A NATURAL HERITAGE INVENTORY OF DELAWARE COUNTY, PENNSYLVANIA
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Submitted to:

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Delaware County Planning Department
or
from the web in electronic format at:
http://www.naturalheritage.state.pa.us/CNAI_Download.aspx

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PREFACE

The Delaware County Natural Heritage Inventory Update is a document compiled and written by the Pennsylvania Natural Heritage Program (PNHP) of the Western Pennsylvania Conservancy (WPC). It builds on the original Natural Areas Inventory of Delaware County completed in 1992 by the Pennsylvania Science Office of The Nature Conservancy. This document contains information on the locations of rare, threatened, and endangered species and of the highest quality natural areas in the county; it is not an inventory of all open space. It is intended as a conservation tool and should in no way be treated or used as a field guide. Accompanying each site description are general management recommendations that would help to ensure the protection and continued existence of these natural communities, rare plants, and animals. The recommendations are based on the biological needs of these elements (communities and species). The recommendations are strictly those of WPC and do not necessarily reflect the policies of the state or the policies of the county or townships for which the report was prepared.

Managed areas such as state, county and township lands as well as those of various conservation organizations and homeowner associations are also provided on the maps based on information obtained from the Delaware County GIS Department. This information is useful in determining where gaps occur in the protection of land with ecologically significant habitats, natural communities, and rare species. The mapped boundaries are approximate and our list of managed areas may be incomplete, as new sites are always being added.

Implementation of the recommendations is up to the discretion of the landowners. However, cooperative efforts to protect the highest quality natural features through the development of site-specific management plans are greatly encouraged. Landowners working on the management of, or site plans for specific areas described in this document are encouraged to contact the PNHP for further information.

The Pennsylvania Natural Heritage Program is responsible for collecting, tracking, and interpreting the information regarding the Commonwealth's biological diversity. County Natural Heritage Inventories (CNHIs) are an important part of the work of PNHP. Since 1989, PNHP has conducted county inventories as a means to both gather new information about natural resources and to pass this information along to those responsible for making decisions about the resources in the county. This County Natural Heritage Inventory focuses on the best examples of living ecological resources in Delaware County. The county must address historic, cultural, educational, water supply, agricultural and scenic resources through other projects and programs.

Natural Heritage Inventories and Environmental Review

The results presented in this report represent a snapshot in time, highlighting the sensitive natural areas within Delaware County. The sites in the Delaware County Natural Heritage Inventory have been identified to help guide land use and county planning. The Delaware County Natural Heritage Inventory is a planning tool, but is not a substitute for environmental review, as information is constantly being updated as natural resources are both destroyed and discovered. Applicants for building permits and Planning Commissions can conduct free, online, environmental reviews to inform them of project-specific potential conflicts with sensitive natural resources. Environmental reviews can be conducted by visiting the Pennsylvania Natural Heritage Program's website, at http://www.naturalheritage.state.pa.us/. If conflicts are noted during the environmental review process, the applicant is informed of the steps to take to minimize negative effects on the county's sensitive natural resources. If additional information on species of concern becomes available during environmental review, the review may be reconsidered by the jurisdictional agency.

Particular species names, common and scientific, are provided in coordination with the appropriate jurisdictional agency. Some species are especially vulnerable to disturbance or unauthorized collection and are therefore not identified in the text of this report at the request of the agencies, in order to provide some measure of protection. Plants and terrestrial invertebrates are under the jurisdiction of the Pennsylvania Department of Conservation and Natural Resources (DCNR). Mammals and birds are under the jurisdiction of the Pennsylvania Game Commission (PGC). Aquatic animals, reptiles, and amphibians are under the jurisdiction of the Pennsylvania Fish and Boat Commission (PFBC).

Although the inventory was conducted using a tested and proven methodology, it is best viewed as a preliminary report on the county's natural heritage. Further investigations could, and likely will, uncover

previously unidentified areas of significance. More in-depth investigations of sites listed in this report could reveal features of further or greater significance than have been documented. Likewise, as land use patterns in the county change, species may be lost, changing the significance of already documented sites. We encourage additional inventory work across the county to further the efforts begun with this study. Keep in mind that that this document can be updated as necessary to accommodate new information.

Consider this inventory as an invitation for the people of Delaware County to explore and discuss their natural heritage and to learn about and participate in the conservation of the living ecological resources of the county. Ultimately, it will be up to the landowners, residents, and officials of Delaware County to determine how to use this information. Several potential applications for the information within the County Natural Heritage Inventory for a number of user groups follow:

Planners and Government Staff: Typically, the planning office in a county administers county inventory projects. Often, the inventories are used in conjunction with other resource information (agricultural areas, slope and soil overlays, floodplain maps, etc.) in review for various projects and in comprehensive planning. Natural Heritage Areas may be included under various categories of zoning, such as conservation or forest zones, within parks and greenways, and even within agricultural security areas. There are many possibilities to provide for the conservation of Natural Heritage Areas within the context of public amenities, recreational opportunities, and resource management.

County, State and Federal Agencies: In many counties, Natural Heritage Areas lie within or include county, state, or federal lands. Agencies such as the Pennsylvania Game Commission, the Pennsylvania Bureau of Forestry, County Parks and Township Parks can use the inventory to understand the extent of the resource. Agencies can also learn the requirements of the individual plant, animal or community elements, and the general approach that protection could assume. County Conservation Districts may use the inventories to focus attention on resources (high diversity streams or wetlands) and as a reference in encouraging good management practices.

Environmental and Development Consultants: Environmental consultants are called upon to plan for a multitude of development projects including road construction, housing developments, commercial enterprises, and infrastructure expansion. Design of these projects requires that all the resources impacted be known and understood. Decisions made with inadequate information can lead to substantial and costly delays. County Natural Heritage Inventories (CNHIs) provide a first look at biological resources, including plants and animals listed as rare, threatened, or endangered in Pennsylvania and/or at the federal level. Consultants can then see potential conflicts long before establishing footprints or developing detailed plans and before applying for permits. This allows projects to be changed early on when flexibility is at a maximum.

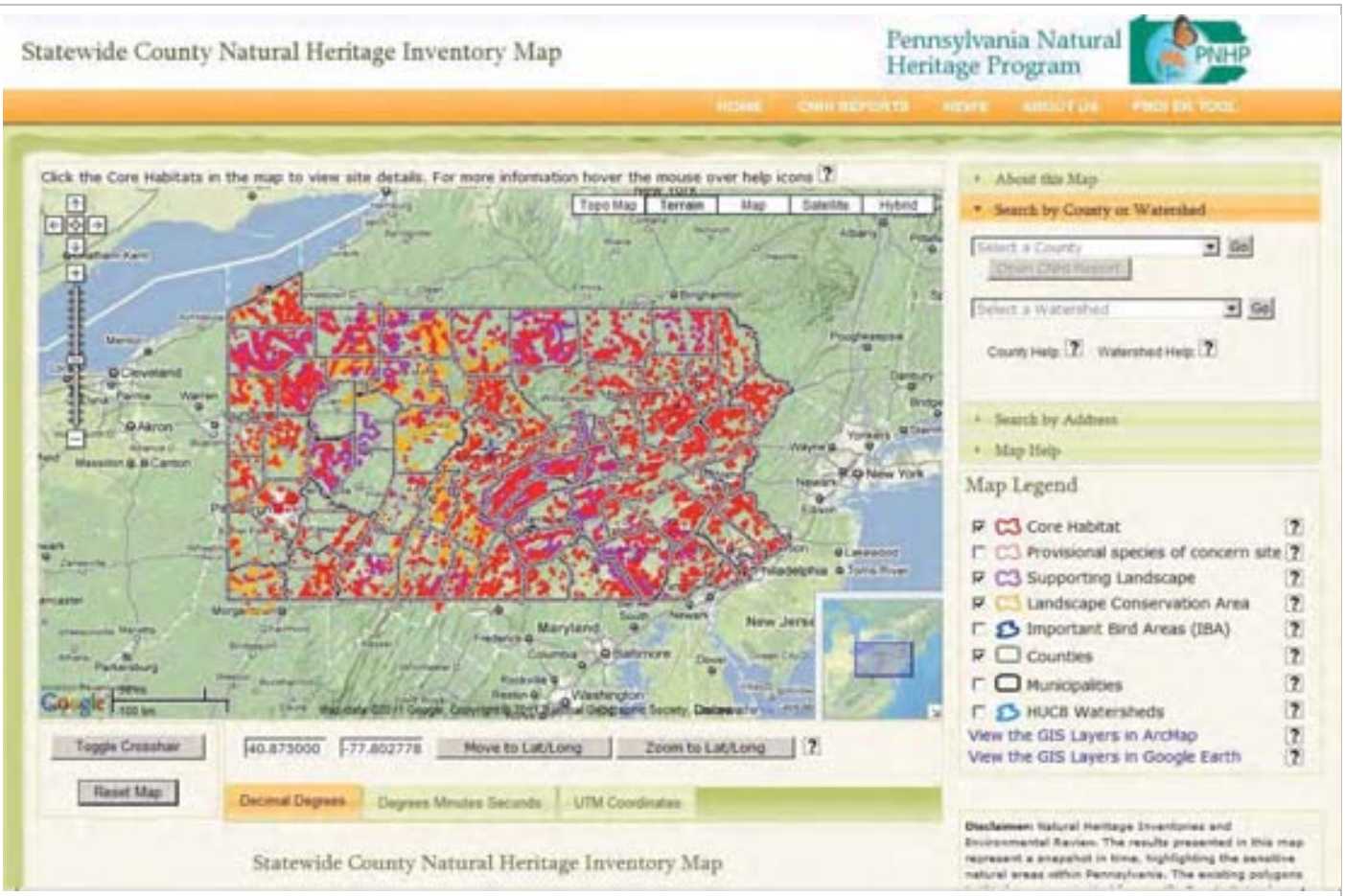
Environmental consultants are increasingly called upon to produce resource plans (e.g. River Conservation Plans, Parks and Open Space Plans, and Greenways Plans) that must integrate a variety of biological, physical, and social information. CNHIs can help define watershed-level resources and priorities for conservation and are often used as the framework for these plans.

Developers: Working with environmental consultants, developers can consider options for development that add value while protecting key resources. Incorporating green-space, wetlands, and forest buffers into various kinds of development can attract homeowners and businesses that desire to have natural amenities nearby. Just as parks have traditionally raised property values, so too can natural areas. CNHIs can suggest opportunities where development and conservation can complement one another.

Educators: Curricula in primary, secondary and college level classes often focus on biological science at the chemical or microbiological level. Field sciences do not always receive the attention that they deserve. Natural areas can provide unique opportunities for students to witness, first-hand, the organisms and natural communities that are critical to maintaining biological diversity. Educators can use CNHIs to show students where and why local and regional diversity occurs, and to aid in curriculum development for environment and ecology academic standards. With proper permission and arrangements through landowners and the Pennsylvania Natural Heritage Program, students can visit Natural Heritage Areas and establish appropriate research or monitoring projects.

Conservation Organizations: Organizations that have a mission related to the conservation of biological diversity can turn to the inventory as a source of prioritized places in the county. Such a reference can help guide internal planning and define the essential resources that can be the focus of protection efforts. Land trusts and conservancies throughout Pennsylvania have made use of the inventories to do just this sort of planning and prioritization, and are now engaged in conservation efforts on highly significant sites in individual counties and regions.

Statewide Coverage: The information depicted in this report will be integrated into the PNHP "Statewide County Natural Heritage Inventory Map", a web-based application of all existing PA CNHI information (http://www.naturalheritage.state.pa.us/cnhi/cnhi.htm).
The areas highlighted in the CNHIs representing sensitive natural features within each county have been merged into a single layer to provide a seamless statewide coverage. Until now, one would have to sift through the various CNHI projects to get a preview of the primary locations for species of concern and other sensitive natural features prior to submitting a project for environmental review. This statewide layer of existing CNHI sites allows for a landscape level review of the sensitive ecological features of the state.



ACKNOWLEDGEMENTS

We would like to acknowledge the citizens and landowners of Delaware County and surrounding areas who volunteered information, time, and effort to the inventory and granted permission to access land. A special thank-you goes to the people of Delaware County for their interest and hospitality. A big thank you goes to those who suggested areas of interest and assisted with field surveys, including: Janet Ebert, Jack Holt, Steve Johnson (independent biological consultants); Roger Latham (Continental Conservation); Tim Block, Ann Rhoads (Morris Arboretum); Robert Lonsdorf, Tom Larson, Kevin Fryberger, Tara Tracy, Estelle Wynn Dolan (Brandywine Conservancy); Scott Wendle, Joe Vinton, David Steckel (Natural Lands Trust); Rick Colbert, Andy Brundage, Dick Cloud (Tyler Arboretum); Mark McAlpine (Pennsylvania Game Commission); Danielle Kreeger, Krista Laudenbach-Nelson (Partnership for the Delaware Estuary); Brendalee Phillips (John Heinz National Wildlife Refuge at Tinicum); Sara Strassman (American Rivers), Kitt Heckscher, (Delaware State University); Robert Coxe, (Delaware Natural Heritage Program).

The Delaware County Planning Department provided much support and guidance with the inventory including Karen Holm, Zachary Barner, Julie Del Muto, Shaun Bollig, Rachelle Green, Steven Beckley, Andrew Adams and Timothy Lucas. The Delaware County Natural Heritage Inventory has benefited greatly from your input, and we thank you for your assistance.

We want to recognize the Pennsylvania Natural Heritage Program and NatureServe for providing the foundation for the work that we perform for these studies. Current and former PNHP staff that contributed to this report include JoAnn Albert, Jake Boyle, Tony Davis, Alice Doolittle, Charlie Eichelberger, Rocky Gleason, Susan Klugman, Matt Kowalski, John Kunsman, Betsy Leppo, Sally Ray, Erika Schoen, Andrew Strassman, Christopher Tracey, Jeff Wagner, Mary Walsh, Denise Watts and Peter Woods.

The species information utilized in the inventory came from many sources as well as our own field surveys. We wish to acknowledge all of those who carried out botanical and zoological survey work over the years. Without their contributions, this report would have been far less complete.

Finally, we especially wish to thank the landowners who granted us permission to conduct inventories on their lands. The task of inventorying the natural heritage of Delaware County would have been far more difficult without this tremendous pool of information gathered by many people over many years.

This project was funded through grants provided by the Pennsylvania Department of Conservation and Natural Resources, Wild Resources Conservation Program, and Delaware County.

We encourage comments and questions. The success of the report will be measured by the use it receives and the utility it serves to those making decisions about resources and land use throughout the county. Thank you for your interest.

The Pennsylvania Natural Heritage Program (PNHP) is a partnership between the Western Pennsylvania Conservancy (WPC), the Pennsylvania Department of Conservation and Natural Resources (DCNR), the Pennsylvania Game Commission (PGC), and the Pennsylvania Fish and Boat Commission (PFBC). PNHP is a member of NatureServe, which coordinates natural heritage efforts through an international network of member programs—known as natural heritage programs or conservation data centers—operating in all 50 U.S. states, Canada, Latin America and the Caribbean.

The Western Pennsylvania Conservancy served as the principal investigator, prepared the report, and created the maps for this study. Established in 1932, WPC is a private non-profit conservation organization headquartered in Pittsburgh. WPC's mission is to save the places we care about by connecting people to the natural world. As part of its mission, WPC works to sustain the natural heritage of the Commonwealth: its native plant, animal, and habitat resources. To reach these goals, WPC initiates conservation projects independently, and establishes partnerships with like-minded agencies and organizations.

Delaware County Natural Heritage Inventory Site Index

#	Natural Heritage Area Name	#	Natural Heritage Area Name
1	Skunk Hollow Woods	19	Harvey Run Powerline ROW
2	Ithan - Darby Creek Wetlands	20	Brandywine Summit
3	Haverford State Hospital Borrow Field	21	Chadds Ford Old Fields
4	Cobbs Creek	22	Chadds Ford Swamp
5	Crum Woods of Swarthmore College	23	Brandywine Creek Corridor
6	Martin Forest	24	Beaver Valley Woods
7	Crum Creek Floodplain and Reservoir	25	Johnsons Corner, Naamans Creek Road
8	Media Wetlands	26	Clayton Park, Shavertown Woods
9	Mineral Hill	27	Sun Oil Woods
10	Riddle Hospital Serpentine Barrens	28	Naamans Creek near Ogden
11	Pink Hill Serpentine Barrens	29	Naamans Creek Woods
12	Tyler Arboretum, Ridley Creek SP Woodland	30	Marcus Hook to Commodore Barry Bridge
13	Springton Reservoir	31	Ridley Creek - Crum Creek Mouth Tidal Wetlands
14	Ridley Creek Woods	32	Darby Creek Mouth Mudflat
15	Ridley Creek Headwaters	33	Tinicum Woods
16	Bonner Park Woods	34	Little Tinicum Island
17	Brinton Lake Wetland	35	Airport Tidal Wetlands
18	Todd Woods	36	John Heinz National Wildlife Refuge

Initial	Name	Initial	Name
C	Colwyn Boro	PS	Parkside Boro
CH	Clifton Heights	R	Rutledge Boro
EL	East Lansdowne Boro	RV	Rose Valley Boro
M	Millbourne Boro	S	Springfield
MO	Morton Boro	UD	Upper Darby

Site Identification # and Significance

- *exceptional significance*
- *high significance*
- *notable significance*
- *local significance*

- Core Habitat
- Supporting Landscape
- Subwatershed
- TOWNSHIP BOUNDARIES
- *USGS Quadrangles*

Scale 1:114,000

0 0.5 1 2 3 4 5 Miles

0 0.5 1 2 3 4 5 Kilometers

Delaware County Natural Heritage Inventory, Update 2011

A County Natural Heritage Inventory (CNHI) is designed to identify and map areas that support species of concern, exemplary natural communities, and broad expanses of intact natural ecosystems that support important components of Pennsylvania's native biodiversity. In addition, this project has identified the most intact natural connections between and among these rare species habitats as a means to help prevent their isolation from the natural landscape. While the habitats of species of concern are a primary focus of this project, many other ecological factors were weighed when defining the "Green Infrastructure" of Delaware County and the surrounding area. These include: steep slopes; intact forests; interior forests; native habitat quality; wetlands, floodplains of streams and rivers; riparian buffer width and quality. These natural attributes, or the "green infrastructure" of the area was compared to the built landscape, or "gray infrastructure" to highlight those areas that are most in need of conservation action. In order to connect the larger, more intact pieces of the landscape, a series of corridors will be necessary as potential migratory pathways to help facilitate animal and plant movement in a rapidly changing environment. The restoration of streamside vegetation, or riparian buffers, may have the most significant effect on improving habitat connections while simultaneously improving water quality passing through the county to the Delaware River. Conservation Value Summary: While all of the natural habitats within the county contribute to the overall health of the County's ecological systems, the highest priority natural habitats and the potential connections between them become evident by combining the landscape features discussed above.

The map on the right indicates the potential natural value of all areas within the county. Darker colors indicate a higher relative ecological value than lighter colors. The primary connecting features within the county are the contiguous forested areas and the network of streams and rivers in the county. Many streams will require restoration of the riparian buffer area to fully function as habitat and migratory corridors within the county.

Large natural landscapes of the county that contain concentrations of high quality habitats and Natural Heritage Areas are the primary areas with highest relative ecological value in the County. In addition to those areas containing species of concern, the analysis of the combined landscape features helped to determine the most intact habitats as well as the most likely potential linkages. These habitat linkages are necessary to help keep natural habitats from becoming isolated islands in a sea of human modified landscape.

These areas currently provide habitat and regional migratory potential for most of the County's native plants and animals and are the primary components of the County's natural environments. Corridors are those areas identified as contributing to the local migratory potential within the County that help to bridge the gaps between the larger pieces of the landscape. These areas were typically highlighted because of the presence of existing fragments of linking habitats such as smaller patches of forest, woodlots, and stream corridors. In most cases, these corridors are in need of restoration to improve their utility as habitats and migratory potential.

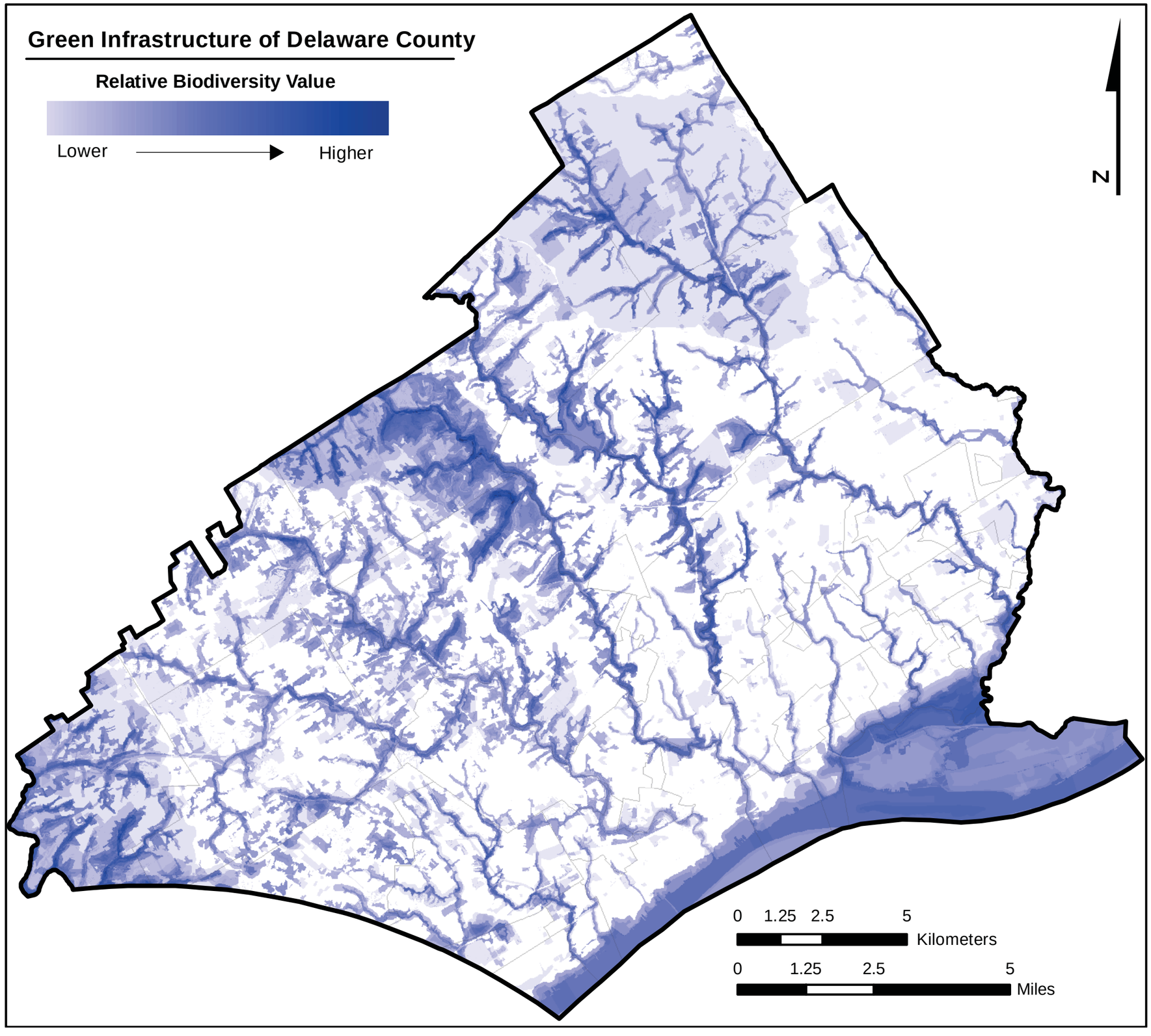


Table 2. Natural Heritage Areas categorized by significance. Significance ranks are Exceptional, High, Notable, and County (for a full explanation of these ranks, see page83). Sites are arranged alphabetically within each category.

Site Name	Municipality	Description	Page
Exceptional Significance			
Darby Creek Mouth Mudflat	Ridley and Tinicum Townships	Remnant tidal flat wetland at the confluence of Darby Creek and the Delaware River shoreline supports fourteen species of concern.	167
John Heinz National Wildlife Refuge	Darby, Norwood, Ridley, Tinicum Townships, and Colwyn, Folcroft, Norwood, Prospect Park, Sharon Hill Boroughs	Tidal estuary along Darby Creek before it meets the Delaware River supports numerous plant and animal species of concern and provides essential migratory habitat for waterfowl. This area is designated as a National Wildlife Refuge.	187
Little Tinicum Island	Tinicum Township	Island within the Delaware River is flanked by a "Freshwater Intertidal Mudflat Natural Community". The upland and aquatic habitats support numerous plant and animal species of concern.	203
Pink Hill Serpentine Barrens	Middletown Township	A small, but intact serpentine barrens habitat within a forested context supports five species of concern that are characteristic of serpentine habitats.	243
High Significance			
Airport Tidal Wetlands	Tinicum Township and Philadelphia County	Fragments of freshwater tidal marsh among the mostly bulk-headed shoreline of the Delaware River provide suitable habitat for numerous species of concern.	99
Beaver Valley Woods	Chadds Ford and Concord Townships Delaware County; Newcastle County in the State of Delaware	A mosaic of upland forest, forested wetlands, open wetlands, spring seeps, successional old fields and pipeline rights-of-way within an agricultural and residential context supports five species of concern.	105
Chadds Ford Swamp	Chadds Ford Township, Delaware County and Birmingham, Pennsbury Townships, Chester County	Wetland, floodplain and old field habitats along the Brandywine Creek provide habitat for six species of concern and essential migratory habitat for waterfowl.	137
Clayton Park, Shavertown Woods	Bethel and Concord Township	Mixed hardwood forest bisected by utility rights of way contains seeps and springs. Powerline maintenance keeps the corridor in a state of early succession. These habitats support eight plant species of concern.	143
Crum Woods of Swarthmore College	Nether Providence and Springfield Townships and Swarthmore Borough	Forested riparian corridor and adjacent uplands along Crum Creek supports two species of concern.	159
Haverford State Hospital Borrow Field	Haverford Township	Successional woodland and meadow-like openings support three plant species of concern.	177

Site Name	Municipality	Description	Page
High Significance (Continued)			
Johnsons Corner, Naamans Creek Road	Bethel and Concord Townships	Remnant coastal plain forest and old field habitat fragmented by roads, utility rights-of-way and residential development supports thirteen species of concern including a tree species only recently documented in the state.	195
Martin Forest	Nether Providence and Springfield Townships	This mature old-growth forested area with dramatic cliffs and rock outcrops provides an essential part of a nearly continuous habitat connection along Crum Creek between Chester County to the north and the Delaware River to the south. Floodplain habitat at this location also supports a plant species of concern.	213
Naamans Creek Woods	Upper Chichester and Lower Chichester Townships	Remnant coastal plain forest is fragmented by Interstate 95 and utility rights of ways. A mixture of forest, old fields, spring seeps and a small open wetland provide habitat for eight plant species of concern.	237
Riddle Hospital Serpentine Barrens	Middletown Township	Development pressure has greatly reduced this former serpentine barren natural community to a few scattered remnants that still manage to support six plant species of concern.	249
Ridley Creek - Crum Creek Mouth Tidal Wetlands	Chester City, Eddystone Borough and Ridley Township	This highly industrialized portion of the Delaware River shoreline contains remnant freshwater tidal marsh and mudflat habitats in a much degraded context. These habitats support three species of concern.	257
Ridley Creek Headwaters	Edgmont Township, Delaware County; East Goshen, Westtown, Willistown Townships, Chester County	Small wetlands, spring seeps and successional old fields occurring along and adjacent to the creek floodplain support four species of concern.	261
Springton Reservoir	Edgmont, Marple, Newton and Upper Providence Townships	Aquatic and riparian habitats associated with the reservoir provide habitat for two species of concern.	275
Tyler Arboretum, Ridley Creek SP Woodland	Edgmont and Middletown Townships	Rich, moist, forested ravine and adjacent slopes along Ridley Creek support five species of concern.	295
Notable Significance			
Bonner Park Woods	Thornbury Township	Mixed hardwood forest provides habitat for a plant species of concern.	113
Brandywine Creek Corridor	Chadds Ford Township	This wide forested area adjacent to the Brandywine Creek provides and essential buffer for the creek, a continuous habitat corridor and supports a plant species of concern.	117
Brandywine Summit	Chadds Ford Township	Mixed age hardwood forest provides buffer for two headwater streams and provides habitat for a plant species of concern.	123
Brinton Lake Wetland	Thornbury Township	A combination of active farm fields, seepy wet woods and wet meadows has recently been developed for residential uses. Two plant species of concern manage to persist is roadside habitat.	129
Chadds Ford Old Fields	Chadds Ford Township	Forested floodplain and old field habitats supports a plant species of concern.	133

EXECUTIVE SUMMARY

Preface

The ability of a community to bring its vision for the future to fruition depends on its capacity to assemble information that will enable it to act effectively and wisely. Since 1989, County Natural Heritage Inventories (CNHIs) have served as a way to both gather new information and to pass along new and existing information to those responsible for land use decisions, as well as to all residents who wish to know more about the natural heritage of their county. The Delaware CNHI focuses on the best examples of *living ecological resources* in the county. This inventory presents the known outstanding natural features in the county.

The Pennsylvania Natural Heritage Program (PNHP) is a partnership between the Western Pennsylvania Conservancy (WPC), the Pennsylvania Department of Conservation and Natural Resources (DCNR), the Pennsylvania Game Commission (PGC), and the Pennsylvania Fish and Boat Commission (PFBC) and is responsible for collecting, tracking, and interpreting information regarding the Commonwealth's biological diversity. The Western Pennsylvania Conservancy (WPC) served as the principal investigator, prepared the report, and created the maps for this study.

Introduction

Our natural environment is key to human health and sustenance. A healthy environment provides clean air and water; supports fish, game, and agriculture; and furnishes renewable sources of raw materials for countless aspects of our livelihoods and economy.

An ecosystem is "the complex of interconnected living organisms inhabiting a particular area or unit of space, together with their environment and all their interrelationships and relationships with the environment" (Ostroumov 2002). All the parts of an ecosystem are interconnected—the survival of any species or the continuation of a given natural process depends upon the system as a whole, and in turn, these species and processes contribute to maintaining the system. An important consideration in assessing ecosystem health is the concept of biodiversity. Biodiversity can be defined as the full variety of life that occurs in a given place, and is measured at several scales: genetic diversity, species, natural communities, and landscapes. One of the first steps in ensuring protection of our natural environment is to recognize environmentally sensitive or ecologically important areas and to provide information regarding their vulnerability to various land use activities.

A County Natural Heritage Inventory (NHI) is designed to identify and map areas that support species of concern (those considered rare, threatened or endangered at state or federal level), exemplary natural communities, and broad expanses of intact natural ecosystems that support important components of Pennsylvania's native species biodiversity. In addition, this project has

Natural Heritage Inventories and Environmental Review

The results presented in this report represent a snapshot in time, highlighting the sensitive natural areas within Delaware County. The sites in the Delaware County Natural Heritage Inventory have been identified to help guide land use and county planning. The Delaware County Natural Heritage Inventory is a planning tool, but is not a substitute for environmental review, as information is constantly being updated as natural resources are both destroyed and discovered. Applicants for building permits and Planning Commissions can conduct free, online, environmental reviews to inform them of project-specific potential conflicts with sensitive natural resources. Environmental reviews can be conducted by visiting the Pennsylvania Natural Heritage Program's website, at http://www.naturalheritage.state.pa.us/. If conflicts are noted during the environmental review process, the applicant is informed of the steps to take to minimize negative effects on the county's sensitive natural resources. If additional information on species of concern becomes available during environmental review, the review may be reconsidered by the jurisdictional agency.

Particular species names, common and scientific, are provided in coordination with the appropriate jurisdictional agency. Some species are especially vulnerable to disturbance or unauthorized collection and are therefore not identified in the text of this report at the request of the agencies, in order to provide some measure of protection. Plants and terrestrial invertebrates are under the jurisdiction of the Pennsylvania Department of Conservation and Natural Resources (DCNR). Mammals and birds are under the jurisdiction of the Pennsylvania Game Commission (PGC). Aquatic animals, reptiles, and amphibians are under the jurisdiction of the Pennsylvania Fish and Boat Commission (PFBC).

mapped and described natural connections between and among these species of concern habitats as a means to help prevent their isolation from the natural landscape. The intended purpose of this report is to provide information to municipal, county, and state governments, local conservation organizations, private individuals, and business interests so that they may plan development with the preservation of an ecologically healthy landscape for future generations in mind.

Sixty-four of Pennsylvania's sixty-seven counties have completed Natural Heritage Inventories to date. The original Delaware County NHI, (originally called Natural Areas Inventory or NAI), was completed in 1992 and followed up by a "data-review update' in 1998 that highlighted the species of concern information documented since the original Delaware CNAI report was completed. This update is intended to build on the information generated in those reports and to provide Delaware County with additional knowledge useful for the conservation of its unique natural heritage.

A significant emphasis of this report is on identifying the connections between the high quality habitats of Delaware County, to provide a regional ecological framework for the County. Many mapping features were incorporated into the analysis to help identify and define the high priority natural habitats of Delaware County.

Methods

In order to determine the long-term needs of the priority landscapes of the County and their connections to the landscape, we conducted this assessment in three phases:

1) Reviewed and updated the status of species and natural communities of concern.
2) Conducted a landscape-level analysis to determine the role of individual natural areas within the larger ecological picture of southeastern Pennsylvania, their utility as components of Green Infrastructure, and to identify the natural connections between them.
3) Provided site-specific recommendations for the conservation of biodiversity within and between high priority landscapes.

Site selection for the CNHI was guided by information from a variety of sources including the Pennsylvania Natural Heritage Program database, aerial photographs, local citizens, academic institutions, conservation organizations, the Delaware County Planning Department, and state and federal agencies that steward natural resources. Areas identified as inventory sites were surveyed in 2009 and 2010 after permission was obtained from landowners. Areas that were denied sufficient survey access were not surveyed for this project. Sites were examined to evaluate the condition and quality of the habitat, and to classify the communities present with boundaries for each site drawn using computer mapping software (geographic information systems - GIS).

Information Gathering

A review of the Pennsylvania Natural Heritage Program (PNHP) database determined where locations for special concern species and important natural communities were known to exist in Delaware County. Since the original Delaware County NHI (NAI) was completed, many professional and recreational naturalists, including those from our own office, have visited and revisited many of the county's most significant natural areas. The data generated from these visits has accumulated over the years in the PHNP database. Field forms submitted from these visits were reviewed to determine if updates to the information was necessary or desirable.

Knowledgeable individuals were consulted concerning the occurrence of rare plants, animals and unique natural communities in the county. Voluminous GIS data sets were provided by the county for our analysis. Recent aerial photos, Geological maps, United States Geologic Survey (USGS) topographical maps, National Wetlands Inventory maps, United States Department of Agriculture (USDA) soil surveys and many other published materials were also used to identify and characterize areas of potential ecological significance.

Field Work

A limited number of ground surveys were conducted to collect detailed information on the status of the species and communities present at a location, and to identify the threats and management needed to preserve

the unique habitat. Inventory Ecologists concentrated on the areas with the most interesting, unique, diverse and suitable habitat for species of concern and exemplary natural communities. The flora, fauna, level of disturbance and local threats were among the most important data recorded for each site. Sites were not ground surveyed in cases where permission from private property owners to visit a site was not granted or when enough information was available from other sources.

Data Analysis

Data obtained during the field season was combined with prior existing data and summarized. All sites with species of concern and/or natural communities of statewide significance were selected for inclusion in Natural Heritage Areas. The Natural Heritage Areas are mapped to include both the immediate habitat (Core Habitat) and surrounding lands (Supporting Landscape) important in the support of these special elements as well as the natural corridors that connect them. The boundaries defining core habitat and supporting landscape for each Natural Heritage Area were based on physical and ecological factors, and specifications for individual species of concern protection developed by PNHP biologists based on scientific literature review and professional judgment.

Natural Heritage Areas are habitats that contain plant or animal species considered rare, threatened or endangered at state or federal levels. Natural Heritage Areas can also be delineated around high quality natural communities, which are those considered to be uncommon in the state, or among the best of their type within the state. The Natural Heritage Area is delineated into two zones based on its susceptibility to habitat disturbance:

- **Core Habitat** delineates the actual and adjacent similar habitat of individual species of concern (plants and/or animals considered rare, threatened or endangered at state or federal levels) exemplary natural communities, or exceptional native diversity. This level of mapping delineates essential habitat that cannot absorb significant levels of habitat-disturbing activity without substantial impact to the elements of concern.
- **Supporting Landscape** includes areas necessary to maintain vital ecological processes or secondary habitat that typically can accommodate some degree of low-impact activities, but intensive development of these areas could put the species of concern at risk. Much of the Supporting Landscape overlaps between the various Natural Heritage Areas creating a rather continuous and integrated area that should be considered the framework of the County's Greenways Infrastructure. Many of the Supporting Landscape areas were derived from the riparian corridor adjacent to the species of concern core habitat. Activities that occur within the upstream portions of the watershed can have a significant impact on the Natural Heritage Area Core Habitat.

The priority natural habitats identified in this report were designated and ranked according to their contribution to the biological diversity and ecological integrity of Delaware County to provide the information necessary to plan for the conservation at the species, natural community, and ecosystem levels. The sites were assigned a significance rank based on rarity of the species of concern or unique feature, and the size, condition, and quality of the immediate habitat and the surrounding landscape. Spatial data on the elements of concern were then compiled in a geographic information system (GIS) and combined with other available GIS layers for landscape analysis. For more information on specific descriptions or recommendations for an area, refer to the text for that Natural Heritage Area.

Results

Natural Heritage Areas

Thirty-seven Natural Heritage Areas are recognized in Delaware County for this NHI Update. The distribution of Natural Heritage Areas across the county is shown on the site index map. Documented are 214 individual occurrences of 84 species of concern including 62 plants, 11 birds, 4 reptiles, two amphibians, one fish, one dragonfly and 3 types of natural communities of state-wide significance. Many of these species have multiple population occurrences in the county. See Appendix I for a complete list of species of concern currently known to occur in Delaware County.

Significance ranks of Natural Heritage Areas (exceptional, high, notable and local) in order of their importance for the protection of the biological diversity and ecological integrity of the region are given

in Table 2: Delaware County Natural Heritage Areas Summary (page 7). The highest ranked Natural Heritage Areas in Delaware County for their contribution to Statewide and Global biodiversity include the tidally influenced wetlands along the shore of the Delaware River: "Darby Creek Mouth Mudflat", "John Heinz National Wildlife Refuge", "Little Tinicum Island"; the coastal plain remnant at "Johnson's Corner, Naaman Creek Road"; and the serpentine barren habitat at "Pink Hill".

Landscape Analysis

Combining ranked ecological variables can help reveal patterns and trends in the landscape. Several mapping elements went into determining and defining the ecological context that provides the framework for a network of natural habitats within Delaware County. The primary elements include:

- Species of Concern Habitat
- Forested Habitats
- Interior Forests
- Natural Communities
- Wetlands
- Riparian Corridors
- Floodplains (100 & 500-year)
- Steep Slopes (>15% & >25%)
- Trails & Abandoned Railways

Species of Concern Habitat - Relative Biodiversity Value

All of the Natural Heritage Areas are highly important for the species of concern they harbor, but ranking them based on number of species of concern and the degree of rareness of individual species helps to illustrate the relative importance of each area in relation to one another. This map integrates the number, quality and rarity of the species of concern in each area. Darker shading on the map represents areas where more species of concern 'stack up' and represent concentrations of species of concern into "hotspots".

Forested Habitats:

Through the conservation of large forested blocks, the necessary environmental conditions for whole suites of species both common and rare are preserved. The largest contiguous forest blocks of the county were identified and ranked according to size, with the assumption that bigger is better. These forest blocks and their natural habitats should be considered the backbone of wildlife habitat in the county. Conservation efforts in the County should concentrate on maintaining these large forest blocks by avoiding further fragmentation with additional roads, development, and utility rights-of-way. The largest forest blocks are concentrated within and around Ridley Creek Sate Park while other concentrations of forest blocks are primarily in the western section of the County.

Interior forests:

Interior forest, for this report, is defined as forest at least 100 meters in from the edge of any human-created opening such as a field, road, railway line or utility rights-of-way. Interior forest is an important habitat type for many species of plants and animals. The area between the forest edge and 100 meters into the forest is considered highly influenced by edge effects, such as increased levels of light, temperature, wind and dryness which create much different habitat conditions from those found in interior forest. Interior forest patches were ranked according to size with larger patches considered relatively more valuable than smaller patches. Interior forest patches smaller than five acres were dropped from the analysis as likely too small to be suitable habitat for forest interior species. As with the Forest Block analysis, the results reveal that the largest interior forest blocks in the county are concentrated within and around Ridley Creek Sate Park.

Natural Communities:

The natural habitats of Delaware County are not a uniform expanse of shrubs, trees and other plants, but instead contain species that reflect the environmental conditions found in that general location such as wetness, slope, sunlight, and bedrock geology. When plant distributions are examined at a finer level, patterns

of characteristic plant associations can be determined. A natural community is defined as a group of organisms occurring in a particular area based on the environmental conditions found there. The natural communities for this project were delineated from the inspection of aerial photographs taken in 2005 and followed up by selective targeted ground-truthing. All of the primary areas of natural vegetation have been classified based on "Terrestrial & Palustrine Plant Communities of Pennsylvania" (Fike 1999). All areas were given a quality rank based on the perceived degree of naturalness of the vegetation community present.

Natural communities were ranked by assigning a 3 (highest rank) to a habitat identified as a "natural community type" as in "Terrestrial & Palustrine Plant Communities of Pennsylvania" by Jean Fike, published by Pennsylvania DCNR in 1999. These were regarded as essentially 'natural' communities with little evidence of invasion by introduced species. Those habitat types identified as a natural community with a negative influence, such as "weedy" or "grazed", were given a rank of 2. At the low end of the scale, ranked 1, were those habitats considered in an early stage of succession, recovering from recent past disturbances such as farming or repeated timber harvest. These forests are typically highly invaded by introduced plants and are consequently a low quality natural community. Highly modified landscapes such as those dominated by agriculture or urban areas were not considered in this analysis.

Riparian Corridors:

Riparian areas are lands directly adjacent to streams, creeks, and rivers. Land adjacent to waterways and wetlands has an immediate influence on the quality of the water and the habitat it supports. Protect, enhance and restore riparian buffers to help improve water quality while also providing habitat and migratory corridors for many animals and plants through all parts of the county.

Riparian Buffer Quality: Each riparian buffer segment in the county, excluding the mainstem of the Delaware River, was analyzed using eight variables and ranked according to their potential cumulative effect on water quality. The cumulative scores were then sorted from best to lowest quality and represent four categories of potential conservation status:

1. Highest Restoration Priority (lowest potential quality)
2. Secondary Restoration Priority (second-lowest potential quality)
3. Secondary Conservation Priority (second-best potential quality)
4. Highest Conservation Priority (best potential quality)

This analysis helps to highlight those riparian areas that meet a goal for 100-meter vegetated buffers and should be considered priorities for preservation. This also highlights those that are furthest from meeting the 100-meter riparian buffer goal and should be considered priorities for restoration. However, another way to consider this analysis is to focus on those that fall in the middle of the spectrum. Those that are in the second-best potential quality would take much less effort and expense to raise them to the highest level of quality. Similarly, those that are in the second lowest quality category could be in danger of falling into the lowest quality category if they do not receive prompt restoration action.

Additional layers:

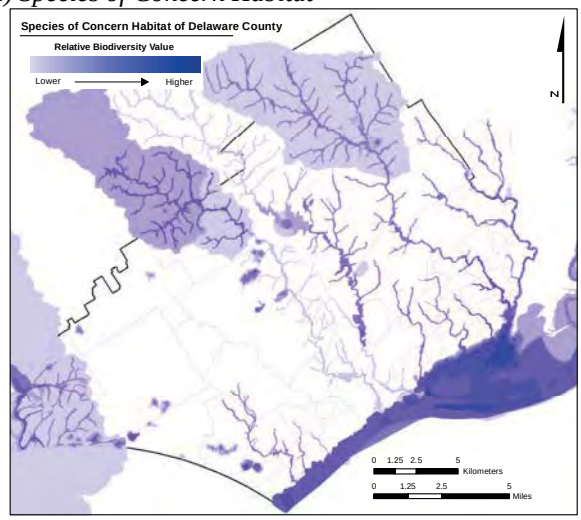
Steep slopes were considered within this analysis at two levels – slopes between 15 % and 25%, and slopes greater than 25%.

Floodplains were incorporated at two levels – the 100 year FEMA floodplain and the 500 year FEMA floodplain.

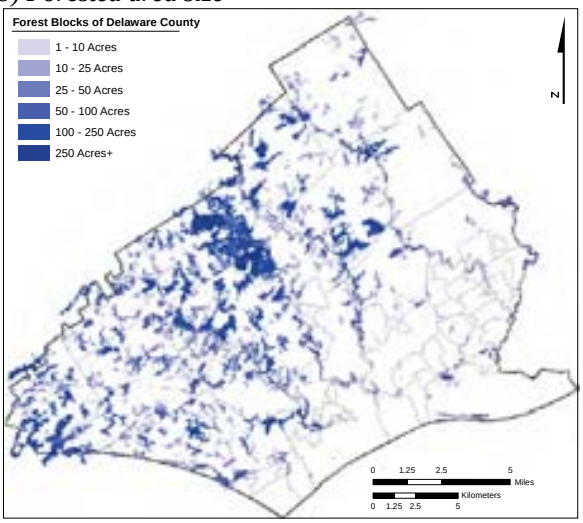
Wetlands from the National Wetland Inventory were incorporated and ranked according to degree of naturalness. Those that were the result of dams or artificial impoundments were considered of lower value than naturally occurring wetlands.

Existing trails and abandoned railways were incorporated into the analysis as narrow linear elements that typically support a fringe of natural habitat and connect larger habitats together.

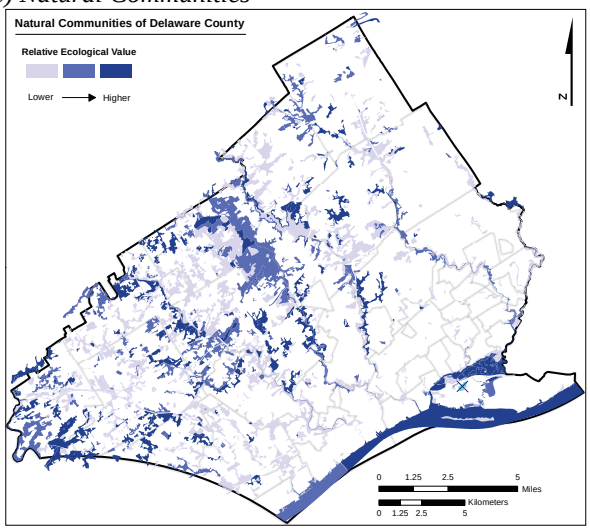
a) Species of Concern Habitat



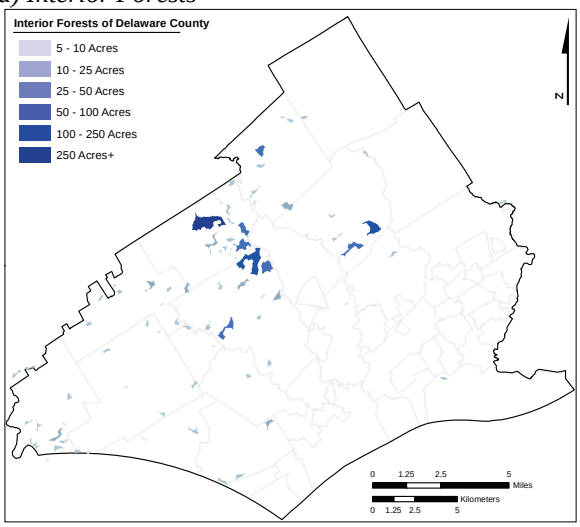
b) Forested area size



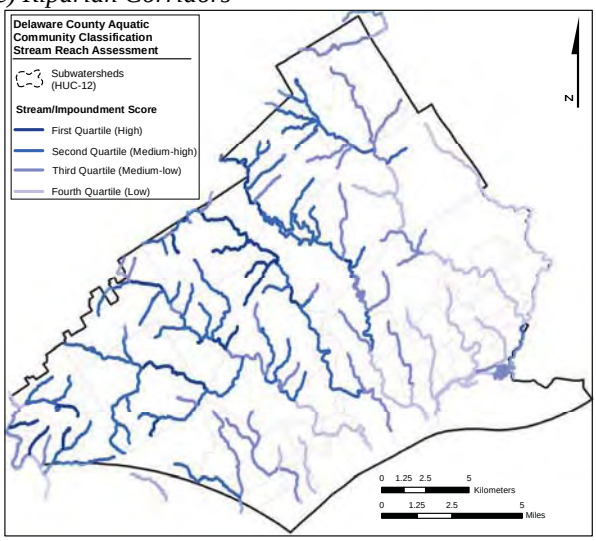
c) Natural Communities



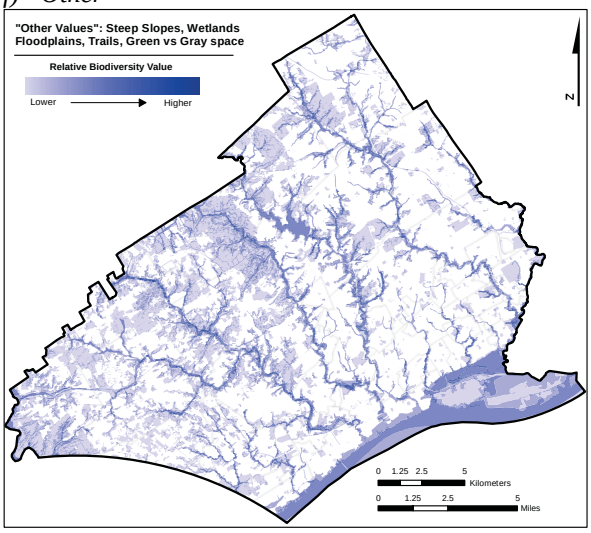
d) Interior Forests



e) Riparian Corridors



f) "Other"

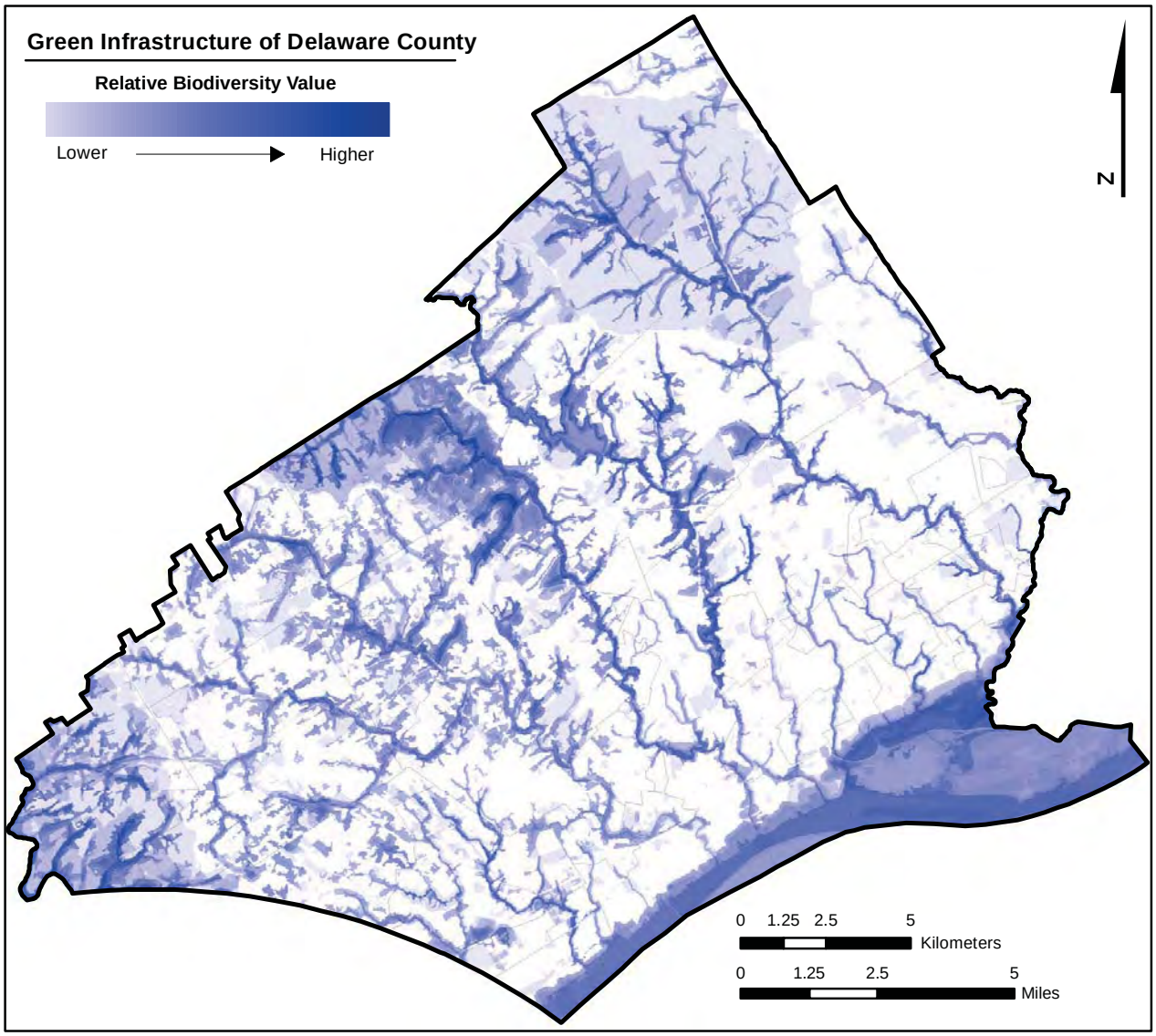


Landscape Analysis Results:

While all of the natural habitats within the County contribute to the overall health of the County's ecological systems, the highest priority natural habitats and the potential connections between them become evident by combining the landscape features discussed above.

The map below indicates the potential natural value of all areas within the County. Darker colors indicate a higher relative ecological value that lighter colors. The highest priority habitats in the County include the Delaware River tidal shoreline, including Little Tinicum Island and John Heinz National Wildlife Refuge Ridley Creek State Park, and the riparian corridors and adjacent forested uplands associated with Brandywine Creek, Chester Creek, and Crum Creek.

The primary connecting features within the County are the contiguous forested areas and the network of streams and rivers in the County. Many streams will require restoration of the riparian buffer area to fully function as habitat and migratory corridors within the County.



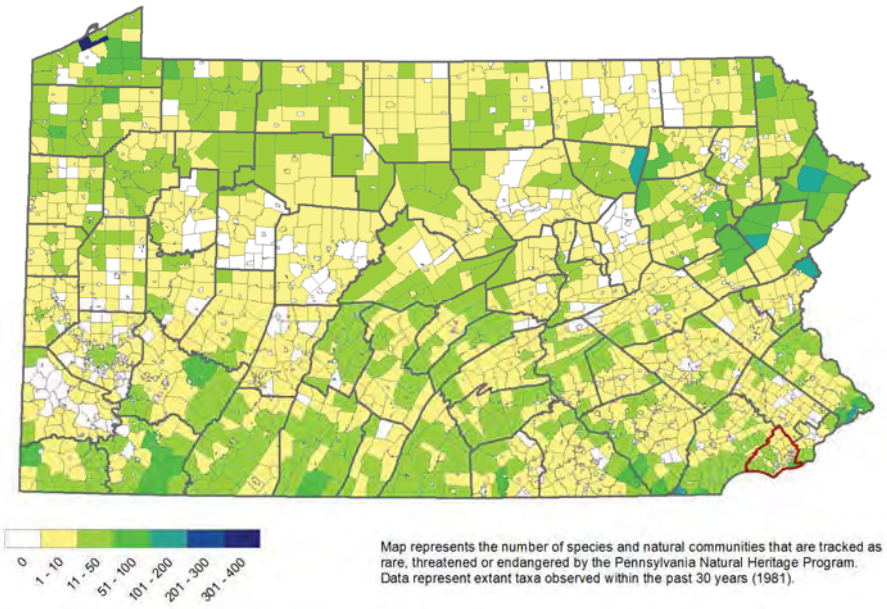
Discussion and General Recommendations

For this County Natural Heritage Inventory Report, the ecologists, zoologists, and botanists of the Pennsylvania Natural Heritage Program and partner organizations have explored the natural resources of Delaware County. This work represents an organized effort to inventory the biodiversity present throughout the County. Earlier survey work in this area was completed by botanists and other naturalists over the past several centuries. Records from these early explorers provided the baseline for this report.

Delaware County's contribution to biodiversity in Pennsylvania

Delaware County has 215 individual occurrences of species tracked by PNHP, including those listed as endangered, threatened, and rare species; it falls 19th out of the Commonwealth's 67 counties. The map below shows the distribution of these species by municipality across the Commonwealth.

Despite extensive land use changes in this heavily developed portion of the state Delaware County contains a significant number of rare species and communities that represent an important part of the Commonwealth's biodiversity. Two of these, bog turtle, and serpentine aster, are considered globally rare.



Future natural resource research in Delaware County

Though many hours of field research over multiple years were undertaken for this inventory, this is not a comprehensive, final word on Delaware County's natural resources. The data in this report represents a snapshot of Delaware County's natural resources at the time the report was written. Any further work in the County will likely yield additional records of species of concern while future land use changes may result in the extirpation of species documented in this report. This is partially due to the fact that natural systems are dynamic and constantly changing due to natural and human induced pressures. Also, sites were surveyed only when landowner permission was granted and access to some exemplary sites was restricted. Additional survey efforts are encouraged for these reasons. The PNHP sees this report as a working document – a guide for conservation of known rare, threatened, and endangered species, their habitats, and other resources of conservation importance in Delaware County.

Submitting Additional Data

As the state repository for biodiversity data, the Pennsylvania Natural Heritage Program appreciates all potential data regarding rare, threatened, and endangered species and potential survey sites. Species we currently track are listed on our website at: http//www.naturalheritage.state.pa.us/

A series of biodiversity and conservation planning services are available through the PNHP to supplement the results of this inventory. Please contact the Pennsylvania Natural Heritage Program for additional information regarding these services (http://www.naturalheritage.state.pa.us/).

A Final Note on Rare, Threatened, and Endangered Species

The rare, threatened, and endangered species highlighted in this report are some of the several hundred species in Pennsylvania that are threatened with extirpation or extinction. If a species becomes extinct, or is lost from a portion of its native range, the ecosystem in which it lived will lose an important element. Often the repercussions of extinctions are not known until the species is gone, and the species is generally irreplaceable in the system. This may be because the habitat has been altered to the point that the biological system no longer functions properly. Species of concern are often indicative of fragile ecosystems that easily degrade; their protection may help monitor the quality of Delaware County's ecosystems. A great example of a species of concern acting as an indicator of environmental quality is the bald eagle - a species which indicated the deleterious effects of the pesticide DDT in our environment. Banning DDT led to the eventual recovery of the species.

Another reason for protecting species of concern is for their value as unique genetic resources. Every species may provide significant information for future use in genetic research and medical practices. Beyond these practical considerations, perhaps the most compelling reasons for stewardship are the aesthetic and ethical considerations; there is beauty and recreational value inherent in healthy, species-rich ecosystems. The protection of rare, threatened, and endangered species depends on several factors, including increasing scientific knowledge and concerted efforts from government agencies, conservation organizations, educational institutions, private organizations, and individuals. The following section outlines general recommendations to begin to protect the species outlined in this report

Using the Natural Heritage Inventory in the Delaware County Planning Process

One of the main roles of this document is to integrate ecological and conservation information into the planning process. Through early integration, costly conflicts with rare, threatened and endangered species can be avoided and these resources can be protected for future generations. Comprehensive land use planning and its related ordinances can be effective tools for the conservation of Delaware County's biological diversity.

Land use planning establishes guidelines for the kinds of land uses that are suitable in an area and provides a basis for guiding public and private development to benefit communities, the local economy and the environment. Zoning and subdivision ordinances then set out rules that implement the land use plan. Planning, zoning and subdivision ordinances are not only valuable tools for urban and suburban areas where development pressures have already affected the use of open space and the integrity of the natural environment, but also for rural areas where current losses are less pronounced. These areas can apply planning to avoid the haphazard losses of valuable regional resources, while still achieving desirable levels of development. The following is a brief overview on land use tools available in Delaware County as well as a brief commentary of their relevance to the NHI:

- Comprehensive Plan - Delaware County is currently in the process of preparing a comprehensive plan. All of Delaware County's municipalities have individual comprehensive plans, some of which are several years old. The County should integrate information from this report into its new comprehensive plan, specifically in sections that involve development, natural resources, recreation, and open space. Municipalities should also consider integrating this information into their comprehensive plans and future updates.
- Zoning – All of Delaware County's municipalities currently have zoning ordinances and are encouraged to integrate Natural Heritage information into their zoning process. Zoning maps can be potentially amended to reflect conservation measures to help preserve Natural Heritage Areas presented in this report.
- Subdivision and Land Development Ordinances (SALDO) – SALDOs can be used as a conservation tool to draw attention to Natural Heritage Inventory information. Many Delaware County municipalities have their own SALDOs, and the County has a new SALDO currently being prepared

that will cover municipalities without their own. Both the County and the municipalities should consider incorporating a requirement that any CNHI areas identified in this report to be noted on subdivision and land development plans. The ordinance could also require developers to address potential impacts of their development on the resource/s.

Natural Heritage Areas identified in the County Natural Heritage Inventory reports have been used to form the backbone of many plans for Greenway and Open Space networks in the Commonwealth. After completion of the Greenway the CNHI should be further consulted for site-level planning and trail alignments as it can help decided the best compatibility of the resource with the designated use. Although many of the Natural Heritage Areas outlined in this report will likely be integrated into a greenway plan, additional planning and protection will ensure the viability of the conservation elements present at the site.

Planning for the land use decisions of today and those of the future is an important task and this Natural Heritage Inventory can serve as a useful tool. Pennsylvania Natural Heritage Program staff and expertise are available for additional technical assistance and planning for the conservation of these sites.

General Recommendations

The following are general recommendations for the protection of the Natural Heritage Areas within Delaware County. Approaches to protecting a Natural Heritage Area are wide ranging, and factors such as land ownership, time constraints, and tools and resource availability should be considered when prioritizing protection of these sites. Prioritization works best when incorporated into a long-term county or region-wide plan. Opportunities may arise that do not conform to a plan, and the decision on how to manage or protect a natural heritage area may be made on a site by site basis. Keep in mind that personnel in the Pennsylvania Natural Heritage Program and staff from state natural resource agencies are available to discuss more specific options for preservation. The following are approaches and recommendations for natural heritage area conservation.

1. **Consider conservation initiatives for natural heritage areas on private land.**
   Conservation easements protect land while leaving it in private ownership. An easement is a legal agreement between a landowner and a conservation or government agency that permanently limits a property's use in order to protect its conservation values. It can be tailored to the needs of both the landowner and the conservation organization, and will not be extinguished with new ownership. Tax incentives may apply to conservation easements donated for conservation purposes.

   Lease and management agreements also allow the landowner to retain ownership and temporarily ensure protection of land. There are no tax incentives for these conservation methods. A lease to a land trust or government agency can protect land temporarily, and ensure that its conservation values will be maintained. This can be a first step to help a landowner decide if they want to pursue more permanent protection methods. Management agreements require landowners and land trusts to work together to develop a plan for managing resources (such as plant or animal habitat, watersheds, forested areas, or agricultural lands) with the land trust offering technical expertise.

   Land acquisition by a conservation organization can be at fair market value or as a bargain sale where a purchase price is set below fair market value with tax benefits that reduce or eliminate the disparity. One strategy is to identify areas that may be excellent locations for new county or township parks. Sites that can serve more than one purpose such as wildlife habitat, flood and sediment control, water supply, recreation, and environmental education are ideal. Private lands adjacent to public lands should be examined for acquisition when a natural heritage area is present on either property, and there is a need of additional land to complete protection of the associated natural features.

   Fee simple acquisition is when a buyer purchases land outright, and has maximum control over the use and management of the property and its resources. This conservation initiative is appropriate

when the property's resources are highly sensitive, and protection cannot be guaranteed using other conservation approaches.

Unrestricted donations of land are welcomed by land trusts. The donation of land entitles the donor to a charitable deduction for the full market value, as well as a release from the responsibility of managing the land. If the land is donated because of its conservation value, the land will be permanently protected. A donation of land that is not of high biological significance may be sold, with or without restrictions, to a conservation buyer, and the funds used to further the land trust's conservation mission.

Land Trusts working in the Delaware County region: The Pennsylvania Land Trust Association website offers a search engine to find land trusts (http://conserveland.org). The primary land trusts operating in the Delaware County region include:

Brandywine Conservancy (http://www.brandywineconservancy.org/)
Delaware Nature Society (http://www.delawarenaturesociety.org/).
Heritage Conservancy **(**www.heritageconservancy.org**)**
Natural Lands Trust **(**www.natlands.org**)**
Radnor Conservancy **(**www.radnorconservancy.org**)**.
Willistown Conservation Trust **(**www.wctrust.org**)**

Local zoning ordinances are one of the best-known regulatory tools available to municipalities. Examples of zoning ordinances a municipality can adopt include: overlay districts where the boundary is tied to a specific resource or interest such as riverfront protection and floodplains, and zoning to protect stream corridors and other drainage areas using buffer zones. Often it is overlooked that zoning can prevent municipal or county-wide development activities which are undesirable to the majority of the residents, and allow for planning that can meet the goals of the county residents.

2. **Prepare management plans that address species of concern and natural communities.** Many of the natural heritage areas that are already protected are in need of additional management plans to ensure the continued existence of the associated natural elements. Site-specific recommendations should be added to existing management plans, new plans should be prepared. Recommendations may include: removal of invasive plant species; leaving the area alone to mature and recover from previous disturbance; creating natural areas within existing parks; limiting land-use practices such as mineral extraction, residential or industrial development, and agriculture; or implementing sustainable forestry practices. For example, some species simply require continued availability of a natural community while others may need specific management practices such as canopy thinning, mowing, or burning to maintain their habitat requirements.

   Existing parks and conservation lands provide important habitat for plants and animals at both the county level and on a regional scale. For example, these lands may serve as nesting or wintering areas for birds or as stopover areas during migration. Management plans for these areas should emphasize a reduction in activities that fragment habitat. Adjoining landowners should be educated about the importance of their land as it relates to habitat value, especially for species of concern, and agreements should be worked out to minimize activities that may threaten native flora and fauna.

3. **Protect bodies of water.**
   Protection of reservoirs, wetlands, rivers, and creeks is vital for ensuring the health of human communities and natural ecosystems; multiple qualities can be preserved by protecting aquatic habitats which harbor biodiversity, supply drinking water, and provide recreational resources. Many rare species, unique natural communities, and locally significant habitats occur in wetlands and water bodies; these are directly dependent on natural hydrological patterns and water quality for their continued existence. Ecosystem processes also provide clean water supplies for human communities and do so at significant cost savings in comparison to water treatment facilities; therefore, protection of high quality watersheds is the only way to ensure the viability of natural habitats and water quality. Scrutinize development proposals for their impact on entire watersheds, not just the immediate

project area. Cooperative efforts in land use planning among municipal, county, state, and federal agencies, developers, and residents can lessen the impact of development on watersheds.

4. **Provide for buffers around natural heritage areas.**
Development plans should provide for natural buffers between disturbances and natural heritage areas. Disturbances may include construction of new roads and utility corridors, non-sustainable timber harvesting, and fragmentation of large pieces of land. Storm runoff from these activities results in the transport of nutrients and sediments into aquatic ecosystems (Trombulak and Frissell, 2000). County and township officials can encourage landowners to maintain vegetated buffer zones within riparian zones. Vegetated buffers (preferably of Pennsylvania native plant species) help reduce erosion and sedimentation while shading and cooling the water. Preserving water quality in rivers and streams is important to fish as some species, such as brook trout and some darters, are highly sensitive to poor water quality. Sensitive fish are readily lost from streams when water quality starts to decline. Creating or maintaining a vegetated buffer benefits aquatic animal life, provides habitat for other wildlife species, and creates a diversity of habitats along the creek or stream. Staff at the Pennsylvania Natural Heritage Program (PNHP) or natural resources agencies can provide further guidance regarding buffer considerations appropriate for various kinds of natural resources.

   Waterways that include natural heritage areas, identified in the *Results* section of this report, are important, sensitive areas that should be protected. For example, conserving natural areas around watersheds that supply municipal water provides an additional protective buffer around the water supply, maintains habitat for wildlife, and may also provide (low impact) recreation opportunities.

5. **Reduce fragmentation of the landscape surrounding natural heritage areas.**
Encourage development in sites that have already seen past disturbances (especially mined and heavily timbered areas). Care should be taken to ensure that protected natural areas do not become islands surrounded by development. In these situations, the site is effectively isolated, and its value for wildlife is greatly reduced. Careful planning can maintain natural environments along with the plants and animals associated with them. A balance between growth and the conservation of natural and scenic resources can be achieved by guiding development away from the most environmentally sensitive areas.

   The reclamation of previously disturbed areas for commercial and industrial projects, also known as *brownfield development*, presents one way to encourage economic growth while allowing ecologically sensitive areas to remain undisturbed. For example, reclaimed surface mines can be used for development (potentially even wind development) when feasible. Cluster development can be used to allow the same amount of development on much less land, and leave the remaining land intact for wildlife and native plants. By compressing development into already disturbed areas with existing infrastructure (villages, roads, existing rights-of-way), large pieces of the landscape can be maintained intact. If possible, networks or corridors of woodlands or greenspace should be preserved linking natural areas to each other. Preserving greenspace around development can provide ample recreation opportunities, and potentially increase nearby property value.

6. **Encourage the formation of grassroots organizations.**
County and municipal governments can do much of the work necessary to plan for the protection and management of natural areas identified in this report; however, grassroots organizations are needed to assist with obtaining funding, identifying landowners who wish to protect their land, and providing information about easements, land acquisition, management, and stewardship of protected sites. Increasingly, local watershed organizations and land trusts are taking proactive steps to accomplish conservation at the local level. When activities threaten to impact ecological features, the responsible agency should be contacted. If no agency exists, private groups such as conservancies, land trusts, and watershed associations should be sought for ecological consultation and specific protection recommendations.

7. **Manage for invasive species.**
Invasive species threaten native diversity by dominating habitat used by native species and by disrupting the integrity of the ecosystems they occupy. Management for invasive species depends upon the extent of their establishment. Small infestations may be easily controlled or eliminated but larger, well established populations typically present difficult management challenges. The earlier exotic invasive species are identified and controlled, the greater the likelihood of eradication with the smallest expenditure of resources. Below is a list of sources for invasive species information.

The *Mid-Atlantic Exotic Plant Pest Council* (MA-EPPC) is a non-profit organization (501c3) dedicated to addressing the problem of invasive exotic plants and their threat to the Mid-Atlantic region's economy, environment, and human health by providing leadership, representing the mid-Atlantic region at national meetings and conferences, monitoring and disseminating research on impacts and controls of invasives, facilitating information development and exchange, coordinating the on the ground removal of invasives, and providing access to training on species identification and management. Information is available at http://www.ma-eppc.org.

Several excellent websites exist to provide information about invasive exotic species. The following sources provide individual species profiles for the most troublesome invaders, with information such as the species' country of origin, ecological impact, geographic distribution, and control techniques.

- The Nature Conservancy's Weeds on the Web at http://tncinvasives.ucdavis.edu/
- The Virginia Natural Heritage Program's invasive plant page at http://www.dcr.virginia.gov/natural_heritage/invspinfo.shtml
- The Missouri Department of Conservation's Missouri Vegetation Management Manual at http://mdc.mo.gov/nathis/exotic/vegman/
- U.S. Department of the Interior, National Park Service invasive species monitoring resources at http://www.nature.nps.gov/biology/invasivespecies/ or http://science.nature.nps.gov/im/monitor/invasives/
- Invasive species information clearinghouse listing numerous other resources on a variety of related topics at http://www.invasivespeciesinfo.gov/

Beaver Valley Woods

Delaware County, PA

Natural Heritage Inventory

N

Painters Crossroads

Legend

- Core Habitat (focus NHI site)
- Core Habitat (other NHI sites)
- Supporting Landscape
- 100 meter Riparian Buffer
- 100 foot Riparian buffer
- Township Boundary
- County Boundary
- Interior Forest
- Forested habitat

OpenSpace & Recreation

- Public Park
- Homeowner's Association
- Privately Eased Land

0 0.25 0.5 1 Kilometers

0 0.25 0.5 1 Miles

PNHP

Beaver Valley Woods – *High significance*

Species of Concern:	Taxa[1]	PNDI Rank[2] Global	PNDI Rank[2] State	Legal Status[2] State (Proposed)	Last Seen	Quality[2]
Velvety panic-grass (*Dichanthelium scoparium*)	P	G5	S1	PE (PE)	2010	C
Soapwort gentian (*Gentiana saponaria*)	P	G5	S1S2	TU (PE)	2010	C
Grass-leaved rush (*Juncus biflorus*)	P	G5	S2	TU (PT)	1995	B
Downy lobelia (*Lobelia puberula*)	P	G5	S1	PE (PE)	2010	C
Tawny ironweed (*Vernonia glauca*)	P	G5	S1	PE (PE)	2010	C
Sensitive species of concern[3]	---	---	---	---	2010	C
Sensitive species of concern[3]	---	---	---	---	2010	E

[1] A = Amphibian; B = Bird; C = Community; F = Fish; L = Lepidopteran; O = Odonate; P = Plant; M = Mammal; R= Reptile, U = Unionoid (Mussel)
[2] Please refer to Appendix III for an explanation of PNHP ranks and legal status
[3] This species is not named by request of the jurisdictional agency overseeing its protection

Location: This large area includes adjoining habitats along Beaver Creek and its tributaries roughly bounded on the east by Route 202, on the south by the Delaware State Line, and on the west and north by Ridge Road.

- Municipalities:
  - Chadds Ford Township
  - Concord Township
  - New Castle County, State of Delaware
- USGS Quadrangles:
  - Wilmington North Quadrangle
- Watersheds:
  - Brandywine Creek
- 1992 Delaware County Natural Areas Inventory reference:
  - "SP525" (Wilmington North Quadrangle)
  - "Quarry Woods" (Wilmington North Quadrangle)
- 1998 Delaware County Natural Areas Inventory Update reference:
  - "SP535, SP536, SP537, SP539, SP540 - Beaver Valley Road Pipeline Site"- (West Chester Quadrangle)

Description: A mosaic of upland forest, forested wetlands, open wetlands, spring seeps, successional old fields and pipeline rights-of-way are set within an agricultural and residential context. Forested habitats include several significant patches of interior forest, which is forested habitat at least 100 meters away from any canopy fragmenting feature such as roads, powerlines, residences or open fields. Interior forest is critical nesting habitat for many of Pennsylvania's neotropical migrant songbirds. This area combines two sites from the original 1992 CNHI report "SP525" and "Quarry Woods" and the subsequent 1998 update: "Beaver Valley Road Pipeline Site" into this enlarged area that hosts a wide variety of habitats and scattered populations of several species of concern.

Species of Concern Considerations:

- Five plant species of concern, velvety panic-grass, soapwort gentian, grass-leaved rush, downy lobelia and tawny ironweed are plants that typically grow in damp to seasonally wet clearings, abandoned fields, woods borders, thickets, marshes, and disturbed ground. Active management, such as periodic mowing or prescribed fire, may be needed to create the proper successional stage and ecological conditions for these species to thrive. Vegetation maintenance along agricultural field edges and the pipeline at this location helps to reduce competition from woody and aggressive species and keep the habitat in a state of early succession. Habitat loss, deer browse and the indiscriminate spraying of herbicides are threats to these species in some locations.
- A sensitive species of concern, which is not named at the request of the jurisdictional agency overseeing its protection, occurs in several locations within this forested area. Its preferred habitat is moist deciduous forests and stream banks. These high quality woodlands may be altered by encroachment of invasive species, over-browsing by deer, and fragmentation. Fragmentation can have a drying effect on the habitat and promote invasive species growth. Creating buffers around fragmented habitat and removal of invasive species will help to maintain populations and encourage new population growth.
- An additional sensitive species of concern, which is not named at the request of the jurisdictional agency overseeing its protection, occurs in several locations within this forested area. Its preferred habitat is moist deciduous forests requires specific plant communities within a matrix of open canopied habitats. Restoration of the marshy habitats historically associated with the Beaver Creek floodplain will help to provide expanded habitat opportunities for this species of concern.

Forest Cover / Natural Communities: The plant community types depicted are approximations delineated from 2005 aerial photography interpretation and were followed up with minimal selective ground-truthing. Community types follow "Terrestrial & Palustrine Plant Communities of Pennsylvania" (Fike 1999) where appropriate, and otherwise describe general land cover types (*).

- Terrestrial (upland) communities:
  - Red oak – mixed hardwood forest
  - Tuliptree – beech-maple forest
  - modified successional forest*
- Palustrine (wetland) communities:
  - Silver maple floodplain forest

- Some of the forest patches are in the long process of reverting from past agricultural uses, while other patches exhibit a much more undisturbed and pristine quality. Though the forest was likely selectively cut for fuel wood and timber several times since colonial times, much of the existing forest has apparently been standing for well over 100 years. Some of the trees were in the past likely considered less desirable for lumber and fuel or were less accessible due to steep slopes and were left in place. While this tract of forest can't be considered virgin timber, some individual trees in the area may be 200-300 years old or older. Although there is invasion of exotic plant species into the woods the overall quality of the woods is remarkably natural and aesthetically pleasing.
- The forest canopy is dominated by a mix of large tuliptrees (*Liriodendron tulipifera*), American beeches (*Fagus grandifolia*) and mixed oaks (*Quercus alba, Q. rubra, Q. palustris, Q. montana*). The shrub layer is dominated by invasive species in much of the area, though some areas have a relatively good representation of native shrub species. In other areas, the shrub layer is missing altogether, giving the forest an open, park-like look. This openness is likely due to excessive deer pressure on the reproductive success of understory vegetation including tree seedlings. The herbaceous layer is variable within the diversity of habitat types present.

Ownership:

- This large area is owned by two primary owners, but also includes several secondary property owners. The reduced number of landowners of this large piece of the green infrastructure of Delaware County can be tremendously helpful towards implementation of consistent conservation action across this significant piece of the landscape.

Habitat Disturbances:

- Historic:
  - Most of the original forest cover of the area had been removed and converted to agricultural or other uses over the past several centuries, leaving little of the original vegetation in place. Aerial photographs from 1937 show scattered forested woodlots within a landscape dominated by active agriculture. Though the forest was likely cut for fuel wood and timber several times since colonial times, the existing forest has likely been standing for over 100 years.
  - The gas pipeline right-of-way was cut east to west through the lower portion of the area. Though this was a disturbance to the integrity of the forested habitats, it established a narrow strip of vegetation that was maintained as early successional habitat up to the present day.
- Current:
  - Much of the area remains as it was at the time of the 1937 aerial photos, with scattered forested areas surrounded by open pastures and agricultural fields.
  - Rapid development has occurred outside of and on the periphery of the core habitat area, fragmenting the landscape with additional buildings, roads and infrastructure and increasing the amount of impervious surface and edge habitat in the immediate watershed.
  - Stormwater runoff from the highly developed surrounding communities flows into the creek system with little opportunity to be slowed or filtered. This results in increased downstream flooding and erosion and is a potentially significant non-point source of pollution. Runoff from these sources has significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through natural vegetation.
  - Exotic Species – The edge habitat provided by reverting agricultural fields and residential development creates conditions favorable for many introduced species of plants. Some of the primary invasive species occurring in this location include:
    - Norway maple *(Acer platanoides)*
    - garlic-mustard *(Alliaria petiolata)*
    - Japanese barberry (*Berberis thunbergii*)
    - Asiatic bittersweet (*Celastrus orbiculatus*)
    - autumn olive (*Elaeagnus umbellata*)
    - wintercreeper (*Euonymus fortunei)*
    - Japanese honeysuckle *(Lonicera japonica)*
    - amur honeysuckle *(Lonicera maackii)*
    - Japanese stiltgrass *(Microstegium vimineum)*
    - mile-a-minute weed *(Persicaria perfoliata)*
    - common reed *(Phragmites australis)*
    - multiflora rose *(Rosa multiflora)*
    - wineberry (*Rubus phoenicolasius*)
    - linden viburnum (*Viburnum dilatatum*)
  - Control options for invasive plants range from mechanical to chemical. However, indiscriminate use of herbicides as rights-of-way defoliants is not acceptable. A smarter, more selective use of chemical controls is required in these areas that contain both invasive species and species of concern.
  - Invasive species management needs to be coordinated by individuals familiar with the rare species as well as the invasive species present.
  - High priority for invasive species control at this site should be targeted towards removing small populations of newly established invasive plants in the most weed-free portions of the Natural Heritage Area. Invasive species control efforts should try to maintain weed-free areas first, and then concentrate on removing invasive species in lightly infested areas, continually pushing back the line of invasion. Invasive species removal should be conducted in coordination with native species replacement to avoid

denuding the understory vegetation. This needs to be a continual and sustained process of monitoring and control efforts.

- The relatively low volume of understory herbs and shrubs noted in this forest may be attributable to an oversized deer herd. Over-browsing by white-tailed deer is a serious threat to the overall understory plant diversity. An overabundance of deer can create the effect of park-like forests in which the understory and vertical stratification is greatly reduced. Removal of understory species eliminates habitat for some nesting songbirds as well as increasing competition between deer and other wildlife due to reduced food sources. Deer have strong, species-specific feeding preferences. The most highly preferred species are the first to decline or disappear when deer numbers are high. Furthermore, deer have been shown to be prolific seed dispersers for many of the most invasive nonnative species. The result is greatly impoverished native species diversity, failure of native tree regeneration, and the rapid proliferation of invasive species. It is likely their selective feeding habits and effective seed dispersal make the spread of invasives much faster than would be the case without deer, even where herds are only moderately oversized.

Conservation Actions:

- Overall:
  - Allow the forested habitats to achieve and maintain old growth conditions.
  - Prevent the conversion of the surrounding agricultural lands to residential or industrial development.
  - Conserve and expand the forested riparian buffers of Beaver Creek and its tributaries. Establish at least a 100 meter (328 feet) buffer of woody vegetation along the creek to help reduce erosion, sedimentation, and pollution. Additionally, best management practices (BMPs) that focus on limiting the introduction of non-point sources of pollution into surface and groundwater should be applied to the surrounding area.
  - Beaver Creek, as indicated by its name, was likely heavily influenced by beaver activity in the historical past. Habitat modification by beavers could help to improve the integrity of this Natural Heritage Area, by reestablishing the matrix of open and canopied wetland complexes. Beaver numbers are on the rise in Pennsylvania, and it is very possible that they could be documented here in the future. If beavers expand into this system, they should be left to modify and restore some of the open habitats that previously existed at this site.
- Within the Core Habitat:
  - The Core Habitat for this location was drawn to exclude the most unnatural portions of the adjacent habitat, which are primarily active agricultural fields and residential areas.
  - Avoid fragmenting the existing forested areas with additional buildings or infrastructure. Avoid logging in this area except as it relates to invasive species removal. The forest cover should be allowed to achieve and maintain old-growth characteristics. Leave fallen trees in place to help provide habitat, soil nutrients, humus and tilth. Trees that have fallen over approved trails can be cut through as necessary.
  - Restore and protect the hydrology of the landscape. Avoid altering the hydrology of Beaver Creek, its tributaries, springs and wetlands. This may require that road crossings involve bridge systems that would preserve the wide sluggish waters associated with marshes and slow flowing waterways.
  - Forested and open wetlands each require special consideration to maintain their unique attributes. Existing wet meadows should not be modified (i.e. dammed, planted in trees or farmed), as this will deprive the open wetlands adapted species of suitable habitat. Light grazing with pastoral animals can be an effective tool to maintain these soggy meadows in their preferred condition. Once the open habitat within the historic floodplain has been restored, light grazing, often considered compatible with high financial yield organic meat and dairy production, could be an effective tool to maintaining the habitat for all wet meadow species.

- As existing farm ponds deteriorate and are in need of maintenance, the removal of such ponds should be explored, in order to recreate the natural hydrologic flows of the landscape.
- Because several of the species of concern noted from this site rely upon open canopied habitats, programs that support establishment of riparian buffers with trees, such as CREP, should be avoided in areas along the pipeline rights-of-way. In addition, removal of woody shrubs appears to be necessary to restore habitat for several of the open habitat adapted plant species as formerly open fallow fields have become dominated by the invasive woody shrub autumn olive (*Elaeagnus umbellata*). Autumn olive should be cut, stump treated with herbicide to avoid resprouting and the area mowed every other year in early spring to help maintain the early successional conditions favorable for these plant species of concern.
- The stormwater runoff from development and agriculture should be considered a potential source of significant contamination for the creek and its floodplain habitat. Runoff from these sources have significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through a natural habitat. Stormwater management measures such as the creation of detention basins or vegetated swales should be implemented to decrease the unfiltered flow into the creek.
- Remove invasive species of plants (see below).
- Reduce the deer density in the area. Uncommon species of native plants are particularly susceptible to deer herbivory.

- Potential Restoration Activities:
  - Streams through forested areas should be considered high priority for conservation. The forested riparian corridor helps to regulate the temperature of the stream and creates streamside conditions that contribute to improved water quality and aquatic habitat. Streams through non-forested areas should be restored with native trees and shrubs appropriate to the habitat.
    - Careful determination is needed to avoid planting trees in floodplains that contain herbaceous wetland habitats. These habitats should be maintained in their current open condition, with tree plantings to occur at the periphery of natural wetland openings.
    - Riparian Buffers:
      - An ideal vegetated stream buffer should be at least 100 meters (328 feet) in width from the edge of the 100-year floodplain.
      - An intermediate vegetated stream buffer should be at least 100 feet in width from the edge of the 100-year floodplain.
      - A minimum vegetated buffer should be at least 35 feet in width from the edge of the 100-year floodplain.
  - Remove invasive species of plants. Invasive species management needs to be coordinated by individuals familiar with the rare species as well as the invasive species present.
  - Control options for invasive plants range from mechanical to chemical. However, indiscriminate use of herbicides as rights-of-way defoliants is not acceptable. A smarter, more selective use of chemical controls is required in these areas that contain both invasive species and species of concern.
  - High priority for invasive species control at this site should be targeted towards removing woody shrubs, especially autumn olive, from the successional old fields adjacent to the pipeline rights-of-way.
  - Invasive species control efforts should try to maintain weed-free areas first, and then concentrate on removing invasive species in lightly infested areas, continually pushing back the line of invasion. Invasive species removal should be conducted in coordination with native species replacement to avoid denuding the understory

vegetation. Control of invasive species in the area will require extensive and continual effort.

- Target pioneer populations of invasive plants for immediate and continued removal. It is much easier and more effective to keep a place invasive-free than to try and repair a heavily infested habitat.

Photo Source: Rocky Gleason (PNHP)

Large, older trees contribute to the canopy of the forested habitats in Beaver Valley.

Clayton Park, Shavertown Woods

Delaware County, PA Natural Heritage Inventory

N

Legend

- Core Habitat (focus NHI site)
- Core Habitat (other NHI sites)
- Supporting Landscape
- 100 meter Riparian Buffer
- 100 foot Riparian buffer
- Township Boundary
- County Boundary
- Interior Forest
- Forested habitat

OpenSpace & Recreation

- Public Park
- Homeowner's Association
- Privately Eased Land

0 0.125 0.25 0.5 Kilometers

0 0.125 0.25 0.5 Miles

PNHP

Clayton Park, Shavertown Woods – *High significance*

Species of Concern:	Taxa[1]	PNDI Rank[2] Global	PNDI Rank[2] State	Legal Status[2] State (Proposed)	Last Seen	Quality[2]
Slender three-awn (*Aristida longespica var. longespica*)	P	G5T5?	S3S4	N (Watch)	2010	E
Screw-stem (*Bartonia paniculata*)	P	G5	S3	N (PR)	2010	C
Nuttalls' tick-trefoil (*Desmodium nuttallii*)	P	G5	S2	TU (PT)	1995	F
Vervain thoroughwort (*Eupatorium pilosum*)	P	G5	S4	(SP)	2010	E
Grass-leaved goldenrod (*Euthamia tenuifolia*)	P	G5	S1	PT (PT)	1991	F
Spring ladies'-tresses (Spiranthes vernalis)	P	G5	S1	PE (PE)	1995	D
Netted chainfern (*Woodwardia areolata*)	P	G5	S2	N (PT)	2010	BC
Sensitive species of concern[3]	---	---	---	---	2008	C

[1] A = Amphibian; B = Bird; C = Community; F = Fish; L = Lepidopteran; O = Odonate; P = Plant; M = Mammal; R= Reptile, U = Unionoid (Mussel)
[2] Please refer to Appendix III for an explanation of PNHP ranks and legal status
[3] This species is not named by request of the jurisdictional agency overseeing its protection

Location: This area includes parts of Clayton Park and the powerline and pipeline right-of-ways and Green Creek that pass through the park. The site is roughly bounded by Featherbed Lane on the north, Route 322 on the east, Garnet Mine Road on the south, and Kirk road on the west.

- Municipalities:
  - Bethel Township
  - Concord Township
- USGS Quadrangles:
  - Marcus Hook Quadrangle
  - Wilmington North Quadrangle
- Watersheds:
  - West Branch Chester Creek
- 1992 Delaware County Natural Areas Inventory reference:
  - "SP513" (Marcus Hook Quadrangle)
  - "Shavertown Woods" (Wilmington North Quadrangle)
- 1998 Delaware County Natural Areas Inventory Update reference:
  - "Clayton Park" (Marcus Hook Quadrangle)
  - "Shavertown Woods" (Wilmington North Quadrangle)

Description: This area is a mosaic of upland forest, forested wetlands, open wetlands, spring seeps, successional old fields and pipeline right-of-way set within a residential context. The forested area is bounded by roads and bisected by both a powerline right-of-way and a pipeline right of way. The slope has scattered diabase boulders. Several springs originate in the woods and Green Creek meanders through the forest. Vegetation maintenance of the powerline right-of-way has kept the linear corridor in an early successional stage of development, which is the preferred habitat of several of the plant species of concern at this location. Forested habitats include a 12 acre patch of interior forest, which is forested habitat at least

100 meters away from any fragmenting feature such as roads, powerlines, residences or open fields. Interior forest is critical nesting habitat for many of Pennsylvania's neotropical migrant songbirds. This area combines two sites from the original 1992 CNHI report "SP513" and "Shavertown Woods" and the subsequent 1998 update: "Clayton Park" and "Shavertown Woods" into this enlarged area that hosts a wide variety of habitats and scattered populations of several species of concern.

Species of Concern Considerations:

- Five of the plant species of concern, slender three-awn, Nuttalls' tick-trefoil, vervain thoroughwort, grass-leaved goldenrod, and spring ladies'-tresses are plants that typically grow in damp to seasonally wet clearings, abandoned fields, woods borders, thickets, and disturbed ground. Active management, such as periodic mowing or prescribed fire, may be needed to create the proper successional stage and ecological conditions for these species to thrive. Vegetation maintenance along agricultural field edges and the pipeline at this location helps to reduce competition from woody and aggressive species and keep the habitat in a state of early succession. Habitat loss, deer browse and the indiscriminate spraying of herbicides are threats to these species in some locations.
- Two of the plant species of concern, screwstem and netted chainfern, typically occur in swamps, seepages, wet woods, boggy wetlands and along the margins of streamlets. At this location, they inhabit some of the seeps within the forested area. The viability of populations of these species and their habitat may be enhanced by establishing buffers around wetlands, controlling invasive plant species, and protecting the natural hydrology surrounding wetlands.
- A sensitive species of concern, which is not named at the request of the jurisdictional agency overseeing its protection, occurs in several locations within this forested area. Its preferred habitat is moist deciduous forests and stream banks. These high quality woodlands may be altered by encroachment of invasive species, over-browsing by deer, and fragmentation. Fragmentation can have a drying effect on the habitat and promote invasive species growth. Creating buffers around fragmented habitat and removal of invasive species will help to maintain populations and encourage new population growth.

Forest Cover / Natural Communities: The plant community types depicted are approximations delineated from 2005 aerial photography interpretation and were followed up with minimal selective ground-truthing. Community types follow "Terrestrial & Palustrine Plant Communities of Pennsylvania" (Fike 1999) where appropriate, and otherwise describe general land cover types (*).

- Terrestrial (upland) communities:
  - Red maple terrestrial forest
  - Red oak – mixed hardwood forest
  - Tuliptree – beech-maple forest
  - modified successional forest*

- The canopy consists of relatively large trees, mostly of tuliptree (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), and white ash (*Fraxinus americana*), but with at least 20 additional species mixed in. The shrub zone varies from dense spice bush (*Lindera benzoin*) to dense exotic species including multiflora rose (*Rosa multiflora*) and Asiatic bittersweet (*Celastrus orbiculatus*) to more of an open woods with scattered shrubs. The herbaceous species are most numerous and diverse in areas near diabase boulders or where small rivulets flow downslope. These rivulets are lined with skunk cabbage (*Symplocarpus foetidus*). The forest appears to get more weedy as one goes upslope. Some parts of the lower slope have very few exotics suggesting that perhaps some exotic plant removal has occurred, while other parts of the lower slope have plenty of exotics.
- Some of the forest patches are in the long process of reverting from past agricultural uses, while other patches exhibit a much more undisturbed and pristine quality. Though the forest was likely selectively cut for fuel wood and timber several times since colonial times, much of the existing forest has apparently been standing for well over 100 years. Some of the trees were in the past likely considered less desirable for lumber and fuel or were less accessible due to steep slopes and were left in place. While this tract of forest can't be considered virgin timber, some individual trees in the area

are likely 100-200 years old. Although there is invasion of exotic plant species into the woods the overall quality of the woods is remarkably natural and aesthetically pleasing.

Ownership:

- Roughly half of this area is owned by the county and the township as public parks and open space. The remainder is owned by numerous landowners, some with larger parcels than others. Fragmentation of ownership can make coordinated conservation actions more difficult, but not impossible to achieve.

Habitat Disturbances:

- Historic:
  - Most of the original forest cover of the area had been removed and converted to agricultural or other uses over the past several centuries, leaving little of the original vegetation in place. Aerial photographs from 1937 show that most of the currently forested area was forested in 1937 within a landscape dominated by active agriculture. Though the forest was likely selectively cut for fuel wood and timber several times since colonial times, much of the existing forest has been standing for over 100 years and individual trees could be much older.
  - The electric powerline rights-of-way was cut east to west through the upper portion of the wooded area by 1971. Though this was a disturbance to the integrity of the forested habitats, but helped to maintain the habitat preferred by several of the plant species of concern; it established a narrow strip of vegetation that was maintained as early successional habitat up to the present day.
- Current:
  - Rapid development has occurred outside of and on the periphery of the core habitat area, fragmenting the landscape with additional buildings, roads and infrastructure and increasing the amount of impervious surface and edge habitat in the immediate watershed.
  - Stormwater runoff from the highly developed surrounding communities flows into the creek system with little opportunity to be slowed or filtered. This results in increased downstream flooding and erosion and is a potentially significant non-point source of pollution. Runoff from these sources has significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through natural vegetation.
  - Exotic Species – The edge habitat provided by reverting agricultural fields and residential development creates conditions favorable for many introduced species of plants. Some of the primary invasive species occurring in this location include:
    - tree-of-heaven (*Ailanthus altissima*)
    - garlic-mustard *(Alliaria petiolata)*
    - Japanese angelica tree (Aralia elata)
    - Japanese barberry (*Berberis thunbergii*)
    - Asiatic bittersweet (*Celastrus orbiculatus*)
    - winged euonymous (*Euonymus alatus*)
    - winter creeper (*Euonymus fortunei*)
    - Japanese honeysuckle *(Lonicera japonica)*
    - amur honeysuckle *(Lonicera maackii)*
    - sweet cherry *(Prunus avium)*
    - Japanese stiltgrass *(Microstegium vimineum)*
    - multiflora rose *(Rosa multiflora)*
    - wineberry (*Rubus phoenicolasius*)
    - linden viburnum (*Viburnum dilatatum*)
  - Control options for invasive plants range from mechanical to chemical. However, indiscriminate use of herbicides as rights-of-way defoliants is not acceptable. A smarter, more selective use of chemical controls is required in these areas that contain both invasive species and species of concern.

- Invasive species management needs to be coordinated by individuals familiar with the rare species as well as the invasive species present.
- High priority for invasive species control at this site should be targeted towards removing small populations of newly established invasive plants in the most weed-free portions of the Natural Heritage Area. Invasive species control efforts should try to maintain weed-free areas first, and then concentrate on removing invasive species in lightly infested areas, continually pushing back the line of invasion. Invasive species removal should be conducted in coordination with native species replacement to avoid denuding the understory vegetation. This needs to be a continual and sustained process of monitoring and control efforts.

- The relatively low volume of understory herbs and shrubs noted in this forest may be attributable to an oversized deer herd. Overbrowsing by white-tailed deer is a serious threat to the overall understory plant diversity. An overabundance of deer can create the effect of park-like forests in which the understory and vertical stratification is greatly reduced. Removal of understory species eliminates habitat for some nesting songbirds as well as increasing competition between deer and other wildlife due to reduced food sources. Deer have strong, species-specific feeding preferences. The most highly preferred species are the first to decline or disappear when deer numbers are high. Furthermore, deer have been shown to be prolific seed dispersers for many of the most invasive nonnative species. The result is greatly impoverished native species diversity, failure of native tree regeneration, and the rapid proliferation of invasive species. It is likely their selective feeding habits and effective seed dispersal make the spread of invasives much faster than would be the case without deer, even where herds are only moderately oversized.

<u>Conservation Actions</u>:

- Overall:
  - Allow the forested habitats to achieve and maintain old growth conditions.
  - Maintain early successional habitats where they currently exist by periodically removing woody vegetation and invasive plant species.
  - Conserve and expand the forested riparian buffers of Beaver Creek and its tributaries. Conserve at least a 100 meter (328 feet) buffer of woody vegetation where it exists along the creek and establish at least a 100 foot buffer where it is lacking to help reduce erosion, sedimentation, and pollution. Additionally, best management practices (BMPs) that focus on limiting the introduction of non-point sources of pollution into surface and groundwater should be applied to the surrounding area.
- Within the Core Habitat:
  - Because several of the species of concern noted from this site rely upon open canopied habitats, removal of woody shrubs will be necessary to maintain habitat for several of the open habitat adapted plant species. Mowing of the powerline and pipeline every other year in early spring can help maintain the early successional conditions favorable for these plant species of concern. Mowing more frequently or broadcast herbicide spraying can have a severely negative impact on the plant species of concern and their habitat.
  - Avoid fragmenting the existing forested areas with additional buildings or infrastructure. Avoid logging in this area except as it relates to invasive species removal. The forest cover should be allowed to achieve and maintain old-growth characteristics. Leave fallen trees in place to help provide habitat, soil nutrients, humus and tilth. Trees that have fallen over approved trails can be cut through as necessary.
  - Avoid altering the hydrology of Green Creek, its tributaries, springs and wetlands.
  - The stormwater runoff from development and agriculture should be considered a potential source of significant contamination for the creek and its floodplain habitat. Runoff from these sources have significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through a natural habitat. Stormwater management measures

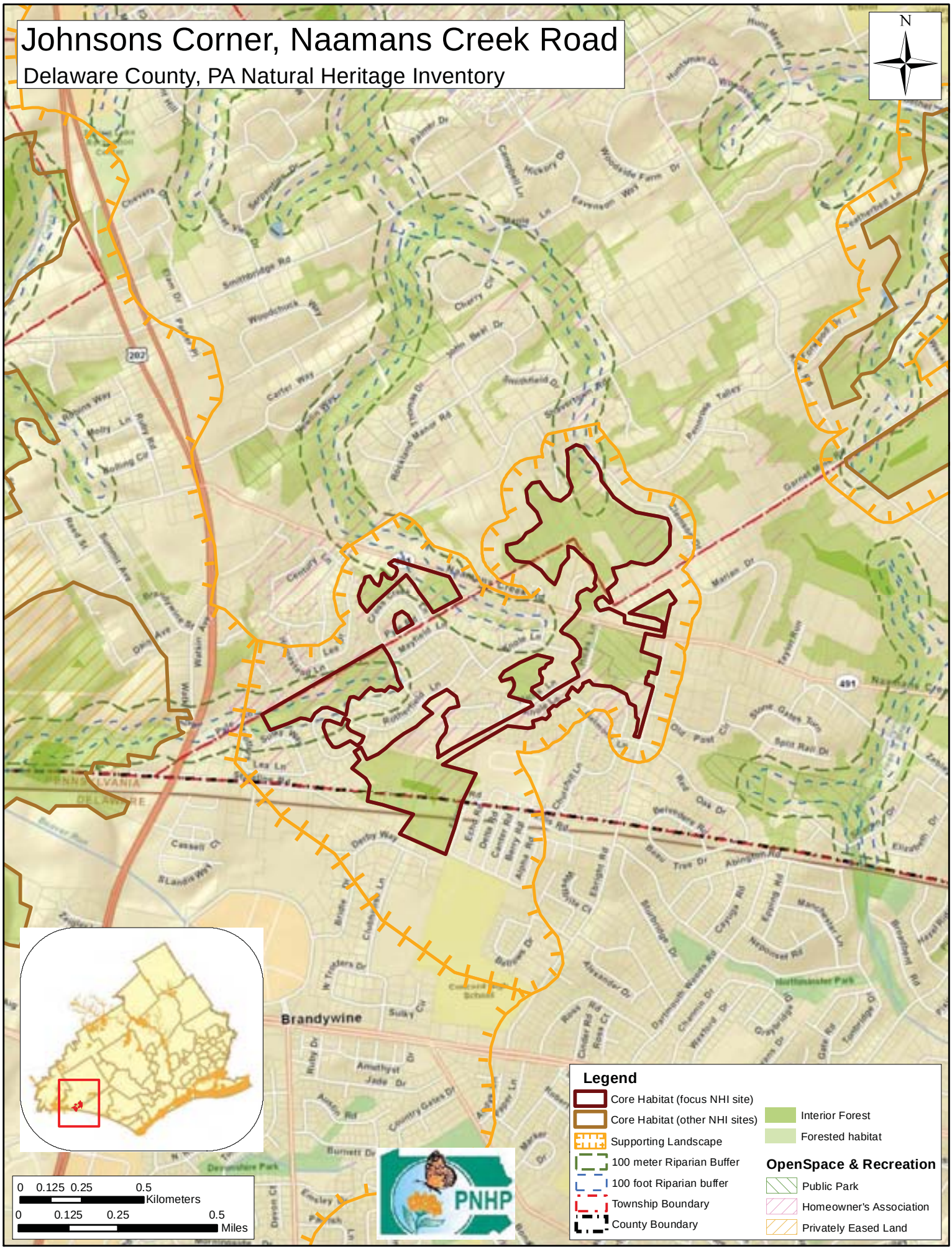
such as the creation of detention basins or vegetated swales should be implemented to decrease the unfiltered flow into the creek.
    - Remove invasive species of plants.
    - Reduce the deer density in the area. Uncommon species of native plants are particularly susceptible to deer herbivory..
- Potential Restoration Activities:
    - Streams through forested areas should be considered high priority for conservation. The forested riparian corridor helps to regulate the temperature of the stream and creates streamside conditions that contribute to improved water quality and aquatic habitat. Streams through non-forested areas should be restored with native trees and shrubs appropriate to the habitat.
        - Riparian Buffers:
            - An ideal vegetated stream buffer should be at least 100 meters (328 feet) in width from the edge of the 100-year floodplain.
            - An intermediate vegetated stream buffer should be at least 100 feet in width from the edge of the 100-year floodplain.
            - A minimum vegetated buffer should be at least 35 feet in width from the edge of the 100-year floodplain.
    - Remove invasive species of plants. The creek floodplain and edge habitats associated with agricultural fields are particularly susceptible to weedy plant invasion and will require a sustained and targeted approach to invasive management. Aggressive invasive species along the powerline rights-of-way can have a significant impact on the available habitat for the species of concern. Control of invasive species in the area will require extensive and continual effort. Focus non-chemical control efforts on selected areas surrounding species of concern.
        - Target pioneer populations of invasive plants for immediate and continued removal. It is much easier and more effective to keep a place invasive-free than to try and repair a heavily infested habitat.
        - Invasive species management needs to be coordinated by individuals familiar with the rare species as well as the invasive species present.
        - Continual invasive species monitoring and control will be necessary.

Photo Source: PNHP

Diabase boulders are scattered beneath a maturing forest canopy along the floodplain of Green Creek.

Johnsons Corner, Naamans Creek Road

Delaware County, PA Natural Heritage Inventory



Johnsons Corner, Naamans Creek Road – *High significance*

Species of Concern:	Taxa[1]	PNDI Rank[2] Global	PNDI Rank[2] State	Legal Status[2] State (Proposed)	Last Seen	Quality[2]
Oblong-leaf serviceberry (*Amelanchier canadensis*)	P	G5	S1	N (PE)	1998	CD
Colic-root (*Aletris farinosa*)	P	G5	S1	TU (PE)	2010	C
Round-leaved thoroughwort (*Eupatorium rotundifolium*)	P	G5	S3	TU (TU)	1989	X
Soapwort gentian (*Gentiana saponaria*)	P	G5	S1S2	TU (PE)	1995	BC
Grass-leaved rush (*Juncus biflorus*)	P	G5	S2	TU (PT)	2010	E
Forked rush (*Juncus dichotomus*)	P	G5	S1	PE (PE)	1989	X
Narrowleaf bushclover (*Lespedeza angustifolia*)	P	G5	S1	PE (PE)	1989	X
Swamp dog-hobble (*Leucothoe racemosa*)	P	G5	S2S3	TU (PT)	2010	C
Downy lobelia (*Lobelia puberula*)	P	G5	S1	PE (PE)	2010	C
Southern bog clubmoss (*Lycopodiella appressa*)	P	G5	S2	PT (PT)	1990	X
Stiff cowbane (*Oxypolis rigidior*)	P	G5	S2	TU (PT)	1995	BC
Many-flowered panic-grass (*Panicum polyanthes*)	P	G5	S4	N (SP)	2009	BC
Cross-leaved milkwort (*Polygala cruciata*)	P	G5	S1	PE (PE)	1995	C
Swamp chestnut oak (*Quercus michauxii*)	P	G5	S1	N (PE)	2009	C
Willow oak (*Quercus phellos*)	P	G5	S2	PE (PE)	2009	D
Spring ladies'-tresses (*Spiranthes vernalis*)	P	G5	S1	PE (PE)	1990	D
Sensitive species of concern	---	---	---	---	1991	D

[1] A = Amphibian; B = Bird; C = Community; F = Fish; L = Lepidopteran; O = Odonate; P = Plant; M = Mammal; R= Reptile, U = Unionoid (Mussel)
[2] Please refer to Appendix III for an explanation of PNHP ranks and legal status
[3] This species is not named by request of the jurisdictional agency overseeing its protection

Location: This fragmented habitat is loosely bounded on the west by Route 202, on the north by Shavertown Road, on the east by Ebright Road, and on the south by the Maryland state line. This area is at the drainage divide of three watersheds and hosts the headwaters of two tributaries of the West Branch Chester Creek and one tributary of Beaver Creek.

- Municipalities:
  - Bethel Township
  - Concord Township
- USGS Quadrangles:

- Wilmington North Quadrangle
- Watersheds:
  - Brandywine Creek
  - Naamans Creek
  - West Branch Chester Creek
- 1992 Delaware County Natural Areas Inventory reference:
  - "Johnsons Corner Quarry Woods"- (Wilmington North Quadrangle)
- 1998 Delaware County Natural Areas Inventory Update reference:
  - "Naamans Creek Road Site" – (Wilmington North Quadrangle)

Description: Considered one of the top sites of statewide significance for the protection of biological diversity in the original 1992 Delaware CNHI and the 1998 update, this area has been severely impacted by accelerated development in the past 20 years. This site was part of a larger mosaic of habitats of coastal plain affinity including forest, wetlands, fallow and active fields, and a former sand and gravel quarry (coastal plain deposits) that left a wet, sandy irregular surface. This area is underlain by bedrock and soils that have a high water table and the flat topography limits drainage. Seasonal ponding of water is typical for the area. This wetness has provided suitable habitat for numerous coastal plain affinity species, many of which continue to persist in scattered patches of suitable habitat. This area was one of very few in the state to support species associated with the Atlantic coastal plain in an intact habitat. Of special note was the presence of a cranberry wetland, a very unusual habitat for this region of the state. Much of the area has since been converted to residential development leaving scattered remnants of habitat that in many cases still manage to support species of concern. Several of the species of concern noted on past surveys have failed to be relocated in recent surveys due to the destruction of their former habitat and may be extirpated from this site.

Species of Concern Considerations:

- Nine of the plant species of concern, colic-root, soapwort gentian, grass-leaved rush, downy lobelia, stiff cowbane, many-flowered panic-grass, cross-leaved milkwort and spring ladies'-tresses are plants that typically grow in open canopy conditions such as damp to seasonally wet clearings, woods borders, thickets, abandoned fields, and disturbed ground. Active management, such as bi-yearly mowing or prescribed fire, may be necessary to create the proper successional stage and ecological conditions for these species to thrive. Vegetation maintenance along road edges, open fields and the pipeline at this location can help to reduce competition from woody and aggressive species and keep the habitat in a state of early succession. Habitat loss, natural succession deer browse and the indiscriminate spraying of herbicides are threats to these species in some locations.
- Oblong-leaf serviceberry and swamp dog-hobble are understory shrubs or small trees that typically occur in swamps and wet thickets. Much of the formerly suitable habitat in this area has been modified for residential development, but the species continue to persist within wet roadside ditches, swales, moist stream banks and swamp forests in this area. Preserve and restore the natural hydrology of the habitat and protect the species from excessive deer browse.
- Two tree species of concern, swamp chestnut oak and willow oak occur in the seasonally wet forested habitats and bottomlands in this area. Closely associated with the Atlantic coastal plain habitat, naturally occurring populations of these species are typically restricted to the extreme southeastern counties in Pennsylvania. Swamp chestnut oak is a recent addition to the known flora of Pennsylvania, having only been documented as occurring in the state in the past five years. Currently, there are only two known populations of this species in the state. Known populations of both of these tree species are threatened by habitat loss, disruptions to the site hydrology, habitat degradation by invasive species of plants, and in some locations, over-browsing by deer. Forests may be negatively altered by habitat fragmentation, which can have a drying effect on the habitat and promote invasive species growth. Establish protective buffers around fragmented habitat and remove invasive species to help maintain populations of these tree species of concern and encourage new population growth. Fencing of seedlings and saplings may be necessary to protect future generation of these trees from deer herbivory.
- Four of the plant species of concern documented within this habitat during the initial inventory, round-leaved thoroughwort, forked rush, narrowleaf bushclover and southern bog clubmoss, have not been relocated during subsequent surveys. The habitat was essentially destroyed by development and the

- populations are presumed extirpated, though more thorough searching may uncover remnant populations of these species in the degraded habitat that remains.
- A sensitive species of concern, which is not named at the request of the jurisdictional agency overseeing its protection, occurs in several locations within this forested area. Its preferred habitat is moist deciduous forests and stream banks. These high quality woodlands may be altered by encroachment of invasive species, over-browsing by deer, and fragmentation. Fragmentation can have a drying effect on the habitat and promote invasive species growth. Creating buffers around fragmented habitat and removal of invasive species will help to maintain populations and encourage new population growth.

Photo source: Andrew Strassman (PNHP)

A massive swamp chestnut oak and its progeny in Jack King Memorial Park is one of only two populations of this tree species currently known to occur in Pennsylvania.

Forest Cover / Natural Communities: The plant community types depicted are approximations delineated from 2005 aerial photography interpretation and were followed up with minimal selective ground-truthing. Community types follow "Terrestrial & Palustrine Plant Communities of Pennsylvania" (Fike 1999) where appropriate, and otherwise describe general land cover types (*).

- Terrestrial (upland) communities:
  - Red maple terrestrial forest
  - Red oak – mixed hardwood forest
  - modified successional forest*
- Palustrine (wetland) communities:
  - Black willow scrub/shrub wetland
  - Mixed forb marsh

- The habitat has been severely fragmented. Patches of forest are frequently seasonally wet dominated by mixed oaks and other hardwoods, with a strong representation by sweet-gum (*Liquidambar styraciflua*) in the canopy and understory. Some trees in these woodlots are of impressive girth and height, suggesting a relatively mature habitat. Vestigial patches of early succession habitat are maintained as powerline/pipeline rights-of-way, roadsides, lawns, and open space fields. Most of the remaining non-forested wetland habitat is the result of earthmoving and habitat modification.
- The native canopy species characterizing the forested habitat are northern red, pin and white oaks (*Quercus rubra, Q. palustris* and *Q. alba*), sweet-gum, (*Liquidambar styraciflua*), American beech (*Fagus grandifolia*), tuliptree (*Liriodendron tulipifera*), white ash (*Fraxinus americana*), black cherry (*Prunus serotina*), shagbark hickory (*Carya ovata*), black-gum (*Nyssa sylvatica*) and red maple (*Acer rubrum*).
- Besides numerous invasive shrub species the characteristic native sub-canopy trees and shrubs include spicebush (*Lindera benzoin*), winterberry (*Ilex verticillata*), American hazelnut (*Corylus americana*), American hornbeam (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*) and several native viburnums (*Viburnum acerifoli*um, *V. dentatum & V. prunifolium*).

Ownership:

- Much of the habitat has been subdivided into suburban lots, though a fair part of the habitat is owned by Bethel Township and maintained as Jack King Memorial Park. Additional portions of the habitat are

owned by various homeowner associations and maintained as open space. Fragmentation of ownership of larger landscapes can make consistent conservation action more difficult, but not impossible to achieve.

Habitat Disturbances:

- Historic:
  - Most of the original forest cover of the region had been removed and converted to agricultural or other uses over the past several centuries, leaving little of the original vegetation in place. Aerial photos from 1937 show that much of the forested area in the core habitat that remains today was forested then, reflecting a relatively high degree of habitat maturity. Most of the surrounding area in 1937 was in active agricultural production, with some portions of the forested habitat in the early stages of recovering from past clearing.
  - A gravel quarry operated in the vicinity of the some significant plant populations, perhaps helping to create favorable conditions for these species.
- Current:
  - Development has steadily increased in the past decade. The large farms have mostly been converted to smaller residential lots and expansive suburban developments and associated retail business and infrastructure, fragmenting the landscape with additional buildings, roads and infrastructure.
  - Much of the primary habitat indicated as hosting species of concern in the original CNHI report has been converted to a residential development, leaving fragments of the former habitat surrounded by houses, lawns, roads and infrastructure. In some cases these habitat fragments can continue to support these populations of species of concern, while other habitats are considered destroyed.
  - Stormwater runoff from the highly developed surrounding communities flows into the creek system with little opportunity to be slowed or filtered. This results in increased downstream flooding and erosion and is a potentially significant non-point source of pollution. Runoff from these sources has significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through natural vegetation.
  - Portions of the immediate floodplain are maintained as large patches of lawn, eliminating essential floodplain habitat and reducing the filtering capacity of the riparian corridor.
  - The relatively low volume and diversity of native understory herbs and shrubs in this forest may be attributable to an oversized deer herd.
- Exotic Species:
  - The edge habitat provided by reverting agricultural fields and residential development creates conditions favorable for many introduced species of plants. Informing other neighboring property owners of the benefits of invasive species removal could result in additional improvement. Some of the primary invasive species occurring in this location include:
    - Norway maple *(Acer platanoides)*
    - garlic-mustard *(Alliaria petiolata)*
    - oriental bittersweet *(Celastrus orbiculatus)*
    - border privet *(Ligustrum obtusifolium)*
    - Japanese honeysuckle *(Lonicera japonica)*
    - amur honeysuckle *(Lonicera maackii)*
    - Japanese stiltgrass *(Microstegium vimineum)*
    - mile-a-minute weed *(Persicaria perfoliata)*
    - common reed *(Phragmites australis)*
    - multiflora rose *(Rosa multiflora)*
  - Control options for invasive plants range from mechanical to chemical (see individual fact sheets). High priority for invasive species control at this site should be targeted towards removing small populations of newly established invasive plants in the most weed-free areas of the Natural Heritage Area. Invasive species control efforts should try to maintain weed-free areas first, and then concentrate on removing invasive species in lightly infested areas, continually pushing back the line of invasion. Invasive species removal should be conducted in

coordination with native species replacement to avoid denuding the understory vegetation. This needs to be a continual and sustained process of monitoring and control efforts.

- Overbrowsing by white-tailed deer is a serious threat to the overall understory plant diversity. An overabundance of deer can create the effect of park-like forests in which the understory and vertical stratification is greatly reduced. Removal of understory species eliminates habitat for some nesting songbirds as well as increasing competition between deer and other wildlife due to reduced food sources. Deer have strong, species-specific feeding preferences. The most highly preferred species are the first to decline or disappear when deer numbers are high. They avidly consume seedlings of virtually all native tree species and generally avoid eating invasive plants. The result is greatly impoverished native species diversity, failure of native tree regeneration, and the rapid proliferation of invasive species. Furthermore, deer have been shown to be prolific seed dispersers for many of the most invasive nonnative species. It is likely their selective feeding habits and effective seed dispersal make the spread of invasives much faster than would be the case without deer, even where herds are only moderately oversized.

Conservation Actions:

- Because several of the species of concern noted from this site rely upon open canopied habitats, removal of woody shrubs and invasive species in early successional habitats such as open fields, pipeline/powerline rights-of-way, and roadsides will to be necessary to maintain habitat for several of the open habitat adapted plant species. Mowing of these habitats every other year in early spring can help maintain the early successional conditions favorable for these plant species of concern. Mowing more frequently or broadcast herbicide spraying can have a severely negative impact on the plant species of concern and their habitat.
- Preserve and expand permanent and seasonal wetlands. The natural hydrology should be maintained and restored. Wet habitats should be thoroughly surveyed for remnant populations of species of concern and other coastal plain affinity species. Remove invasive species to allow native species to expand their populations. Establish vegetated buffers around wet and moist habitats to help protect the water quality entering the system.
- Avoid fragmenting the existing forested areas with additional buildings or infrastructure. The primary conservation concern for forested habitats should be to focus on safeguarding the quality and expanse of the forested landscape. While providing the primary habitat for several populations of species of concern, the forested landscape also helps to protect water quality of the small streams that drain through this Natural Heritage Area into the Delaware River and provides refuge and habitat for other forest dependent species. Prevent fragmentation and incursions into the forested landscape.
- Avoid logging in this area except as it relates to invasive species removal and stand improvement. The forest cover should be allowed to achieve and maintain old-growth characteristics. Leave fallen trees in place to help provide habitat, soil nutrients, humus and tilth. Trees that have fallen over approved trails can be cut through as necessary.
- Suppress and reverse the establishment and spread of invasive species of plants. Improve the quality of the forest composition by removing aggressive invasive and early successional species of plants in favor of existing native climax species. Enhance the stratification of the canopy by encouraging the establishment of native tree saplings, shrubs, and herbaceous species.
- Reduce the deer density in the area. Uncommon species of native plants are particularly susceptible to deer herbivory. This may require erecting deer exclosures coupled with a significant reduction in the deer population to protect these elements of the landscape.
- Conserve and expand the forested riparian buffers of all streams and wetlands. Conserve at least a 100 meter (328 feet) buffer of woody vegetation where it exists along the waterways and establish at least a 100 foot buffer where it is lacking to help reduce erosion, sedimentation, and pollution. Additionally, best management practices (BMPs) that focus on limiting the introduction of non-point sources of pollution into surface and groundwater should be applied to the surrounding area.
- The significant habitats of the area can be strongly affected as a result of nearby land use decisions. Reduce the amount of impervious surfaces in the watershed to diminish the impact of

flooding and erosion during storm events. Stormwater runoff through urban and suburban areas can be a significant source of chemical pollutants for the waterways, which can severely impact water quality and the food chain of the waterway. The use of herbicides, pesticides and fertilizers in residential developments can also have a significant impact on the water quality at this location. Runoff from these sources have significantly higher levels of sediment, nutrients, pesticides, herbicides and other pollutants than runoff filtered through a natural habitat. Stormwater management measures such as the creation of detention basins or vegetated swales should be implemented to slow and capture water flow in these expanses of urban and cultivated landscapes.

- Residents who live adjacent to this area should be informed and continually reminded of the effects their everyday actions have on the natural habitat that adjoins or overlaps their property.
    - In many cases, their house and yard may occupy formerly highly significant habitats for species of concern. In some cases, species of concern may still persist on their property. Homeowners should consider improving habitat conditions within their property for these species of concern. Permanently or seasonally wet areas of their property are likely areas that can support these species. Reduce the area of mowed lawn and cultivated gardens in favor of existing native plants suitable to the coastal plain habitat. Permanent and seasonal wetland habitats should be protected and expanded to reclaim a portion of the habitat lost to recent development.
    - Individual households can be a significant source of pesticide, herbicide, nutrient and other chemical runoff entering the streams and creeks. Neighbors of the woods should be encouraged to minimize the use of yard chemicals and watering by using native species of plants that are already adapted to the local growing conditions. Native plants in the yard can help increase the available habitat for native plants and animals, especially native birds and insect pollinators.
    - Municipal sewage systems may need to be upgraded to help improve water quality.
    - Yard waste dumped into or near natural areas can be a significant source of invasive species of plants.
    - Domestic pets (cats and dogs) can take a significant toll on native animals. Pets should be kept indoors, on leashes or within enclosed yards.
    - Ruts created by trail bikes can fragment the landscape, damage understory vegetation and disrupt wildlife. Off-trail pathways cut through the woods by trail bikers should be blocked and the use of trail bikes discouraged or prohibited.
    - Excessive outdoor lighting can affect the quality of the natural habitat for native animals. Street and residential lighting should have shielding to direct lights downward. Unnecessary outdoor lighting should be minimized or eliminated.
- Potential Restoration Activities:
    - Former agricultural fields that have been allowed to revert to woody vegetation may require selective management to speed the succession process. Remove weedy woody species and favor native climax community species. Use the higher quality adjacent forests in similar topographic and geologic settings as natural community reference examples and mimic the forest composition. Use local native seed sources and root stock whenever possible in restoration efforts.
    - Areas currently maintained as lawn, particularly in the active floodplain of the streams in the area, should be restored to native floodplain forest or open meadow habitats appropriate for the region.
    - Remove invasive species of plants. The creek floodplain and edge habitats associated with agricultural fields and residential neighborhoods are particularly susceptible to weedy plant invasion and will require a sustained and targeted approach to invasive management. Control of invasive species in the area will require extensive and continual effort. Focus non-chemical control efforts on selected areas surrounding species of concern.
        - Target pioneer populations of invasive plants for immediate and continued removal. It is much easier and more effective to keep a place invasive-free than to try and repair a heavily infested habitat.

- Invasive species management needs to be coordinated by individuals familiar with the rare species as well as the invasive species present.
- Continual invasive species monitoring and control will be necessary.

Photo Source: (PNHP)

Open wet meadows, like this one adjacent to Jack King Memorial Park, would benefit from early spring mowing every other year to help keep the habitat in an early successional stage preferred by several plant species of concern found here.