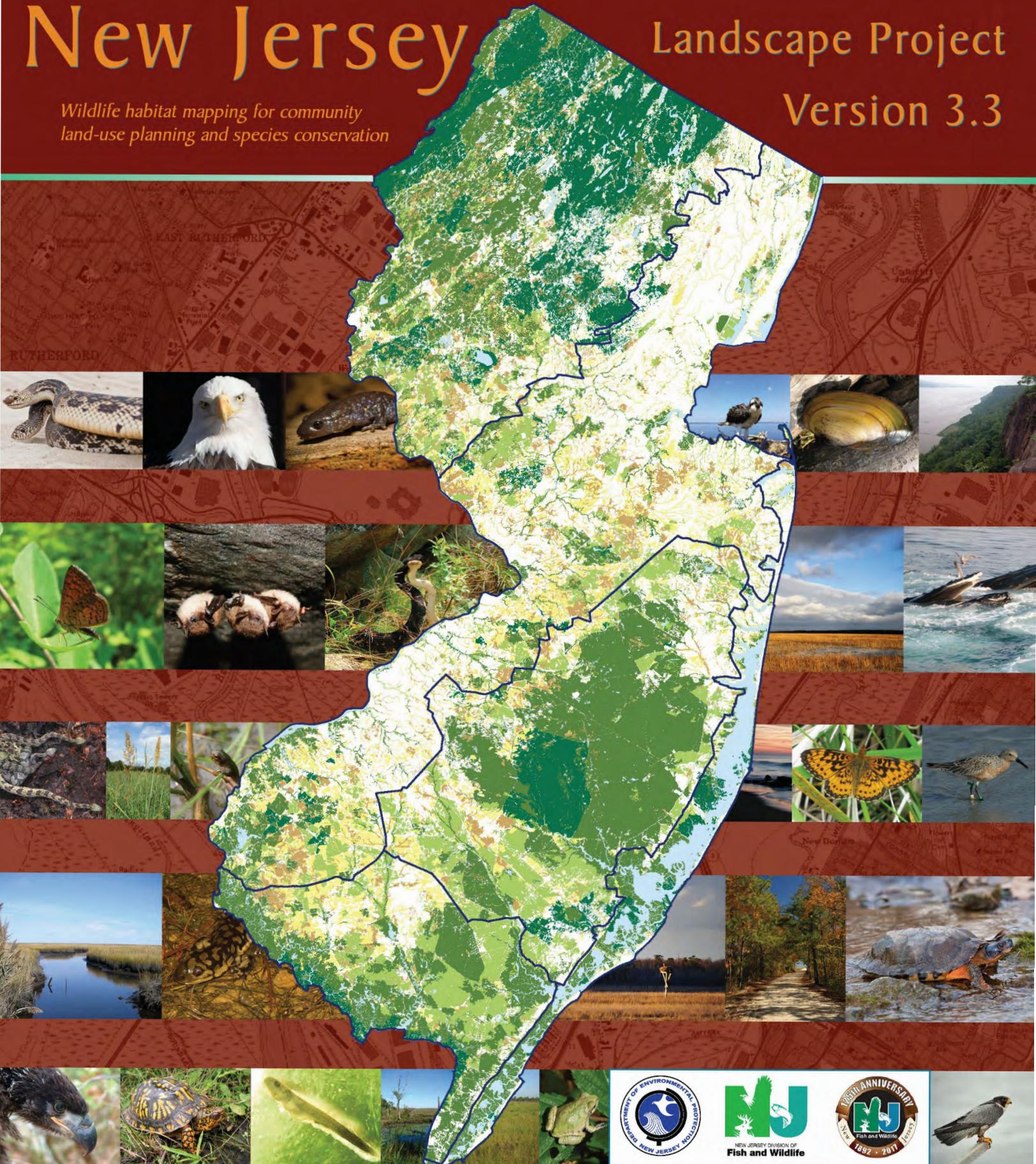


New Jersey

*Wildlife habitat mapping for community
land-use planning and species conservation*

Landscape Project Version 3.3



STATE OF NEW JERSEY

Chris Christie, Governor
Kim Guadagno, Lieutenant Governor

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bob Martin, Commissioner
David Glass, Deputy Commissioner

OFFICE OF NATURAL AND HISTORIC RESOURCES

Richard Boornazian, Assistant Commissioner

DIVISION OF FISH AND WILDLIFE

Larry Herrighty, Director

Endangered and Nongame Species Program

Dave Jenkins, Bureau Chief

Jeanette Bowers-Altman, Principal Zoologist
Kathleen Clark, Supervising Zoologist
Christina Davis, Senior Environmental Specialist
Amanda Dey, Principal Biologist
Gretchen Fowles, Geographic Information Systems Specialist
MacKenzie Hall, Environmental Specialist
John Heilferty, Environmental Specialist
Brian Henderson, Geographic Information Systems Specialist
Sharon Petzinger, Senior Zoologist
William Pitts, Wildlife Technician
Kris Schantz, Principal Zoologist
Robert Somes, Senior Zoologist
Patrick Woerner, Geographic Information Systems Specialist
Brian Zarate, Senior Zoologist

ENDANGERED AND NONGAME SPECIES ADVISORY COMMITTEE

Barbara J. Brummer, Ph.D., Chair
James E. Applegate, Ph.D.
Joanna Burger, Ph.D.
Emile DeVito, Ph.D.
Jane Morton Galetto
Howard Geduldig
Richard Lathrop, Ph.D.
Erica Miller, D.V.M.
David Mizrahi, Ph.D.
Howard K. Reinert, Ph.D.
James A. Shissias

New Jersey Landscape Project

VERSION 3.3

WILDLIFE HABITAT MAPPING FOR COMMUNITY
LAND-USE PLANNING AND SPECIES CONSERVATION

New Jersey Department of Environmental Protection
Division of Fish and Wildlife
Endangered and Nongame Species Program



NEW JERSEY DIVISION OF
Fish and Wildlife

ACKNOWLEDGEMENTS

Since its inception, the Landscape Project has been a collaborative effort that has relied on the collective knowledge and labor of the entire staff at the Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP). ENSP is indebted to former staff members who played a role in laying the foundation upon which the project has developed, including Pete Winkler, Mick Valent, Dave Golden, Patrick Meola, Jim Myers, former Bureau Chief Larry Niles, Steve Paturzo, Jim Sciascia, Eric Stiles, Jeff Tash, Jason Tesauro, and Melissa Woerner.

Special thanks are due to Mike Davenport who played a critical role in incorporating marine species into the Landscape Project.

Finally, a special thanks to those who contributed to various sections of this report: Tim Dunne, USDA Natural Resources Conservation Service; Gail Kenny, NJDEP Natural and Historic Resources; John Thomas, NJDEP Green Acres Program; Larry Torok, NJDEP Division of Land Use Regulation; Eric Schrading, U.S. Fish and Wildlife Service; and staff from the Endangered and Nongame Species Program.

The Landscape Project has been supported by:

United States Fish and Wildlife Service
Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act)
Partnerships for Wildlife Act
State Wildlife Grants
NJ Department of Environmental Protection
National Fish and Wildlife Foundation
Geraldine R. Dodge Foundation
Conserve Wildlife Foundation of New Jersey

The citizens of New Jersey, who have purchased the Conserve Wildlife License Plate, checked-off for wildlife on their state income tax return or made a direct donation to the Division of Fish and Wildlife's (DFW) Endangered and Nongame Species Program (ENSP) or the Conserve Wildlife Foundation of New Jersey.

The general methods described in this document have been peer reviewed by: John F. Bunnell, Pinelands Commission; Dr. Joanna Burger, Rutgers University; Dr. William Cromartie, The Richard Stockton College of New Jersey; Dr. Michael Gochfeld, Rutgers University; Dr. John Hasse, Rowan University; Dr. Daniel Hernandez, The Richard Stockton College of New Jersey; Dr. Eric Karlin, Ramapo College of New Jersey; Dr. Richard Lathrop, Rutgers University; Dr. Howard Reinert, The College of New Jersey; Dr. Lance S. Risley, William Paterson University; and Dr. David Tulloch, Rutgers University.

Report layout design based on Massachusetts' *BioMap2* Summary Report.

Report prepared by: Patrick Woerner, Brian Henderson, Peter Winkler, William Pitts, and Melanie Mason.

Suggested Reference: New Jersey Division of Fish and Wildlife. 2017. New Jersey Landscape Project, Version 3.3. New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program. pp. 33.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	2
CHAPTER 1. A Tool for Strategic Wildlife Habitat Conservation	4
CHAPTER 2. New Jersey’s Diverse Landscapes	13
CHAPTER 3. A Method for Delineating Imperiled and Special Concern Wildlife Habitat	17
DATA AVAILABILITY	26
LITERATURE CITED	27
GIS DATA SOURCES	28
GLOSSARY AND CONVERSIONS	29
PHOTO AND MAP CREDITS	33
APPENDICES (AVAILABLE ONLINE)	33

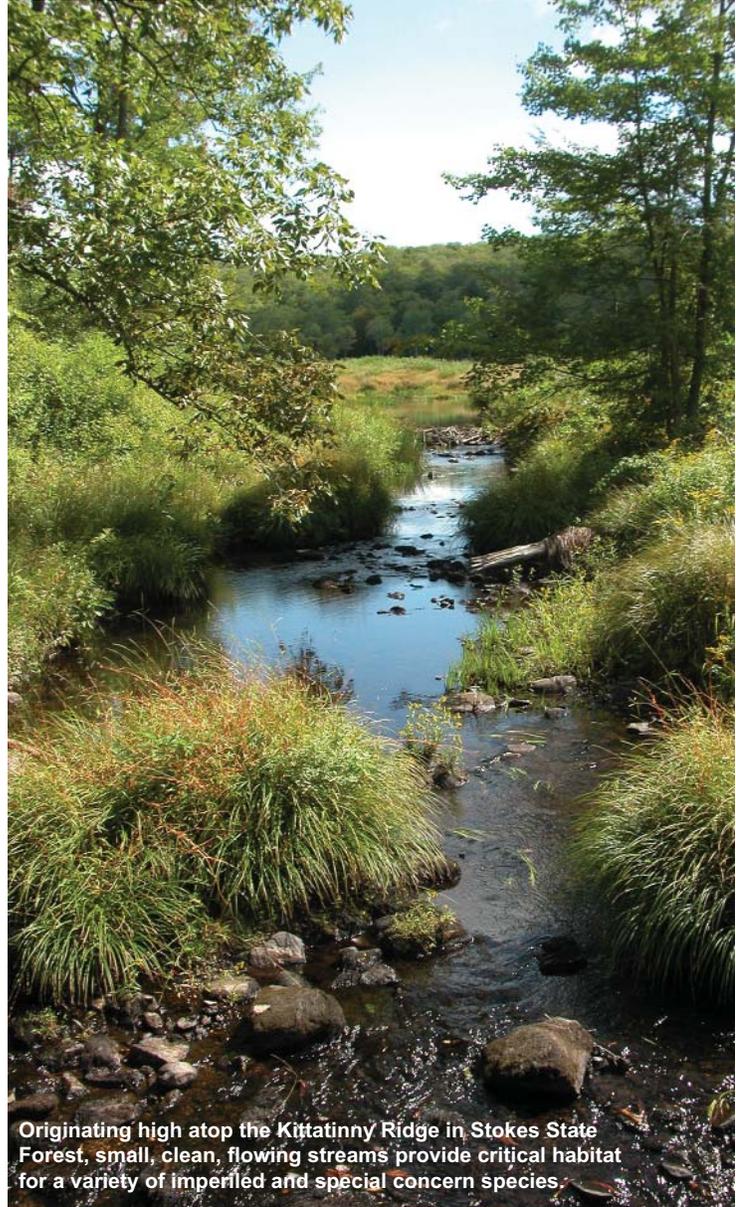


CHAPTER 1

A Tool for Strategic Wildlife Habitat Conservation

Although New Jersey is one of the smallest states in the nation, it is home to a diverse assemblage of natural landscapes. From the ridgetops and extensive forests of the Highlands in the northwest, to the waterways of the Delaware River Basin, to the Atlantic and Delaware Bay coastal beaches and salt marshes, to the unique ecosystem of the Pinelands, New Jersey is composed of a remarkable assortment of habitats. People have begun to appreciate the benefits and necessity of protecting these natural areas. For example, we know that wetlands play a critical role in lessening the severity of floods and naturally breaking down contaminants in the environment. Forests and grasslands protect the quality of our drinking water, improve the quality of the air we breathe and provide important areas for outdoor recreation. Collectively, these habitats are of critical importance to the diverse array of wildlife found in New Jersey, including endangered, threatened and special concern species.

Meanwhile, wildlife populations, particularly imperiled wildlife, face an array of interrelated pressures that impede their ability to maintain themselves in the state. These include invasive species, chemical contaminants, road mortality, human disturbance, and, most importantly, habitat loss, fragmentation and degradation resulting from poorly planned development patterns. These and other stressors are all occurring in the context of the developing impacts of climate change that will likely exacerbate the existing threats to wildlife species and habitats.



Originating high atop the Kittatinny Ridge in Stokes State Forest, small, clean, flowing streams provide critical habitat for a variety of imperiled and special concern species.

Habitat loss due to large lot low-density residential development.



LANDSCAPE PROJECT 3.3: CONSERVING IMPERILED WILDLIFE OF NEW JERSEY

The Landscape Project provides a starting point from which to develop strategies for the protection and enhancement of habitat for New Jersey's imperiled wildlife. In 1994, the New Jersey Division of Fish and Wildlife's (DFW) Endangered and Nongame Species Program (ENSP) adopted a landscape level approach to endangered, threatened and special concern species conservation by developing the Landscape Project. Through geographic information systems (GIS) technology, the Landscape Project uses documented species location data and land-use/land-cover as well as species life history information to produce maps that depict habitat for endangered, threatened and special concern wildlife species throughout the state. The goal of the project is to provide a tool that fosters protection of New Jersey's biological diversity by facilitating the recovery and sustainability of endangered, threatened and special concern wildlife populations within healthy, functioning ecosystems.



Piping Plover, Federal Threatened.



Spatterdock Darner, Special Concern.

A NEW VERSION OF THE LANDSCAPE PROJECT

The previous version of the Landscape Project was based on species occurrence data collected prior to 2012 and habitat data derived from 2007 Land Use/Land Cover (LULC). Since that time, more than 3,400 new species occurrence records have been added to New Jersey's Biotics database and habitat data has been updated to reflect the most recent (2012) LULC. In addition, the new version incorporates species not previously represented in the Landscape Project, including Atlantic sturgeon and northern long-eared bat (northern myotis).

Version 3.3 of the Landscape Project applies to the entire state a methodology that was



Atlantic Sturgeon, Federal Endangered.



Northern Myotis, Federal Threatened.

developed under peer-review. It includes precise methods for delineating habitat based on species-specific habitat associations. In addition to providing access to a list of species that occur in an area of interest defined by a user, Version 3.3 provides detailed information, including the type of occurrence, or feature label (e.g., colony, den, nest, foraging, etc.), and the last recorded year of occurrence.

In Version 3.3 of the Landscape Project, all information has been updated to reflect

- ▶ the existing endangered species list and the nongame wildlife list
- ▶ a standard, consistent, peer-reviewed method applied throughout the state
- ▶ over 3,400 new species occurrence records in the Biotics database
- ▶ the most recent Land Use/Land Cover data from 2012

The information available in Version 3.3 includes enhancements that

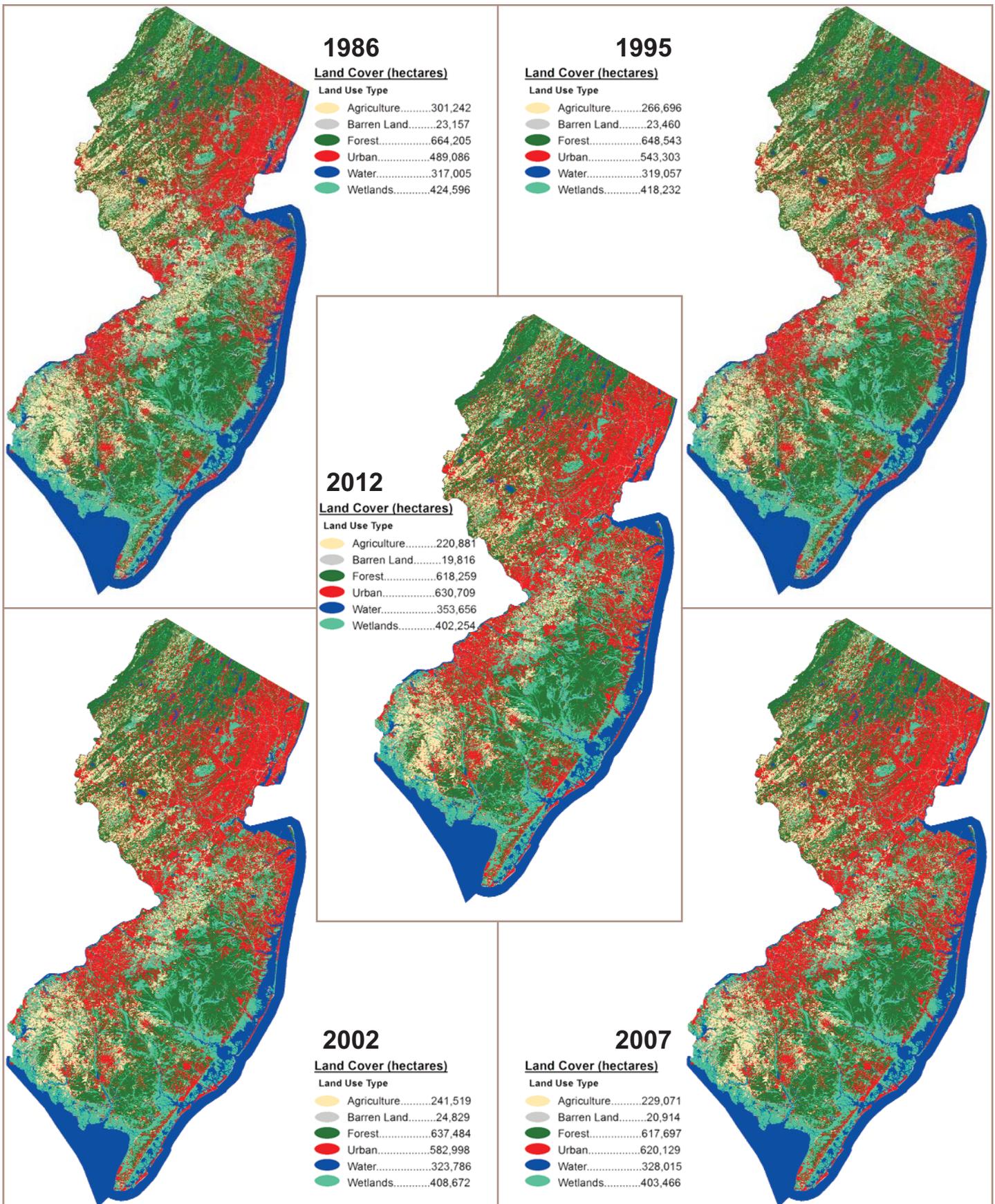
- ▶ provide precise habitat mapping built on species-specific habitat associations
- ▶ encompass species previously not represented, including Atlantic Sturgeon, Carpenter Frog and Northern Long-eared Bat
- ▶ provide detailed species information, such as type of occurrence and last year of occurrence
- ▶ transparently document the mapping method that is based on scientific literature

Perhaps most importantly, Version 3.3 features easily accessible documentation that includes transparent descriptions of the methods used and references to supporting scientific literature. Many of these enhancements are a result of recommendations that ENSP has received from the public through outreach efforts and information obtained from evaluation forms completed by attendees of Landscape Project training and information sessions conducted over several years. Additional feedback was received during an evaluation of the Landscape Project maps conducted in partnership with the Endangered and Nongame Species Advisory Committee (ENSAC). The evaluation process included two stakeholder meetings that generated constructive input from a cross-section of Landscape Project end-users representing federal agencies, county governments, environmental commissions and the consultant community.

WHY WE NEED THE LANDSCAPE PROJECT

New Jersey's landscape is rapidly changing. As the most densely populated state in the nation, pressure to consume land for development has increased as the population has grown. Yet population growth cannot be isolated as the only, or even the primary, driving force of habitat loss in New Jersey. Instead, land has been consumed for residential development at nearly twice the rate of population growth over the past two decades as a result of a large-lot, area-intensive land use zoning and development pattern that has encroached on rural landscapes throughout the state (Hasse & Lathrop 2008, 2010; Hasse et al. 2010). Such a land development pattern also contributes to higher traffic volumes that can lead to increased wildlife mortality or create complete barriers to movement for certain species (Seiler 2003; Fahrig & Rytwinski 2009).

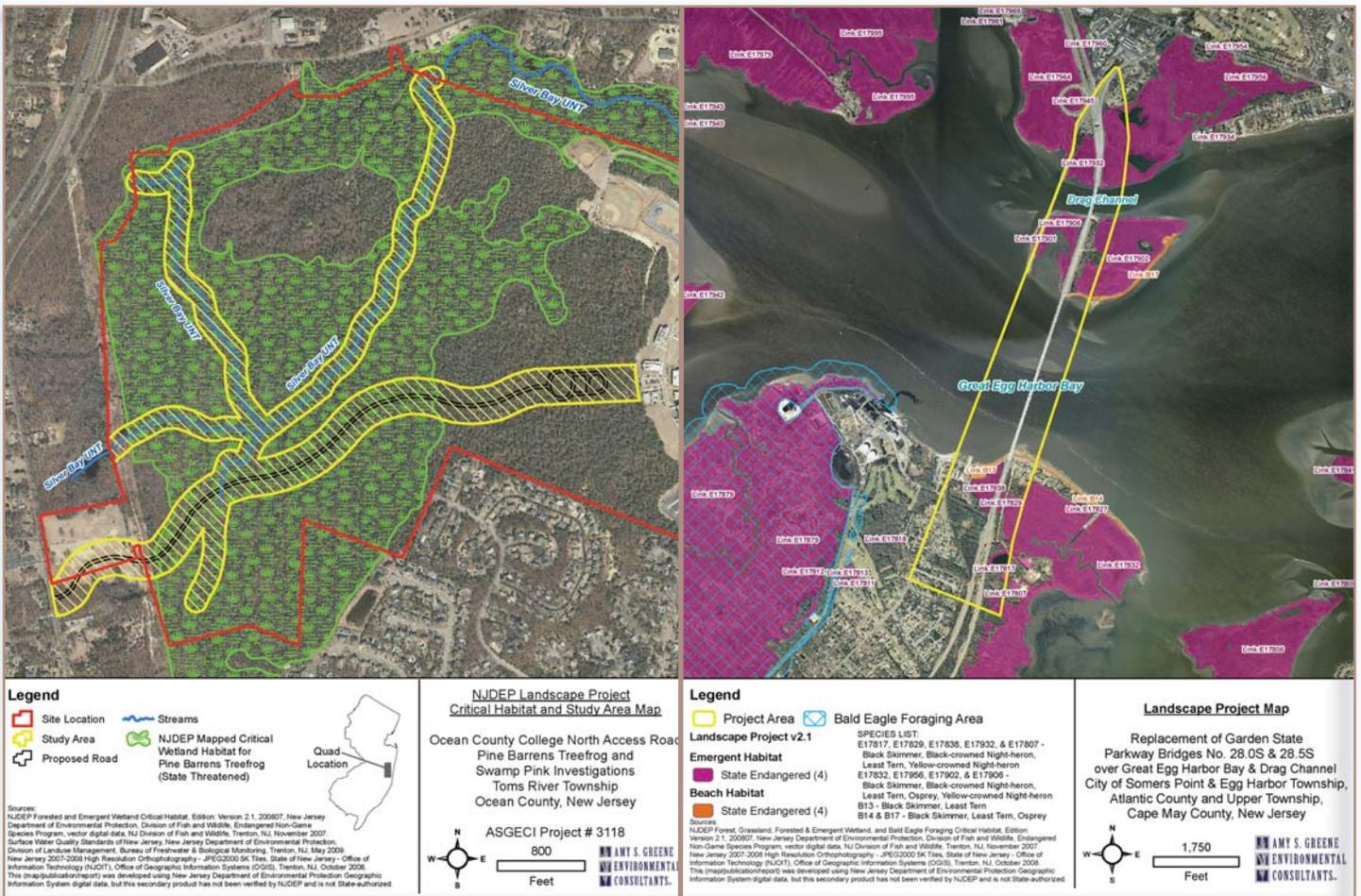
A detailed landscape analysis performed by Hasse and Lathrop (2010) that utilized DEP Land Use/Land Cover (LULC) datasets from 1986 to 2007 revealed that a sprawl development pattern continued undeterred and actually gained momentum over the two decade period. Breaking the study into three time periods (1986-1995, 1995-2002, 2002-2007), the analysis shows a "7% increase in the development rate to 16,061 acres of urbanization per year by 2007, up from the previous rate of 15,123 acres per year during the 1995 through 2002 time period," which also experienced an increase up from the rate of 14,866 acres per year in the 1986 through 1995 time period (Hasse & Lathrop 2010, p.4). Increasing deforestation, largely due to sprawling residential development, led to urban land surpassing forest land as the most prominent land type covering the state as of 2007 (Hasse & Lathrop 2010). Studies project that if the current building pattern continues, all remaining available land will be developed sometime in the middle of this century, making New Jersey possibly the first state in the nation to reach build-out (Hasse & Lathrop 2001, 2010). The Landscape Project serves as a tool to help facilitate growth patterns more sensitive to the needs of wildlife and their habitats.



NJDEP Land Use/Land Cover 1986 - 2012. New Jersey's Landscape is rapidly changing. In the 1986 - 2007 period, urbanization resulted in the loss of approximately 5,000 hectares of wildlife habitat per year. Although this rate slowed significantly in the 2007 - 2012 period, much of the habitat that remains is less suitable for wildlife due to habitat fragmentation. This is especially detrimental to imperiled wildlife, as many of these species require large, contiguous tracts of habitat.

THE PURPOSE OF THE LANDSCAPE PROJECT

The Landscape Project was designed to provide users with peer-reviewed, scientifically sound information that transparently documents threatened and endangered species habitat. Landscape Project data are easily accessible and can be integrated with the planning, protection and land management programs of non-government organizations and private landowners and at every level of government – federal, state, county and municipal. Landscape maps and overlays provide a foundation for proactive land use planning, such as the development of local habitat protection ordinances, zoning to protect critical wildlife areas, management guidelines for imperiled species conservation on public and private lands, and land conservation projects. The maps help increase predictability for local planners, environmental commissions, and developers, and help facilitate local land use decisions that appropriately site and balance development and habitat protection. The Landscape Project maps allow the regulated public to anticipate potential environmental regulation in an area and provide some level of assurance regarding areas where endangered, threatened or species of special concern are not likely to occur, affording predictability to the application and development process. Thus, Landscape Project maps can be used proactively by regulators, planners and the regulated public in order to minimize conflict and protect imperiled species. This minimizes time and money spent attempting to resolve after-the-fact endangered and threatened species conflicts.



Landscape Project data used for project review: Left) Landscape Project data used to show the extent of Pine Barrens Treefrog habitat in order to determine if a proposed new access road for the Ocean County College campus would impact this species. Right) Landscape Project data used to help conduct a habitat assessment for a proposed Garden State Parkway bridge replacement project over Great Egg Harbor Bay and Drag Channel in Atlantic and Cape May counties. The map shows areas of suitable habitat capable of supporting State and Federal listed threatened and endangered species within the project area, including Black Skimmer, Black-crowned Night-heron, Yellow-crowned Night-heron, Least Tern, and Osprey.



A volunteer plants a native tree seedling on an old fairway inside Cox Hall Creek Wildlife Management Area to help restore forested habitat that will benefit migratory songbirds and other wildlife.

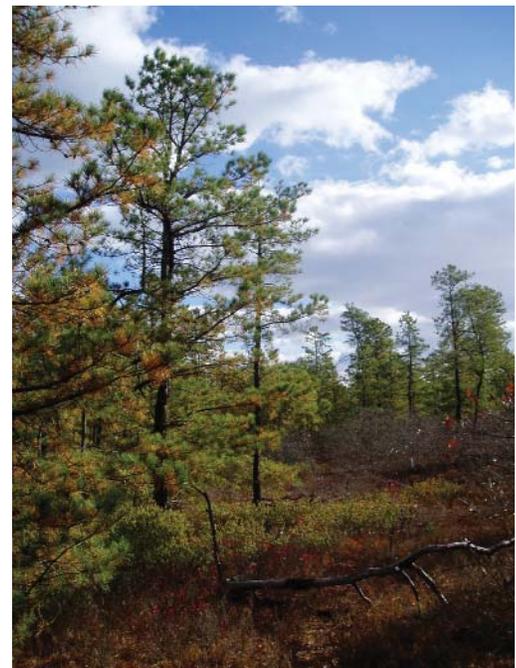
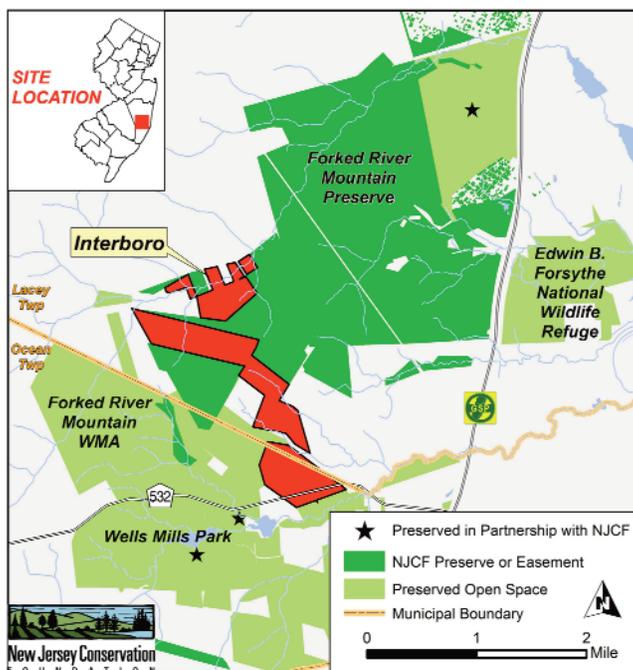
LANDSCAPE PROJECT APPLICATIONS

DEP Agencies:

NJDEP's Natural and Historic Resources: The Natural & Historic Resources (N&HR) programs within NJDEP are responsible for managing over 900,000 acres of parks and forests, recreation areas, historic sites, wildlife management areas, and natural areas. Managing these lands in a manner that avoids harm to imperiled species habitats requires that land managers subject proposed activities to an internal review process before undertaking any activity on state lands that may modify the terrestrial or aquatic landscape. Land managers use Landscape Project maps to conduct an initial screening to determine the presence of habitat patches ranked 3, 4 or 5. If these features are on the proposed project site the land manager is required to request a detailed review by ENSP. This review allows land managers to alter proposed activities in a manner that avoids or minimizes damage to critical imperiled species habitat.

Division of Fish and Wildlife's Landowner Incentive Program: The Landscape Project is an important tool for the Landowner Incentive Program (LIP). When applications are submitted to LIP, biologists use the Landscape Project as a screening tool to determine the species that may inhabit the site. Based on the Landscape Project and the project description, biologists determine if the project warrants a site visit and use the Landscape Project to create a map of the site and surrounding landscape. LIP staff also use the Landscape Project to support the species and habitat management plan developed for each property.

Green Acres: The Landscape Project is used by the Department's Green Acres Program to support the preservation of high quality natural resources in three valuable ways. First, the mapped data is represented on site-specific planning maps showing habitat locations so that consideration is given to these prime areas during decision making. Site specific maps are also submitted as part of the application for the Federal Land and Water Conservation Fund to show characteristics of those applicant properties. Lastly, but perhaps most importantly, the data is used in the evaluation of lands offered to the State for acquisition. The Green Acres Program scores all land offers based on their natural resource values. Wildlife occurrence is one of the criteria evaluated. The Landscape Project data format allows for statistical analysis to determine the quality and quantity of state and federal endangered species habitats on the offered properties.



Green Acres provided grant funding to the New Jersey Conservation Foundation to help purchase the Interboro tract in the Forked River Mountains area that serves as habitat for a number of threatened and endangered wildlife species.

Division of Land Use Regulation: The Division of Land Use Regulation (DLUR) uses the Landscape Project maps to identify habitat for endangered and threatened species and to help apply regulations designed to protect those areas. Several state land use regulations contain provisions for the protection of habitats determined to be critical to endangered and threatened wildlife. These include the Coastal Permit Program Rules (N.J.A.C. 7:7), the Coastal Zone Management Rules (N.J.A.C. 7:7E), the Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A), the Flood Hazard Area Control Act Rules (N.J.A.C. 7:13), the Highlands Water Protection and Planning Act Rules (N.J.A.C. 7:38), and the Water Quality Management Planning Rules (N.J.A.C. 7:15).

Landscape Project data are reviewed to help determine whether a particular site contains “documented habitat” for State or Federal listed species. Within areas of documentation, ground surveys are typically conducted to confirm actual site suitability for a specific documented species. Permit applications received by DLUR are now better prepared because the public has access to the Landscape Project data. Since applicants now have access to baseline data concerning endangered and threatened species occurrences, they can better address potential impacts to State or Federal listed species in their permit applications or environmental impact statements, thereby minimizing environmental impacts and the time required to issue permits.

Federal Agencies:

U.S. Fish and Wildlife Service: The U.S. Fish and Wildlife Service (USFWS), New Jersey Field Office staff use the data layers in the Landscape Project to assist with project planning, assessment, and implementation of habitat restoration projects through the *Partners for Fish and Wildlife* program. Specifically, information in the Landscape Project on wetlands, sensitive species, grasslands, and other habitat types assist USFWS in large-scale geographic planning and targeting of habitat restoration projects. The Landscape Project is also useful for site-specific assessments of wetland restoration and creation opportunities.

U.S. Department of Agriculture Natural Resources Conservation Service: The Natural Resources Conservation Service (NRCS) has utilized the Landscape Project for several years as part of its day to day activities. NRCS field staff conducts environmental evaluations for all projects where federal funds are utilized as part of its National Environmental Policy Act (NEPA) responsibilities. These evaluations include threatened and endangered species assessments of planned NRCS actions.

The Landscape Project provides invaluable information regarding the possibility of threatened and endangered species occurrence at a site and helps guide NRCS planning efforts. The Landscape Project has also been used for several years in the competitive ranking of Wildlife Habitat Incentive Program (WHIP) projects. Projects that will have positive impacts to threatened and endangered species habitat receive additional points in the WHIP ranking system and have a greater chance of being funded. The Landscape project data is used as the basis for the threatened and endangered portion of the ranking.

This farm in Harmony Township, Warren County, falls within a high-priority grassland bird conservation area. The landowner planted more than 100 acres of perennial grasses with assistance from the NJ Landowner Incentive Program (LIP), US Fish and Wildlife Service, NRCS, New Jersey Audubon, and Conserve Wildlife Foundation of NJ. The fields remain un-mowed during the bird nesting season to allow species like the bobolink, grasshopper sparrow, and eastern meadowlark to nest and fledge their young.



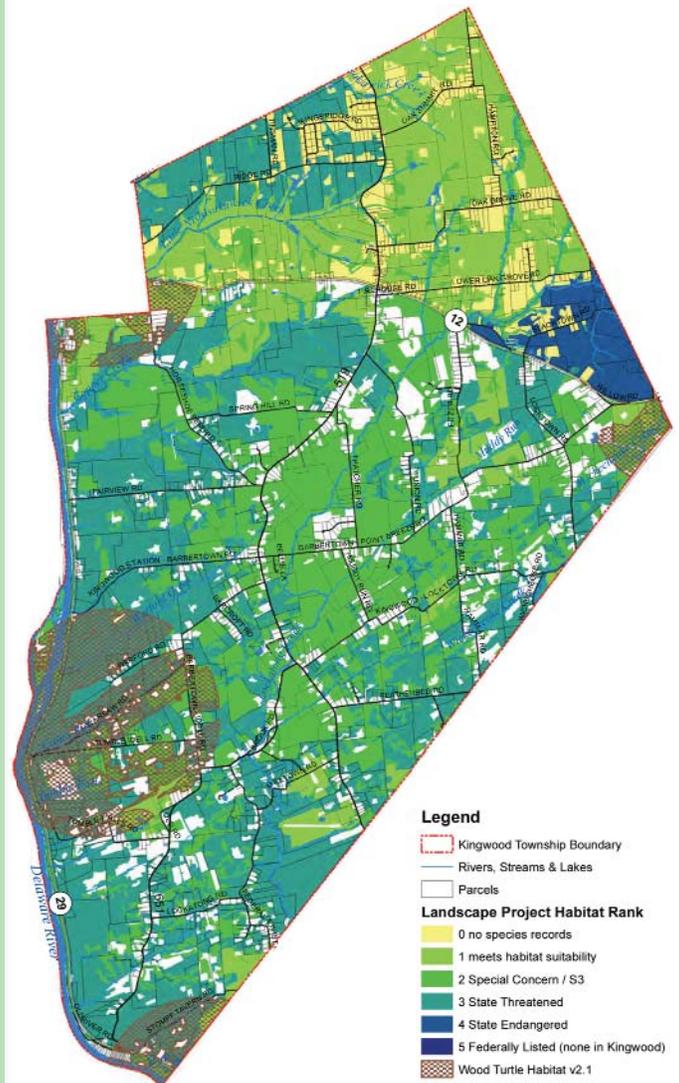
Landscape Project maps enable state, county, municipal and private agencies to identify important habitats and protect them in a variety of ways:

Prioritize conservation acquisitions: The Landscape Project is used to assist with prioritizing land parcels for purchase through acquisition programs such as Farmland Preservation and the USFWS's refuge system.

Guide regulators and planners: Landscape Project maps provide those who administer land use regulations and state, county and local planners with a crucial tool used to enhance protection and properly plan development through the regulatory and planning process.

Provide citizens with conservation tools: The Landscape Project provides a transparent and readily accessible tool to help guide citizen actions to protect imperiled and special concern species habitat at the local level.

Guide stewardship of conserved areas: New Jersey has more than 400,000 hectares of open space. These lands are managed by a variety of agencies and organizations, both public and private. Landscape Project maps identify important imperiled and special concern species habitats on these lands. ENSP staff work closely with land managers and landowners to develop appropriate best management practices for the long-term conservation of imperiled and special concern species.



Landscape Project maps are widely used in municipal and county Environmental Resource Inventories (ERI) to document threatened and endangered wildlife habitat. ERI for Kingwood Township, Hunterdon County, shown above.

WHO BENEFITS

Conservation of large expanses of fields, forests and wetlands helps to ensure that wildlife will remain a part of New Jersey's future. Conserving imperiled and special concern species habitat identified in the Landscape Project also results in more land contributing ecosystem services and more open space for outdoor recreation. Surveys by the US Fish and Wildlife Service (2006) reveal more than 87.5 million U.S. residents sixteen and older participate in some form of wildlife-related recreation. Open spaces provide places where people can escape the confines and stresses of urban and suburban living. Retaining habitats in their natural state provides other benefits such as reducing the threat of flooding, allowing for the biodegradation and filtering of environmental contaminants and recharging ground water reserves. In short, planning that employs the Landscape Project habitat mapping provides potential benefits for everyone.

CHAPTER 2

New Jersey's Diverse Landscapes

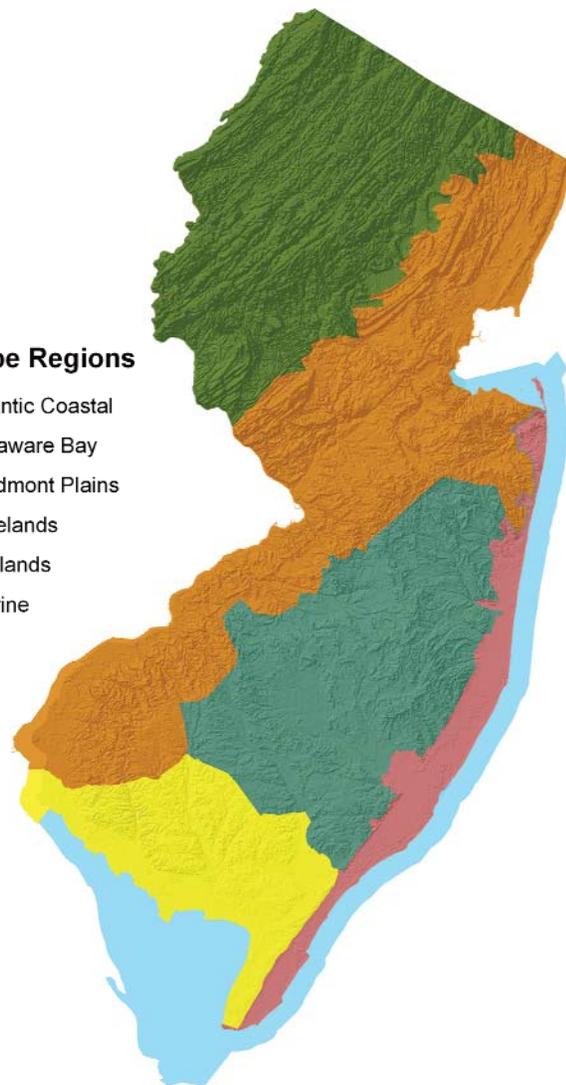


The Palisades cliffs rising next to the Hudson River are one of the historic habitats for nesting Peregrine Falcons, which recolonized the area in 2003 after an absence of more than 50 years.

New Jersey's dunes, beaches, tidal marshes, cedar swamps, vast pitch pine forests, extensive grasslands, peat bogs, maple-oak forests, ridgetops, brackish bays, rivers, streams and the Atlantic Ocean support an amazing array of wildlife. That is true despite the fact that much of its diverse landscape has been greatly altered by human enterprises such as agriculture and development that fragments and degrades wildlife habitat. Sustaining wildlife populations over time requires large healthy landscapes with broad expanses of natural habitat. Thus, the Landscape Project focuses on ecoregions or Landscape Regions where plant and animal communities are ecologically similar and closely interlinked.

Landscape Regions

-  Atlantic Coastal
-  Delaware Bay
-  Piedmont Plains
-  Pinelands
-  Skylands
-  Marine



New Jersey's Landscape Regions.

The delineation of the state into regions serves as a spatial framework for management and conservation of species and their habitats, and as a means to organize information so that it is meaningful and widely accessible to end-users. Geographic features and landforms (e.g., rivers, watershed boundaries, ridgelines, soils, vegetation, etc.) were used to delineate the general area of five Landscape Regions in New Jersey. Region boundaries were shifted to align with major roads (county level or larger) that serve as barriers to movement for many species. A sixth region, the Marine Region, is an exclusively aquatic region that includes the New Jersey portion of the Delaware and Raritan bays as well as the portion of the Atlantic Ocean along the coast of New Jersey. ENSP has identified and mapped habitat for endangered, threatened and special concern wildlife within each Landscape Region utilizing an extensive database that combines species occurrence information with Land Use/Land Cover classification data and species habitat requirements. The resulting Landscape maps provide an accurate, reliable and scientifically sound basis for habitat protection within each region.

One of the Landscape Project's unique features is that it enables users to focus on the big picture, and not just on individual locations of imperiled and special concern species as those areas come under threat. Thus, within large landscapes, the Landscape Project identifies areas of habitat that are important to the maintenance and recovery of New Jersey's endangered and threatened wildlife populations.

ATLANTIC COASTAL LANDSCAPE

This landscape encompasses parts of Monmouth, Ocean, Cape May, and Atlantic counties. New Jersey's Atlantic Coast beaches and marshes are among the most productive coastal habitats in the country. Despite heavy development, they support important portions of Atlantic Coast populations of colonial nesting birds, such as common tern, little blue heron and great egret, and endangered beach-nesting birds such as least tern and piping plover. The coastal habitats also support most of the state's ospreys, peregrine falcons, northern harriers and northern diamond-back terrapins, as well as large concentrations of migrating birds and wintering waterfowl.



Aerial view of Stone Harbor Point, a critically important coastal site for breeding, migrating and wintering shorebirds of conservation concern.



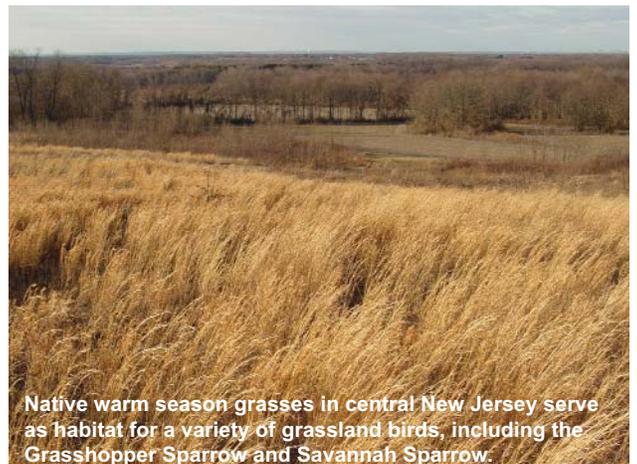
The Maurice River and its tributaries and adjacent forests support many of the State's endangered and threatened wildlife species, including large numbers of wintering and nesting Bald Eagles, Barred Owls, Pine Snakes and Frosted Elfins.

DELAWARE BAY LANDSCAPE

This landscape encompasses all or parts of Cape May, Atlantic and Cumberland counties. It features significant populations of bald eagle, barred owl, eastern tiger salamander, Cope's gray treefrog and 30 other endangered and threatened species. The vast woodland tracts of this region are among the largest in the state and support a large portion of New Jersey's neotropical birds and interior-forest bird populations. The extensive saltwater marsh and sandy overwash beaches support a significant horseshoe crab breeding area and shorebird migrations of worldwide ecological significance, including that of the red knot. Despite significant losses of habitat, the Cape May Peninsula remains one of the country's most important migratory "stopovers" for hundreds of bird and insect species. The expansive habitat mosaic of rivers and streams flowing into the tidal Delaware Bay supports concentrations of rare wildlife and wintering waterfowl.

PIEDMONT PLAINS LANDSCAPE

This landscape region also combines two of New Jersey's physiographic regions, the Piedmont and the Inner Coastal Plain. It encompasses all or parts of Burlington, Camden, Gloucester, Salem, Mercer, Middlesex, Monmouth, Hunterdon, Somerset, Union, Essex, Hudson, Passaic, and Bergen counties. It is dominated by the Delaware and Raritan rivers and is characterized by farmed areas, extensive grasslands, fragmented woodlands and productive tidal marshes. Imperiled species within this landscape include grassland birds such as the endangered upland sandpiper and raptors such as the American kestrel and barred owl.



Native warm season grasses in central New Jersey serve as habitat for a variety of grassland birds, including the Grasshopper Sparrow and Savannah Sparrow.



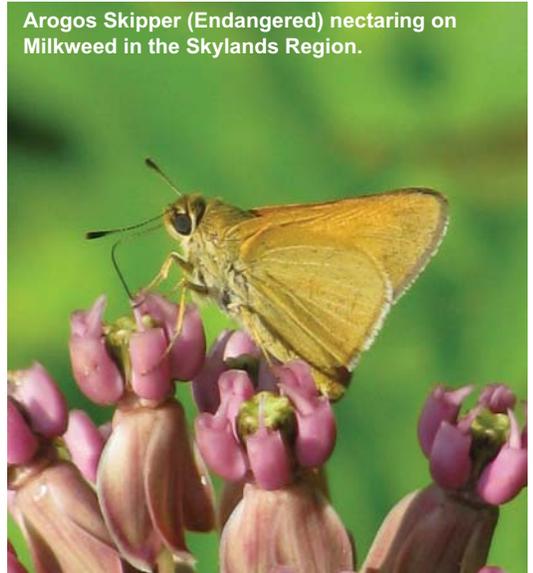
Vast tracts of pine and pine-oak forests of the Pinelands Region provide habitat for many imperiled species including the Threatened Northern Pine Snake and Pine Barrens Treefrog.

PINELANDS LANDSCAPE

This landscape encompasses all or parts of Atlantic, Ocean, Burlington, Camden, and Gloucester counties. An internationally recognized ecosystem, the Pinelands supports extremely diverse reptile, amphibian and invertebrate populations including northern pine snake, corn snake, Pine Barrens treefrog, and Pine Barrens bluet. Extensive cedar swamps and wetland systems contain numerous insect species, as well as sustainable populations of many neotropical birds. Its waterways support aquatic communities unique among mid-Atlantic states.

SKYLANDS LANDSCAPE

This landscape region combines two of New Jersey’s physiographic regions, the Ridge and Valley and the Highlands. It encompasses all or parts of Sussex, Warren, Hunterdon, Somerset, Passaic, Essex, Bergen, and Morris counties. The region contains extensive tracts of contiguous upland and wetland forests that support diverse animal populations including red-shouldered hawk, northern goshawk, cerulean warbler, timber rattlesnake, long-tailed salamander, arogos skipper and the state’s only known wintering populations of Indiana bat. Bog turtles and great blue herons inhabit the extensive freshwater wetland systems found throughout the region.



Arogos Skipper (Endangered) nectaring on Milkweed in the Skylands Region.

MARINE REGION

This region is an exclusively aquatic region that includes the New Jersey portion of the Delaware and Raritan bays. It also includes the portion of the Atlantic Ocean within New Jersey’s jurisdiction, which is defined as the area



New Jersey’s coastal waters provide a critical migratory corridor to Humpback Whales (Federal Endangered).

within 3-nautical miles of the New Jersey shoreline. This region supports commercially valuable shellfish resources as well as a number of fish species of commercial and recreational importance. Over half of New Jersey’s Federal listed species are found exclusively within this region, including several species of whales and sea turtles. The endangered shortnose sturgeon is also found within Delaware Bay. Waters of the Delaware Bay are also critical habitat to one of the largest populations of horseshoe crab in the world. During the summer, near-shore Atlantic Ocean waters are calving and nursery grounds for bottlenose dolphins while many additional species utilize these waters as a migratory corridor.

CHAPTER 3

A Method for Delineating Imperiled and Special Concern Wildlife Habitat

Version 3.3 of the Landscape Project is composed of three spatial components: Species-Based Habitat, Freshwater Mussel Habitat and Vernal Habitat. **Species-Based Habitat**, the main component of the project, identifies imperiled and special concern wildlife habitat within each Landscape Region, with the exception of freshwater mussels. **Freshwater Mussel Habitat** is a separate layer that identifies those stretches of stream that serve as habitat for endangered, threatened and special concern freshwater mussel species. Lastly, **Vernal Habitat** identifies not only vernal and potential vernal pools themselves, but also surrounding habitat that allows for successful breeding, dispersal, foraging, overwintering, and migration of species that use vernal pools.

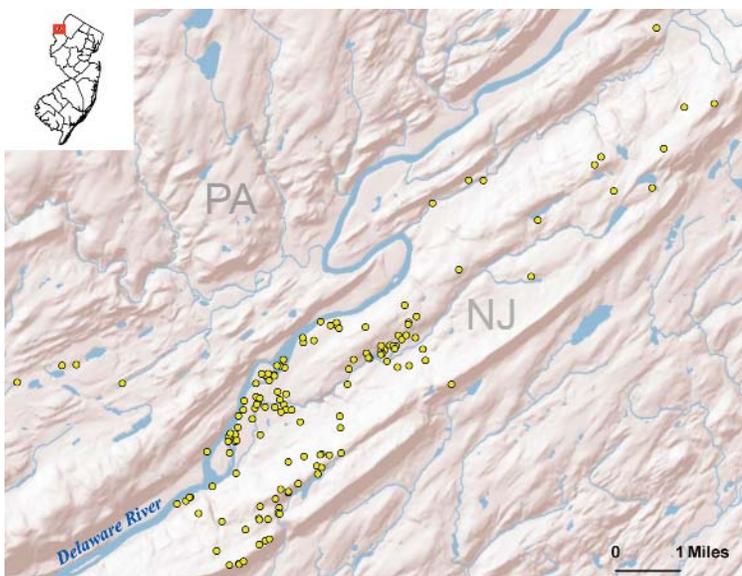
SPECIES-BASED HABITAT



Illegal collection continues to impact the Bog Turtle (Federal Threatened).

The Landscape Project combines documented wildlife locations with NJDEP aerial photo-based 2012 Land Use/Land Cover (LULC) to delineate imperiled and special concern species habitat within New Jersey. Many species occurrence locations cannot be published because they may represent nest sites, roost sites, dens and other sites used by species that are vulnerable to human disturbance and, in some cases, susceptible to illegal collecting. At the same time, wildlife moves and individual animals use various habitat features within the landscape to fulfill their foraging, sheltering and breeding needs. Therefore, protecting individual occurrences or the area used by one individual is generally not sufficient to

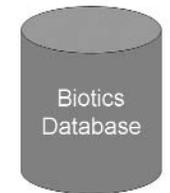
protect the local population. Landscape Project maps address these issues by displaying habitat patches that animals use and that are required to support local populations, rather than pinpointing exact locations of the most sensitive wildlife sites or simply protecting points where species happened to be observed at one point in time. Prior to combining species occurrence data with LULC data to form the habitat patches that make up the Species-Based Habitat layer, each dataset is generated according to a specific data development process.



Left) Shown in yellow are locations of a male Bobcat (Endangered) fitted with a GPS collar by ENSP between March 2004 and July 2005 near the Delaware Water Gap, NJ. The cat crossed the Delaware River into Pennsylvania on three different occasions. Above) Bobcat at the Delaware Water Gap in early spring.

SPECIES OCCURRENCE DATA DEVELOPMENT

Imperiled and special concern wildlife occurrence data are stored and managed in the New Jersey Biotics database. Developed by NatureServe, Biotics software provides established scientific standards for biological inventory and biodiversity data management used by most states, Canada, Latin America and the Caribbean, for tracking species. Imperiled and special concern species records within the New Jersey Biotics database are based on field observations from a variety of sources including reports from the general public, ENSP surveys, and other professional surveys, including those conducted by government agencies and environmental consultants. All records undergo rigorous evaluation performed by ENSP biologists for inclusion into the system according to an established protocol to ensure reliability (*Appendix I*). Moreover, in order for a species occurrence in Biotics to be used in the Landscape Project, it must meet the following additional criteria: the species status must be endangered, threatened or special concern; it must be a “high accuracy” record according to NatureServe (accurate within 6-50 meters [most fall within 20 meters]); it must have a 1980 or later last observation date; and it must be an occurrence associated with habitat essential for survival such as a breeding or foraging site. For example, an occurrence of a migrating bird that is included in Biotics may not be included in the Landscape Project maps if it does not rely on habitat within New Jersey for survival.



All occurrences receive a “location use class” as well as a “feature label” designation. Both of these are used to record more information about the occurrence. A location use class is specified for migratory species and indicates the season or behavior that is associated with the occurrence. A feature label describes the type of occurrence (e.g., nest, den, etc.). A single species occurrence may represent one individual animal (for example, a single timber rattlesnake observed on a rock) or multiple individuals (for example, a timber rattlesnake den supporting many individuals), distinctions indicated by the feature label.



Timber Rattlesnake (Endangered) dens support multiple snakes that return year after year to the same den location.

ENSP has defined a “species occurrence area” (SOA) for every feature label assigned to a species (*Appendix II*). A SOA is a polygon specific to each species-feature label combination that is applied to each occurrence location and used to value habitat in the Landscape Project. The size of each SOA is generally based on the average home range or territory size, or other appropriate life-history parameters as reported in peer-reviewed scientific literature, or from information obtained through ENSP research and expert opinion. In the context of the Landscape Project, a SOA represents the habitat that supports the individual occurrence and often indicates the presence of a species population beyond the individual documented occurrence. A depiction of the SOAs for different types of Indiana bat feature labels is included in the table below.



Indiana Bats (Federal Endangered) with a small cluster of Little Brown Bats at a hibernaculum in northern New Jersey.

Data development process for species occurrence areas.

often indicates the presence of a species population beyond the individual documented occurrence. A depiction of the SOAs for different types of Indiana bat feature labels is included in the table below.

Feature Label	SOA
Hibernaculum	4 kilometer buffer
Non-breeding Sighting	2 kilometer buffer
Maternity Colony	2 kilometer buffer
Breeding Sighting	2 kilometer buffer

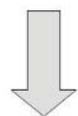
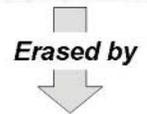
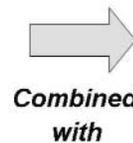
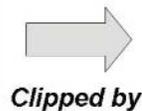
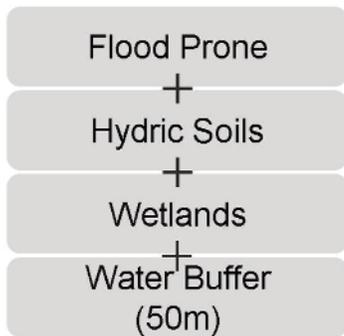
Indiana Bat Feature Labels and SOAs

LANDSCAPE BASE LAYER DEVELOPMENT

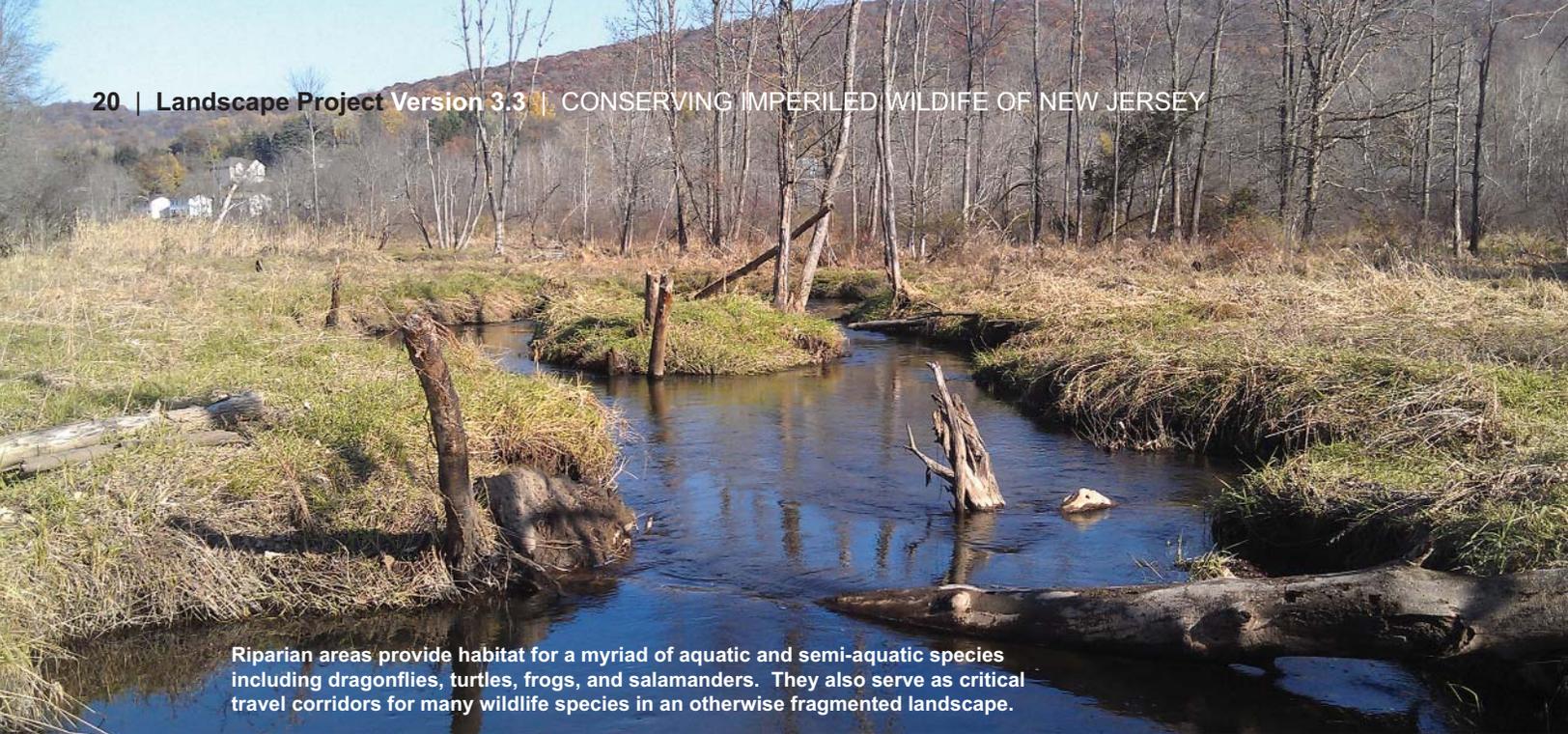
The 2012 Land Use/Land Cover (LULC) spatially depicts the state of the land use and natural land cover statewide based on aerial photography captured in the spring of 2012. Land use and natural land cover are categorized into TYPE12 and LU12 codes using the Anderson classification system (Anderson et. al. 1976). TYPE12 describes the general LULC categories and the LU12 codes represent more detailed LULC classes. The NJDEP 2012 LULC data includes 86 unique LULC classifications (*Appendix III*). This spatial dataset underwent a series of modifications to form the base layer within each Landscape Region. In order to prepare the Landscape Project base layer, the following steps were performed:

Major Roads: NJ Department of Transportation (DOT) Major Roadways (2015) are stored as a GIS line file representing the centerline of the roadways. A subset of roads defined by ENSP as “major roadways” (Interstate Highways, U.S. Routes, NJ State Highways, Toll Authority Routes and 500 and 600 Series County Routes) were buffered, creating a polygon file to bisect LULC classifications and serve as a boundary between contiguous LULC classes. Roadway lines classified as 500 and 600 Series County Routes were buffered by 25 feet, while lines classified as Interstate Highways, U.S. Routes, NJ State Highways and Toll Authority Routes were buffered by 37.5 feet. These road widths were determined by randomly selecting roads and averaging measured widths using aerial imagery. The completed major roads polygon file was then used to erase the LULC in order to bisect contiguous areas of habitat.

Riparian Corridor: Landscape Project Version 3.3 delineates a Riparian Corridor that identifies those streams and riparian habitats that are essential to imperiled and special concern aquatic, semi-aquatic, and floodplain wildlife and that often serve as travel corridors for many wildlife species throughout New Jersey.



Base layer development process.



Riparian areas provide habitat for a myriad of aquatic and semi-aquatic species including dragonflies, turtles, frogs, and salamanders. They also serve as critical travel corridors for many wildlife species in an otherwise fragmented landscape.

The inclusion of the Riparian Corridor makes the Landscape Project mapping a more comprehensive tool for planners, land managers, watershed agencies and associations, and other conservation organizations to protect aquatic wildlife habitat.

The Riparian Corridor was produced according to a modified version of a method developed at the Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA) by Hughes and Lathrop (2001). An area is defined as riparian if it is prone to flooding, contains hydric soils, or is delineated as freshwater wetlands. A number of changes were made to the CRSSA method as described below. There are multiple GIS datasets used to create the ENSP riparian corridor: NJDEP USGS Flood-Prone Areas; FEMA flood data composite (DFIRMS, Preliminary FIRMS, Preliminary Work Maps, Q3) current as of April 2015; U.S. Department of Agriculture, Natural Resources Conservation Service Soil Survey Geographic Soils 2014 (SSURGO); NJDEP 2012 Land use/Land cover Update for New Jersey; NJDEP 2002 Streams Update for New Jersey. Unlike the CRSSA model, these datasets were used in their native vector format instead of converting them to a grid, or raster, format for analysis. Each dataset was recoded as follows:

NJDEP USGS Flood-Prone Areas – all areas coded as “1 USGS Documented Flood-prone Area” or “8 Water” are recoded as “1,” all others recoded as “0.”

FEMA flood data composite – all areas coded as A, AE, AH, AO, Open Water, VE recoded as “1.”

SSURGO – all soils defined as “hydric” recoded as “1,” all others recoded as “0.”

NJDEP 2012 LULC – all Type12 coded as “wetlands” recoded as “1,” all others recoded as “0.”

All polygons coded as “1” from the above layers are combined and dissolved into one layer. Next, all streams (NJDEP 2002 Streams Update for New Jersey) and water bodies (NJDEP 2012 Land use/Land cover Update for New Jersey) with LU12 codes 1419, 5100, 5190, 5200, 5300 and 5410 are buffered by 50 meters to create a continuous corridor surrounding all water sources and to capture any areas that were not previously included because they were not coded as flood prone, hydric, or wetlands, or they occur as an urban LULC class, or are bounded by steep slopes. This 50 meter buffer is combined and dissolved with the previous layer into a riparian corridor. Next, all streams and water bodies are buffered by 100 meters. The dissolved riparian corridor created is then clipped by this maximum distance. Next, the streams layer is overlaid the resultant corridor. Any polygon that does not intersect the streams layer is deleted. The resulting layer is the final Landscape Project Riparian Corridor. This layer is combined with the NJDEP 2012 LULC dataset, to form the base layer for Version 3.3.

Marine Waters: The addition of the Marine Region in Version 3.3 allows for the inclusion of aquatic marine species that were not represented in previous versions of the Landscape Project. New Jersey’s marine waters within the 2012 LULC dataset are mapped as extremely large polygons that are of little utility within the Landscape Project framework. Therefore, all marine waters coded as “Atlantic Ocean,” “Open Tidal Bays,” and “Tidal Rivers, Inland Bays, and Other Tidal Waters” are broken into a grid consisting of cells approximately 1.3 x 1.3 kilometers in size. This method thereby creates polygons which are much smaller, more meaningful, and consistent in the manner of their creation.

For marine species, a more refined approach towards mapping habitat would utilize mapped variables such as bathymetry, slope, sea surface temperature, current direction and velocity, submerged aquatic vegetation, and salinity. Although such information is available for some marine waters, it is absent in other areas and/or often incompatible across the region. It is this lack of a statewide multi-variable marine dataset that necessitates the current use of the gridded approach to mapping marine waters in the Landscape Project base layer.

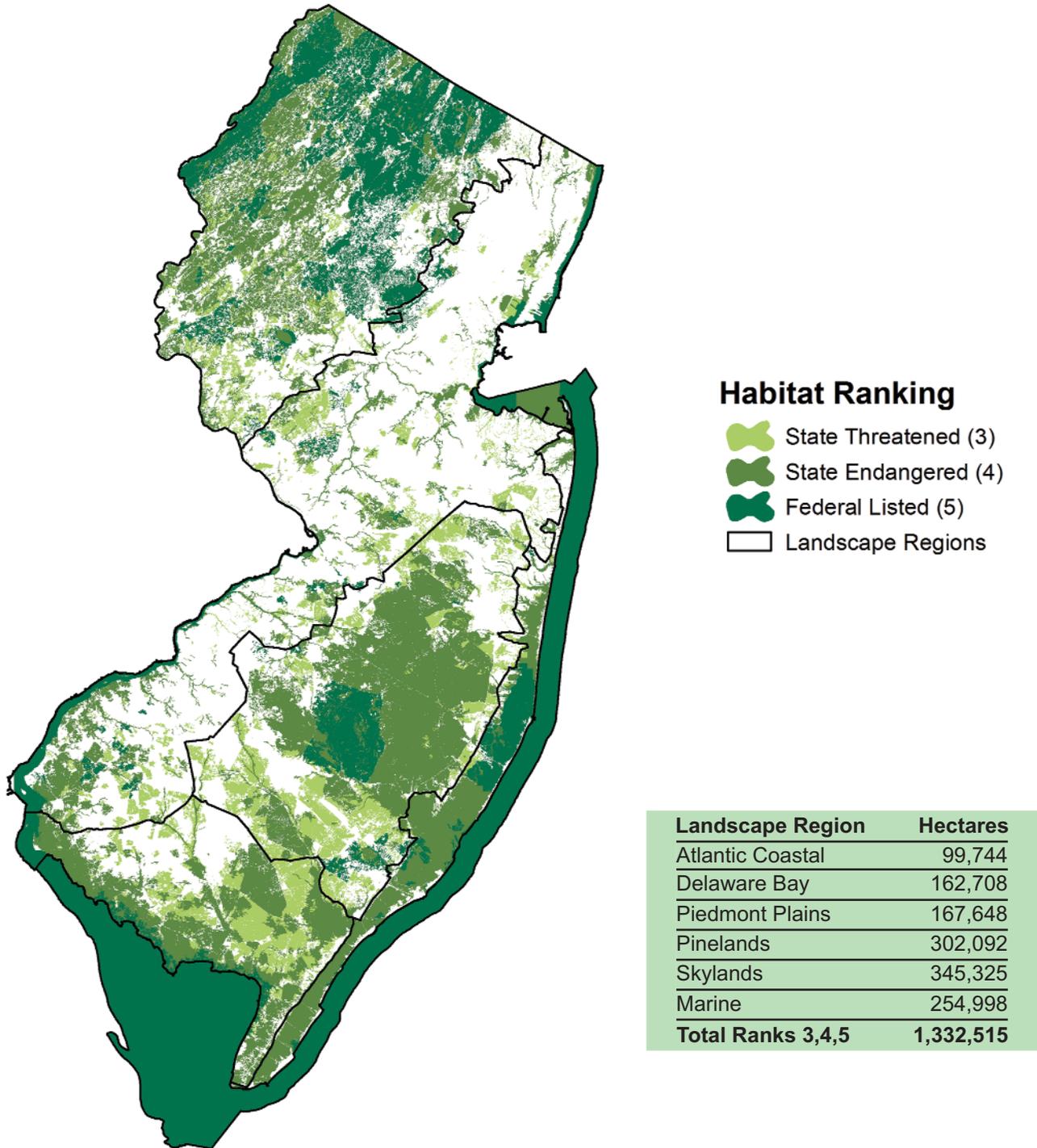
DELINEATING SPECIES-BASED HABITAT

In Version 3.3 a species-based habitat method is implemented by associating each species with a specific set of LULC classes according to the habitat needs of the species. Detailed LULC class delineations allow for an accurate representation of imperiled and special concern species habitat by providing ENSP biologists with the ability to designate a specific set of LULC classes for each individual species-feature label combination. Each species-habitat association is developed by performing a review of scientific literature and/or from information obtained through ENSP research and expert opinion. In addition, a special analysis of the LULC for species and their feature label components is used to guide the selection of particular LULC classes for the creation of species-specific patches of habitat (*Appendix IV*).

In order to create species-based patches of habitat, the relevant LULC polygons from the Landscape base layer are combined into a potential habitat layer specific to each species-feature label. Spatially explicit species occurrence data that meet the criteria required for inclusion in the Landscape Project are then exported from the Biotics database and a species occurrence area (SOA) is applied for every feature label assigned to a species. SOAs are then overlaid onto species-specific habitat patches and patches are classified, or “valued,” based on the status of the species present as follows:

- ▶ **Rank 5** - assigned to species-specific habitat patches containing one or more occurrences of wildlife listed as endangered and threatened pursuant to the Federal Endangered Species Act of 1973.
- ▶ **Rank 4** - assigned to species-specific habitat patches with one or more occurrences of State endangered species.
- ▶ **Rank 3** - assigned to species-specific patches containing one or more occurrences of State threatened species.
- ▶ **Rank 2** - assigned to species-specific habitat patches containing one or more occurrences of species considered to be species of special concern.
- ▶ **Rank 1** - assigned to species-specific habitat patches that meet habitat-specific suitability requirements such as minimum size or core area criteria for endangered, threatened or special concern wildlife species, but that do not intersect with any confirmed occurrences of such species (see *Appendix V* for descriptions of all habitat-specific suitability requirements). Rank 1 habitat patches without documented occurrences are not necessarily absent of imperiled or special concern species. Patches with a lack of documented occurrences may not have been systematically surveyed. Thus, the Rank 1 designation is used for planning purposes, such as targeting areas for future wildlife surveys.

A SOA will value habitat that it overlays only if that habitat is appropriate for the species. Habitat patches ranked 2, 3, 4, or 5 intersect with or contain at least one documented SOA. Since imperiled species are typically not abundant across the landscape, a single occurrence may represent a significant portion of the local population and often indicates the presence of a larger population within a habitat patch. The Landscape Project habitat patch mapping approach is designed to capture and represent the habitat needed to support the local population indicated by the individual SOA.



Federal Listed (5), Endangered (4) and Threatened (3) Species-Based Habitat.

In the delineation of Species-Based Habitat, each species-feature label combination is assigned a “Patch Type,” or category that describes the method employed to form the valued habitat area from polygons in the Landscape base layer. In addition, for each LULC class selected for a particular species-feature label combination, a “LULC Treatment,” or rule, is applied that determines how polygons of a LULC class will interact with a SOA and/or with polygons of other LULC classes in order to construct patches of habitat. The four general patch types are described below and the LULC treatments are defined in *Appendix V*. A comprehensive list of species-feature labels and their assigned patch type is included in *Appendix V*. For those species-feature label combinations that utilize variations, or subtypes of the four general types, an explanation of the subtype is also included within *Appendix V*.

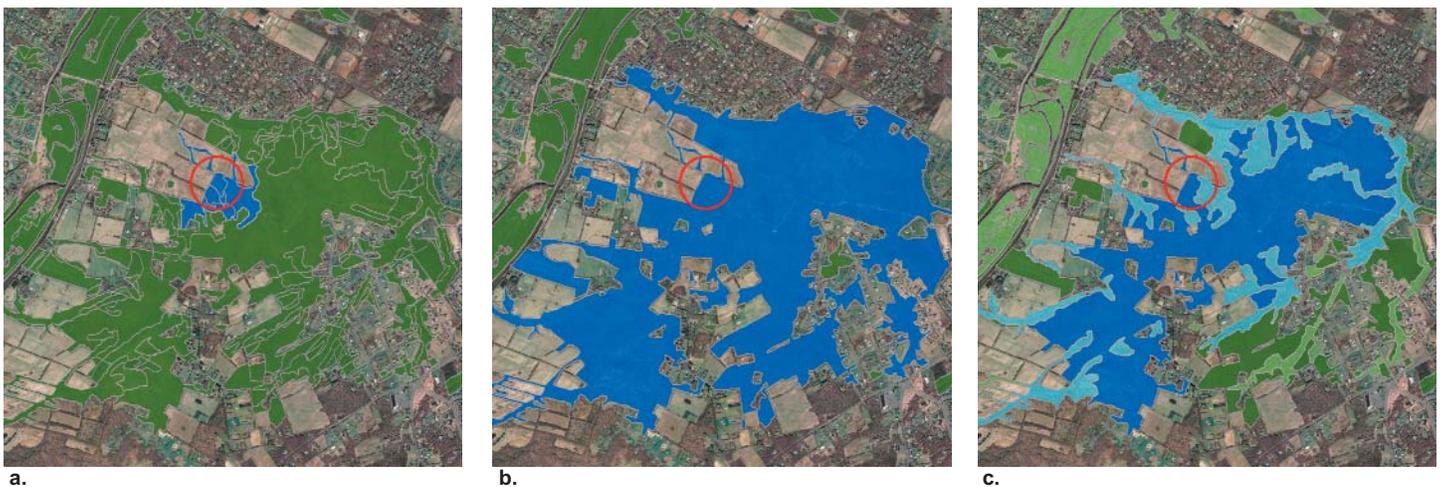
Each species-feature label combination is grouped into one of the following patch type categories.

Limited Extent – polygons from a select set of LULC classes are valued upon intersection with a SOA. Once the valued habitat area is identified, any internal holes or gaps containing polygons of selected LULC classes are also valued if they are completely enclosed by, and contiguous with, the valued area.

Contiguous Area – polygons from a select set of LULC classes are dissolved/combined into contiguous areas and valued upon intersection with a SOA.

Cardinal-Proximate – polygons from an initial, or cardinal, set of LULC classes are valued upon intersection with a SOA and then polygons from a second, proximate set of LULC classes are valued based on a spatial relationship (e.g., adjacency) with polygons from the cardinal set of LULC classes and/or a SOA. Once the valued habitat area is identified, any internal holes or gaps containing polygons of selected LULC classes are also valued if they are completely enclosed by, and contiguous with, the valued area.

Stream Centerline – stream centerlines are valued upon intersection with a SOA. In Version 3.3 of the Landscape Project, only freshwater mussel species utilize the Stream Centerline patch type, described more thoroughly in the next section.



Examples of patch types. The red circle represents a SOA. Areas depicted in green are LULC polygons that can be valued, while the valued LULC polygons are depicted in blue. a) Limited Extent - LULC polygons that directly intersect the SOA are valued. b) Contiguous Area - LULC polygons are dissolved/combined into contiguous areas and then valued upon intersection with the SOA. c) Cardinal-Proximate - a cardinal set of LULC classes that can be valued is depicted in dark green and dark blue, while a proximate set that can be valued is depicted in light green and light blue. The cardinal LULC polygons are valued upon intersection with the SOA (dark blue) and the proximate set is valued based on adjacency to the valued cardinal set. Valued cardinal LULC polygons are depicted in dark blue, while valued proximate LULC polygons are depicted in light blue.

FRESHWATER MUSSEL HABITAT

DEP maintains a Stream Network data layer that is a subset of the USGS 1:24,000 high-resolution National Hydrography Dataset (NHD). In Version 3.3 of the Landscape Project, stream and water body centerlines from the NHD Streams 2002 data layer are used to represent freshwater mussel habitat.



The Eastern Pondmussel (Threatened) can be found in the lower half of the Delaware River and several of its tributaries.

Water body centerline and stream centerline data are valued exclusively by freshwater mussel species occurrence areas while other aquatic species habitats are represented with polygons from the Species-Based Habitat layer. In order to form representative “patches” of habitat from the NHD Streams 2002 layer, centerlines were broken at the confluence of two or more streams or the inflow/outflow of a water body.

Stretches of stream intersected by a mussel SOA are valued as habitat. All valued streams are buffered by 0.75 kilometers upstream and downstream. The 0.75 kilometer distance is chosen as a conservative buffer estimate because scientific literature based largely upon larval transport by host fishes, indicates that if there are two occurrences within two kilometers of each other (assuming unsuitable habitat between), these occurrences should be considered as part of the same local population (NatureServe 2011). In the cases where stream buffers of separate occurrences of the same species meet, either upstream or downstream, the stream segments between those occurrences are also valued for that species. In addition, in cases where dams are barriers the extent of stream valued was limited.



The tidewaters of Pompeston Creek in Burlington County provide ideal habitat for the Eastern Pondmussel.



Stream centerlines are used to represent freshwater mussel habitat in Version 3.3 of the Landscape Project.

VERNAL HABITAT

In 2001, ENSP partnered with Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA) to develop a method for mapping potential vernal pools throughout New Jersey. Through an on-screen visual interpretation of digital orthophotography, CRSSA identified over 13,000 potential pools throughout the state. A subset of these pools was field verified and confirmed, with an 88% accuracy rate, to meet the physical characteristics to qualify as a vernal pool (Lathrop et al. 2005).



Eastern Tiger Salamander (*Desmognathus tigris*), a vernal pool breeder.

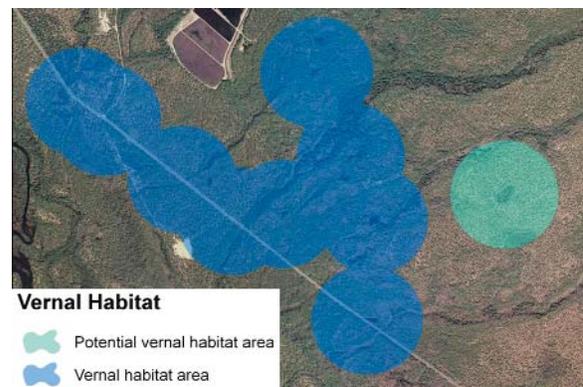
In accordance with N.J.A.C. 7:7A-1.4, the term “vernal habitat” includes a vernal pool - or the area of ponding - plus any freshwater wetlands adjacent to the vernal pool. Vernal habitat areas mapped in the Landscape Project rely upon those data developed by the DEP and CRSSA to identify sites that should be field checked for

possible identification as vernal habitat areas. DEP staff is in the process of field-verifying these pools. The Department also maps vernal habitat areas based upon on-the-ground assessment of sites not captured by the CRSSA mapping. The Landscape Project includes all of the CRSSA-identified sites, as well as sites identified by on-the-ground reconnaissance, categorized as either “potential vernal habitat areas” or “vernal habitat areas” as defined below.

- ▶ **Potential vernal habitat area** - These are areas identified by CRSSA as possibly containing a vernal pool that meets the criteria of a “vernal habitat” pursuant to N.J.A.C. 7:7A-1.4. These sites include sites that have been field inspected and have been found to meet the physical characteristics of a vernal habitat, but for which biological criteria have not yet been measured, as well as sites that have not been checked by DEP staff.
- ▶ **Vernal habitat areas** - These are areas that contain pools that have been field-verified by the Department and have been determined to meet both the physical and biological characteristics of a vernal habitat in accordance with N.J.A.C. 7:7A-1.4.



A vernal pond in northern New Jersey.



Vernal habitat areas identified in the Landscape Project.

All areas mapped as “potential vernal habitat areas” and “vernal habitat areas” are derived from a point location estimated to be the center of an individual vernal pool and include all areas within 300 meters of the point. Note that the occurrence area is not intended to suggest or correspond with any specific regulatory requirement. Rather, the area added around the point accounts for variations in the size of individual vernal pools, variations in the width of freshwater wetlands adjacent to the pool, plus adjacent habitats sufficient to include the estimated home range for vernal pool obligate species. If there is an overlap between areas mapped around two or more nearby points, the boundaries are conjoined to generate contiguous patches. If the resulting patch contains areas mapped as “vernal habitat area” and areas mapped as “potential vernal habitat areas,” the entire patch is labeled as a “vernal habitat area.”

DATA AVAILABILITY

Landscape Project maps are available in file geodatabase format and projected to New Jersey State Plane feet, datum NAD 83, zone 4701. The maps are best viewed using ArcGIS 10.x. These software products allow the user full functionality for viewing and manipulating Landscape Project data. Non-GIS users can view the maps using the DEP's interactive mapping application listed below or ArcGIS Explorer, a free GIS data browser that can be downloaded from the Esri Web site: <http://www.esri.com/software/arcgis/explorer/index.html>

Landscape Project data and maps are available by the following methods:

GIS Data

- ▶ Download on NJDEP's Bureau of GIS website (<http://www.nj.gov/dep/gis>).

Online Mapping Application

- ▶ Access GIS layers on NJDEP's interactive mapping application site (<http://njdep.maps.arcgis.com/apps/webappviewer/index.html?id=0e6a44098c524ed99bf739953cb4d4c7>).

For more information, contact:

New Jersey's Landscape Project
Department of Environmental Protection
Division of Fish and Wildlife
Endangered and Nongame Species Program
Mail Code 501-03
P.O. Box 420
Trenton, NJ 08625-0420
Phone: (609) 292-9400
Fax: (609) 984-1414

LITERATURE CITED

- Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E. Witmer. 1976. *A land use and land cover classification system for use with remote sensor data*. U.S. Geological Survey Professional Paper 964. 28 p.
- Fahrig, L., and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. *Ecology and Society* 14(1): 21.
- Hasse, J., and R. G. Lathrop. 2010. *Changing Landscapes in the Garden State: Urban Growth and Open Space Loss in New Jersey 1986 thru 2007*. Glassboro, NJ: Rowan University, Geospatial Research Lab. Retrieved from <http://gis.rowan.edu/projects/lulc/>
- Hasse, J. and R. G. Lathrop. 2008. *Tracking New Jersey's Dynamic Landscape: Urban Growth and Open Space Loss 1986-1995-2002*. Glassboro, NJ: Rowan University, Geospatial Research Lab. Retrieved from <http://www.crssa.rutgers.edu/projects/lc/urbangrowth/index.html>
- Hasse, J, and R.G. Lathrop. 2001. *Measuring urban growth in New Jersey. A report on recent land development patterns utilizing the 1986-1995 NJ DEP Land Use/Land Cover Dataset*. Center for Remote Sensing and Spatial Analysis. Rutgers University.
- Hasse, J., J. Reiser, and A. Pichacz. 2010. *Evidence of Persistent Exclusionary Effects of Land Use Policy with Historic and Projected Development Patterns in New Jersey: A Case Study of Monmouth and Somerset Counties*. Glassboro, NJ: Rowan University, Geospatial Research Lab. Retrieved from <http://gis.rowan.edu/labprojects/exclusionary/>
- Hughes, M., and R. G. Lathrop. 2001. *A Methodology for Defining and Characterizing the Health of Riparian Areas in the Musconetcong and Pohatcong Watersheds using Geographic Information Systems*. Rutgers University Grant F. Walton Center for Remote Sensing and Spatial Analysis. CRSSA Technical Report 0101.
- Lathrop, R.G., P. Montesano, J. Tesauro, and B. Zarate. 2005. *Statewide mapping and assessment of vernal pools: A New Jersey case study*. *Journal of Environmental Management* 76: 230-238.
- NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life (web application). Version 7.1. NatureServe, Arlington, VA. Accessed: August 25, 2011 from <http://www.natureserve.org/explorer>
- Seiler, A. 2003. The toll of the automobile: wildlife and roads in Sweden. Dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden.
- U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau. 2006. *2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*.

GIS DATA SOURCES

NJ Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). 2015. NJDEP 2012 Land use/Land cover Update.

Online Linkage: <http://www.nj.gov/dep/gis/lulc12.html>

New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). 2010. National Hydrography Dataset (NHD) Streams 2002.

Online Linkage: <http://www.nj.gov/dep/gis/nhd2002.html>

New Jersey Department of Environmental Protection (NJDEP), Division of Fish and Wildlife (DFW), Endangered and Nongame Species Program (ENSP) and Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA). 2006. Potential Vernal Pools.

Online Linkage: <http://www.dbcrrsa.rutgers.edu/ims/vernal/index.html>

New Jersey Department of Environmental Protection (NJDEP), Division of Fish and Wildlife (DFW), Endangered and Nongame Species Program (ENSP). 2016. Species Occurrence Areas, Version 11.

Online Linkage: Unpublished.

New Jersey Department of Environmental Protection (NJDEP). New Jersey Integrated Terrain Unit Maps (ITUM) Flood Prone Areas.

Online Linkage: http://www.epa.gov/region2/gis/atlas/fld_itum.htm

New Jersey Department of Transportation (DOT), Geographic Information Systems. NJDOT Major Roadways 2015.

Online Linkage: <http://www.state.nj.us/transportation/gis/map.shtm>

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) Database. Accessed [06/01/2015].

Online Linkage: <https://sdmdataaccess.sc.egov.usda.gov>.

United States Department of Homeland Security, Federal Emergency Management Agency (FEMA), Flood Map Service Center. 2015.

Online Linkage: <https://msc.fema.gov/portal>

GLOSSARY

Biological and Conservation Database (BCD) - Biodiversity data management software developed by NatureServe that was formerly used by the New Jersey Department of Environmental Protection's Natural Heritage Program and Division of Fish and Wildlife's Endangered and Nongame Species Program before it was replaced by Biotics in 2004.

Biotics - Biodiversity data management software used by the Endangered and Nongame Species Program (ENSP). The successor to the Biological and Conservation Database, this data management software is developed by NatureServe and, within New Jersey, is maintained jointly by ENSP (animal data) and the Natural Heritage Program (plant and ecological community data).

certified vernal pool - Four criteria must be satisfied in order for a vernal pool to be classified as certified. These criteria are: 1. The area must occur in a confined basin or depression without a permanently flowing outlet; 2. The pool must feature evidence of breeding by at least one obligate or two facultative vernal habitat species (these species are identified in N.J.A.C. 7:7A, Appendix 1); 3. The area must maintain ponded water for at least two continuous months between March and September of a normal rainfall year, and; 4. The area must remain free of fish populations throughout the year, or it must dry up at some time during a normal rainfall year.

endangered species - A species included on the list of endangered species at N.J.A.C. 7:25-4.13 and any species or subspecies of wildlife appearing on any Federal endangered species list. The Endangered and Nongame Species Conservation Act (N.J.S.A. 23:2A et seq.) defines an endangered species (with respect to wildlife) to be a species or subspecies of wildlife whose prospects for survival or recruitment are in jeopardy or are likely within the foreseeable future to become so due to any of the following factors: (1) the destruction, drastic modification, or severe curtailment of its habitat, or (2) its over-utilization for scientific, commercial or sporting purposes, or (3) the effect on it of disease, pollution, or predation, or (4) other natural or manmade factors affecting its prospects of survival or recruitment within the State, or (5) any combination of the foregoing factors. The term shall also be deemed to include any species or subspecies of wildlife appearing on any Federal endangered species list.

feature label - A label assigned to each occurrence that describes the occurrence type (e.g., nest, den, dead on road, etc.).

Highlands Region - The New Jersey Highlands Region is the area designated pursuant to the Highlands Water Protection and Planning Act, at N.J.S.A. 13:20-7; an over 800,000 acre region covering over 1,250 square miles and 88 municipalities in seven counties (Bergen, Hunterdon, Morris, Passaic, Somerset, Sussex and Warren). The Highlands Region is an essential source of drinking water for half of the residents of New Jersey.

imperiled species - Includes all wildlife species considered to be endangered or threatened as defined elsewhere in this document.

location use class - A label used for aerial and marine migrants that occupy disjunct locations by season (i.e. breeding or nonbreeding). Applies to migratory species only.

Land Use/Land Cover (LULC) - A geographic information system (GIS) dataset produced by visually interpreting color infrared aerial photography of New Jersey. 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. 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.

LULC treatment - A specific rule applied to an individual LULC class that determines how that LULC class will interact with a SOA and/or other LULC classes in order to construct patches of habitat for each species-feature label combination.

major roadway - A roadway classified by the New Jersey Department of Transportation as a 600 Series County Route or higher. Major roadways are Interstate Highways, U.S. Routes, NJ State Highways, Toll Authority Routes and 500 and 600 Series County Routes.

Natural Heritage methodology - A set of standard procedures for gathering, organizing, and managing information on biodiversity, used throughout the NatureServe network.

NatureServe - A non-profit conservation organization that provides scientific information and tools to help guide effective conservation action. NatureServe represents an international network of biological inventories (known as natural heritage programs or conservation data centers) operating in all 50 states, Canada, Latin America, and the Caribbean.

patch type - A category that describes the method employed to form the valued habitat area from the Landscape base layer for each species-feature label combination. Each species-feature label combination is grouped into one of the patch type categories.

riparian - Of, or pertaining to, the bank of a river or stream.

Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA) - An active research and development program focusing on advancing the application of various geo-spatial technologies including remote sensing, geographic information systems and global positioning systems. CRSSA also develops spatial-statistical analysis/modeling techniques for the environmental, agricultural and natural resource sciences and management.

species occurrence area - A polygon specific to each species-feature label combination that is applied to all occurrences in the Biotics database and that is used to value habitat in the Landscape Project. The area of the polygon is generally based on the average home range/territory size, or other appropriate life-history parameter as reported in peer-reviewed scientific literature or from information obtained through ENSP research. When searching the scientific literature to gather information to support the occurrence area polygon size, efforts were made to select research that was conducted in habitat types similar to those found in New Jersey. For many species that value habitat patches in the Landscape Project maps, insufficient information exists in the scientific literature to support the designation of an occurrence area. In these cases, a default occurrence area (71.25m radius) is applied to take into account locational uncertainty.

species of special concern - Nongame wildlife species that warrants special attention by the Department because of inherent vulnerability to environmental deterioration or habitat modification that would result in its becoming threatened if conditions surrounding the species begin or continue to deteriorate. Factors that can lead to classification as special concern include, but are not limited to, species rarity in the State, highly specialized food and/or habitat requirements, low reproductive rate, isolated populations of the species within the State

and/or other characteristics that make the species particularly susceptible to environmental or habitat changes. This category includes a species that meets the foregoing criteria and for which there is little understanding of its current population status in the State. Species determined to be “special concern” are so-designated at N.J.A.C. 7:25-4.17.

threatened species - An indigenous nongame wildlife species of New Jersey designated pursuant to the Endangered and Nongame Species Conservation Act, N.J.S.A.23:2A et. seq., and its implementing rules, N.J.A.C. 7:25-4.17, as most recently amended. Threatened species are generally defined to be species that may become endangered if conditions surrounding them begin or continue to deteriorate.

vernal pool - Vernal pools are confined depressions, either natural or man-made, that hold water for at least two consecutive months out of the year, and are devoid of breeding fish populations. Vernal pools provide habitat to many species of amphibians, insects, reptiles, plants, and other wildlife. The absence of fish is the essence of these ecosystems.

**Geographic Information Systems Terminology from Environmental Systems Research Institute's
Online GIS Dictionary (<http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway>)**

ArcView - Full-featured geographic information system software for visualizing, analyzing, creating, and managing data with a geographic component.

ArcView Shapefile - A vector data storage format for storing the location, shape, and attributes of geographic features. A shapefile is stored in a set of related files and contains one feature class.

dissolve - A geoprocessing command that removes boundaries between adjacent polygons that have the same value for a specified attribute.

feature class - In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes.

feature dataset - In ArcGIS, a collection of feature classes stored together that share the same spatial reference; that is, they share a coordinate system, and their features fall within a common geographic area. Feature classes with different geometry types may be stored in a feature dataset.

geodatabase - A database or file structure used primarily to store, query, and manipulate spatial data. Geodatabases store geometry, a spatial reference system, attributes, and behavioral rules for data. Various types of geographic datasets can be collected within a geodatabase, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others.

geoprocessing - A geographic information system (GIS) operation used to manipulate GIS data. A typical geoprocessing operation takes an input dataset, performs an operation on that dataset, and returns the result of the operation as an output dataset. Common geoprocessing operations include geographic feature overlay, feature selection and analysis, topology processing, raster processing, and data conversion. Geoprocessing allows for definition, management, and analysis of information used to form decisions.

- GIS** - Acronym for geographic information system. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed.
- GPS** - Acronym for Global Positioning System. A system of radio-emitting and –receiving satellites used for determining positions on the earth. The orbiting satellites transmit signals that allow a GPS receiver anywhere on earth to calculate its own location through trilateration. Developed and operated by the U.S. Department of Defense, the system is used in navigation, mapping, surveying, and other applications in which precise positioning is necessary.
- raster** - A spatial data model that defines space as an array of equally sized cells arranged in rows and columns, and comprised of single or multiple bands. Each cell contains an attribute value and location coordinates. Unlike a vector structure, which stores coordinates explicitly, raster coordinates are contained in the ordering of the matrix. Groups of cells that share the same value represent the same type of geographic feature.
- union** - A topological overlay of two or more polygon spatial datasets that preserves the features that fall within the spatial extent of either input dataset; that is, all features from both datasets are retained and extracted into a new polygon dataset.
- vector** - A coordinate-based data model that represents geographic features as points, lines, and polygons. Each point feature is represented as a single coordinate pair, while line and polygon features are represented as ordered lists of vertices. Attributes are associated with each vector feature, as opposed to a raster data model, which associates attributes with grid cells.

CONVERSIONS

Area:

1 hectare = 2.47 acres

Distance:

1 meter = 3.28 feet

1 kilometer = 0.62 miles

PHOTO CREDITS

Allen Barlow: page 5 top right, 24 top. **Jeanette Bowers-Altman:** page 24 bottom. **©Hal Brundage, ERC Inc.:** cover row 5 (3). **©George Cevera:** page 17 bottom right. **Kathy Clark:** cover row 1 (6), row 2 (4), row 4 (1,3,4), row 5 (1,4,5,7), page 3, 4 top right, 13, 15 top. **Heather Corbett:** page 5 bottom left. **Dey:** cover row 3 (6). **Michael Davenport:** cover row 1 (5), row 2 (5), page 16 bottom. **Christina Davis:** page 5 top left, 14. **Daniel Ferrigno:** page 15 bottom. **David Golden:** cover row 3 (1), row 5 (2,6), page 16 top, 18 right. **MacKenzie Hall:** cover row 3 (2), page 5 bottom right, page 11. **New Jersey Conservation Foundation:** page 10. **Robert Somes:** cover row 2 (1), row 3 (5), page 16 middle. **Ben Trotter:** cover row 3 (4). **Mick Valent:** cover row 2 (2). **Melissa Woerner:** cover row 2 (3), page 18 left. **Ben Wurst:** cover row 1 (4), page 9. **Brian Zarate:** cover row 1 (1-3), row 3 (3), row 4 (2,5), page 17 top left, 20, 25.

MAP CREDITS

Unless noted below all maps created by: **Patrick Woerner, Brian Henderson, Pete Winkler, William Pitts and Melanie Mason.**

Amy S. Greene Environmental Consultants, Inc.: page 8.

Kingwood Township/Kratzer Environmental Services, Inc.: page 12.

New Jersey Conservation Foundation: page 10.

APPENDICES (Available Online Only)

Appendix I. Protocol for Accepting or Rejecting Species Sighting Reports.

http://www.state.nj.us/dep/fgw/ensp/landscape/appendix_i.pdf

Appendix II. Species Occurrence Area Justifications.

http://www.state.nj.us/dep/fgw/ensp/landscape/appendix_ii.pdf

Appendix III. NJDEP 2012 Land Use/Land Cover Categories.

http://www.state.nj.us/dep/fgw/ensp/landscape/appendix_iii.pdf

Appendix IV. Land Use/Land Cover Analysis for Species and their Feature Label components.

http://www.state.nj.us/dep/fgw/ensp/landscape/appendix_iv.pdf

Appendix V. Land Use/Land Cover Selections and Patch Type Justifications.

http://www.state.nj.us/dep/fgw/ensp/landscape/appendix_v.pdf

