBURG BLUFFS**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Side-oats Grama Grass	Bouteloua curtipendula	G5T5	S1	YES
False Pennyroyal	Isanthus brachiatus	G4G5	S1	YES

SITE ID: **58**

SITE NAME: **HARDISTONVILLE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **59**

SITE NAME: **PEQUEST**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Foamflower	Tiarella cordifolia	G5T5	S1	YES

SITE ID: **60**

SITE NAME: **RUDEVILLE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **61**

SITE NAME: **EDISON BOG**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Pale-laurel	Kalmia polifolia	G5	S1	YES
Large-pod Pinweed	Lechea intermedia var. intermedia	G5T4T5	S2	NO
Northern Beech Fern	Phegopteris connectilis	G5	S2	NO
Small Cranberry	Vaccinium oxycoccos	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **62**

SITE NAME: **LAKE GRINNELL BOG**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Pale-laurel	Kalmia polifolia	G5	S1	YES
Cornel-leaf Aster	Doellingeria infirma	G5	S2	NO
Stiff Gentian	Gentianella quinquefolia var. quinquefolia	G5T4T5	S2	NO
Indian Physic	Porteranthus trifoliatus	G4G5	S2	NO

SITE ID: **63**

SITE NAME: **SHERMANS GLEN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **64**

SITE NAME: **FIRST TIME FEN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Rush Aster	Aster borealis	G5	S1	YES
Cyperus-like Sedge	Carex pseudocyperus	G5	S1	YES
Brown Sedge	Carex buxbaumii	G5	S3	NO

SITE ID: **65**

SITE NAME: **MOUNT FREEDOM**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **66**

SITE NAME: **POMPTON RIVER GRAVEL BAR SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Small-flower Halfchaff Sedge	Hemicarpha micrantha	G4	S1	YES

SITE ID: **67**

SITE NAME: **SPARTA AVENUE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hemlock-parsley	Conioselinum chinense	G5	S1	YES

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **68**
SITE NAME: **WATERLOO**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **69**
SITE NAME: **LUSE POND**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Few-flower Spike-rush	Eleocharis pauciflora	G5	S1	YES

SITE ID: **70**
SITE NAME: **SPARTA STATION SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Purple Bittercress	Cardamine douglassii	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **71**
SITE NAME: **DILDINE ISLAND**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Pale Dogwood	Cornus amomum var. schuetzeana	G5T5	S1	YES
Smartweed Dodder	Cuscuta polygonorum	G5	S2	NO
Great St. John's-wort	Hypericum pyramidatum	G4	S3	NO
Muskflower	Mimulus moschatus var. moschatus	G4G5TNR	S2	NO

SITE ID: **72**
SITE NAME: **MOUNT HOPE BOG**

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Black Spruce Woodland Bog	Picea mariana / (Vaccinium corymbosum, Gaylussacia baccata) /Sphagnum sp. Woodland	G3G5	S1	NO

SITE ID: 73

SITE NAME: FRANKLIN YARD

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 74

SITE NAME: SEEMS LIKE A GOOD PLACE

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Narrow-leaf Pinweed	Lechea tenuifolia	G5	S1	YES

SITE ID: 75

SITE NAME: LUCK LOW SITE

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Fleshy Hawthorn	Crataegus succulenta	G5	S1	YES

SITE ID: 76

SITE NAME: BUDD LAKE OUTLET

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Blunt-leaf Pondweed	Potamogeton obtusifolius	G5	S1	YES
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: 77

SITE NAME: DANCING LEAVES SITE

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Broad-leaf Waterleaf	Hydrophyllum canadense	G5	S1	YES

SITE ID: **78**

SITE NAME: **FRANKLIN QUARRY**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Side-oats Grama Grass	Bouteloua curtipendula	G5T5	S1	YES
Early Buttercup	Ranunculus fascicularis	G5	S1	YES

SITE ID: **79**

SITE NAME: **HARMONY SHORE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Pear Hawthorn	Crataegus calpodendron	G5	S1	YES

SITE ID: **80**

SITE NAME: **MANUNKA CHUNK BLUFFS**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Hairy Lipfern	Cheilanthes lanosa	G5	S2	NO

SITE ID: **81**

SITE NAME: **GHOST LAKE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Long-beak Water Buttercup	Ranunculus longirostris	G5	S2	NO

SITE ID: **82**

SITE NAME: **LUBBERS RUN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Rock Buttercup	Ranunculus micranthus	G5	S2	NO
Data Sensitive	Data Sensitive	Data Sensitive	Data Sensitive	N/A

SITE ID: **83**

SITE NAME: **PLUCKEMIN OVERLOOK**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Cornel-leaf Aster	Doellingeria infirma	G5	S2	NO
Rock Spike-moss	Selaginella rupestris	G5	S2	NO

SITE ID: **84**

SITE NAME: **CUSHETUNK MOUNTAIN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Virginia Pennywort	Obolaria virginica	G5	S2	NO

SITE ID: **85**

SITE NAME: **SWAYZE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Angled Spike-rush	Eleocharis quadrangulata	G4	S2	NO

SITE ID: **86**

SITE NAME: **VALHALLA HEMLOCK GLEN**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Blunt-lobe Grape Fern	Botrychium oneidense	G4Q	S2	NO

SITE ID: **87**

SITE NAME: **PEQUANNOCK RIVER**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Thread-leaf Water Buttercup	Ranunculus trichophyllus var. trichophyllus	G5T5	S2	NO

SITE ID: **88**

SITE NAME: **ISABELS SITE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Virginia Pennywort	Obolaria virginica	G5	S2	NO

SITE ID: **89**

SITE NAME: **BARTLEY RAVINE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Oak Fern	Gymnocarpium dryopteris	G5	S2	NO

SITE ID: **90**

SITE NAME: **RIEGELSVILLE BLUFFS**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Maple-leaf Goosefoot	Chenopodium simplex	G5	S2	NO

SITE ID: **91**

SITE NAME: **FOUL RIFT**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Leatherwood	Dirca palustris	G4	S2	NO
Great St. John's-wort	Hypericum pyramidatum	G4	S3	NO

SITE ID: **92**

SITE NAME: **BURNT MILLS**

ECOLOGICAL COMMUNITIES:

COMMUNITY NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Floodplain Forest	Floodplain forest	G4	S3?	NO

SITE ID: **93**

SITE NAME: **PICATINNY LAKE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Floatingheart	Nymphoides cordata	G5	S3	NO
Purple Bladderwort	Utricularia purpurea	G5	S3	NO

SITE ID: **94**

SITE NAME: **STOCKHOLM SLOPE**

SPECIES OCCURRENCES:

COMMON NAME	SCIENTIFIC NAME	GLOBAL RANK	STATE RANK	STATE ENDANGERED
Fraser's St. John's-wort	Triadenum fraseri	G4G5	S3	NO

SITE ID: **95**

SITE NAME: **VERNOY**

SPECIES OCCURRENCES:

Frank's Sedge	Carex frankii	G5	S3	NO

F-2. Significant Natural Areas - Global and State Element Ranks

The Nature Conservancy and NatureServe have developed a ranking system for use in identifying elements of natural diversity (rare species and ecological communities) most endangered with extinction. Each element is ranked according to its global, national, and state rarity. These ranks are used to prioritize conservation work so that the most endangered elements receive attention first. Definitions for element ranks are after The Nature Conservancy. Natural Heritage Program Operations Manual (Arlington, VA, 1982: Chapter 4, 4.1-1 through 4.4.1-3).

Note: Not all GRANKS and SRANKS are used in any given edition of the Natural Heritage Priority Sites file.

GLOBAL ELEMENT RANK (GRANK)

G1 - Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.

G2 - Imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.

G3 - Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range; with the number of occurrences in the range of 21 to 100.

G4 - Apparently secure globally; although it may be quite rare in parts of its range, especially at the periphery.

G5 - Demonstrably secure globally; although it may be quite rare in parts of its range, especially at the periphery.

GH - Of historical occurrence throughout its range i.e., formerly part of the established biota, with the expectation that it may be rediscovered.

GU - Possibly in peril range wide but status uncertain; more information needed.

GX - Believed to be extinct throughout range (e.g., passenger pigeon) with virtually no likelihood that it will be rediscovered.

G? - Species has not yet been ranked.

GNR - Species has not yet been ranked.

STATE ELEMENT RANK (SRANK)

S1 - Critically imperiled in New Jersey because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres). Elements so ranked are often restricted to very specialized conditions or habitats and/or restricted to an extremely small geographical area of the state. Also included are elements which were formerly more abundant, but because of habitat destruction or some other critical factor of its biology, they have been demonstrably reduced in abundance. In essence, these are elements for which, even with intensive searching, sizable additional occurrences are unlikely to be discovered.

S2 - Imperiled in New Jersey because of rarity (6 to 20 occurrences). Historically many of these elements may have been more frequent but are now known from very few extant occurrences, primarily because of habitat destruction. Diligent searching may yield additional occurrences.

S3 - Rare in state with 21 to 100 occurrences (plant species and ecological communities in this category have only 21 to 50 occurrences). Includes elements which are widely distributed in the state but with small populations/acreage or elements with restricted distribution, but locally abun¬dant. Not yet imperiled in state but may soon be if current trends continue. Searching often yields additional occurrences.

S4 - Apparently secure in state, with many occurrences.

S5 - Demonstrably secure in state and essentially ineradicable under present conditions.

SA - Accidental in state, including species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range; a few of these species may even have bred on the one or two occasions they were recorded; examples include European strays or western birds on the East Coast and vice versa.

SE - Elements that are clearly exotic in New Jersey including those taxa not native to North America (introduced taxa) or taxa deliber¬ately or accidentally introduced into the State from other parts of North America (adventive taxa). Taxa ranked SE are not a conservation priority (viable introduced occurrences of G1 or G2 elements may be exceptions).

SH - Elements of historical occurrence in New Jersey. Despite some searching of historical occurrences and/or potential habitat, no extant occurrences are known. Since not all of the historical occurrences have been field surveyed, and unsearched potential habitat remains, historically ranked taxa are considered possibly extant, and remain a conservation priority for continued fieldwork.

SP - Element has potential to occur in New Jersey, but no occurrences have been reported.

SR - Elements reported from New Jersey, but without per¬suasive documentation which would provide a basis for either accepting or rejecting the report. In some instances documentation may exist, but as of yet, its source or location has not been determined.

SRF - Elements erroneously reported from New Jersey, but this error persists in the literature.

SU - Elements believed to be in peril but the degree of rarity uncertain. Also included are rare taxa of uncertain taxonomical standing. More information is needed to resolve rank.

SX - Elements that have been determined or are presumed to be extirpated from New Jersey. All historical occurrences have been searched and a reasonable search of potential habitat has been completed. Extirpated taxa are not a current conservation priority.

SXC - Elements presumed extirpated from New Jersey, but native populations collected from the wild exist in cultivation.

SZ - Not of practical conservation concern in New Jersey, because there are no definable occurrences, although the taxon is native and appears regularly in the state. An SZ rank will generally be used for long distance migrants whose occurrences during their migrations are too irregular (in terms of repeated visitation to the same locations), transitory, and dispersed to be reliably identified, mapped and protected. In other words, the migrant regularly passes through the state, but enduring, mappable element occurrences cannot be defined.

Typically, the SZ rank applies to a non-breeding population (N) in the state - for example, birds on migration. An SZ rank may in a few instances also apply to a breeding population (B), for example certain lepidoptera which regularly die out every year with no significant return migration.

Although the SZ rank typically applies to migrants, it should not be used indiscriminately. Just because a species is on migration does not mean it receives an SZ rank. SZ will only apply when the migrants occur in an irregular, transitory and dispersed manner.

B - Refers to the breeding population of the element in the state.

N - Refers to the non-breeding population of the element in the state.

T - Element ranks containing a "T" indicate that the infraspecific taxon is being ranked differently than the full species. For example Stachys palustris var. homotricha is ranked "G5T? SH" meaning the full species is globally secure but the global rarity of the var. homotricha has not been determined; in New Jersey the variety is ranked historic.

Q - Elements containing a "Q" in the global portion of its rank indicates that the taxon is of questionable, or uncertain taxonomical standing, e.g., some authors regard it as a full species, while others treat it at the subspecific level.

.1 - Elements documented from a single location.

Note: To express uncertainty, the most likely rank is assigned and a question mark added (e.g., G2?). A range is indicated by combining two ranks (e.g., G1G2, S1S3).

F-3. Global and State Biodiversity Significance Ranking

Each site is ranked according to its significance for biological diversity using a scale developed by The Nature Conservancy, the network of Natural Heritage Programs, and the New Jersey Natural Heritage Program. These ranks can be used to distinguish between sites that are of global significance for conservation of biodiversity vs. those that are of state significance. The global biodiversity significance ranks range from B1 to B5. The global biodiversity significance rank is then combined with a state biodiversity significance rank which provides information about the significance of the site on a state level. State biodiversity significance ranks range from V1 to V5.

GLOBAL BIODIVERSITY RANK

B1 - Outstanding significance on a global level, generally the "last of the least" in the world, such as the only known occurrence of any element (species or ecological community), the best or an excellent occurrence of an element ranked critically imperiled globally, or a concentration (4+) of good or excellent occurrences of elements that are imperiled or critically imperiled globally. The site should be viable and defensible for the elements or ecological processes contained.

B2 - Very high significance on a global level, such as the most outstanding occurrence of any ecological community. Also includes areas containing other occurrences of elements that are critically imperiled globally, a good or excellent occurrence of an element that is imperiled globally, an excellent occurrence of an element that is rare globally, or a concentration (4+) of good occurrences of globally rare elements or viable occurrences of globally imperiled elements.

B3 - High significance on a global level, such as any other viable occurrence of an element that is globally imperiled, a good occurrence of a globally rare element, an excellent occurrence of any ecological community, or a concentration (4+) of good or excellent occurrences of elements that are critically imperiled in the State.

B4 - Moderate significance on a global level, such as a viable occurrence of a globally rare element, a good occurrence of any ecological community, a good or excellent occurrence or

only viable state occurrence of an element that is critically imperiled in the State, an excellent occurrence of an element that is imperiled in the State, or a concentration (4+) of good occurrences of elements that are imperiled in the State or excellent occurrences of elements that are rare in the State.

B5 - Of general biodiversity interest on a global level.

STATE BIODIVERSITY RANK

V1 - Outstanding significance on a state level. Only known occurrence in the state for an element or Site with an excellent occurrence or the best occurrence in the state for an element ranked critically imperiled in the state or a concentration (4+) of good or excellent occurrences of elements that are imperiled or critically imperiled in the state.

V2 - Very high significance on a state level. Includes sites containing other occurrences of elements that are critically imperiled in the state or a concentration (4+) of other occurrences of state imperiled elements and/or good or excellent occurrences of state rare elements.

V3 - High significance on a state level. Includes sites containing the best occurrence in the state or an excellent occurrence of a state imperiled element or multiple (2+) other occurrences for state imperiled elements and/or excellent, good or moderate quality occurrences of state rare elements.

V4 - Moderate significance on a state level. Includes sites containing the best occurrence in the state or an excellent occurrence of a state rare element or any site with other occurrences of a state imperiled element or multiple (2+) other occurrences of state rare elements.

V5 - Any site with any other occurrence of a state rare element.