Philadelphia Parks & Recreation

Parkland Forest Management Framework



April 2013

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Acknowledgements

Project Lead
City of Philadelphia, Parks and Recreation
Michael Nutter, Mayor
Michael DiBerardinis, Deputy Mayor for Environmental and Community Resources
Mark Focht, First Deputy Commissioner Parks and Facilities

Project Sponsor
William Penn Foundation

Project Contributors
Parks and Recreation, Urban Forestry and Ecosystem Management Division
Joan Blaustein, Director
Tom Witmer, Director Natural Resources
Tom Dougherty, Land Steward
Curtis Helm, Project Manager
Nora Dougherty, Spatial Analysis Specialist

Project Consultant
Biohabitats, Inc.
Ed Morgereth, Project Manager
Jennifer Dowdell, Technical Lead
Justin Bowers, Spatial Analyst
Jean Wisenbaugh, Graphic Design

Special thanks to:
Mark Mead, City of Seattle and Green Seattle Partnership
Robert Loeb, Ph.D., Associate Professor of Biology and Forestry, Pennsylvania State University
DuBois; and Springer Briefs in Ecology, Springer Science+Business Media, LLC 2011

Biohabitats

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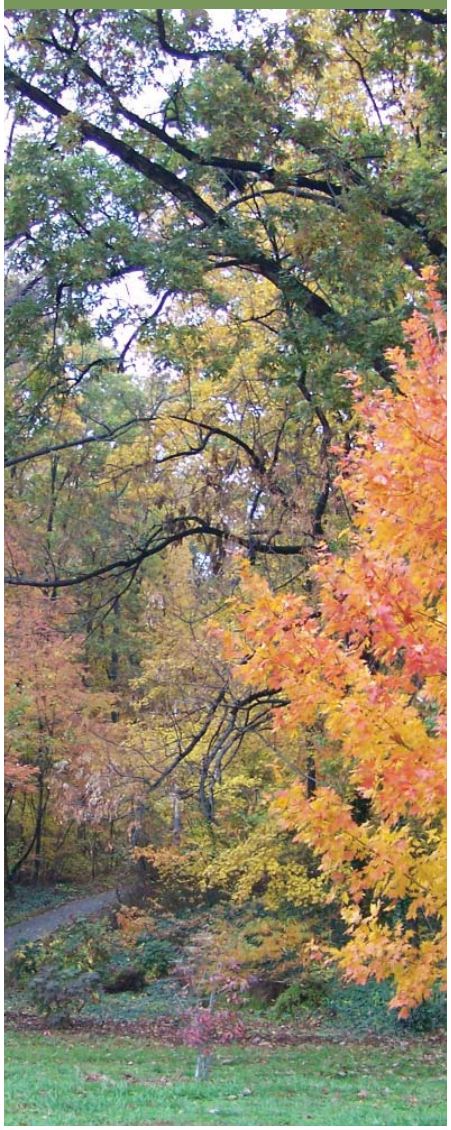
Executive Summary

Philadelphia Parks and Recreation Parkland Forest Management Framework

The ultimate goal of the Parkland Forest Management Framework and recommendations included in this document is to achieve a viable, self-perpetuating, native-dominated and resilient forest ecosystem.



PURPOSE AND GOALS

With its emphasis on natural resources planning and green infrastructure, the City of Philadelphia is ahead of many municipalities in efforts to protect and enhance existing natural resources in the parks. The City's parkland forest resources have benefited from years of preservation, enhancement and restoration through faithful care by the city and local stewards. However, in order to maintain a healthy urban forest additional efforts are needed. After a history of significant deforestation and land conversion in the region, there has been an extended period of forest re-growth, including invasion by nonnative species. Currently a substantial portion of forested areas in municipal Philadelphia occurs within the City's park system, and some of the largest tracts of urban forest lands are under the jurisdiction of Parks and Recreation.

The diverse benefits of a healthy urban forest include improved water quality, protection of native biodiversity, wildlife habitat, energy savings, temperature modification, air pollution reduction, and property value enhancement, among others. The Parks' forest lands provide significant economic benefit to the City of Philadelphia, both through improved ecosystem function and social benefit. In Philadelphia the urban tree canopy stores almost 500,000 metric tons of carbon, at an estimated value of close to $10 million and air pollutant removal associated with urban forest canopy is valued at nearly $5 million annually. Property values in neighborhoods across the City see a 10% increase with the inclusion of enhanced forest canopy, translating to a $4 million gain in property values associated with increased urban forest.

This Forest Management Framework serves as a guide to long-term, holistic management of the forest resources. The framework provides a broad-brush ecological assessment of the Parks' forest ecosystem, focused mainly on the stream valley and estuary parks, as well as a select number of neighborhood parks with significant canopy. It addresses issues associated with natural resource needs and opportunities. Its focus is on resource conditions in need of ecological enhancement, restoration and management. Its aim is to protect, restore and maintain the natural forestlands of the parks for the benefit of the citizens of Philadelphia and the surrounding region. The framework includes chapters summarizing assessment, adaptive management, future needs, and pilot projects. It is intended to guide management for a 10-year time horizon, during which time it may undergo periodic updates based on progress, emerging needs and resources addressed by adaptive management measures.

SETTING THE CONTEXT, OPPORTUNITIES, THREATS & CONSTRAINTS

Through a legacy of settlement, industry, and agricultural cultivation and development, the forest resources of Philadelphia have been subjected to a multitude of threats, impacts and system-wide changes. Threats and stressors of today are not all that different from those found historically, but the forests' degraded condition leaves them more susceptible to these stressors. Historic stressors included chestnut blight, other insects and diseases (e.g., Dutch elm disease, butternut canker, and anthracnose), industry, clearing of old growth forests, change in stream morphology, roads and trails, development threats, trampling, lack of funding and others. Contemporary stressors include deer browse and rubbing; a broad array of invasive plant species; insects and diseases (including the emergent issue of emerald ash borer); a lack of old growth forest cover, roots and associated soils; new rogue trails, and an overall lack of funding.

Based on in-depth conversations with park staff, review of existing data, as well as limited field visits, there are a number of themes associated with threats, stressors and opportunities that arise with regard to forest management. These include:

- **Deer pressures** – browsing and rubbing , clearing understory, minimizing regeneration of native biodiversity
- **Invasions** – plants, animals, insects & pests
- **Edges** – ecological threats/vectors, importance for community, perception of safety
- **Stormwater pressures** – erosion, runoff, stream function, sediment transport, slope instability
- **Neighborhood/community abuse (Non-compatible uses)** – ATVs, rogue trails, unsanctioned uses
- **Successful restoration initiatives** – building on energy of success, community investment, volunteer activities
- **Sensitive habitats** – vernal pools, forested wetlands, older growth forest remnants, threatened and endangered species
- **Infrastructure interface** – conflicts and harmonies
- **Strong foundation of existing resources** – organic materials, staff, community
- **Future pressures that may alter the existing tree canopy** – climate change (warming, intense weather events), emerging disease, emerging invasive plants or pests

ADAPTIVE MANAGEMENT FRAMEWORK & MANAGEMENT RECOMMENDATIONS

Adaptive management is a tool and process used to cope with the inherent changes and uncertainty fundamental to natural resources management, the ecological processes that encompass them, and changes in available funding. The goal of adaptive management is to build resilience into both the resource conditions as well as the management system, allowing flexibility and the incorporation of new information into the decision making process.

Management recommendations have been provided for invasive species management, deer management, insect infestation and disease management, forest fragmentation and disturbance – reforestation, forest soil health, & green infrastructure. Each provides a summary description of management recommendations, approach and techniques, phased implementation, and coordination opportunities.

An important part of long-term successful ecological restoration and management is a well-developed and executed monitoring program. Monitoring provides data on resource conditions and functions and helps determine the effects of restoration and management interventions.

LOOKING TO THE FUTURE

One valuable step for future forest management is adopting a version of the adaptive management process presented in this document that fits the Philadelphia Parks and Recreation organizational mission and the goals of its collaborative partners. Future efforts rely on implementing actions that continually re-evaluate forest resource conditions, identifying evolving strategies for restoration and management, and testing the effectiveness of interventions through comprehensive monitoring and feedback-based decision-making. Other valuable parts of forest management planning include the identification of pilot demonstration projects and staffing, equipment, and contracted implementation projects costs. Future efforts that can further develop a comprehensive forest management plan/natural resource management plan would involve a more detailed park investigation, analysis, and detailed implementation recommendations.

Maintaining and operating a large municipal park system requires significant expenditures of capital for staff time, equipment procurement, and contracting. The associated challenges of park management are particularly difficult in periods of fiscal spending reductions. Maintaining the ecological integrity of park system natural lands requires sufficient investments, in order to maximize natural capital for park use and program value.

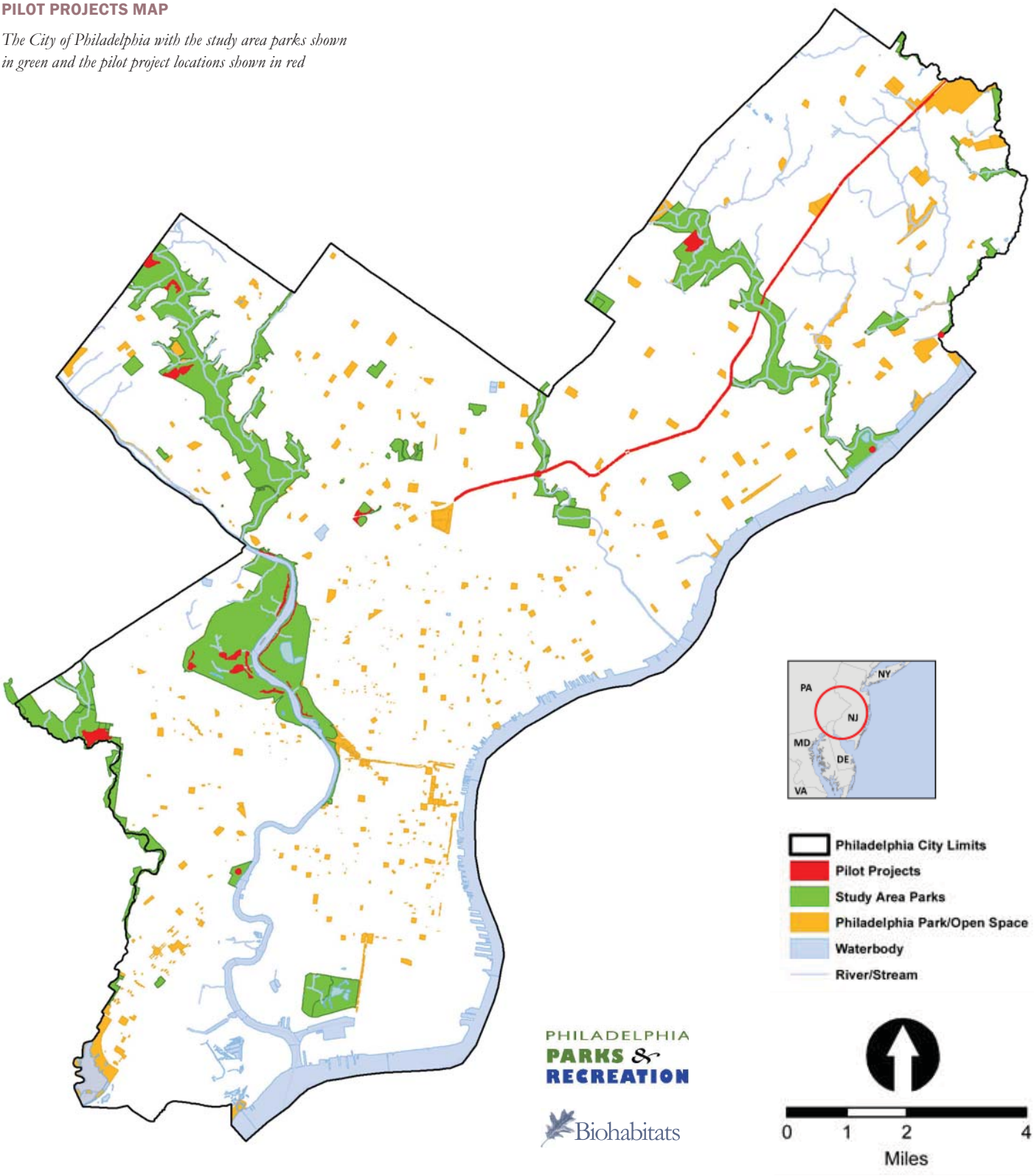
PILOT PROJECTS

Pilot projects have the added potential benefit of garnering stakeholder support, providing stewardship opportunities, and promoting collaboration with partnering organizations and funders. Pilot projects provide opportunities to test approaches and methods across a spectrum of forest resource needs and also can be tailored to spread pilot projects out across the system parklands and diverse neighborhoods. Based on the collective work of this framework, the following potential pilot projects are provided:

1. **Big Woods Reclamation/Deer Protection**–Implement vegetation and habitat improvements to a large (20+ acre) section of largely-unfragmented park forest in both Pennypack and Wissahickon Parks.
2. **Trunks, Chips & Fungus**–Introduce woody debris from the park to demonstrate how forest soils can be improved with recycled wood wastes.
3. **Fernhill Forest Reclamation**–Remove invasive vegetation parkwide and establish native forest and evergreen buffer plantings in this neighborhood park immediately across from the Wissahickon Charter School.
4. **Philadelphia's "Big Dig"**–Install 3,000 plants (trees and shrubs) in a one-day event utilizing approximately 500 volunteers. Project is to be done inside one of the Big Woods reclamation sites, in the Bocce Woods expansion, or in Fernhill Park (after clearing).
5. **Bocce Woods Expansion–**Restore an additional 25 acres of degraded forest in the largest area of core forest in Cobbs Creek Park. Remove invasive vegetation (including European black alder) and trash, plant native trees and shrubs and install deer fence around as much of the area as possible (15 acres).
6. **Horticulture Center Native Demonstration Forest**–Remove invasive vegetation, defunct fence, and concrete rubble and establish native forest in the 30 acres of exotics-infested natural areas surrounding this historic park location.
7. **Cedrela Smackdown**–Eliminate Cedrela trees (Chinese toon tree (*Cedrela sinensis*)) and other invasive vegetation in a 16-acre area around the Wissahickon Environmental Center and replace with native forest vegetation. Install 5-acre deer exclosure to protect a diverse forest planting.
8. **Stopping the Cork**–Eliminate invasive cork-trees around the perimeter of the restored Houston Meadow to stop their spread into restored areas. Plant native forest vegetation in cork removal areas.
9. **Holding the Edge (plan)**–Develop a planning document that identifies high, medium and low priority edges to "secure" against light and wind penetration park wide (PP&R staff project).
10. **Holding the Edge (project)**–Remove invasive plants on problematic edge sites, including Kelly Drive and West River Drive.
11. **Sustainable Connections**–Construct a new trail from Market Street to Cobbs Creek Community Environmental Education Center (CCCEEC) in Cobbs Creek Park to enhance access for Delaware County residents. Construct gateways and trailheads and provide signage for trails in this low-income section of the city. Remove invasive vegetation and trash "from street to creek" in northern section of trail.
12. **Andorra Innovative Stormwater Management**–Employ a range of practices from soakage trenches to wetland creation in order to capture and infiltrate uncontrolled stormflows and stop erosion problems throughout Andorra Natural Area.
13. **Roosevelt Parkway**–Using a variety of approaches, promote a new understanding of the parkway as a greenway corridor that helps to connect the community with the stream valley parks.
14. **Agroforestry Edges**–Enhance and expand edges along forested areas to reflect the agricultural and industrial landscape legacy. This concept aims to support forest stewardship, enhance soils, and promote innovative urban agriculture/agroforestry. An opportunity for a pilot could be explored at Bartram's Garden.
15. **For the Birds**–Provide improved migratory and residential nesting songbird habitat by enhancing and managing disturbed and altered forest edges. A woodland stand edge at Pennypack on the Delaware is a potential candidate for this pilot.
16. **To the River**–Enhance the interface of riparian parkland at a confluence with the Delaware River at Poquessing Creek Park. This green infrastructure project would be strategically located to address issues associated with stormwater runoff or piped discharge to the creek, while at the same time improving riparian forest and aquatic edge habitat.

PILOT PROJECTS MAP

The City of Philadelphia with the study area parks shown in green and the pilot project locations shown in red



I–Introduction

1.1 Background and Purpose

The City of Philadelphia's park system, a collection of extensive stream valley parks and smaller neighborhood parks interspersed throughout the urban fabric, has a rich history of cultural, recreational, and ecological resource use. Through a legacy of settlement, industry, and agricultural cultivation and development, the forest resources have been subjected to a multitude of threats, impacts and system-wide changes. With its emphasis on natural resources planning and green infrastructure, the City of Philadelphia is ahead of many municipalities in efforts to protect and enhance existing natural resources in the parks. The City's parkland forest resources have benefited from years of preservation, enhancement and restoration through faithful care by the city and many local stewards (including nearly 100 Friends groups). The parks have also been the subject of comprehensive natural resources planning and land management for many decades, historically through the efforts of the Fairmount Park Commission (FPC) and currently through the recently established Department of Parks and Recreation, along with various stakeholder groups.

Wissahickon circa early 1870s

The diverse benefits of a healthy urban forest include wildlife habitat enhancement, improved water quality, protection of native biodiversity, energy savings, temperature modification, air pollution reduction, and property value enhancement, among others. The parks' forest lands provide significant economic benefit to the City of Philadelphia, both through improved ecosystem function and social benefit. In Philadelphia the urban tree canopy stores 481,000 metric tons of carbon, at an estimated value of $9.8 million and air pollutant removal associated with urban forest canopy is valued at $4.8 million annually (USDA Forest Service 2005). Property values in neighborhoods across the city see a 10% increase with the inclusion of enhanced forest canopy, translating to a $4 million gain in property values associated with increased urban forest. The economic benefit of stormwater management associated with the City's parkland and urban forest is $5.9 million annually (Alliance for Community Trees 2011). See graphics on page I–2.

In order to maintain a healthy forest in the Philadelphia Park system, additional effort is needed to recover and restore functional, resilient and vibrant forest resources for the community. The ultimate goal of the parkland forest management framework and recommendations included in this document is to achieve a viable, self-perpetuating, native-dominated and resilient forest ecosystem. It is important that management decisions and actions account for the connection between urban forest integrity, water quality protection, wildlife habitat provision, the conservation of native biodiversity, recreation and cultural resources, and the delivery of other ecosystem services we rely on as a society. There is a vital link between healthy forests and community well-being.

1.2 Mission and Guiding Principles

1.2.1 Mission

The mission of Philadelphia Department of Parks and Recreation is to promote the well being of the City, its citizens and visitors, by offering beautiful natural landscapes and parks, historically significant resources, high quality recreation centers and athletic programs, along with enriching cultural and environmental programs. In delivering on the mission, Parks and Recreation has a responsibility for the stewardship of parkland forest resources.

1.2.2 Guiding Principles

- Philadelphia's forest parkland serves as an important connective tissue of the city's open space network.
- Conservation, restoration and preservation of the Park's woodland as an important ecological resource will serve to strengthen the open space network that underpins the city parks.
- Bodies of water, including the main stream valleys of Philadelphia, are protected through the management of natural buffers that include extensive forest.
- Buffers along natural areas provide increased ecological interior habitat for sensitive woodland and meadow wildlife species.

Courtesy of the Green Seattle Partnership–City of Seattle Contact Mark Mead

PRESENT
Forested natural areas are dominated by deciduous trees, mainly big-leaf maples and alders, nearing the end of their life. After decades of neglect, non-native invasive plants, such as English ivy and wild clematis, cover the ground and grow up into the tree canopy.

IN 20 YEARS
Invasive plants outcompete and grow over existing native vegetation, blocking the sunlight plants and trees need to thrive. English ivy now dominates the tree canopy, making the trees weak, top heavy and susceptible to windfall. Eventually, trees die or fall over.

IN 50 YEARS
The trees are gone. Only a few native shrubs struggle to survive the stress of competition with invasive plants.

IN 100 YEARS
The forest is destroyed. Native trees can no longer establish on their own. We are left with a dense "ivy desert." Very few plant species can live, and forest biodiversity is gone. Such conditions provide homes for rats and scarce habitat for more desirable urban wildlife.

Courtesy of the Green Seattle Partnership–City of Seattle Contact Mark Mead

PRESENT
Forested natural areas are dominated by deciduous trees, such as big-leaf maples and alders, nearing the end of their life. After decades of neglect, non-native invasive plants such as English ivy are smothering native vegetation and weakening native trees.

IN 20 YEARS
Through restoration efforts and long-term maintenance, the non-native plants are removed. Native groundcovers, shrubs and evergreen trees such as Douglas firs and Western red cedars and hemlocks are planted.

IN 50 YEARS
As the evergreen trees grow, they shade out sun-loving invasive plants such as blackberry. Native understory plants thrive.

IN 100 YEARS
With continued stewardship, the maturing forest requires less care and provides greater benefits to the city.

- Successful ecological function and management of park woodlands and associated water bodies will depend on both the efforts of the city as well as the continued care and stewardship offered by existing grassroots organizations, friends groups, and community groups.
- Education and stewardship-based volunteer projects are key to sustained interest, understanding and support of the city's woodland resources.
- Appropriate funding for management and maintenance is another key to successful ecological function in urban forest and parkland.

1.3 Framework Context

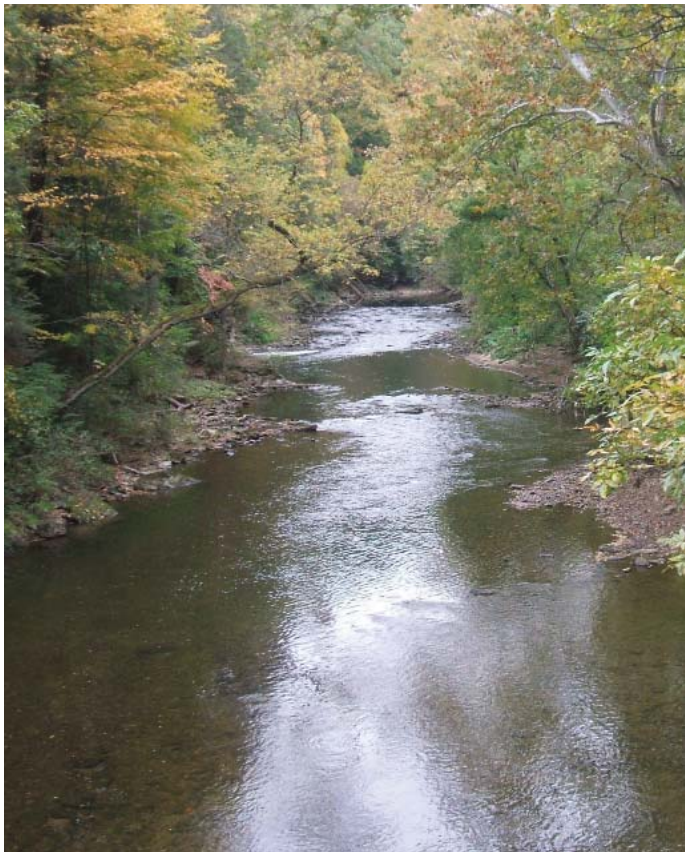
After a history of significant deforestation and land conversion in the region, there has been a long period of forest re-growth. Currently a substantial portion of forested areas in municipal Philadelphia occurs within the city's park system, and some of the largest tracts of urban forest lands are under the jurisdiction of Parks and Recreation. The park system includes buildings, roads, parking and other structures, as well as expanses of mown turf and trees, gardens, meadows, shrublands, and forests. The city park system contains nearly 10,000 acres of land, approximately 5,600 acres of which is considered natural lands and is the subject of this forest management plan framework. The park areas with significant forest areas are the stream valley and estuary parks, which are the primary emphasis of this plan, including:

Cobbs Creek Park
Fairmount (East & West) Park
FDR Park (estuary)
Pennypack Park
Poquessing Creek Park
Tacony Creek Park
Wissahickon Valley

The parks include a variety of public open space typologies including designed landscapes, botanical gardens, recreation centers and playing fields, golf courses, playgrounds, historic estates, as well as natural resource areas including meadows, streams, wetlands and forests. The parkland across the city displays varying degrees of functional woodland condition, based on the associated land use legacy.

The stream valley parks include the Wissahickon and Pennypack Park, both of which have the most continuous and largest existing interior forest habitat, which need to be preserved and enhanced. These parks already provide important wildlife and plant diversity, habitat and corridor capacity.

In addition to the larger forest parks, there are stream valley parks characterized by wooded riparian corridors and some forested patches, with more fragmented land uses that include recreation facilities and fields. These include Cobbs Creek, Tacony Creek,



The Wissahickon in the fall

and Poquessing Creek Parks. All three of these parks have important stream valley characteristics that could be strengthened by further attention to expanding forested riparian buffers, controlling urban runoff, and enhancing biodiversity through native plantings and invasive species control measures. It was noted that in Poquessing, "there are parcels of woods, in particular those located behind the abandoned Byberry buildings on Roosevelt Boulevard, which support a diverse tulip poplar/beech/ash and mixed oak canopy with an understory of oak saplings, ironwood (*Carpinus caroliniana*), witch hazel (*Hamamelis virginiana*) and spicebush" (Fairmount Park Commission, 2001, I-47).

Two of the major parks are characterized as managed landscapes, including old estates, open space and fairground properties where woodland is incorporated into the open spaces through a long history of intentional plantings. These are Fairmount Park (East/West) and FDR Park. "Most remaining forests found in East/West Park are very disturbed and occur as small, scattered patches, mostly in ravines (especially in West Park) or on the slope of the plateau (East Park)"(Fairmount Park Commission, 2001, I-46). "FDR Park includes some ponds and lagoons that are remnants of tidal marsh and channels which had originally occurred in this area between the Schuylkill and the Delaware Rivers" (Fairmount Park Commission, 2001, II-188).

clockwise from top left: Fall foliage at Fisher Park, Volunteers at East Park, Byrne Park golf course, Fernhill Park volunteers

There are dozens of other small to medium-sized parks in the city park system. Of those, the parks with the potential for forest resource management, which are subject to the management considerations in this plan, include the following:

Awbury Park
Bartram's Garden
Burholme Park
Eastwick Park
Fernhill Park
Fisher Park
Germany Hill
John Byrne Golf Course
Lardner's Point Park
Roxborough Reservoir
Wakefield Park
Wissinoming Park
Wister Woods

The neighborhood parks contain forest remnants along playing fields, woodland patches on the edge of older wooded residential neighborhoods, remnant wetlands with some shrub or scrub cover, and community gardens with limited tree canopy. These distinctions of woodland character will be particularly helpful as management and maintenance practices are considered in this framework.

1.4 Framework Focus

This forest management framework is a guide to long-term, holistic management of the forest resources. It is intended to guide management for a 10-year time horizon, during which time it may undergo periodic updates based on progress, emerging needs and resources addressed by adaptive management measures. The framework provides a broad-brush ecological assessment of the Parks' forest ecosystem and addresses associated natural resource needs and opportunities. Its focus is on resource conditions in need of ecological enhancement, restoration and management, in order to protect, restore and maintain the natural forest lands of the parks for the benefit of the citizens of Philadelphia and the surrounding region. The framework includes the following chapters: Park System Forest Assessment, Adaptive Management, and Looking to the Future.

II–Park System Assessment

Tacony Creek Park

Wissahickon Drive, 1914

2.1. Setting the Context: Park Woodlands in Philadelphia

2.1.1 Park History

There is a long legacy of dependence upon the ecological resources of the stream valley parks. From the Lenni Lenape Native American peoples of pre-European settlement through to the industrialists, who realized the potential for mill-powered industry along the streams, it only increased. There is also a history of stewardship, as neighbors took it upon themselves to preserve and celebrate the parks' aesthetic and recreation value. A legacy of ecological degradation balances precariously with an appreciation of the wilderness character and the mystery of the wooded stream valleys.

The comprehensive book series, *Metropolitan Paradise: The Struggle of Nature in the City*, chronicles the long, storied history of the Wissahickon and provides a window into the many layers of change that the stream valley parks have experienced in the last 400 years (Contosta and Franklin 2010). Philadelphia was the first city to build a municipal park system on an interconnected network of stream valleys, initially in response to the public outcry to protect the urban water supply (Contosta and Franklin 2010, xvi). With the lands that formed Fairmount Park, Philadelphia "embarked on an innovative and remarkably ecological park system, although this potential has never been realized" (Contosta and Franklin 2010, 15). In the case of the Wissahickon, the success of the Park is traced to the internal connectivity of public access as well as the overall connectivity of parkland along the stream (Contosta and Franklin 2010, 15).

The old growth eastern deciduous forests of this region were part of the Appalachian oak forest type, once known as Oak-Chestnut Forest. An important element of the old growth forests were their rich soils. The roots of the large trees provided important organic material for continuous soil formation. Fallen trees provided further materials for soil formation and microbial life. According to research and accounts the "pre-settlement forest was deep and springy, created in part by organic materials in various stages of decomposition." Little moisture evaporated within the deep rich soils of the forest (Contosta and Franklin 2010, 45).

Plant communities of the Wissahickon included white pines on the hilltops and chestnut ridges, with chestnut oaks, sassasfras, black cherry, shadbush, mountain laurel, black chokeberry, arrowwood, Pennsylvania sedge, lowbush blueberry, bracken, hayscented fern and rock polypody fern. The oak forests on the plateau included red and black oaks, shagbark, mockernut and pignut hickories, black gum, witchhazel, sassafras, spicebush, blackhaw, arrowwood, viburnum, mayapple, ferns, and wildflowers (Contosta and Franklin 2010, 46). Thick stands of hemlock forests appeared on the north and east-facing sides of the steepest slopes of the gorge in the Wissahickon. Beneath the hemlocks there was little groundcover, but the forest floor was covered in a thick layer of needle mulch. Beech forest occurred on the southern and eastern slopes, and included beech, white oak, mountain laurel, mayapple and ferns, with the canopy more open than in the hemlock stands, and with more variety in the understory. The sycamore, red maple, and ash forest in the valley bottoms experienced seasonal flooding. The bottoms were characterized by sycamores, maples, ash, hickory, and tulip poplar. Hemlocks and beeches were found along the water in some places. Vining species in the bottoms included wild grape, Virginia creeper, native bittersweet, moonseed, wild yam, and wild balsam apple (Contosta and Franklin 2010, 45).

Beginning in the late 1600's "the construction and operation of more than 50 mills along the entire Wissahickon and its tributaries was responsible for a wave of change to the ecosystem of the Valley. Mill owners cleared trees in the floodplain and often on the gentler slopes and changed the configuration and the hydraulics of the creek, and its tributaries with mill dams and raceways. They also built steep, muddy access roads that channeled water and mud into the creek and polluted the water with sediment, nutrients, and toxic water" (Contosta and Franklin 2010, 105). The mills produced flour, oil, textiles, paper and lumber. Philadelphia's growth began on the Wissahickon but by the mid-1700's it had also spread to the other stream valleys in the city, including Pennypack.

The hydrology of the streams was permanently altered through the construction of mill structures in the streams, as well as the filling of wetlands and the alteration of small meanders. The removal of vegetative cover along the banks of the streams, where young fish would have sought hiding places from predators, further inhibited ecosystem function. In order to build the structures, roads, and trails that provided access to the mills, large tracts of woodland were cleared. This led to intensified soil and sediment runoff into the stream corridors, since there were no roots left to hold the soil. "Steep mill roads provided conduits for the rich soil-laden runoff to drain directly into the waterways. Erosion intensified and it is hypothesized that it was during this time period that the deep forest soils, which had provided rich substrate for a diverse selection of plants and microbial organisms were lost" (Contosta and Franklin 2010, 145-146).

The romance of the 'wilderness' and a growing understanding of the impacts of industry along the streams, moved community members to promote improved management. In 1867 the state established the Fairmount Park Commission (FPC) to "maintain, forever, as an open public place and park, for the health and enjoyment of the citizens, and the preservation of the purity of the water supply to the City of Philadelphia" (Contosta and Franklin 2010, 199). There were pastoral parklands along the Schuylkill River and wilderness park areas along the Wissahickon. Forbidden Drive, which had been a major road into and out of the city was integrated into the park landscape and closed as an accessible travel option to all but park pedestrians, equestrians and cyclists. Acquisition of most of the Wissahickon Creek within the city limits was complete by the early 1870's, which then set a precedent for the other stream valleys within the city (Cobbs, Tacony, Pennypack and Poquessing) and preserved the main stream corridors, if not all of the smaller tributaries to these creeks (Contosta and Franklin 2010, 199-205). While activities of the commission were for the most part enhancements of the ecological character, through preservation and conservation activities like the removal of many of the mills, there were some less helpful actions taken. The white-tailed deer was reintroduced to the parks in the 1800's "as a picturesque addition to the forest landscape" after being virtually extinct in the region (Contosta and Franklin 2010, 319). White-tailed deer have since become a serious nuisance species leading to a decline in forest native plant diversity.

Chestnut blight in Fairmount Park, 1908

The chestnut blight arrived in the Wissahickon in 1914 and by the early 1920's most American chestnuts in the valley were infected. The blight decimated the chestnut trees in the parkland forests. Around the same time, the hemlock groves that had been very prominent along the steep slopes of the stream valley parks also began to decline, through a combination of harvest, heavy winds and large storms (ice storm in 1923-24), and old age. An increased number of sewer pipes run through the stream valley parks, as well as roads and bridges, led to the destruction of most of the mature and dense hemlock groves seen along the stream valleys (Contosta and Franklin 2010, 325-26). During the process of building roads and bridges that crisscrossed the parks, much of any remaining topsoil was removed, and the mixing of the soil layers may have destroyed the seed banks of local, forest plants. "Seeds of invasive exotics came in with new fill, were blown in from adjacent areas, or were planted as ornamental or erosion control efforts. Invasive plants took hold along the forest edge as well as deep into the Wissahickon along the trails and roads" (Contosta and Franklin 2010, 535).

In the 1930's one of the park system's important friends groups, the Friends of the Wissahickon (FOW), was formed. The FOW partnered with the FPC on forest restoration efforts, which included guidelines for planting in bare areas identified in aerials (a first sort of gap identification process), screening industrial buildings on the borders of the parks, and planting only native species in the park (Contosta and Franklin 2010, 328).

THE EMERALD ASH BORER

The emerald ash borer (*Agrilus planipennis*) was first discovered in the U.S. in 2002 in southeastern Michigan. This Asian beetle infests and kills North American ash species (*Fraxinus sp.*) including green, white, black and blue ash. Thus, all native ash trees are susceptible. Adults are roughly 3/8 to 5/8 inch long, with metallic green wing covers and a coppery red or purple abdomen and they leave distinctive D-shaped exit holes in the outer bark of the branches and the trunk of ash trees. Signs of infection include tree canopy dieback, yellowing, and browning of leaves. Most trees die within 2 to 4 years of becoming infested. The emerald ash borer is responsible for the destruction of over 50 million ash trees in the U.S. since its discovery. The City of Philadelphia has already completed a management plan specifically focused on the EAB as an emerging threat, ***City of Philadelphia Emerald Ash Borer Management Plan***. Approximately 6% of the forested lands in the city are ash trees.

Ecological degradation continued as species composition changed, new diseases and pests appeared, and large native predators became rare or extinct. Soil degradation led to a number of issues including a decrease in nutrient richness, a lack of moisture to host historic microbial populations, and a decrease in the diversity of native wildflowers, mosses and ferns (Contosta and Franklin 2010, 524).

Threats and stressors of today are not all that different from those found historically, but the forests' degraded condition leaves them more susceptible to these stressors. Historic stressors included chestnut blight, other insects and diseases (e.g., Dutch elm disease, butternut canker, and anthracnose), industry, clearing of old growth forests, change in stream morphology, roads and trails, development threats, trampling, lack of funding and others. Contemporary stressors include deer browse and rubbing; a broad array of invasive plant species; insects and diseases (including the emergent issue of emerald ash borer); a lack of old growth forest cover, roots and associated soils; new rogue trails, and an overall lack of funding.

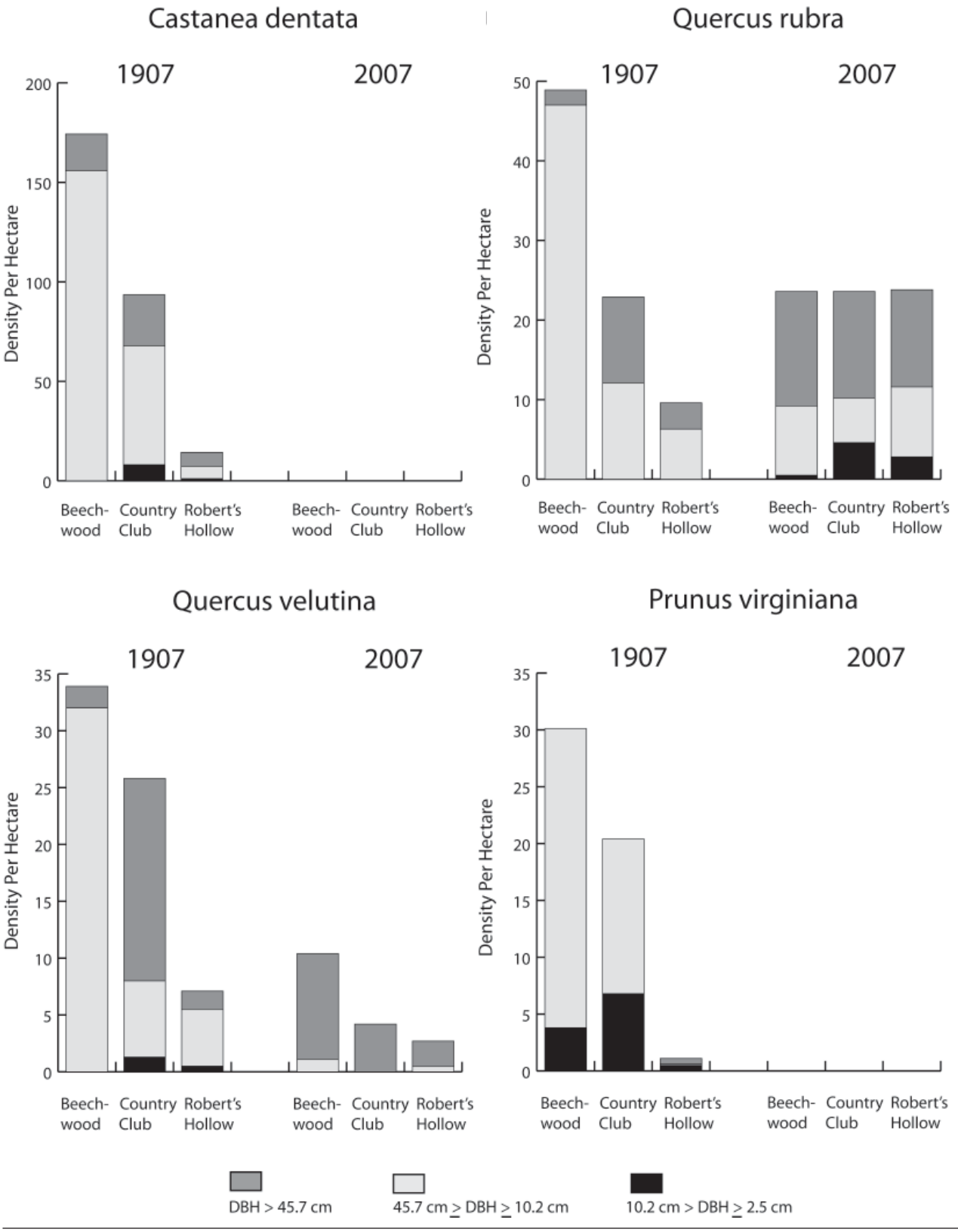
2.1.2 Old Growth Forest Dynamics in Philadelphia

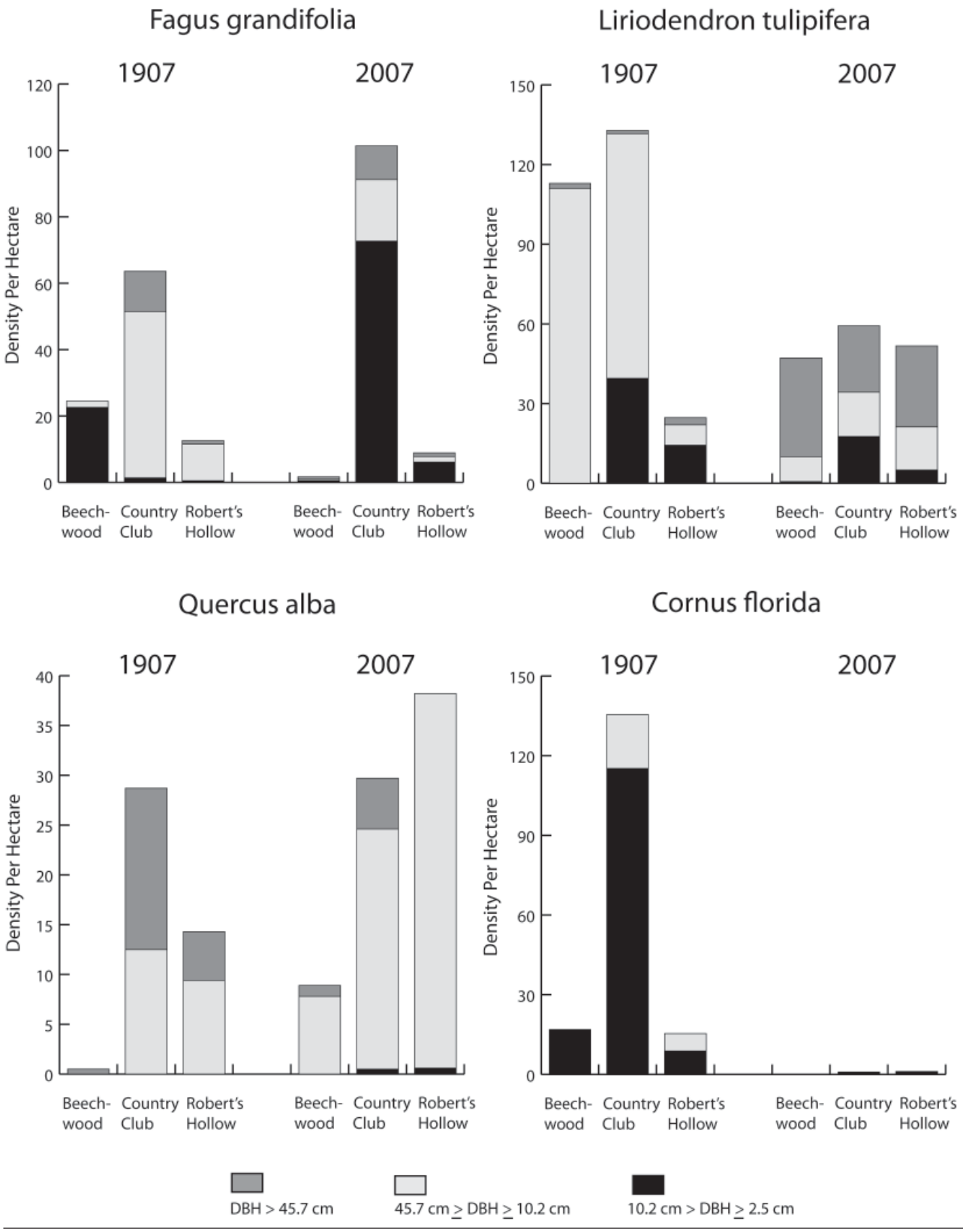
Robert Loeb, Associate Professor of Biology and Forestry at the Pennsylvania State University, has done extensive research on the forest dynamics and historical ecology of old growth forest patches in Fairmount Park. He categorizes old growth forests as street, landscaped and remnant (both those with a history of limited tree harvesting and those that have been reestablished on agricultural fields). Loeb explains that the primary goals of research, restoration and management of old growth forests is historic continuity. In Fairmount Park he focused his research on landscaped old growth patches (those that had once been part of large estates and planted as such). He found that the lands had been primarily planted with natives prior to 1800. He notes that his research indicates that by 1970 Fairmount Park had lost half of the species present in 1880.

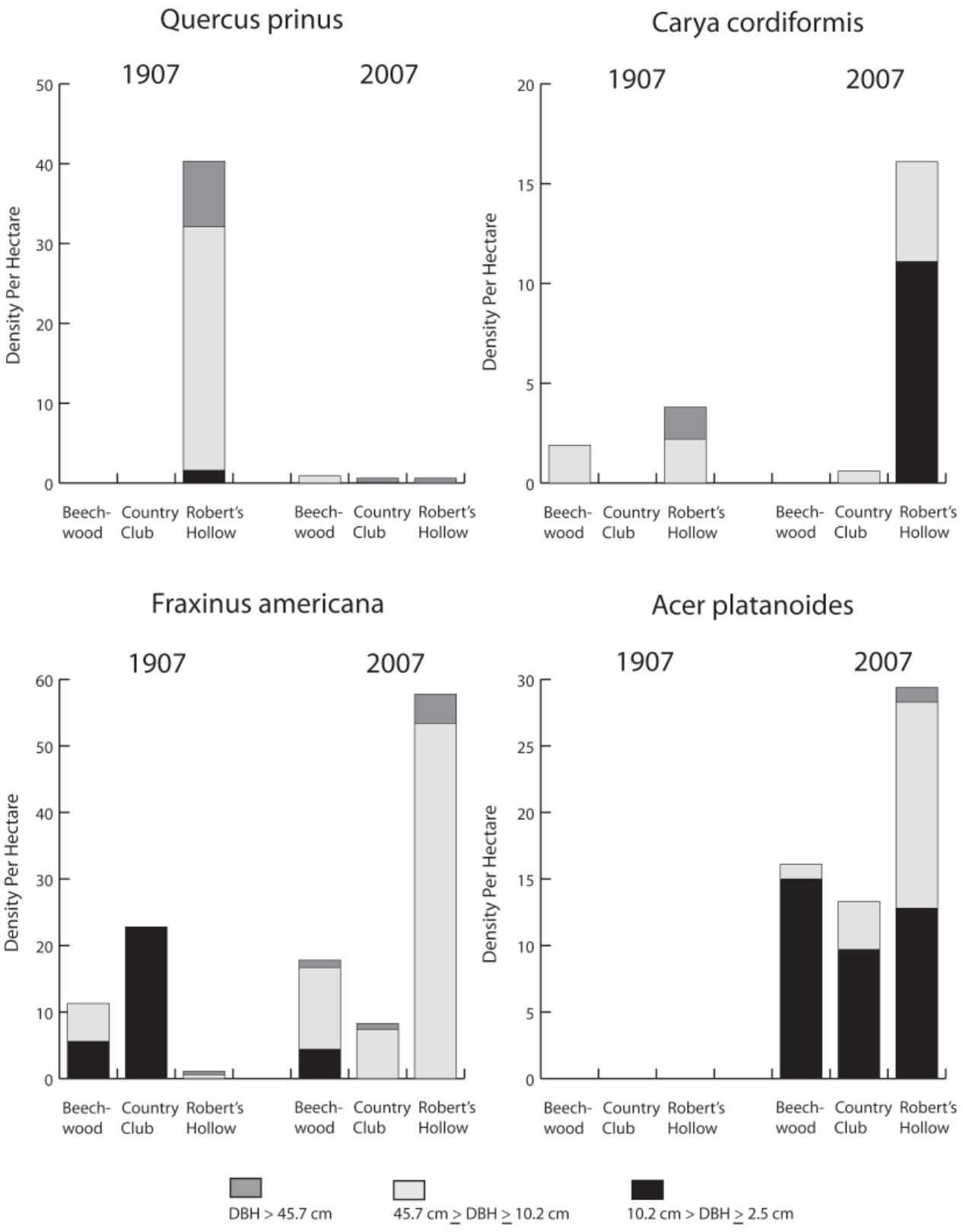
The primary issues that led to forest degradation were insect and disease infestations, fires from sparks of the rail engines along West Park, and pedestrian and horse trampling. "Fires burned the humus layer and killed seedlings and saplings; the public trampled the seedlings and saplings, and sprout growth was short-lived" (Loeb 2011, 34). **See figures on page II–4 to 6.** The following species became more successful after the chestnut blight (as the canopy opened up): red maple, Norway maple, tulip poplar, Hercules club, sweet birch, hornbeam, bitternut hickory, shagbark hickory, white ash, sweet gum, umbrella tree, black gum, wild black cherry, staghorn sumac, sassafras and black locust (Loeb 2011, 49). Records of presettlement forest vegetation indicate oak species were 2/3 of the forest canopy with the chestnut being the second dominant species after oaks (white, black and northern red). Five major changes, evidence of which is found in the paleopalynology record, that affected forest dynamics in the oak-chestnut region were the release of lands from agriculture, loss of chestnut, decimation of hickory, urban expansion of rural forest development, and urban tree plantings (Loeb 2011, 47). In the landscaped forests of the old estates the loss of chestnut, flowering dogwood, and chokecherry permitted the American beech, black gum, northern red oak, Norway maples, red maple, sassafras, tulip tree and white oak to establish. Beeches in particular seemed to be successful in areas where trampling was common, through root sprouting. Loeb highlights the importance of restoration that includes the following elements: adaptive management; partnerships between public and private landowners, schools and community members; education and communication about forest ecology; restoration plantings; and restricted access (from both deer and humans) (Loeb 2011, 55).

Loeb explains that restoration of old growth forests face a myriad of challenges. Invasive species removal and native plant replacement help to address the threats to canopy, sub-canopy and understory layers, but there is also a need for community partnerships and adaptive management techniques. Communications, changing perceptions, and cultivating community ownership are key to successful restoration. "For

remnant old growth urban forests with little or no spontaneous regeneration because of human trampling and deer browsing, a model process for implementing a raised pathway and fenced forest demonstration project is given to enable the survival of the seedling and sapling populations that are essential for restoration of historical continuity" (Loeb 2011, 69).







2.1.3 Research and Studies Conducted in the Park (2001-2011)
Many of the efforts conducted within the last twelve years provide important insights into Philadelphia's woodland health and function, both in terms of the overall trajectory of restoration efforts and the ecological conditions found in the Parks. The studies also stress the important value that the forest provides within the urban park landscape, and the overall needs that have been identified through thorough examination. Several of these studies were reviewed in order to inform this management framework **(Table 1)**. Abstracted summaries of these studies are included in **Appendix A.**

Table 1. Studies reviewed (2001 – 2011) for framework development

YEAR	NAME OF STUDY	AUTHOR
2001	Natural Lands Restoration Master Plan	Fairmount Park Commission
2002	Natural Lands Restoration & Environmental Education Program. Ecological restoration Manual for Natural Lands of Fairmount Parks.	Munro, John W.
2005	Value of Trees Statistics Sheet. Urban and Community Forestry Appreciation Tool Kit.	USDA Forest Service
2007	Assessing urban forest effects and values, Philadelphia's urban forest.	Nowak et al.
2008	How much value does the City of Philadelphia Receive from its Park and Recreation System.	Trust for Public Land
2008	A Natural Heritage Inventory of Philadelphia County Pennsylvania.	Western Pennsylvania Conservancy
2008	Stewardship Handbook for Natural Lands in Southeastern Pennsylvania	Steckel, David B.; Harper, Holly M.
2009	Connections: The Regional Plan for a Sustainable Future: The Long-range plan for the greater Philadelphia region.	Delaware Valley Regional Planning Commission
2009	Philadelphia Urban Conservation Treaty for Migratory Birds	U.S. Fish and Wildlife Service
2010	Natural Areas Stewardship Plan and Trails Recommendations : Manatawna Farm and East 33 Properties	Natural Lands Trust
2010	Green 2015	Penn Praxis
2010	Forest restoration in Philadelphia's Fairmount Park	Monheim et al.
2010	GreenPlan Philadelphia: Our guide to achieving vibrant and sustainable urban places	Wallace Roberts Todd
2010	A Report on the City of Philadelphia's Existing and Possible Tree Canopy	Jarlath O'Neil-Dunne
2010	Diversity gained, diversity lost: long-term changes in woody plants in Central Park , NYC and Fairmount Park, Philadelphia	Robert Loeb
2011	Benefits of Trees and Urban Forests: A Research List. Alliance for Community Trees	AC Trees

A deer in the park

Dennis Mora

Tree planting

2.1.4 Deer Control (1999-2012, ongoing)

Problems identified with intense deer browse include impacts to understory seedlings and saplings in the regenerating forest, severe reduction of native herbaceous plant cover, and exotic seeds dispersed through deer scat. Preferential feeding on native plant species encourages proliferation of exotic invasive plants that take advantage of open ground and understory conditions. In the year 2000 the recommended deer density for the Wissahickon Valley and Pennypack Park was 8-10 per sq mile, while the actual densities were 87 per sq mile and 129 per sq mile (park wide) respectively. Since deer culling began in the two parks, 2,162 deer have been removed (1999-2012). Additional deer have been removed from both Cobbs Creek Park and West Fairmount Park. Although these efforts have been very beneficial, significant deer impacts continue to persist.

2.1.5 Restoration Work in Fairmount Park Natural Areas (1998-2012)

In 1996, the FPC was awarded a $26.6 million grant from the William Penn Foundation to: 1) restore park natural areas in the seven watershed parks, totaling 5,600 acres; and 2) build or enhance environmental education centers to both interpret the natural systems in the Park system and build a larger constituency to help with the Park's protection. To administer this grant the FPC created the Natural Lands Restoration & Environmental Education Program (NLREEP). The work of NLREEP focused on restoring the natural areas of the park and included the following:

- Hired the Academy of Natural Sciences of Philadelphia to develop Natural Lands Restoration Master Plans for the seven largest parks in the system. Field work and other planning was done from summer 1997 to spring 1999, and the plans were published in 1999-2002. (**Summarized in Appendix A**)
- Hired an ecological consultant (Biohabitats, Inc.) to develop site-specific project plans for high-priority projects throughout Cobbs Creek Park and Tacony Creek Park.
- Hired contractors to implement work on sites with project plans
- Retained a landscape architecture firm (Andropogon Associates) to develop trail master plans for five of the largest parks in the system
- Retained a consultant (Natural Lands Trust) to conduct a study of lands adjoining park land that would be appropriate for acquisition by FPC
- NLREEP staff (Volunteer Coordinators) engaged the help of thousands of volunteers to begin restoring long-neglected park forests, meadows and streams.

The grant from William Penn allowed FPC to comprehensively evaluate and document conditions in Park natural areas for the first time and enabled FPC to plan and begin to implement projects specifically aimed at restoring park natural areas.
The NLREEP grant ended in 2004, but fortunately most NLREEP staff members were retained by Fairmount Park Commission through significant funding provided by the Philadelphia Water Department's Office of Watersheds. Since that time, staff has continued to work with consultants, contractors and others to implement restoration work throughout the Parks. Many sites identified in the Academy's master plan as high priority for restoration have been restored in some way. Over the years, many additional sites have emerged as priorities for restoration work. The current parkland management framework reflects the need to take a fresh look at the overall conditions and proposed actions within park natural areas for the next decade.

From the time of NLREEP until the present, a major body of work has been accomplished in park natural areas. The following summarizes some of the accomplishments in this period:

- Herbicided and/or mechanically removed invasive plants on countless sites covering hundreds of acres
- Planted tens of thousands of native trees, shrubs and herbaceous plants, particularly in park forests
- Created 150 acres of native meadows on previously degraded sites or turf areas
- Restored 1,040 feet of stream channel on 6 sites

- Repaired and stabilized 9 major erosion gullies totaling 4,300 linear feet
- Created 4 palustrine wetlands
- Constructed agricultural runoff control systems at 5 sites
- Removed 2 lowhead dams
- Conducted 2 large scale trash removal projects
- Installed 48 gates and 17,500 feet of guide rail to protect park natural areas
- Installed 10,000 feet of 8-foot steel deer exclusion fencing
- Conducted ongoing maintenance of restored sites
- Developed the infrastructure and knowledge to propagate native plants for use in restoration projects (redeveloped Greenland Nursery)
- Developed dozens of restoration and planting plans
- Wrote many bid documents, RFPs and grant applications
- Managed over $800,000 in planning and design work
- Raised grant funding and implemented $8.9 million in contract restoration work on 380 sites covering over 600 acres
- Volunteers, spending tens of thousands of hours, removed invasive plants, installed and maintained new plants, cut vines, removed trash, repaired trails and completed a myriad of other tasks.

Typical projects include access control, invasive plant control, deer control, forest restoration, meadow creation, gully repair, stream restoration, dam removal, wetland creation, and agricultural runoff control.

Greenland Nursery

URBAN FOREST, WATER QUALITY AND STORMWATER MANAGEMENT

The urban forest contributes many benefits to watershed health, water and soil protection. Research has shown that the urban forest plays a pivotal role in treating stormwater, providing water quality improvement and quantity management. Tree canopy helps catch precipitation before it reaches the ground. Some of the water gently drips to the ground, while some evaporates. Research indicates that 100 mature tree crowns intercept about 100,000 gallons of rainfall per year (USDA Forest Service 2005). Roots have been proven to provide for enhanced infiltration of rainwater (Day and Dickinson 2008). The presence of leaf litter on forest floors supports soil conditions that promote infiltration, helping to replenish groundwater and filter stormwater runoff. Floodplain trees along urban streams help to stabilize soils and provide further filtration of runoff before it enters the streams.

2.1.6 Philadelphia Water Department Projects

In addition to work done by Philadelphia Parks and Recreation (PP&R), the Philadelphia Water Department (PWD) has been working on a significant number of large projects in park natural areas, particularly stream restoration and wetland creation. Though these projects are associated with PWD objectives (e.g., stormwater management, sediment load reduction, and infrastructure protection), they are conducted in such a way as to substantially improve conditions in the natural areas where they are implemented. In the coming years, PWD has far-reaching plans including:

- Design and construct repairs and enhancements throughout the entire Cobbs Creek corridor within Philadelphia
- Design and construct repairs and enhancements throughout the entire Tacony Creek corridor within Philadelphia
- Design and construct dozens of stormwater infiltration features (e.g., rain gardens) in the Parks that lie within combined sewage overflow (CSO) areas as part of the Green city Clean Water program.
- Design and construct outfall retrofits throughout the city

2.1.7 Park Friends Groups

Several Park Friends groups regularly conduct natural lands restoration projects, primarily with volunteers, but some with contractors. The Friends of the Wissahickon (FOW), Wissahickon Restoration Volunteers, Friends of Pennypack Park, Morris Park Restoration Volunteers and Friends of Manayunk Canal all implement projects regularly in park natural areas. Over the

Interfaith group planting in Cobbs Creek

years, these groups have collectively restored dozens of sites and created, maintained or closed miles of trails. See a more comprehensive list of Friends Groups in **Appendix E**.

2.2. Assessment and Analysis

2.2.1 Regional Landscape Ecology

General Principles of Landscape Ecology

Native species must have certain basic habitat needs met in order to persist within urban development. In landscape ecology, areas of habitat, which are interspersed with areas of development or disturbance, are called habitat patches or hubs. Patches come in an infinite number of sizes and shapes and can have varying degrees of connectivity with each other. The connections between patches are called habitat corridors or linkages. Many factors affect the quality of habitat patches and corridors. It has been shown through scientific studies that the larger the patches (Robbins et al. 1989, Schiller and Horn 1997) and wider the corridors (Mason et al. 2006, Schiller and Horn 1997), the higher quality the habitat is. Additionally, it has been conclusively shown that larger patches generally support a greater number of species than smaller patches (Laurance et al. 2002, Steffan-Dewenter 2003, Fahrig 2003). It follows that if more large patches are retained, the higher the probability of preserving more native species.

Neotropical migratory birds comprise approximately 50% of the total number of bird species in North America (Franzreb and Phillips 1996). They have been used as habitat indicator species for a broad range of area-sensitive faunal forest species, particularly those that require forest interior habitat. Their use

A healthy stand in Cobbs Creek Park

of the entire range of forest habitat types and vertical vegetation levels and the relative ease with which they can be identified and counted has also contributed to the neotropical migratory birds use as habitat indicator species. Mason et al. (2006) explained that some interior forest species of birds were found primarily in greenways (trails along forest corridors) with buffers wider than 100 meters, while other interior species, including some ground-nesters, were recorded in greenways wider than 300 meters. Freemark and Collins (1992) found that very few forest interior neotropical migrants were found in forested tracts less than 25 acres. Robbins et al. (1989) reported the median minimum size of forest habitat to be 25 acres for isolated forests; however, they stated that the results of their study indicated that a smaller area could possibly support a limited subset of species if there is additional forest area in patches nearby (< 2 km or 1.2 miles away). If the shape of the patch is elongated or narrow, then the amount of interior high quality habitat is diminished as the inner edges of the habitat edge approach and converge on each other, squeezing out interior habitat. The more urbanized the development is along an edge, generally the more detrimental the disturbance. Urbanized or degraded edges provide an opportunity for edge predators (e.g., cowbirds) and invasive plant species, which thrive in disturbed conditions. A more complex

transition of forest edge to other native habitats such as younger successional forest, shrublands or meadows provides better ecosystem health for a greater diversity of species and habitat use. The presence of streams and/or wetlands in patches or corridors enhances their ecological value in that these landscape features provide habitat diversity. In addition, forested riparian buffers often provide corridors for safe movement of wildlife between habitat patches. Riparian buffers also provide important societal services by protecting water supply and surface and groundwater infiltration and purification.

Philadelphia's Place Within Regional Ecological Systems

The City of Philadelphia exists within an important regional ecological matrix of interconnected forest, open space and waterways that provide an important foundation for habitat patches and corridors for various species. The city lies along the Delaware River, a major river corridor along the Atlantic Coast of the US, providing an important stopover for many migratory bird species along the Atlantic Migratory Flyway. Public open spaces and waterways in the region provide important opportunities for habitat patches and corridors for all manner of wildlife species, including migratory birds. Philadelphia's parkland, and its associated forest and other natural resource areas, has the potential to play an important role in the resilience of the region's ecological systems. The parks have the potential to provide even stronger habitat connections for various species that both reside in this region or are just passing through on much longer migratory journeys.

FOREST CORE HABITAT

Forest interior habitat (core forest) is of critical importance for species sensitive to forest fragmentation and edge effects. For forest wildlife, core forest is the most desirable and stable habitat because it provides the food and cover needed to survive (Moyer 2003). Core forest has become more scarce in the eastern US where development pressures have continued to grow. Forest core is that forest area which is at least 300 feet from a forest edge. Depending on its size it can support a wide range of native plants and animals, and can shelter and support ecological processes sensitive to edge effects, including light and noise pollution from roads and development, invasive species dispersal, and microclimate alterations of wind, heat and other variables.

http://www.mass.gov/dfwele/dfw/nhesp/land_protection/biomap/pdf/forest_core.pdf

Protecting habitat for species like the red-bellied woodpecker

By examining forest areas in the region, and then core forest patches within those, one begins to see the habitat opportunities for more sensitive wildlife. The region has many locations that have larger core forest but, not surprisingly, the closer one moves toward the city center, the fewer core forest areas exist. Core interior forest and riparian corridors found within the Parks and Recreation properties provide some of the only core forest in the city, and thus are important for preservation, conservation and enhancement. Re-establishing more connected, less fragmented riparian corridors and larger continuous forest patches can provide needed habitat improvements (**Appendix B, Figure B–1**).

A gap analysis identifies isolated forest patches within Philadelphia associated with the parklands, where further enhancement and expansion of forest patches can improve habitat quality and opportunities for enhancing biodiversity including sensitive species (**Appendix B, Figure B–2**).

2.2.2 Site Observations

In addition to the contextual information gleaned from the work noted above, Biohabitats also conducted a limited-duration site visit to selected park sites. This visit focused specifically on forest parkland management and occurred on December 5-6, 2012. Tom Witmer and Tom Dougherty, PP&R, accompanied the team to selected sites, in a combination of driving tours through various sections of the Philadelphia park system, as well as walking tours of selected parks and sites. The purpose of this visit was to further the contextual understanding of the forest resource management needs, challenges, and opportunities within the Parks. Mr. Witmer and Mr. Dougherty provided valuable insight into the restoration and management efforts that the city has undertaken in the Parks over the past decade and a half. The sites visited included: Fairmount West (Greenland Nursery and the Recycling Center); Fairmount Park East; Tacony Creek

Woodland with healthy native understory

Park (Adams Avenue to Roosevelt Blvd.; new recreation path south of Roosevelt Blvd.); Pennypack Park (Verree Meadow, Fox Chase Farm, recreation path from Algon Ave. to Welsh Rd., Rhawn Street dam removal, Pennypack on the Delaware); and Fernhill Parks.

The information obtained during the two-day visit included notes from observations and discussions related to existing conditions, forest impacts and stressors, management and restoration project efforts completed, needs and opportunities, along with a set of digital photographs. More detailed notes of the field visit are included in **Appendix C**. A partial list of invasive species found in the parks is included in **Appendix D**.

2.2.3 USDA Forest Service Urban Forest Assessment - UFORE and i-Tree Studies

Assessing Urban Forests Effects and Values, Philadelphia's Urban Forests 2007

In order to determine the vegetation structure, function and value of the urban forest in Philadelphia the USDA Forest Service conducted a forest vegetation assessment during the summer of 1996. The subsequent report summarizing the study and results was published in 2007. The report summarizes results and values for:

- Forest structure
- Potential risk to forest from insects and disease
- Air pollution removal
- Carbon storage
- Annual carbon removal (sequestration)
- Changes in building energy use

Field plots and collected data were sampled and analyzed using the Urban Forest Effects Model (UFORE). To assess the city's urban forests, data from 210 field plots located throughout the city were analyzed using UFORE. The field plots were randomly located in different land use types in Philadelphia. The land uses were divided into smaller zones including: Commercial/ Industrial, Institutional, Multi-family Residential, Park, Single Family Residential, Transportation, Vacant and Wooded. The PP&R parklands are included in the Park land use assessment zones. The UFORE analysis is designed to use standardized field data from randomly located plots and local hourly air pollution and meteorological data to quantify urban forest structure and its effects including:

- Urban forest structure (e.g., species composition, tree density, tree health, leaf area, leaf and tree biomass, species diversity, etc.)
- Amount of pollution removed hourly by the urban forest, and the associated air quality improvement (%) throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power plants
- Compensatory value of the forest, as well as the value of air pollution removal and carbon storage and sequestration
- Potential impact of infestations by Asian long-horned beetle, emerald ash borer, gypsy moth and Dutch elm disease.

The report provided results and descriptions of many of the details of Philadelphia's forest composition and conditions as summarized in the findings, including:

- Tree cover accounted for approximately 15.7% of the city land area
- There were an estimated 2.1 million trees in the city
- The most common species was the native black cherry, second most common was crabapple, and the third most common was the non-native invasive tree-of-Heaven.
- Overall, approximately 57% of the tree species were native to Pennsylvania
- Most benefits area was derived by the amount of leaf area of each tree, and the species providing the greatest leaf area per tree were London plane, American beech, and tulip tree
- At the time of the study, Philadelphia had lower tree cover and trees per acre than comparable cities.
- The emerald ash borer has the potential to affect approximately 5.9% of Philadelphia's tree population, at a replacement value of $68 million.

The report also provided and summarized many of the measurable benefits and services provided by Philadelphia's urban forests, including the following measures:

- Philadelphia's urban forests removed approximately 802 tons of pollutants each year, with a societal value of $3.9 million/year.

- The gross carbon sequestration by Philadelphia trees was about 16,100 tons of carbon per year with an associate value of $297,000.
- Trees in Philadelphia were estimated to store 530,000 tons of carbon with an associated value of $9.8 million.
- The interaction between trees and buildings in Philadelphia was estimated to save $1.18 million in heating and cooling energy costs annually (2002 dollars).
- The structural value (the cost of having to replace a tree) of urban forests in Philadelphia was estimated to be about $1.8 billion.

Forest Service's Philadelphia Field Station - i-Tree Eco Data Collection Study 2013

The USDA Forest Service Philadelphia Field Station is performing a forest condition and health assessment under the direction of Sarah Low and Michael Leff and under the leadership of Dr. Lara Roman. Field Station interns collected data from 200 permanent plots throughout Philadelphia during the summer of 2012 to characterize and assess conditions of the urban forest. This effort included 75 plot sites within the City parks' natural areas in order to assess current forest conditions, and to allow for comparison to the overall City forest areas. This assessment is being conducted using the Forest Service's i-Tree Eco Data Collection Protocol, which is based on the UFORE assessment parameters with other added features of the protocol and collection program.

Some of the specific parameters that the study will collect data for and provide assessment results include the following:

- Species composition
- Percent tree canopy cover
- Number of trees
- Trees per acre
- Diameter class distribution
- Average height
- Percent leaf area
- Species percent of population
- Percent shrub cover
- Average shrub height
- Percent ground cover types
- Percent shrub mass and canopy missing
- Crown base and width
- Percent crown dieback
- Percent impervious beneath canopy
- Crown light exposure

Other assessment results from the study will include the following indicators, including a few added (non i-Tree) parameters, including:

- Distance and direction (degrees) to space conditioned building
- Plantable space

Native red-bellied turtle

- Insect and disease impacts
- Vine presence
- Deer browse impacts
- Earthworm presence

The i-Tree study researchers post-process the data, perform analyses, quality check the data, then finalize and report the results. As of the writing of this framework the i-Tree study results are still pending and are being prepared for submittal to the City. Once the results are completed, PP&R will receive the report and will be integrating the valuable results of the study into their parkland forest management measures as they also implement the recommendations in this framework document. The Forest Service i-Tree study is proposed to be repeated every five years and will be a valuable tool for policy and management decision-making as well as providing part of the monitoring results to inform adaptive management.

2.2.4 Spatial Analysis Process

GIS Database Structure

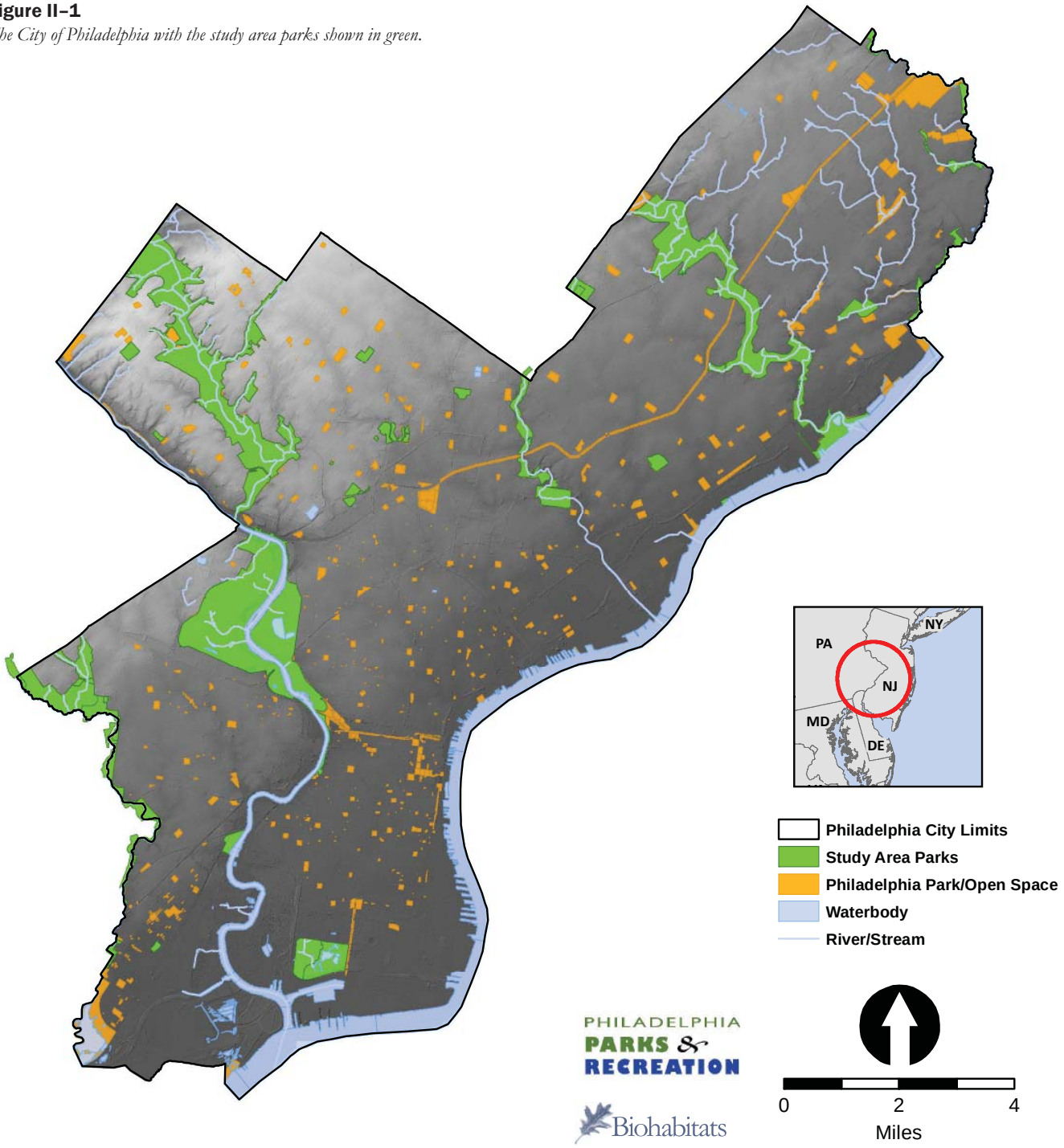
Using spatial data provided by PP&R, as well as additional data gathered from freely available online services, several geospatial analyses maps were prepared. Geographic Information System (GIS) files obtained for mapping include such features as planimetrics (roads and other infrastructure), topography, streams and waterways, wetlands, landcover, as well as data sets associated with previous natural heritage and restoration studies, etc. This existing data has been analyzed in order to prepare mapping that depicts a variety of natural resource attributes and conditions in order to inform the development of the woodland management framework plan.

A Context Map

Overview **Figure II–1** presents a subset of the PP&R Parks data layer, limited to the parks in the scope of this study, shown alongside public open space within the Philadelphia city limits and the significant waterways, including the stream valley parks. This figure also begins to tell the story of the relationships between the open space patches along the stream valley parks in certain locations, and the lack thereof in others. The Parks data is overlaid on a 5-foot Digital Elevation Map (DEM), which provides further context of the overall topography in the city and the relationship to the parklands.

Figure II–1

The City of Philadelphia with the study area parks shown in green.



Regional Landscape Ecology Mapping

A geometric center of the Philadelphia city limits shapefile provided by PP&R was calculated and from that point, a 50-mile radius was created around the city in order to examine the regional landscape ecology and potential relationships that are seen among open space, parkland, waterways of various scales, forest and forest interior.

Appendix B, Figure B–1 presents existing forest and core forest habitat within the 50-mile radius zone described above. Landcover data was extracted from the National Land Cover Dataset (NLCD) provided by the USGS. NLCD is a 30-m resolution raster dataset, and is of a suitable resolution for analysis at this scale. All forest cover types in the NLCD were reclassified to a generic 'forest' type. This provided the basic distribution of forest cover. In order to determine core forest habitat, the forest cover was buffered 100-m inward from the edge of each polygon, any patches of forest existing more than 100-m from the edge of a forest patch were classified as core forest habitat and sorted by size. All figures include water body and stream data extracted from the NHD Plus hydrologic dataset, obtained from EPA/USGS.

Forest Gaps Map

To identify isolated forest patches within Philadelphia, a gap analysis was conducted using the vector-based landcover dataset provided by PP&R. A minimum threshold of 1 acre was selected, and all forest patches 1 acre or greater were initially displayed. Upon examination of the data subset, it appeared that some patches of forest were neighborhood street trees, which were being captured as true forest patches. This was due to the forest land cover type in this dataset being identified via canopy extent. In order to remove non-forest tree patches from the data, the Natural Heritage Inventory (NHI) potential green space layer provided by PP&R was added to the model. All forest patches over one acre that intersected the NHI layer were retained, while all others were removed. Using ArcGIS the distance from each forest patch in the resulting dataset to its nearest neighboring patch was measured, and the results were sorted by distance. Additionally, the hydrological polygon and plotline data provided by PP&R was buffered outward 100ft to illustrate riparian zones around hydrologic features (streams and creeks). Wetland data is taken from the National Wetland Inventory (NWI) provided by USFWS. (**Appendix B, Figure B–2**)

Native red fox

Conservation/Restoration Opportunities Mapping

Forest conservation/restoration opportunities within the parks have been mapped based on a specific set of data layers chosen to best illustrate forest conservation and restoration value. Ten datasets were used in the creation of the conservation/restoration model. Each dataset was assigned a score, or a range of scores, and then the scores of all of the datasets were combined based upon where they overlapped spatially. The datasets and scores used in the model are as follows:

I. National Heritage Inventory Conservation Priority: 1 (Opportunistic or Enhancement), 2 (Near-term), 3 (Immediate)

II. National Heritage Inventory Potential Greenspace Priority: 1 (Low), 2 (Medium), 3 (High)

III. Natural Lands Restoration Master Plan Potential Stream Restoration Sites: 0 (Infeasible), 1 (Low), 2 (Medium), 3 (High)

IV. Natural Lands Restoration Master Plan Potential Vegetation Restoration Sites: 1 (Low), 2 (Medium), 3 (High)

V. Completed Restoration Sites: 2 (Forest Restoration Projects), 1 (All other restoration projects)

VI. Natural Lands Restoration Master Plan Vegetation classified as Forest: 1

VII. Open Space Landcover: 1

VIII. Forest Canopy Landover greater than 0.5 acres: 1

IX. Core Forest Habitat Patches: 1

X. 150 foot Riparian buffer around streams and rivers: 1

The combined results yielded a conservation/restoration matrix with values ranging from 1-15. These values were sorted into four groups representing High, Medium, Low, and Non-Priority conservation/restoration areas within each park. High scoring areas are those that have the most value according to the available data and should be prioritized for conservation and/or restoration. Those with medium values are often along the edges of the high value areas and show the greatest potential for restoration which would support improved function and overall ecological health. These maps are included on the following pages.

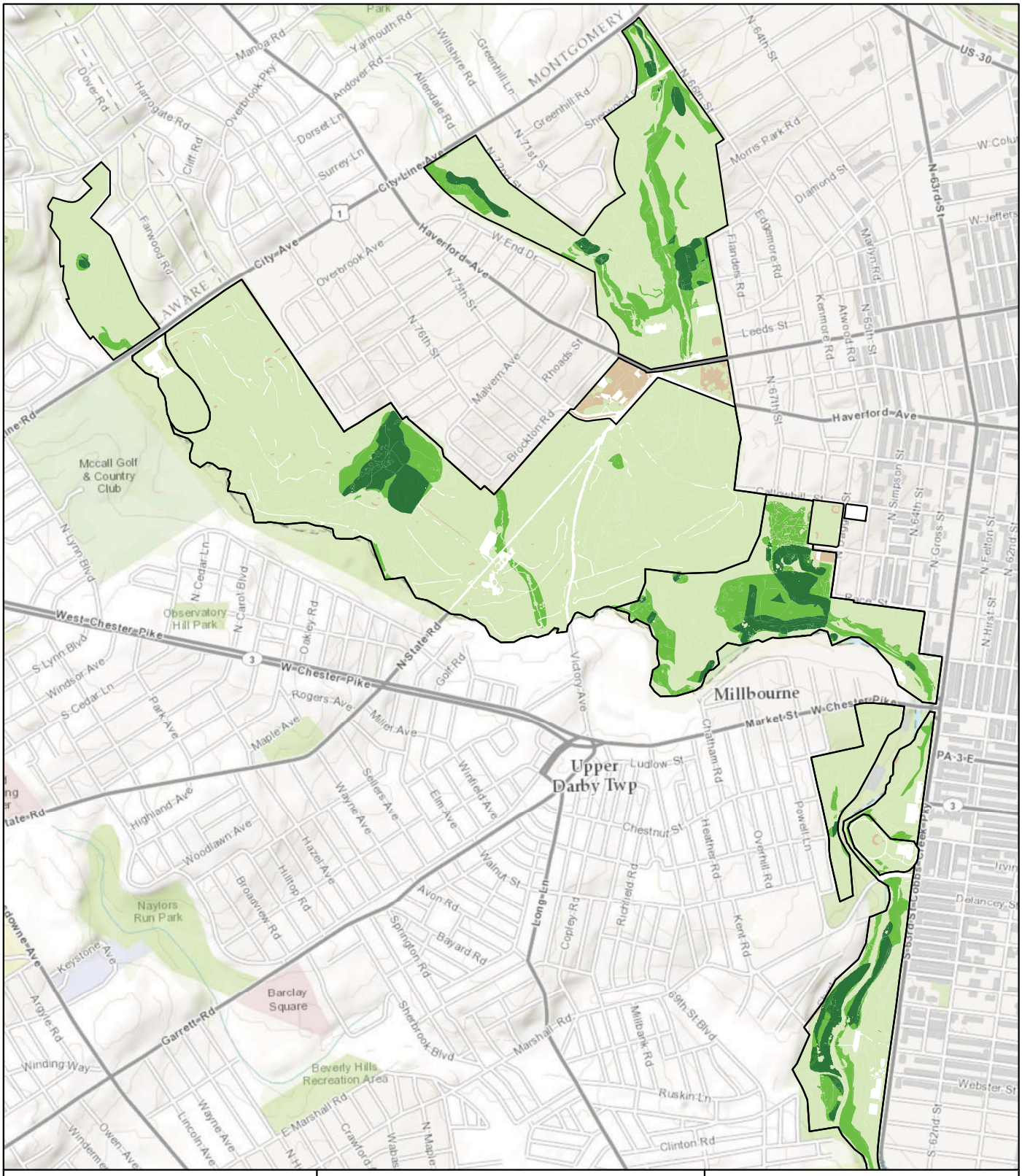
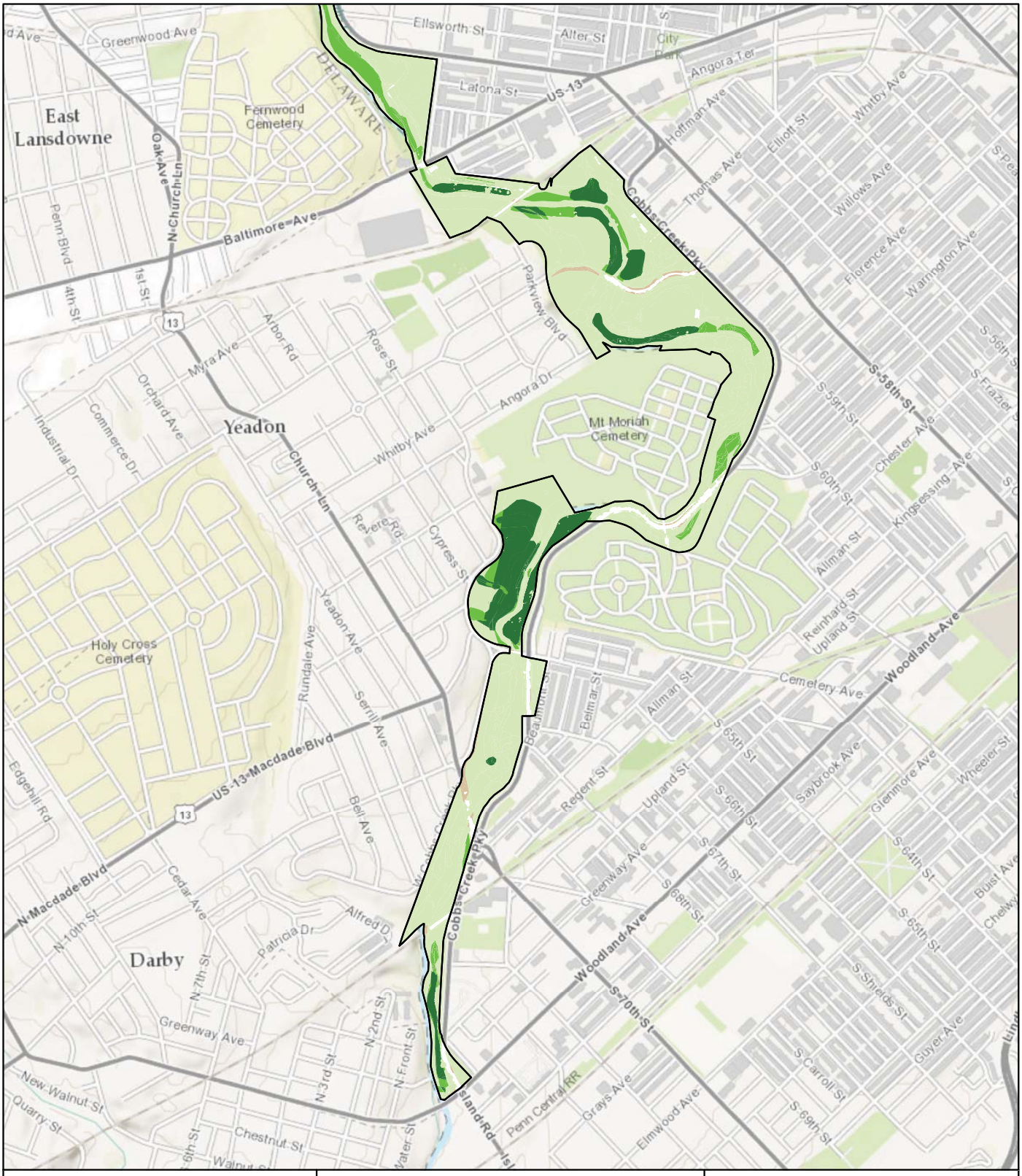


Figure II–2



Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–3

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–4

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–5

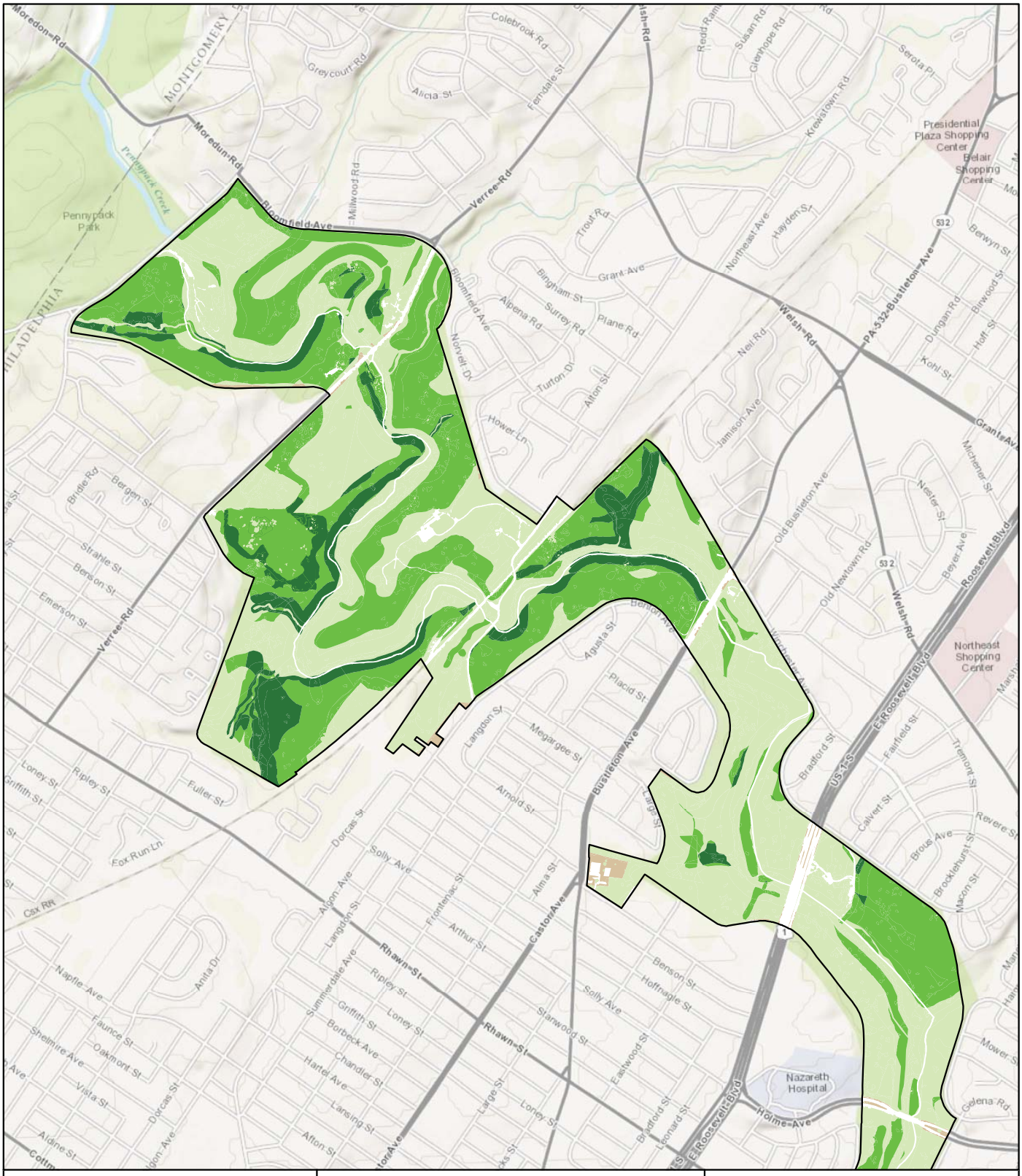


Figure II–6

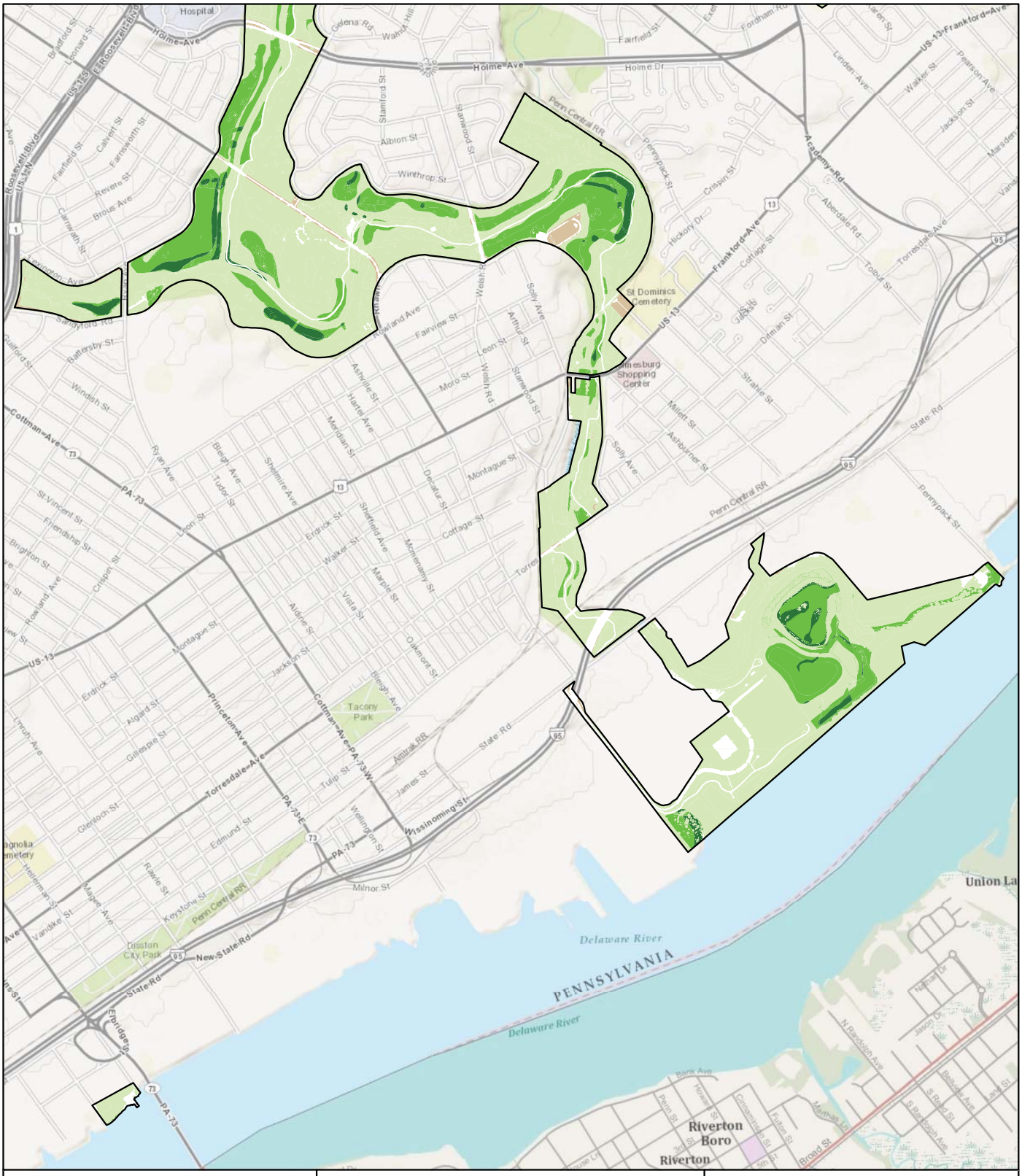

Conservation/Restoration Ranking
PENNYPACK SOUTH
PHILADELPHIA PARKS & RECREATION
Biohabitats
Non-Priority Conservation/Restoration Value
Low Conservation/Restoration Value
Medium Conservation/Restoration Value
High Conservation/Restoration Value
0
1,000
2,000
Feet
Delaware River
PENNSYLVANIA
Delaware River
Riverton Boro
Riverton
Tacony Park
Disston Cay Park
St Dominics Cemetery
Holme Ave
Frankford Ave
Academy Rd
Torresdale Ave
Princeton Ave
Cottman Ave
State Rd
New State Rd
Penn Central RR
Amtrak RR
Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–7

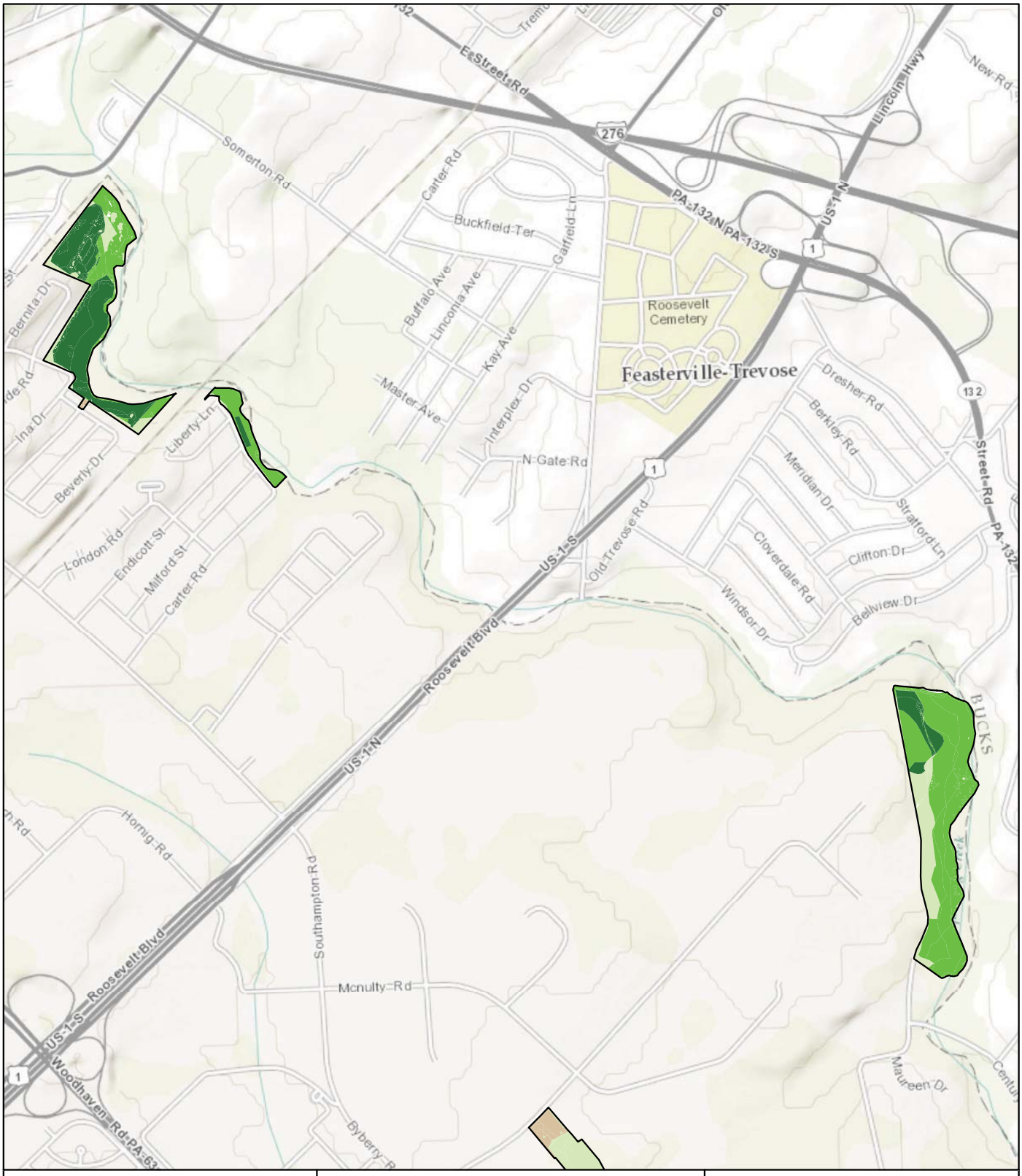


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Figure II–8

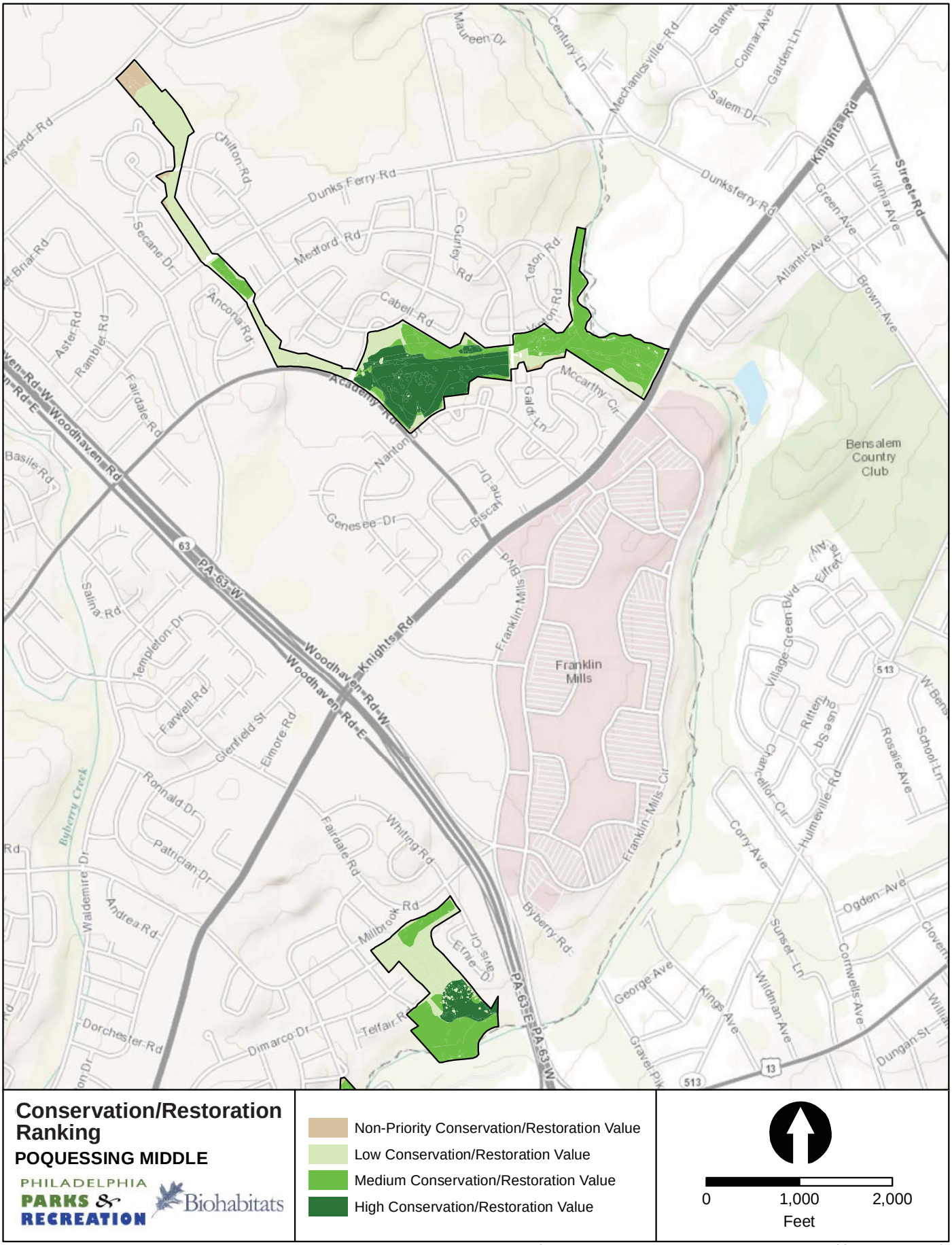
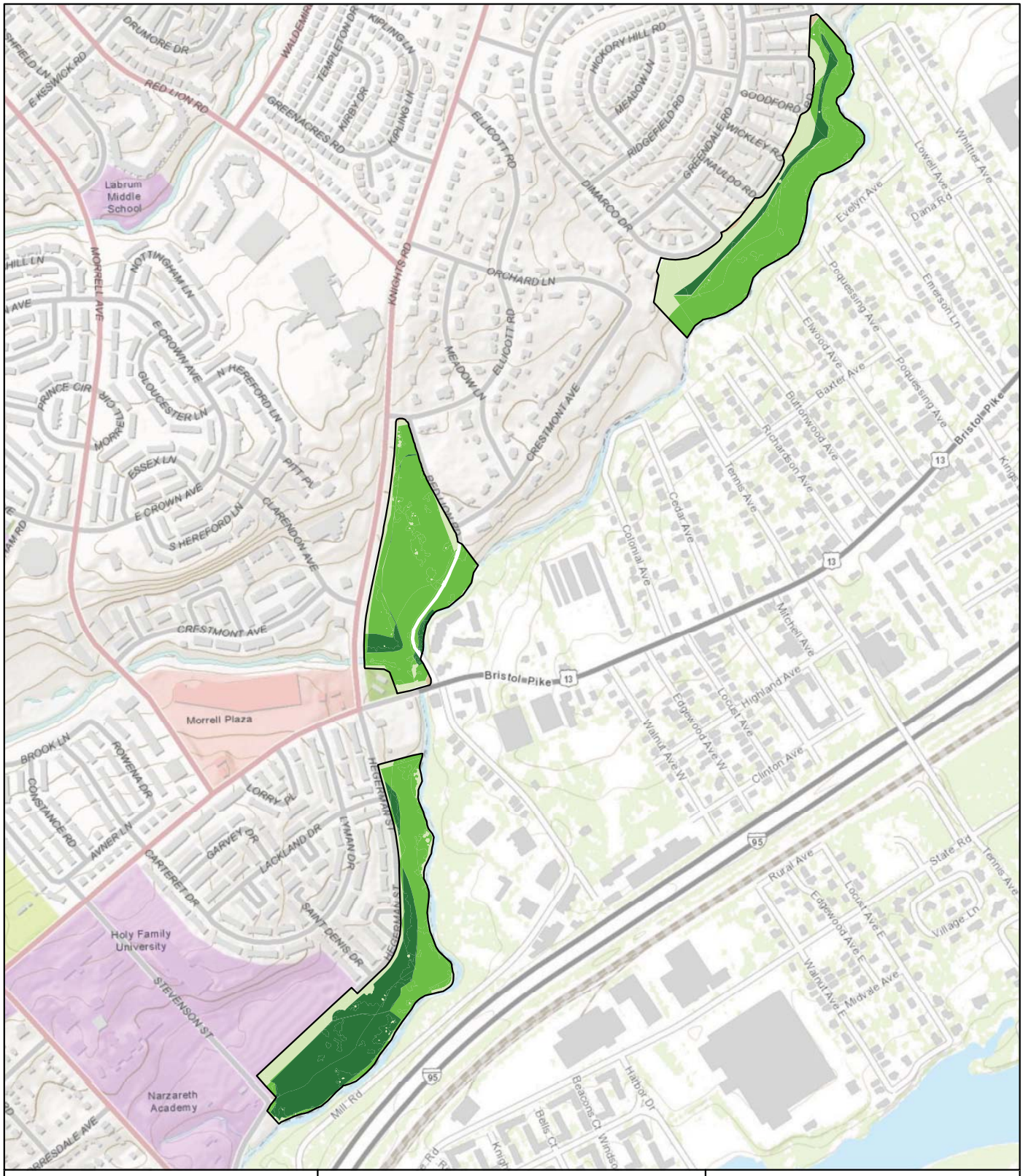

Conservation/Restoration Ranking
POQUESSING MIDDLE
PHILADELPHIA PARKS & RECREATION
Biohabitats
Non-Priority Conservation/Restoration Value
Low Conservation/Restoration Value
Medium Conservation/Restoration Value
High Conservation/Restoration Value
0
1,000
2,000
Feet
Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–9



Conservation/Restoration Ranking

POQUESSING SOUTH

PHILADELPHIA PARKS & RECREATION

Biohabitats

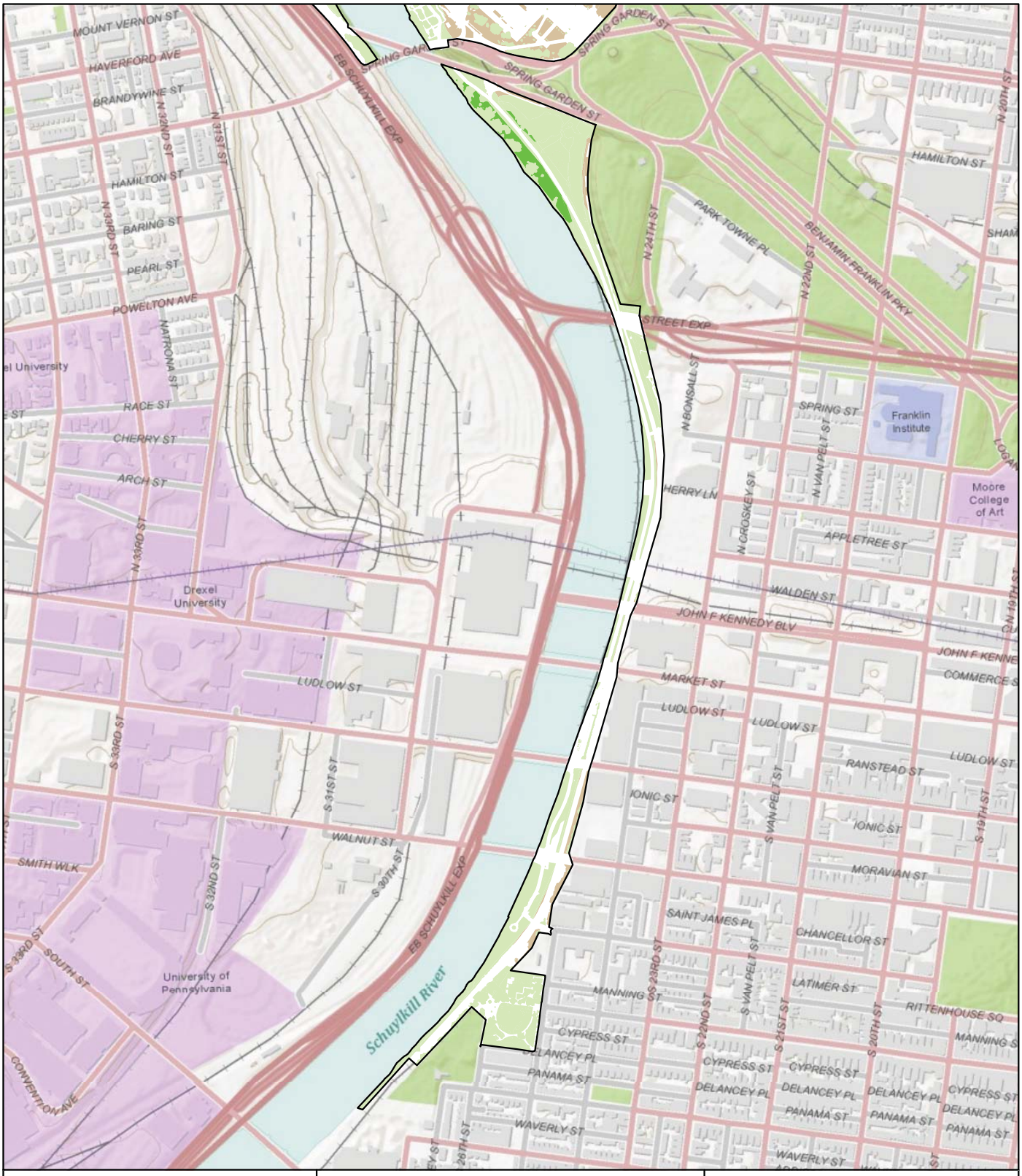
- Non-Priority Conservation/Restoration Value
- Low Conservation/Restoration Value
- Medium Conservation/Restoration Value
- High Conservation/Restoration Value

0 500 1,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–10



Conservation/Restoration Ranking

SCHUYKILL

PHILADELPHIA PARKS & RECREATION

Biohabitats

- Non-Priority Conservation/Restoration Value
- Low Conservation/Restoration Value
- Medium Conservation/Restoration Value
- High Conservation/Restoration Value

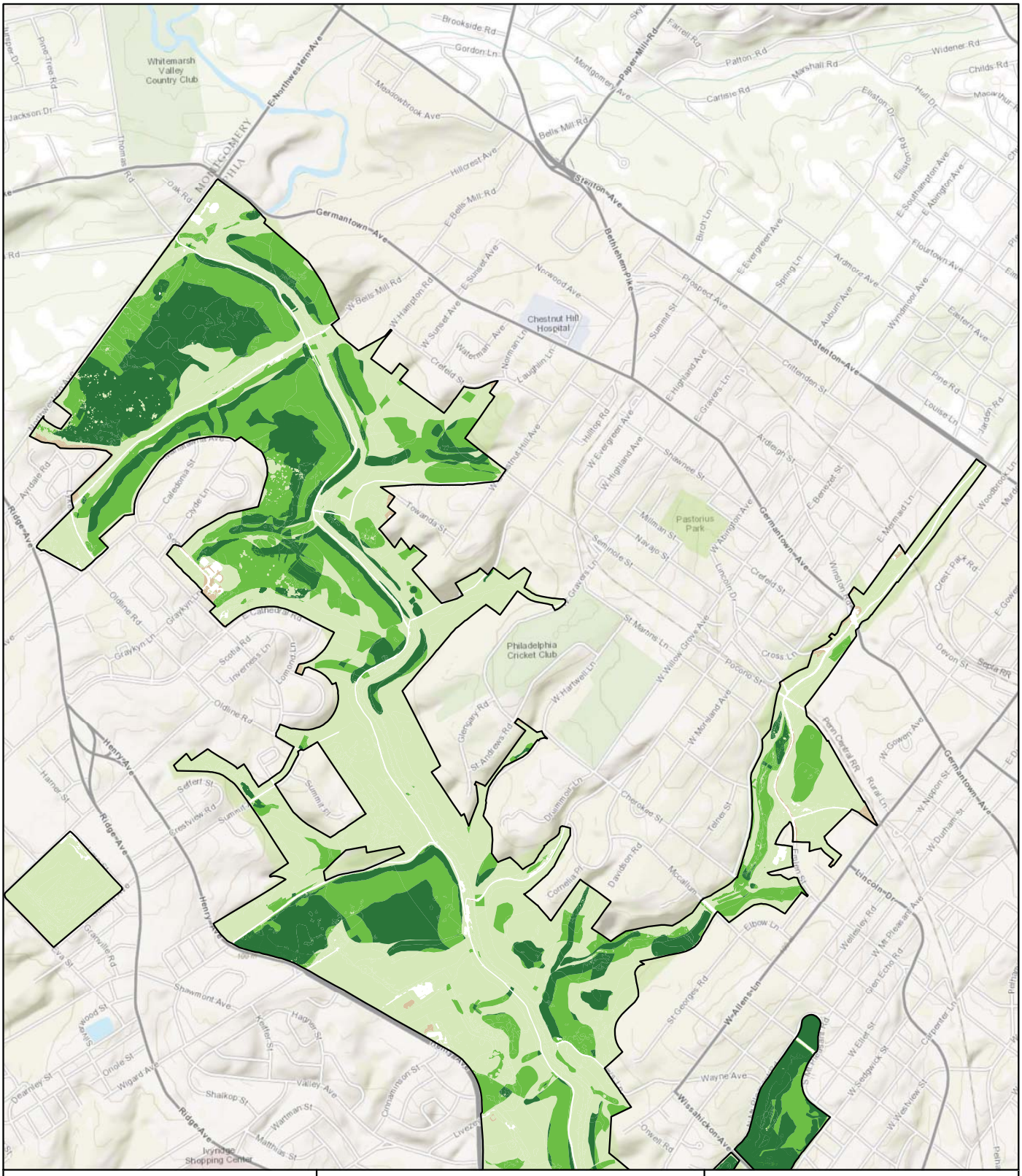
0 500 1,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

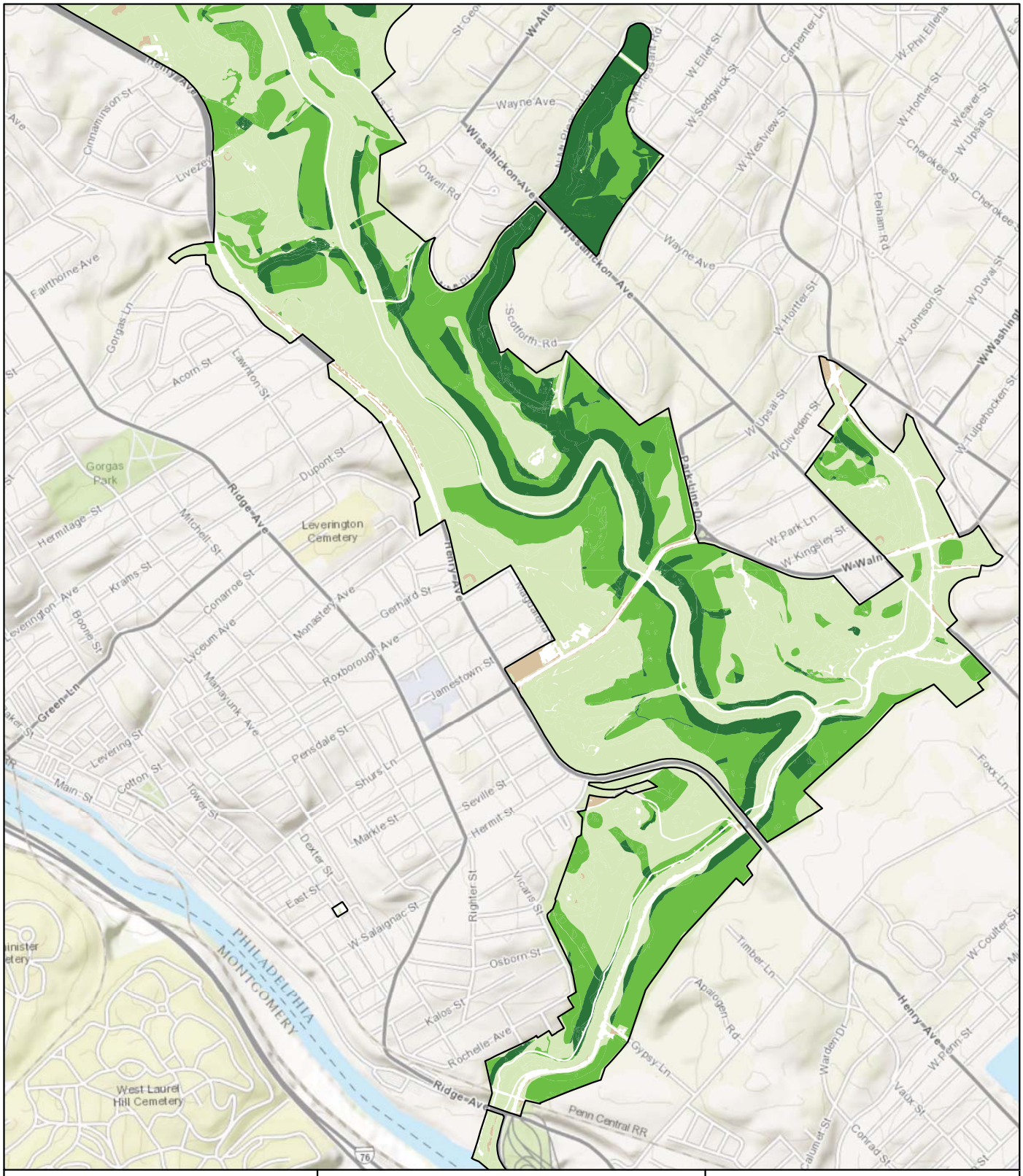
Figure II–11

Figure II–12



Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–13



Conservation/Restoration Ranking

WISSAHICKON SOUTH

PHILADELPHIA PARKS & RECREATION

Biohabitats

- Non-Priority Conservation/Restoration Value
- Low Conservation/Restoration Value
- Medium Conservation/Restoration Value
- High Conservation/Restoration Value

0 1,000 2,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure II–14

A robust native understory that shows good vertical structure

2.2.5 Threats, Constraints and Opportunities

Based on the review of existing literature, discussions with Parks staff, and the brief park visits conducted as part of this project, a number of themes begin to appear with regard to forest management for a resilient and functional forest. These themes most directly relate to threats, stressors and constraints but also bring to light those opportunities that exist within the park system:

1. Deer pressures – browsing and rubbing , clearing understory, minimizing regeneration of native biodiversity

2. Invasions – plants, animals, insects & pests

3. Edges – ecological threats/vectors, importance for community, perception of safety

4. Stormwater pressures – erosion, runoff, stream function, sediment transport, slope instability

5. Neighborhood/community abuse (Non-compatible uses) – ATVs, rogue trails, unsanctioned uses

6. Successful restoration initiatives – building on energy of success, community investment, volunteer activities

7. Sensitive habitats – vernal pools, forested wetlands, older growth forest remnants, threatened and endangered species

8. Infrastructure interface – conflicts and harmonies

9. Strong foundation of existing resources – organic materials, staff, community

10. Future pressures that may alter the existing tree canopy – climate change (warming, intense weather events), emerging disease, emerging invasive plants or pests

The following tables summarize the many of the stressors and threats in Philadelphia's parks; and the variety of opportunities to restore and expand park natural areas (**Tables 2 & 3 below**).

Table 2. Stressors and threats to Philadelphia parks

Invasive plant species (trees, shrubs, vines and herbaceous plants)
Deer browse and rubbing damage
Dumping and encroachments (trash and debris)
Stormwater flow impacts or erosion
Legacy infrastructure (dams, force mains, access roads etc.)
Insect infestations
Disease
Climate change
Incompatible adjacent land uses
Soil compaction
Forest fragmentation
Invasive wildlife – geese, earthworms
Illegal/rogue trails and access (ATVs, cars, dirt bikes)
Roadways and paths as vectors for invasives
Off leash pets
Stream channel erosion
CSO discharges
Lack of in-stream habitat

Table 3. Restoration opportunities in Philadelphia parks

Expanded deer exclosure and deer culling
Organic debris/tree fall stockpiling and reuse
Stewardship and volunteer activities – plantings, invasive clearing
Reforestation plantings
Meadow release/establishment at interface with woodland
Recreational paths designed to avoid sensitive riparian areas and steep slopes
Stream restoration with plantings
Gully restoration and plantings
Slope reforestation
Integrated stormwater treatment practices – at forest interface, along stream drainage
Expansion of 'Friends' groups , engage more park stewards
Gully repair and stabilization
Enhance native plant density and diversity

Visual Glossary of Forest Management Framework Stressors, Threats, Opportunities

The threats, constraints, stressors and opportunities that define those themes are visible in many locations across the park properties and the following visual glossary provides a selection of imagery that helps to illustrate those elements most important to address in a forest management framework.

Some of the strengths of the parks and natural areas noted by Parks staff include:

- Physical area – 5,600 acres (natural area)
- Provides a sanctuary for populations of resident and migratory wildlife
- Holds a remnant of Philadelphia-native flora
- Is a great place for recreation, solitude and education for hundreds of thousands of people who live nearby
- Has a high degree of interest and care from user groups

Some of the weaknesses noted by Parks staff include:

- Highly fragmented with a very high edge-to-core ratio makes them difficult to manage
- Low regeneration of desirable species
- Under assault by many stressors, which are exacerbated by the Park's urban context
- Prone to over-use and abusive uses

DEER PRESSURES

Deer rubs

Deer browse

PLANT INVASIONS

Porcelain berry (seen in winter condition) prevents native succession

Checking for hemlock wooly adelgid/scales

Porcelain berry invasion in Forest Hill

Understory invasion, porcelain berry and knotweed

EDGES

Disturbance, dominance of invasive plants along edge: ailanthus, Norway maple, etc.

Disturbance, dominance of invasive plants along Kelly Drive

STORMWATER PRESSURES

Steep edges in narrow stream valleys, erosion-prone soils and slopes

Pressures associated with interface with stormwater management

Pressures associated with interface with stormwater management

SUCCESSFUL RESTORATION INITIATIVES

Wooded buffers along stormwater conveyances

Gully repair and plantings in Wissahickon Valley

SUCCESSFUL RESTORATION INITIATIVES CONTINUED

Meadow restoration

Meadow restoration

Forest regeneration

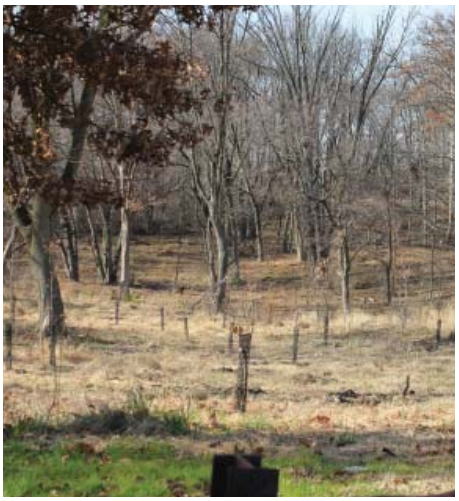
Forest restoration and exclosure success, including regeneration

Andorra meadow

Early establishment phase of meadow restoration at Andorra

SUCCESSFUL RESTORATION INITIATIVES CONTINUED

Riparian planting success along the Wissahickon



Various types of tree guards

SENSITIVE HABITATS

Attempts are being made to balance access with riparian function

Vernal pools

INFRASTRUCTURE INTERFACE–CONFLICTS AND HARMONIES

Conflicts

Interface with structures and stormwater management

Interface with stormwater management, intersection with PWD lines, outfalls

Interface with structures (mansions, hostel, stables, playfields, etc.)

Harmonies

Trails–connections, eyes on the park, integrated with natural resource features–Naylor's Run

New trails provide access and "eyes on the park," increasing safety

Historic Structures

STRONG FOUNDATION OF EXISTING RESOURCES–NATURAL AND SOCIAL CAPITAL

Tree canopy with hemlocks in Wissahickon

Wissahickon ferns

Good vertical structure and diversity of native woodland species

Diverse native understory in Cobbs Creek

Organic materials onsite recycle facility–mulch and logs

STRONG FOUNDATION OF EXISTING RESOURCES–NATURAL AND SOCIAL CAPITAL (CONTINUED)

Student stewards

Reclaimed park along entry edge of Cobbs Creek Park at Locust Gardens

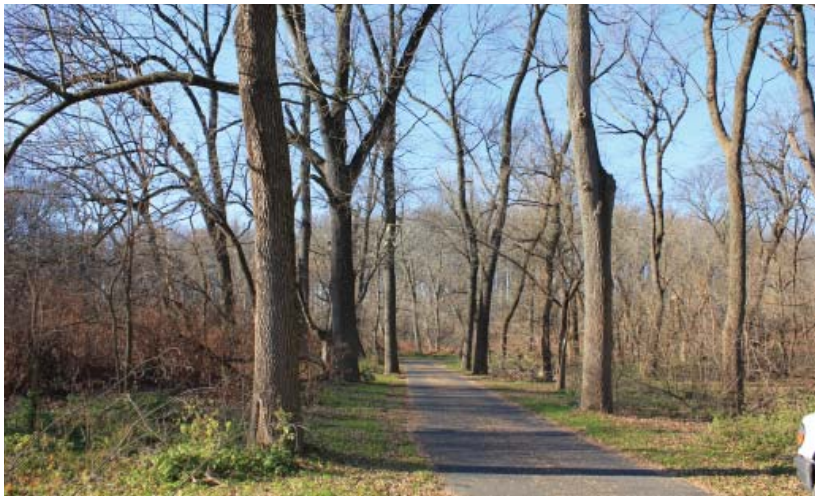
Open space for picnics and recreation

Riparian corridor buffer

FUTURE PRESSURES THAT MAY ALTER EXISTING TREE CANOPY

Increased storm intensity–tree fall after storms, hazards as well as opportunities for snag habitat

Snags and logs for habitat–associated with tree fall ater storms



Prevalence of ash trees in canopy–risk of significant loss and change in canopy cover and diversity

2.2.6 Importance of Meadow Habitats

When found in parks, forest areas often have abrupt transitions to developed areas (i.e., neighborhoods and infrastructure) or to maintained landscapes or programmed open space areas (i.e., mowed lawns and playing fields). This condition is not conducive to protecting interior forest habitats for wildlife species that need a transition of edge habitats, such as scrub-shrub or old field communities. The disturbed or open edges of forests often serve as vectors for predation (e.g., forest bird nest predation), and invasive species colonization and dissemination. A more complex transition of forest edge to other native habitats such as younger successional forest, shrublands or meadows provides better ecosystem health for a greater diversity of species and habitat use. Given the continued impacts of over-abundant deer on forest trees and shrubs, particularly affecting efforts to establish reforestation stands, other types of habitat restoration can serve to fulfill ecological landscape diversification of habitats and native plants. With the goal of more than 200 acres of native meadow restoration throughout the Parks system, the City recognizes the value of increased habitat diversity, particularly in edge transitions between forests and programmed open space or developed lands. The meadow restoration projects undertaken throughout the Parks properties provide successful examples of achieving diversification of native grassland plants including native warm season grasses and wildflowers, as well as supporting meadow use by wildlife species. In fact the Natural Lands Restoration Master Plan and the National Heritage Inventory both recognize meadows as important habitat for certain species of concern. Even where more woody transitions along forests may be desired, successful meadow restoration can provide a temporal placeholder with a valuable habitat type, at least until deer reduction management efforts are more successful in allowing greater woody plant survival (particularly shrubs, seedlings and saplings).

Houston Meadow in Wissahickon Valley Park

Swallowtail butterfly on milkweed in West Park

2.2.7 Trail and Forest Relationship

Trail networks are an important part of the park system, providing access, experience and connection of people and places. Various types and scales of trails provide walking, running, nature experience, bicycling, horseback riding, and neighborhood access connections to the parks. Municipal trail systems provide broader connections between institutions, neighborhoods and various open spaces, while regional greenway trails connect to others. Ultimately, this allows for connections to regional greenways, such as the North Delaware Riverfront Greenway and the nationally significant East Coast Greenway. From an ecological perspective, trails can also have negative consequences, such as habitat fragmentation, vectoring of invasive species, wildlife disturbance and stormwater run-off impacts including erosion, sedimentation and other water quality impacts. Forests and forest-dependent species can be impacted by trails to varying degrees where trails are wide (creating significant forest gaps), numerous and fragmenting, where they concentrate a large amount of human use activity, and where they contribute to significant run-off and associated soil erosion.

Trails are valuable and needed; however, strategic planning, construction and maintenance of trails are necessary to help protect ecological resources including forests. Illegal trails, ATV trails

Good trail

Rogue trail

and other rogue trails or desire paths (e.g., unplanned mountain bike routes), are resource management challenges that significantly affect ecological integrity as well as pulling park system resources from the care and management of the formal trail network. Parks staff have observed and acknowledged that the use of ATV's and rogue trails continue to be a serious problem in the parks. Rogue trails provide further disturbance vectors for the spread of invasive plant species, and ATV's in particular contribute to significant soil erosion and impacts to plants in their paths.

Future park trail master plans and designs need to continue to take into account minimizing forest fragmentation and disturbance through scale (width and distribution) and path hierarchy for intended uses including width, materials, durability, stability and reduction of run-off. A further challenge is the reduction of illegal or rogue trails, through active trail barriers or closure. Stabilization design should include compatible and effective materials, integrated stormwater management, and re-vegetation with appropriate native species for cover, erosion control, and habitat objectives.

III–Adaptive Management

3.1 Adaptive Framework for Forest Management

Adaptive management is a tool and process used to cope with the inherent changes and uncertainty fundamental to natural resources management, the ecological processes that encompass them, and changes in available funding. The goal of adaptive management is to build resilience into both the resource conditions as well as the management system, allowing flexibility and the incorporation of new information into the decision making process.

One conceptual set of specific steps for an adaptive management process (Blann et al. 2003) includes the following:

1. Establish a clear and common purpose
2. Design an explicit model for your system
3. Develop a management plan that maximizes results and learning
4. Develop a monitoring plan to test your assumptions
5. Implement your monitoring and management plans
6. Analyze data and communicate results
7. Use results to adapt and learn

Adaptive Management is incomplete if it only focuses on woodland resource management in isolation. Instead, it should take a more holistic approach, considering water quality and stream system health, meadows, trails and other recreational and park use elements. This is particularly true given the fact that the impetus for forest management within the study area parks ultimately relates to the ecosystem health of the creeks, the Delaware River and the communities of Philadelphia. Incorporating adaptive management into a practical system for forest management involves two components: "adaptive learning" and stakeholder interaction. "Adaptive learning" is a process through which management protocols and priorities can be revised as new data become available.

Bloodroot in Wissahickon Park

GOAL AND DEFINITION OF ADAPTIVE MANAGEMENT

Adaptive management incorporates research into conservation action. Specifically, it is the integration of design, management, and monitoring used to systematically test assumptions in order to adapt and learn. (Salafsky, et al 2002)

Adaptive management is often referred to as experimental management. The management approach is intended to inform process-directed decisions. It has also been referred to as "learning by doing". Two major considerations of adaptive management are model-based process research and experimental design testing. The design of experimental trials has to take into account the costs and constraints of large-scale experimentation. The intent of experimentation is to develop diagnostic field trials that provide response information to better inform resource management or policy changes. It can be used to help determine critical space/time scales and necessary steps in the management process.

To ensure the long-term resilience of the institutional and ecological processes it is important to facilitate a dialogue between resource managers and the stakeholders. The stakeholders can be a discreet group or the broader community, but should include relevant City departments and non-governmental organizations. Particularly important are groups responsible for site operations & maintenance, research, education, volunteer stewardship, natural resource management and funding allocation. Through the incorporation of diverse interests, managers are able to move forward with the combined support of multiple parties, empowering the stakeholders and investing them in the process. This process will work best with PP&R continuing to collaborate with representatives of the various city departments and organizations responsible for related issues, and other interested individuals.

This forest management framework is a guide to long-term healthy and sustainable forest management for Philadelphia's parkland forests. It is a living document that results in a set of activities and steps that return healthy functioning and self-perpetuating processes to the forests. The restoration and management opportunities presented in this report should become part of a continuous feedback loop of continued learning by doing. The more that is tried the more that is learned in a collaborative

process. Those involved in an adaptive management strategy are part of a process that sets a trajectory for achieving established goals, guides current and future management actions, helps acquire necessary funding and resources, implements projects, and monitors and evaluates, in order to adaptively manage and maintain forest resources.

3.2 Goals for forest management

Protection, Maintenance, and Restoration

- Expand and connect existing forests, meadows, shrub lands, and wetlands where feasible, particularly where underutilized maintained parkland can be used for this purpose.
- When possible, acquire parcels owned by others that are adjacent to park natural areas.
- Coordinate future planning projects along open lands associated with the Delaware and Schuylkill Rivers and their tributaries, to support habitat connectivity, riparian forest expansion, and floodplain function.
- Actively maintain existing high-quality natural areas and promote restoration of more degraded spaces.
- Protect natural areas that are already biologically healthy.
- Conduct work only in sites to which regular maintenance can be committed.
- Facilitate natural regeneration where possible.
- Utilize waste wood from the parks to augment soils in reclamation projects.
- Promote structural diversity in forests.
- Do not use cultivars or species known to be invasive for any plantings.
- Reduce forest edge length along good-quality sites where possible, to increase core-to-edge ratio and improve edges at these sites, to decrease light and wind penetration.

Plant Propagation

- Promote native plant density and diversity in natural areas.
- Establish populations of uncommon or absent endemic plant species where feasible.
- Continually collect seed and cuttings from local sources and propagate native plants for use in natural area reclamation. Use native plants (to Philadelphia County) appropriate for a given site.
- Manage greenhouses, propagation areas and holding areas at PP&Rs Greenland Nursery.

Wildlife Enhancement

- Support biodiversity and ecological health, facilitating functional habitat for resident and migratory wildlife (food, cover, breeding and nesting habitat) focusing on Philadelphia's native flora and fauna.
- Maintain a diverse mix of habitat types (e.g., upland forest, riparian forest, old field, meadow, wetland).

Healthy forest in Cobbs Creek Park

- Incorporate habitat structures such as snags, logs and nesting boxes in reclamation plans.
- Create restoration plans that address species of special concern and natural communities as targets of conservation.
- Pay extra attention to maintaining uncommon endemic species.

Invasive Plant Control

- Manage for known invasive species and plan for early detection of new invasive species in key natural areas.
- Sustain efforts to control invasive plants and their destructive effects in high-priority sites.
- Systematically kill problematic invasive plants on all restored or maintained sites, including trees, shrubs and woody vines. Include killing significant patches of invasive herbaceous plants that will impede the growth of native woody plants.
- Utilize biological controls for invasive plants where feasible.

Pest & Disease Control

- Reduce and control problematic (excessive, invasive, and/or exotic) animal populations, including (but not limited to) deer and geese.
- Seek ways to reduce excessive earthworm populations in restoration projects.
- Prepare for and address damages caused by insect and disease outbreaks, including but not limited to Emerald Ash Borer and Hemlock Wooly Adelgid.
- Utilize biological controls for insect pest species where feasible.

Integrated Stormwater Management

- Minimize the impacts of excessive stormwater to streams and their watersheds.

- Protect and increase forested riparian buffers along streams and wetlands.
- Divert, detain and infiltrate excessive stormflows wherever feasible to reduce erosion and increase groundwater recharge.
- Restore and stabilize damaged streams and eroded hillsides.
- Construct means to achieve fish passage around any dam that fails and will not be rebuilt.

Trails and Fragmentation
- Encourage public access, but prevent damages from excessive or inappropriate uses.
- Minimize fragmentation of high quality woodland through comprehensive trail review and planning of new trails.
- Maintain, close, and reroute park trails as needed to insure that trails are safe, stable and minimize environmental impacts.

Site Assessment, Monitoring
- Commit to monitoring and maintenance regimes that strengthen and maintain ecological function and incorporate community involvement.
- Monitor conditions in restored sites periodically to determine project effectiveness and maintenance needs.
- Monitor parkland forests periodically to quantify and evaluate existing conditions and changes. Re-sample permanent sampling plots throughout park natural areas and obtain plot data every 5 years (US Forest Service).
- Adapt management techniques in accordance with changing conditions and knowledge.

Fundraising and Partnerships
- Identify grant opportunities and complete applications to secure outside funding for projects.
- Engage the assistance of volunteers, friends groups, government agencies and others to help implement the Forest Management Framework goals.

3.3 Management Recommendations – Strategies For Restoration and Management

The management recommendations are organized under the main themes of invasive species management, deer management, insect infestation and disease management, forest fragmentation and disturbance – reforestation, forest soil health, & green infrastructure. Each provides a summary description of management recommendations, approach and techniques, phased implementation, and coordination opportunities.

3.3.1 Invasive Species Management

Non-native invasive plant species colonization occurs to varying degrees throughout all of the parkland natural areas including the forests. A large number of invasive species from around the world have become established in the region. Historic disturbance regimes of land clearing, settling and development have perpetuated disturbance cycles of native vegetation cover, soil profiles and hydrologic regimes. Accompanied by the alteration of geochemical and nutrient process, these conditions are conducive to the proliferation of non-native plant species. The management of infrastructure, including roads, sewers and power lines, as well as the associated soil disturbance further act as vectors for the spread of invasive species. Once the ecological processes have been highly impacted, invasive species become persistent and dominant, often outcompeting native species. In order to manage for more resilient native habitats, interventions to manage invasive plants need to be employed.

Philadelphia has been performing invasive species management in the parks for 15 years and these efforts need to continue and be expanded. Targeted species for invasive plant control and areas of concern need to be prioritized for treatment and long-term management. A priority list of targeted forest invasive species includes Norway maple, sycamore maple, tree-of-heaven, princess tree, white mulberry, cork-tree, bush honeysuckle, multiflora rose, privet, winged euonymous, oriental bittersweet, English ivy, porcelain berry, wisteria, Japanese honeysuckle, mile-a-minute, Japanese knotweed, and Japanese stiltgrass. There are numerous additional species that are also problematic. See **Appendix D** for a partial of park system invasive plant species.

Mile-a-minute invasive plants on forest edge

Approach and Techniques

The management techniques available include physical, chemical, biological and cultural control measures including the following:

- Cultural Control: Education programs that identify and describe prohibited species, as well as integrated vegetation management practices.
- Mechanical Control: Pulling & grubbing (small, dispersed individuals and herbaceous plants), cutting (trees, shrubs and vines), mowing (dominated fields), root excavation (occasional as needed), fire (when suitable or allowed per regulatory requirements in the region).
- Chemical Control: Foliar and wick application (suitable for herbaceous patches, small shrubs, monoculture vines, and individual plants).
- Chemical Control: Cut stump/stem, injection, basal bark (suitable for trees and large shrubs).
- Chemical control: Pre-emergent (suitable for woody and herbaceous species with susceptible seed).
- Biological Control: Invasive treatment of specific invasive plant species (e.g., mile-a-minute) through insects and pathogens that have been identified through research.

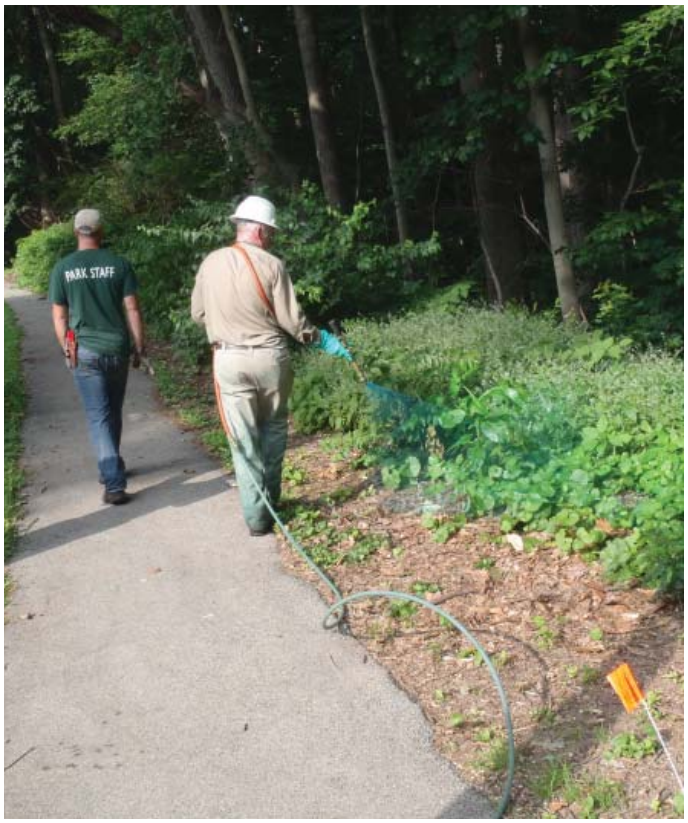
Other newer and emerging approaches, some of which may be suitable for pilot projects in the parkland forests include the following:

- Managed grazing or silvopasture of invaded areas by goats or other select herbivores.
- The use of floral products or other plant-based natural herbicides to treat invasive plants such as oriental bittersweet.
- Identifying and fostering uses for accumulated invasive plant biomass (after clearing activities): biochar (a partially burned soil augmentation), mulch (without viable seed/propagules), pellet for stoves, etc.

Phased Action Implementation

Short-term 1-3 year timeframe

- Continue site invasive pre-treatment at restoration project sites (herbicide, cutting, & mowing), and post-restoration planting, monitoring, and follow-up treatment.
- Select and prioritize monitoring of invasive species locations and activities in a given year (stratified locations, transects) as part of an annual adaptive management monitoring program, in order to watch for new or worsening invasions. (Beginning in 2012 US Forest Service is sampling 75 permanent plots in park natural areas every 5 years.) See monitoring consideration in Section 3.5.
- A continued and prioritized annual mowing regime as a part of meadow management, which promotes resistance to woody plant invasions, specifically for non-native invasive species.



Applying herbicide to various invasive species in Carpenters Woods

- Compile project-specific, annual invasive monitoring data and analyze to determine trends in invasion and treatment effectiveness and to adaptively alter future management approaches.

Long-term 4-10 year timeframe

- Expand invasive plant control beyond project sites into existing forests stands, and work with other landowner partners to expand management onto adjacent private and institutional land.
- Work with collaborative partners to advance invasive plant management research projects in the parks and evaluate future granting and funding opportunities to expand treatment.
- Test alternative techniques in pilot demonstration projects such as large-scale application of course woody debris on a degraded site, invasive biomass biochar or goat grazing (i.e., with regional agricultural community partners and friends groups like FOW).

Implementation Coordination

Stewardship Opportunities

- Expand use of volunteer groups (e.g., FOW 'Vine Crew') and identify targeted species, areas and techniques for expanded forest invasive plant management.
- Hold educational workshops focused on invasive plant control identification & treatment for landowners.

3.3.2 Deer Management

White-tailed deer have dramatically expanded their range and abundance due to a host of factors including lack of predators, changes in land use and land cover, and altered agricultural and landscaping practices, all of which provide for increased habitat suitability and reproduction. Deer have become highly adaptive and tolerant of urban conditions and they proliferate in urban landscapes, especially green space and parklands. The Philadelphia parklands are no exception. An over-abundance of deer in the parks has contributed to the disturbance and alteration of the parkland forests, particularly in terms of browsing consumption of native shrubs and tree seedlings. In many cases this foraging has led to the total absence of native shrubs (or the occurrence of just a few of the more browse-tolerant species) and an understory that is essentially absent of forest seedling regeneration. This has also contributed to the colonization and spread of non-native invasive species, many of which are not preferentially consumed by deer. The City has recognized the extent of the deer problem and for more than a decade has employed deer culling practices in Wissahickon Valley Park and Pennypack Park. Some deer culling has also been done in West Fairmount Park and Cobbs Creek Park. Deer are managed through lethal harvest by professional wildlife control biologists, and then the venison is donated to food distribution programs in the region. Other deer management measures that the City has employed include deer exclosure fencing around forest stands that include reforestation and nursery areas, applying deer repellant to trees and shrubs, and adhering to planting criteria that recommends planting only where deer browse is minimal and varied use of different tree protection devices.

PREDATOR AND PREY RELATIONSHIPS

White-tailed deer in Pennsylvania, as in much of the Eastern US, have unnaturally high population levels, in large part due to the lack of natural predators. The elimination of natural predators in the region (such as wolves, wolverines and mountain lions), coupled with availability of abundant browse material (trees, shrubs, herbaceous vegetation and landscaping plants) has led to an over-abundance of deer. Subsequent over-browsing of native woodland vegetation has caused the loss of intermediate shrub and sapling layers and the ground cover layer of plants. The excessive browsing and deer rubs can alter forest structure, composition and associated functions that the forest provides. In some locations, reintroduction of large predators is being explored, but it is not deemed practical in urban areas and adjacent to suburban communities. Therefore, control of deer populations by human interventions is recognized as the only currently viable management tool through activities such as culling and other lethal control.

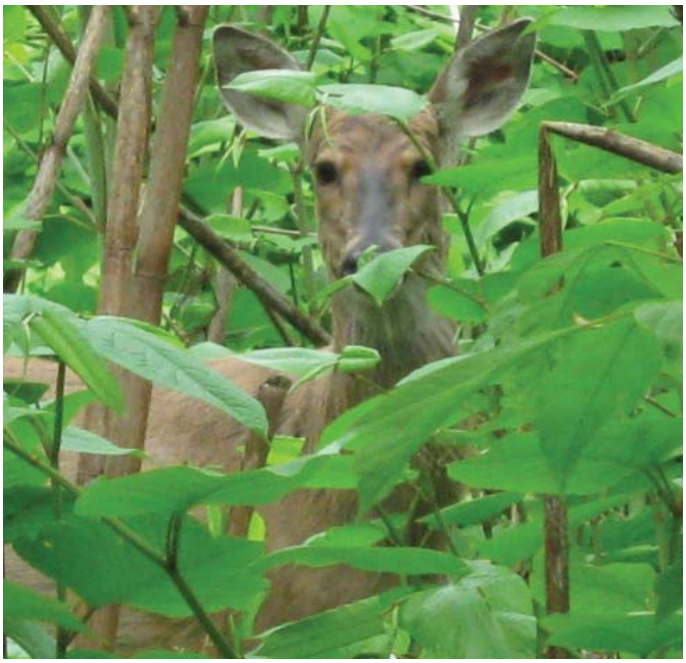
Approach and Techniques

The following types of deer management are available for use in attempting to reduce and control deer density and impacts to forest resources and native plantings:

- Exclosure fencing (tall, rigid and economical) including post and wire mesh, with entry gates.
- Tree protection devices including a variety of plastic tree shelter, tubes, wire cages and wooden slat guards that are deployed around individual trees and sometimes shrubs (mainly during the sapling stage).
- Plant selection–plant choices that are native, browse resistant, and diverse.
- Education programs focused on landscape planting.
- Repellents of varying brands and trade names oriented to contact or taste resistance to deer or that emit deterring odors (these tend to be temporary and need frequent reapplication).
- Population management through lethal harvest (culling) on a repeated (e.g., annual) basis.

Other newer and emerging approaches, some of which may or may not be suitable for pilot projects in the parkland forests include the following:

- Lethal harvest through managed hunts with licensed hunters, using a lottery or permit system with specific duration periods and using bow hunting equipment.



Deer in Cobbs Creek Park

Buck in Houston Meadow

Chestnut blight in Fairmount Park (1908)

Phased Action Implementation

Short-term 1-3 year timeframe

- Continue and expand deer culling into as many areas throughout the park system as possible.
- Continue annual monitoring of deer populations within parks and open spaces city-wide, perhaps with other wildlife agency and research partners (e.g. USDA annual survey).
- Continue and expand deer exclosure projects and associated monitoring programs, to measure success of native woody plant re-colonization. Consider expanding existing exclosures to adjacent areas.
- Test alternative techniques in pilot demonstration projects: less palatable native plant selections and different types of shelters such as wooden slat guards.

Long-term 4-10 year timeframe

- Explore additional methods of culling to obtain increased control over a greater proportion of park land.
- Expand deer culling programs system-wide and work with other land owners to expand their control efforts on their private and institutional land.
- Work with collaborative partners in adjacent counties to support managed deer hunts on county lands that are outside of Parks lands but may provide habitat connections to those lands (is stream valley connective lands).
- Compile project-specific and annual deer monitoring data and analyze to determine trends in populations, technique effectiveness and to adaptively alter future management approaches.

Implementation Coordination

Stewardship Opportunities

- Continue the use of the venison donation program to volunteer groups (e.g., food banks like the Central PA food bank, shelters) and hot meal events.
- Hold educational workshops centered on land-owner landscape planting and deer control.

3.3.3 Insect Infestation and Disease Management

Tree diseases have periodically occurred in the eastern US forests with devastating consequences to certain native species. Two examples are the chestnut blight on American chestnut and Dutch-elm disease on American elm. Other new threats of disease currently present in the Eastern US forests include oak decline, beech bark disease, and thousand cankers disease. Likewise, a variety of insect infestations has threatened or continues to threaten the forests. These include the gypsy moth, which has occurred previously in periodic invasions, and more recent threats like the hemlock wooly adelgid (*Adelges tsugae*), the emerald ash borer (*Agrilus planipennis*), and the Asian long-horned beetle (*Anoplophora glabripennis*). Gypsy moth infestation events have occurred throughout much of Pennsylvania including Philadelphia. Emerald ash borer and Asian long-horned beetle are present in surrounding areas. PP&R has recently completed the City of Philadelphia Emerald Ashe Borer Management Plan. The hemlock wooly adelgid is present in Philadelphia and is specifically observed to be present in hemlock trees along the Wissahickon Valley Park. The infestation of insects and disease requires vigilant monitoring to detect their presence. Once detected, forest managers/stewards can be alerted to critical areas in need of intervention, in order to reduce potential consequences of uncontrolled spread and potential devastating tree loss.

Approach and Techniques

The following types of infestation and disease management are available in order to detect, reduce, and manage impacts to forest resources:

- Establish a monitoring program utilizing certified arborists, certified tree experts and other forestry expertise in order to detect, map and advise on intervention and control.
- Cultural: Tree education program, wood transportation ban, and planting stock inspection.
- Chemical Control: Emerald Ash Borer – Tree-age ®; Hemlock Wooly Adelgid – Imidaclroprid, (chemical treatments by soil drench or select stem injection of insecticide).

Other newer and emerging approaches, some of which may or may not be suitable for pilot projects in the parkland forests include the following:

- Biological Control: For gypsy moth, *Entomophaga maimaiga*; for hemlock wooly adelgid, *Laricobius nigrinus*, or *Sasajiscymnus tsugae*; and for emerald ash borer, *Spathius agraili*, *Tetrastichus planipennisi*, or *Oobius agraili*).
- Adaptable and sustainable use of harvest wood, including reducing vectors of infestation and spread, by approaches such as Upcycle Harvested Trees (*www.citilogs.com*).

Phased Action Implementation

Short-term 1-3 year timeframe

- Develop and employ a disease and insect infestation monitoring program. Make insect infestation and disease detection part of annual adaptive management monitoring program, in order to watch for new or worsening invasions.
- Conduct hazard tree inventory and begin treatments for emerald ash borer.
- Perform infestation extent and distribution survey for hemlock wooly adelgid. Implement a treatment regimen for wooly adelgid infestation in older growth trees/stands, or distinct park sections, based on infestation survey.

Long-term 4-10 year timeframe

- Expand the insect and disease infestation monitoring and treatment program to all parkland forests and other forest lands in the City, including adjacent lands under other ownership.

Woodland area's dense native forest understory

- Work with collaborative partners to advance the understanding of insect and disease infestation in urban forests and research effective treatment and management regimes.
- Compile project-specific and annual monitoring data and analyze to determine trends in infestation and treatment effectiveness and to adaptively alter future management approaches.

Implementation Coordination

Stewardship Opportunities

- Hold and educational seminar for interested community members on the value of urban forests, the threat of infestations and associated threats to community forests.
- Training workshops for tree care and forestry professionals.
- Develop partnering and volunteer participation for legacy tree re-establishment projects, such as the reintroduction of disease resistant American chestnut and American elm trees.

3.3.4 Forest Fragmentation and Disturbance – Reforestation

As previously indicated, the forests of the eastern U.S., including Philadelphia, have been highly altered and heavily impacted by land conversion, development and centuries of land use for agriculture, industry and housing. Some would say that by the beginning of the 20th Century there were essentially no native forest stands left in Philadelphia and that all of the lands that have been reforested have been a result of plantings, and culturally-based spread of plant stock. As to whether or not some or much of the regeneration of forests happened through remnant propagules or reintroduction is debatable, nonetheless many areas of open space and parkland are now covered in forested lands, ranging from old-field or scrub-shrub, to early and mid-successional maturing forest stands, and some areas of mature and declining stands in the Wissahickon. The legacy of

NOVEL ECOSYSTEMS

"Novel ecosystems contain new combinations of species that arise through human action, environmental change, and the impacts of the deliberate and inadvertent introduction of species from other regions. Novel ecosystems (also termed emerging ecosystems) result when species occur in combinations and relative abundances that have not occurred previously within a given biome. Key characteristics are novelty, in the form of new species combinations and the potential for changes in ecosystem functioning, and human agency, in that these ecosystems are the result of deliberate or inadvertent human action" (Hobbs et al 2006).

land use and the invasion of non-native woodland plants, along with an over-abundant deer population have forever altered how the forests of this novel ecosystem will function and develop.

Not only do the historic impacts to parkland forests reveal themselves in the distinct lack of native plant biodiversity, there are also impacts to forest wildlife, like woodland dwelling birds. Decreased water quality in streams and river and impacts on drinking water reservoirs and aquifers provide further evidence of the effects of the loss of intact forest systems that would historically provide cover, infiltration and filtering capacity in headwater areas. Planning and zoning regulations, including buffer ordinances and wetland and floodplain alteration regulations, have been created to reduce environmental impacts.

Reforestation plantings and woodland management regimes are needed to enhance native biodiversity, provide wildlife habitat, perform erosion control and buffer water bodies from stormwater run-off. Successful efforts to restore native forest communities have a direct relationship to other management themes including the deer, invasive plant species, and insect and disease infestation management efforts described above.

Approach and Techniques

The management techniques utilized for reforestation and forest restoration and management include the following:

- Establishment of forest conservation, tree protection and buffer ordinances (for streams, rivers, wetlands & floodplains) which require zones of native forest protection and/or restoration.
- Geographic information system (GIS) mapping and analysis, along with on-site evaluation of opportunities and constraints, in order to develop forest corridor and gap infill area plans.
- Employment of forest planting criteria such as those followed by PP&R, including planting only when invasive plants have been managed and deer browse is minimal. When deer browsing cannot be controlled, plant native species deer prefer not to browse.
- Plant species native to the region (e.g., Philadelphia and its piedmont and/or coastal plain systems). Plant multiple strata of a diverse palette of trees (canopy and understory), shrubs and ground cover, including those that provide for wildlife benefits for cover and foraging.

Other newer, emerging approaches, some of which may be suitable for pilot projects in the parkland forests include the following:

- Holistic forest adaptive management that considers invasive species, deer and insect/disease infestation management as above, but also looks at the relationship to soils, hydrology & biota.
- Use of tree protection including deer exclosures that may remain up for periods of time (multiple-year to decades) in order to protect urban forest regeneration and experimental designs with supplemental restoration planting and seeding.
- Alter disturbed forest soils and restoring functionality by the use of coarse woody debris (chips, mulch) leaf material and beneficial fungi to support reclamation (see Soil Health section).

Regenerating seedling and sapling layer in forest

Phased Action Implementation

Short-term 1-3 year timeframe

- Continue invasive management regimes on project sites, plant within PP&R planting criteria, along with the expansion of tree protection measures including exclosure areas.
- Make forest regeneration and exclosure areas a part of annual adaptive management monitoring programs.
- As a part of meadow management, continue annual mowing regime in meadow areas, in order to resist woody plant invasion specifically non-native invasive species.
- Test alternative techniques in pilot demonstration projects such as green or raw wood chip layers, fungi inoculation (mycchorizal) along with supplemental planting follow-up.

Long-term 4-10 year timeframe

- Expand reforestation to meet projected parkland forest trajectories (ideal forest area goals to be established) as invasive plant control and deer management effectiveness is understood.
- Work with collaborative partners to implement reforestation projects towards citywide goals on their lands (both private and institutional), in synergy with parkland connections and corridors.
- Compile project specific and annual invasive monitoring data, and analyze to determine trends in reforestation (i.e. survival, composition and distribution) in order to adapt future management.

Implementation Coordination

Stewardship Opportunities

- Expand use of volunteer groups ('Friends of' parks) for PP&R led tree-planting events.
- Hold educational workshops with collaborative partners.

Eroding channel at Carroll Park before restoration

- Continue and expand native plant sales or tree giveaways for tree plantings in community open spaces and forest areas.

3.3.5 Forest Soil Health

The impacts of the physical alteration of forests through land conversion, as well as invasive species, deer damage, insect and disease infestations have been discussed throughout this report. Another fundamental but less visible component of urban forest function and resiliency is forest soil health.

Changes in land cover and land use in urban areas lead to a host of soil issues encountered in urban forest systems including over-compaction, excess drainage, shifts in soil organism composition, and high or low pH. Urban land changes have had dramatic impacts on soil function and structure including its organic content, porosity, soil moisture, chemical composition, pH, compaction and presence of beneficial soil organisms, as well as the ability to support endemic native plant regeneration and growth. Nutrient levels and types lead to imbalances that cause non-native invasive species sometimes to thrive while native species adapted to low nutrient conditions are affected by excess nutrients.

The alteration of soils and the associated impacts have ramifications for the success of reforestation efforts, as well as the long-term management of existing forest resources. The condition of forest soil health is an area that appears to need much more attention in urban forest restoration planning, implementation and management. Developing a greater understanding of forest soil conditions, limitations and needs can help tailor adaptive strategies for implementing more successful reforestation efforts but also to support more resilient forests faced with numerous threats and stressors.

Approach and Techniques

The following types of soil health management measures are available for use in managing forest resources:

- Establishing a testing and monitoring program that provides baseline and periodic assessments of soil agronomic properties (texture, organics, pH, conductivity, macro- and micro-nutrients) through field sampling and laboratory analysis.
- Developing an assessment and monitoring component with support from research or academic partners, in order to study exotic earthworms and other soil biota
- Where needed, based on laboratory testing and report recommendations, supplement soils through the incorporation of organic material, sulfur, fertilizer (organic/natural) and/or compost. The total area of sites that need fertilization is very small.
- Develop a high quality compost and compost tea facility using the infrastructure located at the City of Philadelphia Recycling Center.

Other newer and emerging approaches, some of which may be suitable for pilot projects in the parkland forests include the following:

- Biochar application, as soil profile amendment in order to build soil resiliency and capacity
- Application of relatively thin, laminar layers of raw or green wood chips in areas that lack an organic layer and leaf duff, in order to provide a slow release of organic material and alter soil processes for fungi
- Establish new combined reforestation and planting projects that take the form of productive landscapes. These projects could be focused on enhancing and expanding edge conditions along forested areas and reflect the agricultural legacy of this region, with a nod to cultivated landscapes on the old estate, fairgrounds and arboreta found within the park system lands. Forest stewards would cultivate herbs such as ginseng, golden seal or cohosh, or tend native fruit or nut-bearing orchards or groves, while caring for the forest (trash removal, invasive control, deer management, soil amendments).

Phased Action Implementation

Short-term 1-3 year timeframe

- Develop and employ a forest soil assessment and monitoring program and collect sub-sampling location information for restoration sites and existing forest stand areas.
- Include expanded soil testing, topsoil import (type and characteristics), augmentation (organics, amendments, organic fertilizers) and fungi inoculation in restoration project specifications.

Long-term 4-10 year timeframe

- Expand soil testing, monitoring and assessment program to all parkland projects for forest, meadow, wetland restoration, and landscape projects along with standard soil specifications

- Work with collaborative partners including PWD to advance the use and application of soil management measures and specifications for forest, stream, wetland and BMP projects.
- Compile project-specific and periodic (e.g. every 2-3 years) monitoring data and analyze to determine trends in soil condition changes and augmentation effectiveness and to adaptively alter future management

Implementation Coordination

Stewardship Opportunities

- Create a brochure for community members, which covers the importance and benefits of soils for parks, gardens and yards. The brochure can inform the community members of what steps they can take on their own lots and as park volunteers
- Continuing offering screened leaf compost, wood chips, single-ground mulch, double-ground mulch, and herbivore manure.

3.3.6 Green Infrastructure

Green infrastructure stresses the importance of functioning natural systems as integral elements in the built environment. Green infrastructure is a network of practices and features that are contributing to the quality of life in the City, through a better integration of park resources, sustainable stormwater management and other landscape services (e.g. water quality), while providing added benefits in terms of aesthetics, habitat and integration of natural functions and processes. This provides a foundation for more resilient natural systems near parking lots, roads and other built structures, while providing a more natural and seamless interface with forest and meadow areas.

Approach and Techniques

There are already a number of efforts along the interface of the Parks where stormwater management techniques have been used to treat stormwater while promoting habitat function, with vegetated bioswales and bioretention areas.

Implementation

Moving forward it will be important to continue the practices that integrate green infrastructure in a way that creates multifunctional landscapes with many benefits to the natural and human environment. Bioretention and bioswales integrated into street and road designs are effective stormwater management practices, which can also be planted to transition smoothly into the forested landscape interface. Gully repair throughout the parks can be done in a way that is regenerative and vegetated, while stabilizing soils and promoting better infiltration.

This will not necessarily be a phased implementation as much as it is a concurrent effort, as needs arise and as stormwater management techniques are integrated across the City of

A stormwater wetland near the Wissahickon

Philadelphia. The Philadelphia Water Department is actively developing stormwater management practices for many park sites as well as their Combined Sewer Overflow (CSO) Long Term Control Plan Update (LTCPU). More information is available online: *http://www.phillywatersheds.org/what_were_doing/green_infrastructure and http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan*

Short term maintenance/monitoring for adaptation

- Routine inspection and maintenance of bioswales and bioretention areas
- Monitor success and hardiness of plants in areas that may see inundation or effects of extreme weather events.

Long-term maintenance/monitoring for adaptation

- Monitor success of plants and adapt palettes accordingly
- Check infiltration capacity of soils and maintain or alter BMPs
- Monitor overall capacity and functionality of any structures (inlets, drains, etc.) associated with bioretention or bioswales.

Implementation Coordination

Stewardship Opportunities

- In conjunction with PWD, invite community members to help with planting of bioretention or bioswales, or with maintenance, through "adopt a swale program."

3.4 List of potential collaborators

- Philadelphia Parks & Recreation
- Philadelphia Water Department
- Philadelphia City Planning
- Academic institutions: Penn State, Drexel University, Cornell, Temple University, others
- US Forest Service, Philadelphia Field Station
- USDA APHIS Wildlife Services
- PA Department of Conservation and Natural Resources
- Academy of Natural Sciences
- Pennsylvania Environmental Council
- Pennsylvania Horticultural Society
- Pennsylvania Game Commission
- Private and institutional land owners, and adjacent counties
- Delaware River City Corp. and Delaware River Waterfront Corp.
- Consultants and environmental/invasive control contractors
- Stormwater consultants and restoration contractors
- Soils laboratories
- Soil consultants
- Lethal control experts/marksman and licensed hunters
- Forestry Consultants and certified arborists

Volunteers help with clearing and trash removal

3.5 Monitoring Considerations

An important part of long-term successful ecological restoration and management is a well-developed and executed monitoring program. As previously discussed, ecological resources have a variety of needs and considerations for management, and require a variety of types of monitoring. Monitoring provides data on resource conditions and functions and helps determine the effects of restoration and management interventions. Monitoring of various components of the parkland forest system can help to detect changes in the resource conditions, compared to the baseline, and predict or illustrate trends over time.

The feedback loop from a comprehensive monitoring effort can inform future changes in approaches and techniques, while serving to support stakeholder decisions on a given trajectory, leading to adjustments in the long-term forest system goals. Monitoring is especially important to the application of pilot projects in order to understand how tested interventions and approaches are functioning and to inform decisions regarding, use, expansion or changes to forest restoration and management actions. Equally important is the need to evaluate the results in order to reveal the effectiveness of management actions, which can serve to help establish and justify resource and funding needs and allocation levels.

The following representative monitoring components can be further developed for forest management:

Invasive Species Management

- Species composition
- Percent cover by strata
- Interspersion
- Seed production
- Seedling regeneration
- Plant health, viability
- Associated soil properties

Deer Management

- Browse, herbivory
- Native plant cover
- Native plant diversity
- Native plant abundance
- Deer density
- Comparative trials (control and exclosure)

Insect and Disease Infestation

- Disease type, frequency and distribution
- Health characteristics, tree impacts
- Treatment regime effectiveness plots
- Native plant cover
- Native plant species abundance

Forest Growth and Reforestation
- Species composition
- Percent cover, canopy closure
- Interspersion
- Leaf litter cover and depth
- Mast/seed production
- Seedling regeneration
- Native diversity indices
- Plant health
- Downed woody debris

Soil Health
- Nutrients, macro- and micro-
- Bulk density, porosity
- pH, conductivity and soluble salts
- Organic matter
- Earthworms, insects and microbes

Green Infrastructure
- Percent (%) failure versus success of plants
- Infiltration capacity of soils
- Functionality of any structures (inlets, drains, etc.)/ failures of structures

3.5.1 Future Monitoring Program

The future monitoring efforts need to include a monitoring plan (or set of plans) as well as the development of a program to house and manage the monitoring planning, execution and assessments. The recommended monitoring approach involves scientific rigor in quantitative data collection, as well strong qualitative metrics for evaluation of expected functions and values. The monitoring efforts will need to be scientific, replicable, and employ statistical analyses, in order to deliver results for management decision making. Monitoring can be done through a combination of staff time, selective volunteer efforts, and university partnering opportunities.

In terms of timing and frequency, monitoring schedules will have varying timelines, with a typical cycle of annual monitoring for sub-sampling a set of forest area and prior management sites.

Monitoring of projects after implementation is key to long term success

Project-specific monitoring can include baseline monitoring, monitoring during implementation, and post-implementation monitoring, for up to five or more years. Projects and forest management sites selected for monitoring will need to be determined within a comprehensive monitoring program (part of the adaptive management process)which helps determine monitoring priorities based on suitable timing, grant or permitting requirements and available resources. Developing a comprehensive monitoring program can not only set monitoring priorities, but also establish a comprehensive milestone reporting cycle (e.g., 5-year program) that holistically evaluates monitoring efforts including results, emerging needs or information gaps and a plan of action for future monitoring.

Monitoring of forest and other ecological restoration and management efforts in the Parks also provides significant opportunities for academic and research institution partnering in terms of grant-based studies, graduate research projects and internships. There are companion-monitoring opportunities that would be very valuable to a comprehensive understanding of forest resource management, including bird and other wildlife surveys (e.g., amphibians and small mammals) and adjacent stream studies such as water quality, and fish and macro-invertebrates. Results from monitoring and geospatial analyses are suitable for inclusion in a GIS geo-database as file layers and attributes.

IV–Looking to the Future

4.1 Guiding Future Efforts

This parkland forest management framework is a starting point for future efforts that comprehensively manage and maintain the Parks' forest system and related resources. It strives to be a living document and an ongoing process, which builds upon the extensive, successful forest restoration and management efforts conducted in the parks over the last few decades.

One valuable step for future forest management is adopting a version of the adaptive management process presented in this document that fits the PP&R organizational mission and the goals of its collaborative partners. Future efforts rely on implementing actions that continually re-evaluate forest resource conditions, identify evolving strategies for restoration and management, and test the effectiveness of interventions through comprehensive monitoring and feedback-based decision-making. Other valuable parts of forest management planning include the identification of pilot demonstration projects and staffing, equipment, contracted implementation projects costs, as described below.

4.2 Next Planning Level

Other efforts could be undertaken in order to further develop a comprehensive forest management plan/natural resource management plan. These would involve more detailed park investigation, analysis and detailed implementation recommendations as described below.

4.2.1 Detailed Forest Management Survey and Database

This effort involves a comprehensive on-the-ground assessment of a range of forest and other natural resource conditions including species and age composition; distribution, frequency and degree of non-native invasive plant species; natural native seedling regeneration; and woodland soils health investigation. There are additional natural resources conditions assessments that can be performed as part of an overall comprehensive evaluation of the forest system health in the stream valley parks as well as neighborhood parks with extensive tree canopy. Additional assessments that may be appropriate include stream channel and riparian buffer assessment, soil sampling and analysis, meadow assessment, and wildlife habitat/use studies. An additional effort would include an updated forest habitat land cover map using prior mapping, new aerial photography and imaging processing to delineate vegetation types. Some of these assessment items may be partially or primarily addressed in the City's watershed management plans and i-tree assessment for certain park areas. Another effort not currently included in the framework is the development and maintenance of an ecological geodatabase for the parks' forest resource data. A companion component would be an existing trail system evaluation related to forest resource management. This task would be highly variable in scope and cost depending on the level and extent of investigation and survey of trails within the parks and connections to regional trail system. An additional task would be a managed meadow assessment and future needs evaluation.

Healthy native woodland in Cobbs Creek Park

4.2.2 Detailed Site-Specific Restoration and Management Recommendations

This effort would involve providing detailed park-by-park site location assessments and recommendations for specific location-based resource management, restoration and maintenance. This is dependent upon the execution of the detailed forest management survey and database phase described above. These site-specific opportunities would include invasive species management, soil augmentation for health and function, tree and shrub planting needs and plant palettes/lists, and regenerative stormwater and green infrastructure best practices that would reduce impacts and enhance woodland health at certain locations. An associated task would be the generation of GIS map sequences for each stream valley park as well as significant natural areas, which depict more detailed locations and opportunities for the above-referenced site restoration and management recommendations. A companion task for master planning purposes would be the creation of a document that recommends forest health improvement performance metrics and the development of forest health attributes and parameters, guidelines, monitoring protocols, and a detailed adaptive management plan.

4.3 Identification of Potential Pilot Projects

There are innumerable opportunities within the parks and other open spaces in the city to test, implement and manage a variety of techniques and approaches to forest resource management. A valuable part of this process is the identification and implementation of a range of demonstration projects. They present an opportunity for scalable testing of a variety of new techniques and methods, and for designing unique applications for the park system forests. Pilot projects are also particularly important in informing future actions as a part of adaptive management, using the pilots as trials for new techniques to help shape future management interventions and restoration projects. Through careful monitoring of the pilot projects one can see first-hand responses of the system, which will help make the best use of available resources moving forward.

Pilot projects have the added potential benefit of garnering stakeholder support, providing stewardship opportunities, and for collaborating with partnering organizations and funders. Pilot projects provide opportunities to test approaches and methods across a spectrum of forest resource needs and also can be tailored to spread pilot projects out across the system parklands and diverse neighborhoods. Maps showing locations of the proposed pilot projects are included at the end of this section.

Based on the collective work of this framework and input from PP&R, the following potential pilot projects are provided:

1. **Big Woods Reclamation/Deer Protection**–Implement vegetation and habitat improvements to a large (20+ acre) section of largely-unfragmented park forest in both Pennypack and Wissahickon Parks. Significantly enhance native plant diversity, including herbaceous plants in subsequent years. Deer fence as much of the two sites as possible. Monitor plantings, both inside and outside exclosure to determine survival and vigor of each planted species. Install interpretive signage at each site. Engage volunteers in site maintenance. Estimated cost: $480,000 (Pennypack); $360,000 (Wissahickon).

2. **Trunks, Chips & Fungus**–Introduce woody debris from the park to demonstrate how forest soils can be improved with recycled wood wastes. Include pre-implementation soil testing. Also include monitoring of earthworm populations before and after introduction of materials. Test various control measures if earthworms are found. Conduct project within one of the Big Woods reclamation projects. Estimated cost: $20,000.

3. **Fernhill Forest Reclamation**–Remove invasive vegetation parkwide and establish native forest and evergreen buffer plantings in this neighborhood park immediately across from the Wissahickon Charter School. Engage volunteers for site maintenance, including students from the school. Estimated cost: $220,000.

4. **Philadelphia's "Big Dig"**–Install 3,000 plants (trees and shrubs) in a one-day event utilizing approximately 500 volunteers. Project is to be done inside one of the Big Woods reclamation sites, in the Bocce Woods expansion, or in Fernhill Park (after clearing). Estimated cost: Incorporated into project site (e.g., Big Woods reclamation)

5. **Bocce Woods Expansion**–Restore an additional 25 acres of degraded forest in the largest area of core forest in Cobbs Creek Park. Remove invasive vegetation (including European black alder) and trash, plant native trees and shrubs and install deer fence around as much of the area as possible (15 acres). Monitor plantings, both inside and outside exclosure to determine survival and vigor of each planted species. In addition, install deer fence around a 15+ acre area of adjacent previously- restored forest. Engage volunteers in site maintenance. Estimated cost: $500,000.

6. **Horticulture Center Native Demonstration Forest**–Remove invasive vegetation, defunct fence, and concrete rubble and establish native forest in the 30 acres of exotics-infested natural areas surrounding this historic park location. Site includes forested wetlands. Install deer fence and interpretive signs to help Horticulture Center visitors understand elements of a high-quality forest. Engage volunteers in site maintenance. Estimated cost: $440,000.

7. **Cedrela Smackdown**–Eliminate Cedrela trees (Chinese toon tree (*Cedrela sinensis*)) and other invasive vegetation in a 16-acre area around the Wissahickon Environmental Center and replace with native forest vegetation. Install 5-acre deer exclosure to protect a diverse forest planting. Utilize plantings and exclosure in outdoor education programs. Estimated cost: $200,000.

8. Stopping the Cork–Eliminate invasive cork-trees around the perimeter of the restored Houston Meadow to stop their spread into restored areas. Plant native forest vegetation in cork removal areas. Portions of this project can be implemented by Natural Resources staff. Deer control is required. Estimated cost: Cork-tree control can be done by staff.

9. Holding the Edge (Plan)–Develop a planning document that identifies high, medium and low priority edges to "secure" against light and wind penetration park wide (PP&R staff project).

10. Holding the Edge (Project)–Remove invasive plants on problematic edge sites, including Kelly Drive and West River Drive. Plant native evergreens on some sites to block sun to reduce future invasive growth. Estimated cost: To be determined after developing project plans.

11. Sustainable Connections–Construct a new trail from Market Street to CCCEEC in Cobbs Creek Park to enhance access for Delaware County residents into the park. Construct gateways and trailheads and provide signage for trails in this low-income section of the city. Remove invasive vegetation and trash "from street to creek" in northern section of trail to enhance security. Project to be completed in conjunction with Philadelphia Water Department stream restoration work in the adjacent section of stream. Estimated cost: To be determined after developing project plans.

12. Andorra Innovative Stormwater Management–Employ a range of practices from soakage trenches to wetland creation in order to capture and infiltrate uncontrolled stormflows and stop erosion problems throughout Andorra Natural Area. Requires consultant plan. Estimated cost: To be determined after developing project plans.

13. **Roosevelt Parkway**–Using a variety of approaches, promote a new understanding of the parkway as a greenway corridor that helps to connect the community with the stream valley parks. Interpretive signage can describe the watersheds, telling the story of the stream valley parks and the importance of urban forest. The signage could describe how the transit corridor also links many of the stream valley parks and other open space areas in the city. Aesthetic improvements could be made through increased vegetation/tree canopy plantings or a short meadow that would provide visual interest and require annual mowing (this may be limited by safety considerations associated with sight lines and vegetation height or massings along the roadway, but worth some consideration). There is also the potential for integrated stormwater treatment – vegetated bioswales, etc. Estimated cost: To be determined after a feasibility study of the parkway.

14. **Agroforestry Edges**–Enhance and expand edge conditions along forested areas to reflect the agricultural and industrial landscape legacy. This pilot concept aims to support forest stewardship, enhance soils, and promote innovative urban agriculture/agroforestry. A potential pilot opportunity may be found in Bartram's Garden, with a nod to its long history as a nursery. Alternative opportunities may be in Eastwick Community Gardens, Wister Woods, or Wakefield Park. Further study in each of these locations could highlight opportunities for enhanced tree cover along wooded edges that promote woodland function, while supporting productive landscapes (nut or fruit harvest), community engagement and awareness.

15. **For the Birds**–Provide improved migratory and residential nesting song bird habitat by enhancing and managing disturbed and altered forest edges. This effort will include improving the structure and diversity of the forest edge, and expanding it, through native seed and fruit producing shrubs, vines, and herbaceous grasses and wildflowers, and some exclusion fencing. This planting approach can yield a more complex and protective edge that helps protect nesting birds from predation as well as providing foraging habitat and protective cover. Informational signage and a bird viewing location to highlight the forest/bird relationships (monitoring station where birders can record observations in a journal). A woodland stand edge at Pennypeck on the Delaware is a potential candidate for this pilot (costs to be determined).

16. **To the River**–Enhance the interface of riparian parkland at a confluence with the Delaware River. This green infrastructure pilot project would be strategically located to address issues associated with stormwater runoff or piped discharge to the creek, while at the same time improving riparian forest and aquatic edge habitat. This demonstration could include a combination of a regenerative conveyance (gully, drainage channel or outfall repair) and improving floodplain habitat connectivity through bank stabilization, forest buffer enhancement, trash, debris and other creek obstruction removal, and native plantings for stability, shading and habitat value. This pilot project is proposed for the area of Poquessing Creek Park located at the interface with the Delaware River, and is a candidate for collaboration with PWD on their related GI initiatives (costs to be determined).

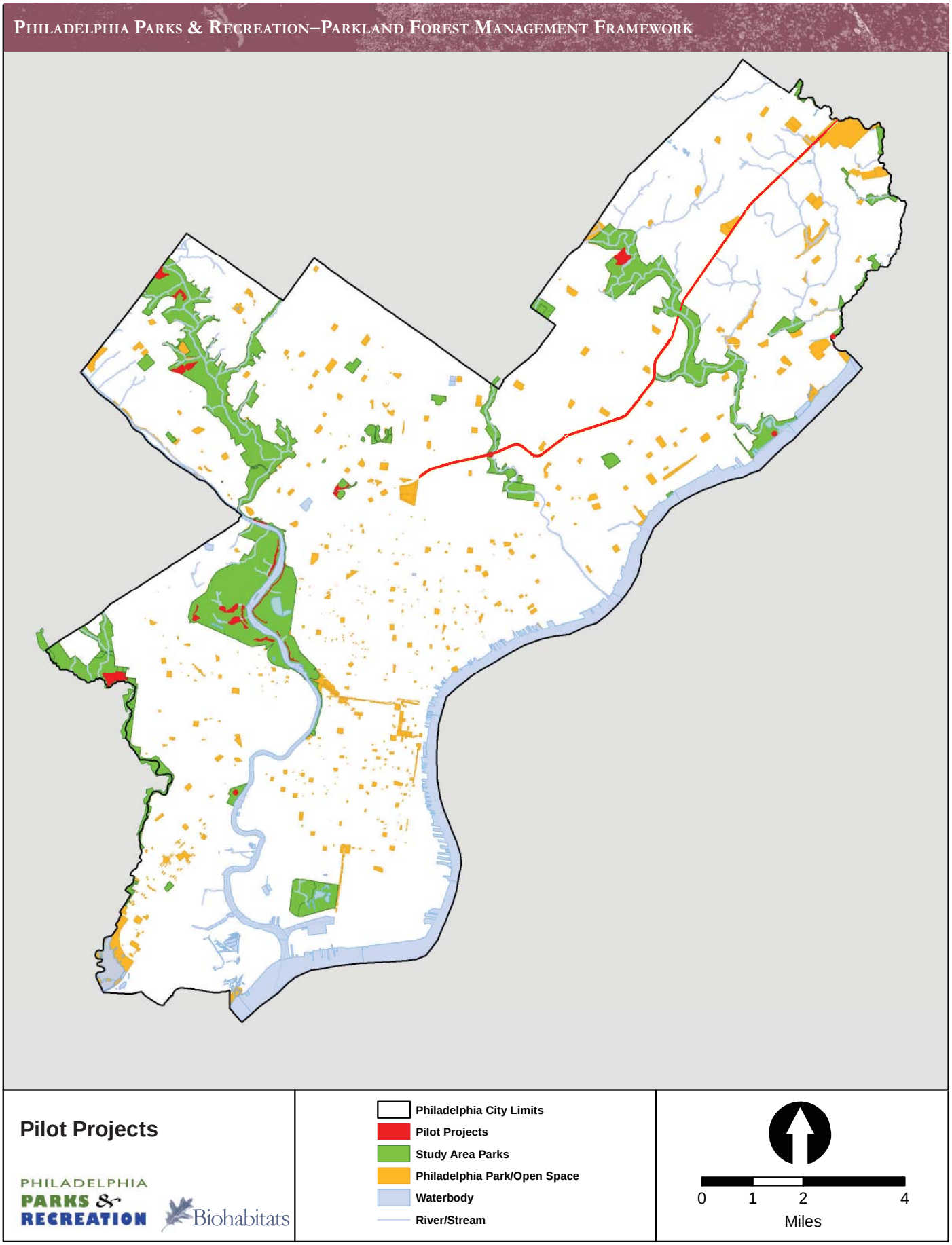
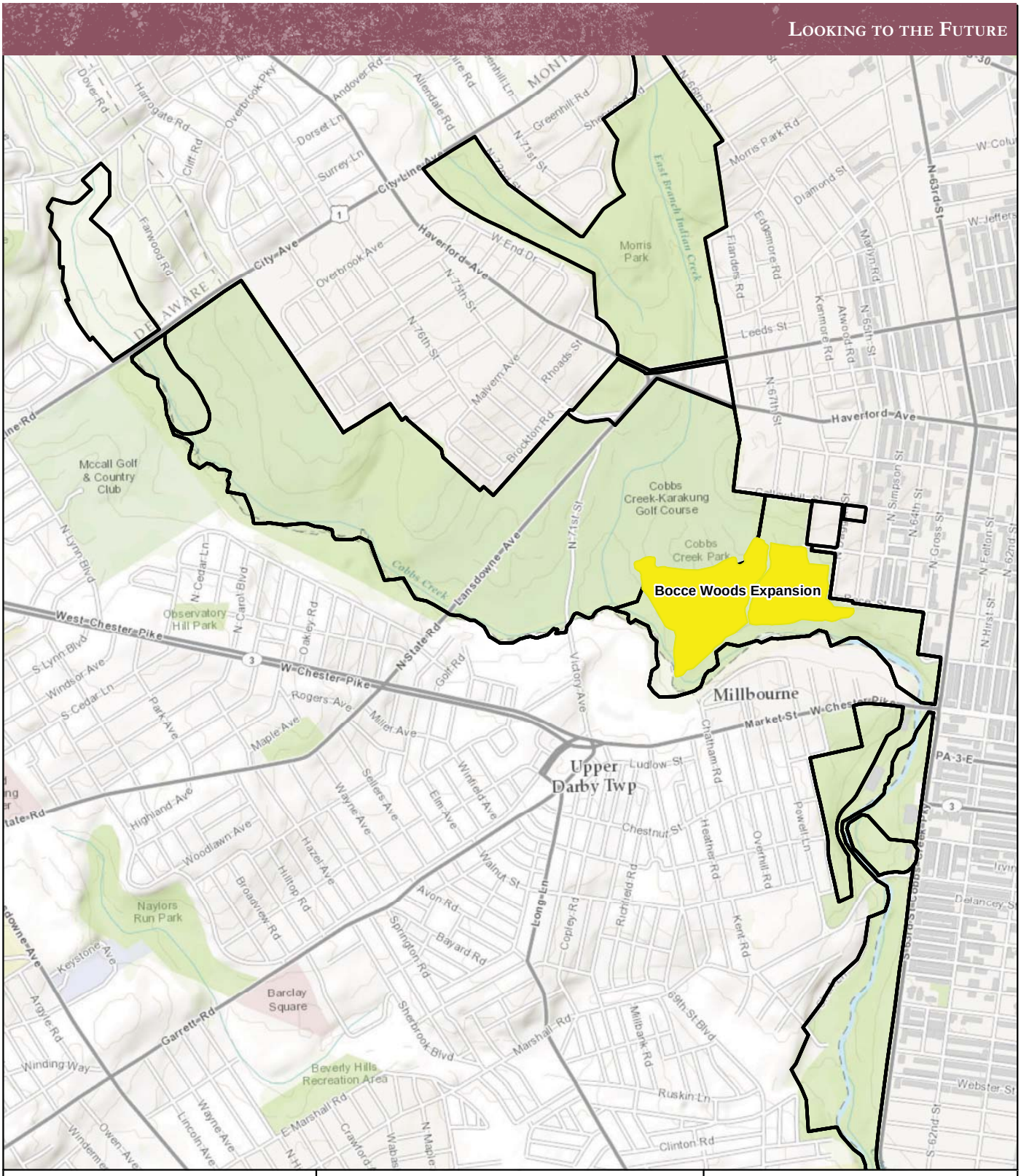


Figure IV–1



Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure IV–2

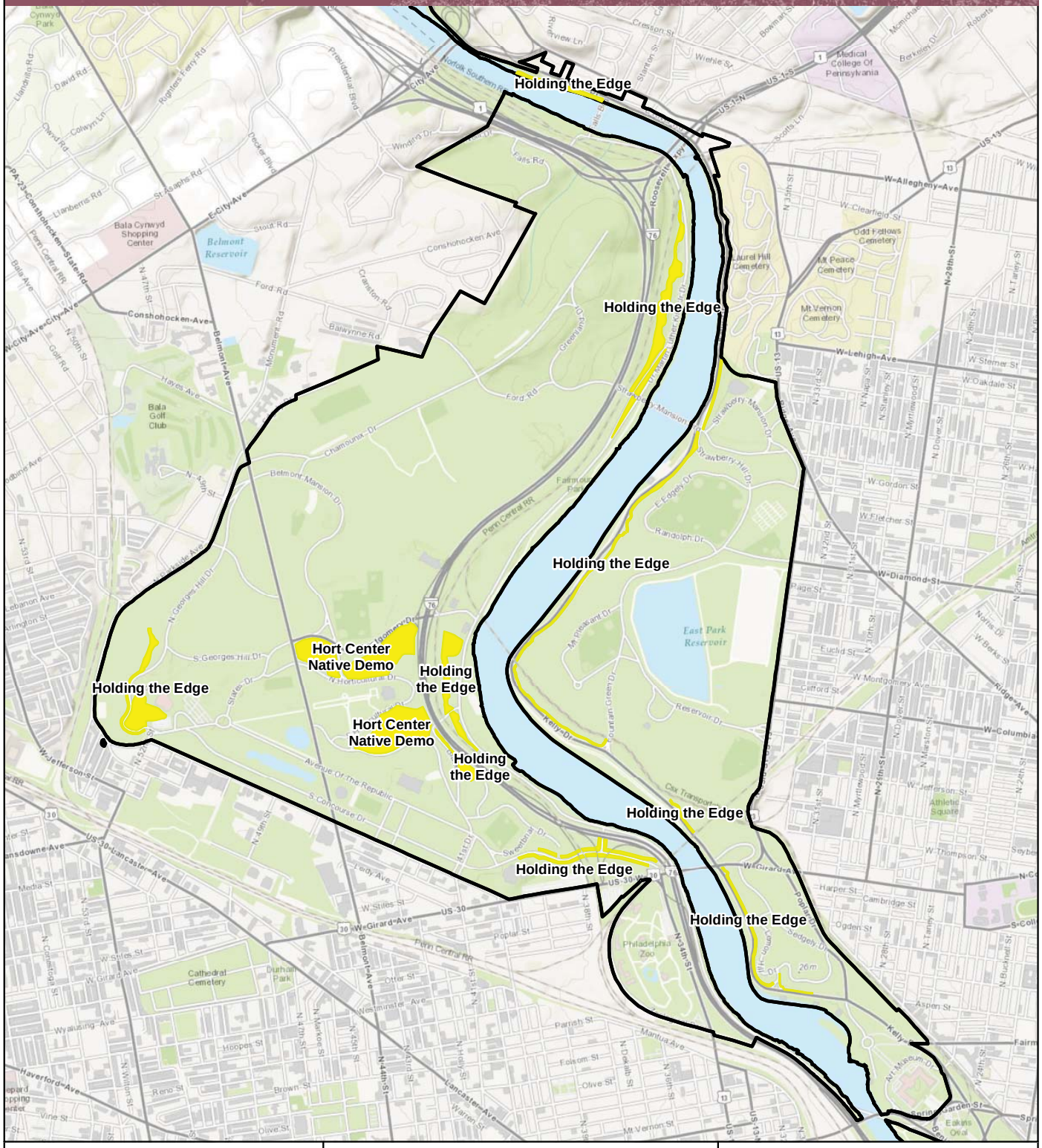


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Figure IV–3

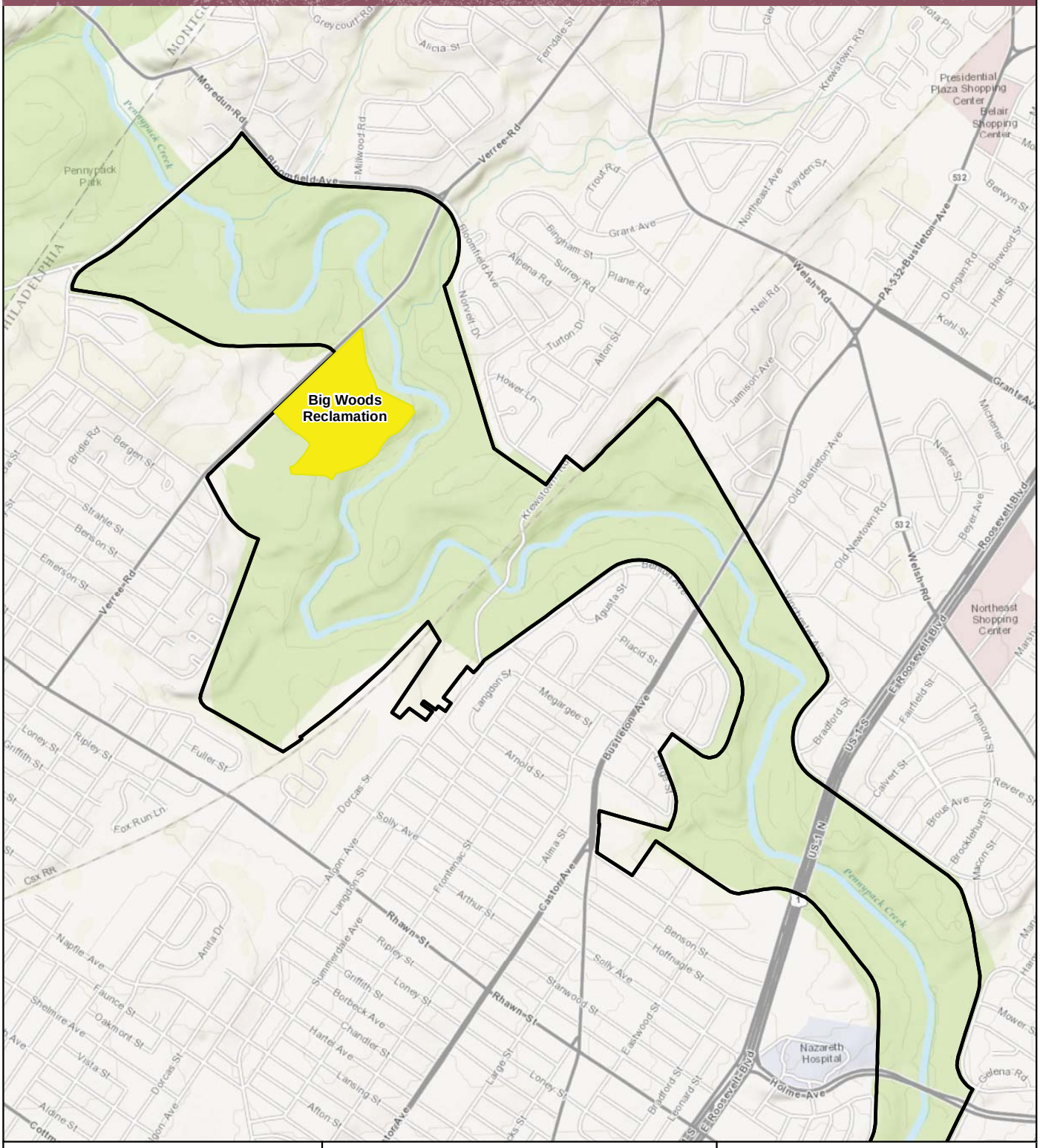

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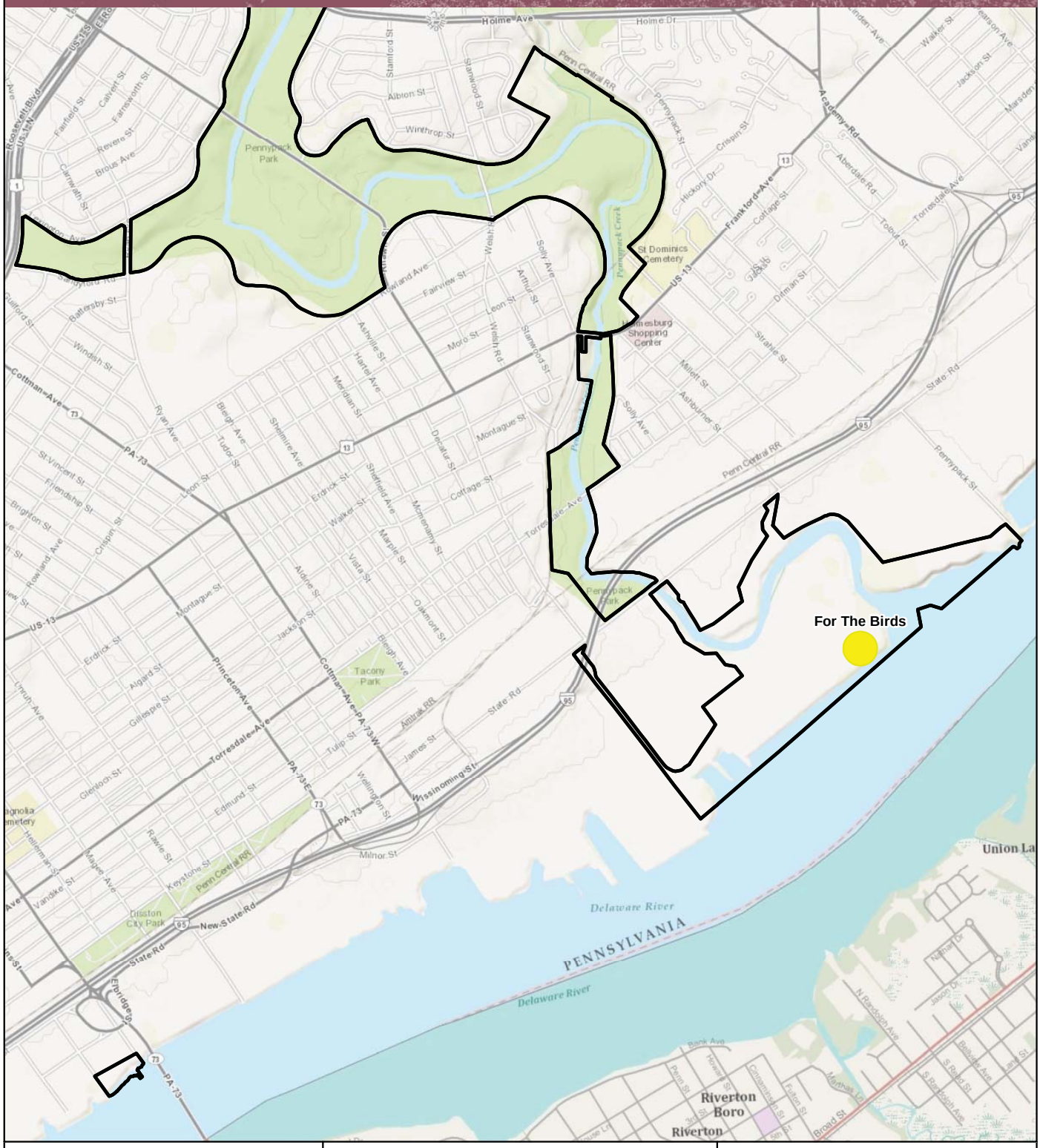
Figure IV–4



Pilot Projects

PENNYPACK SOUTH

PHILADELPHIA PARKS & RECREATION · Biohabitats

Pilot Project

0 1,000 2,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure IV–5

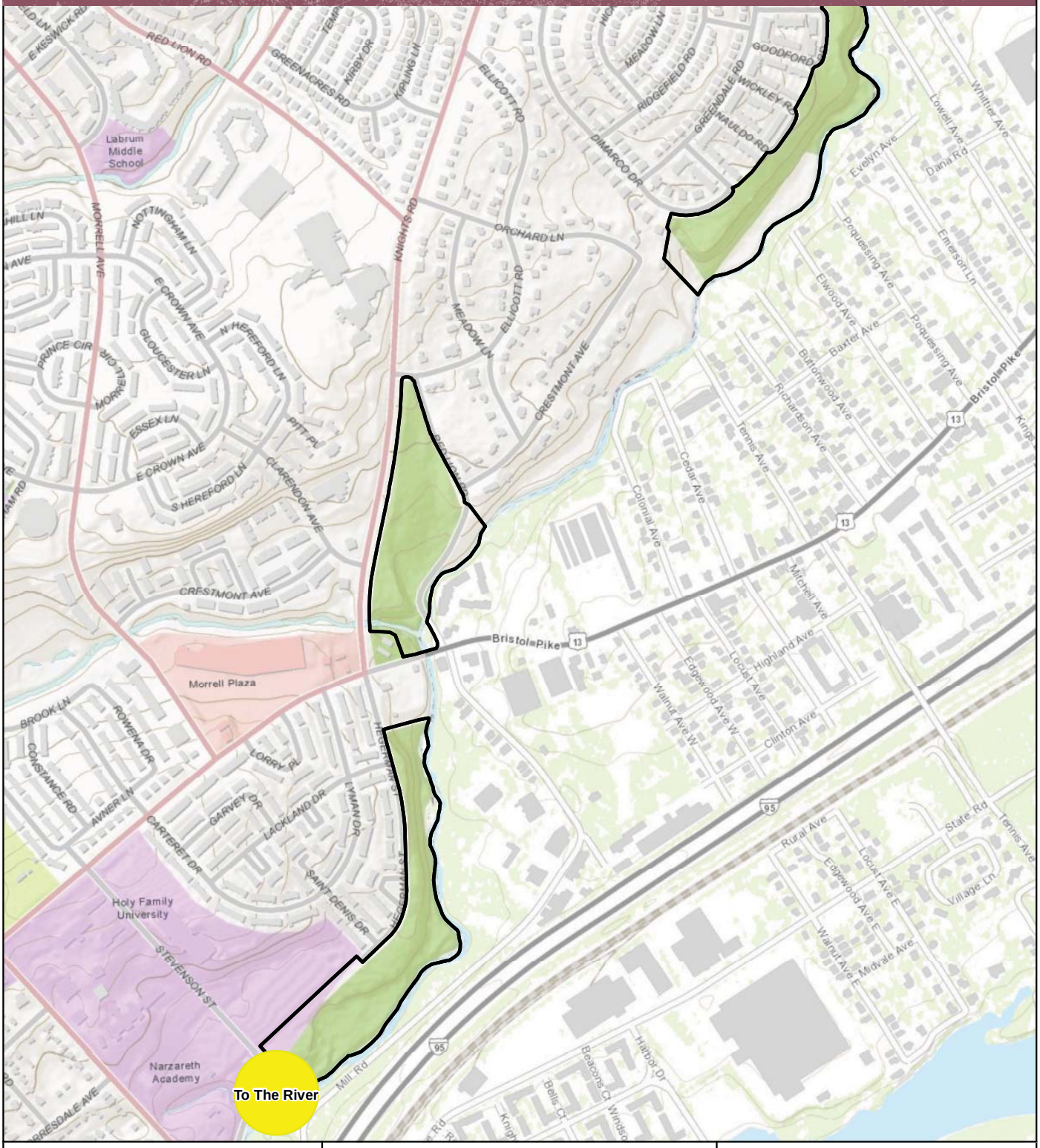


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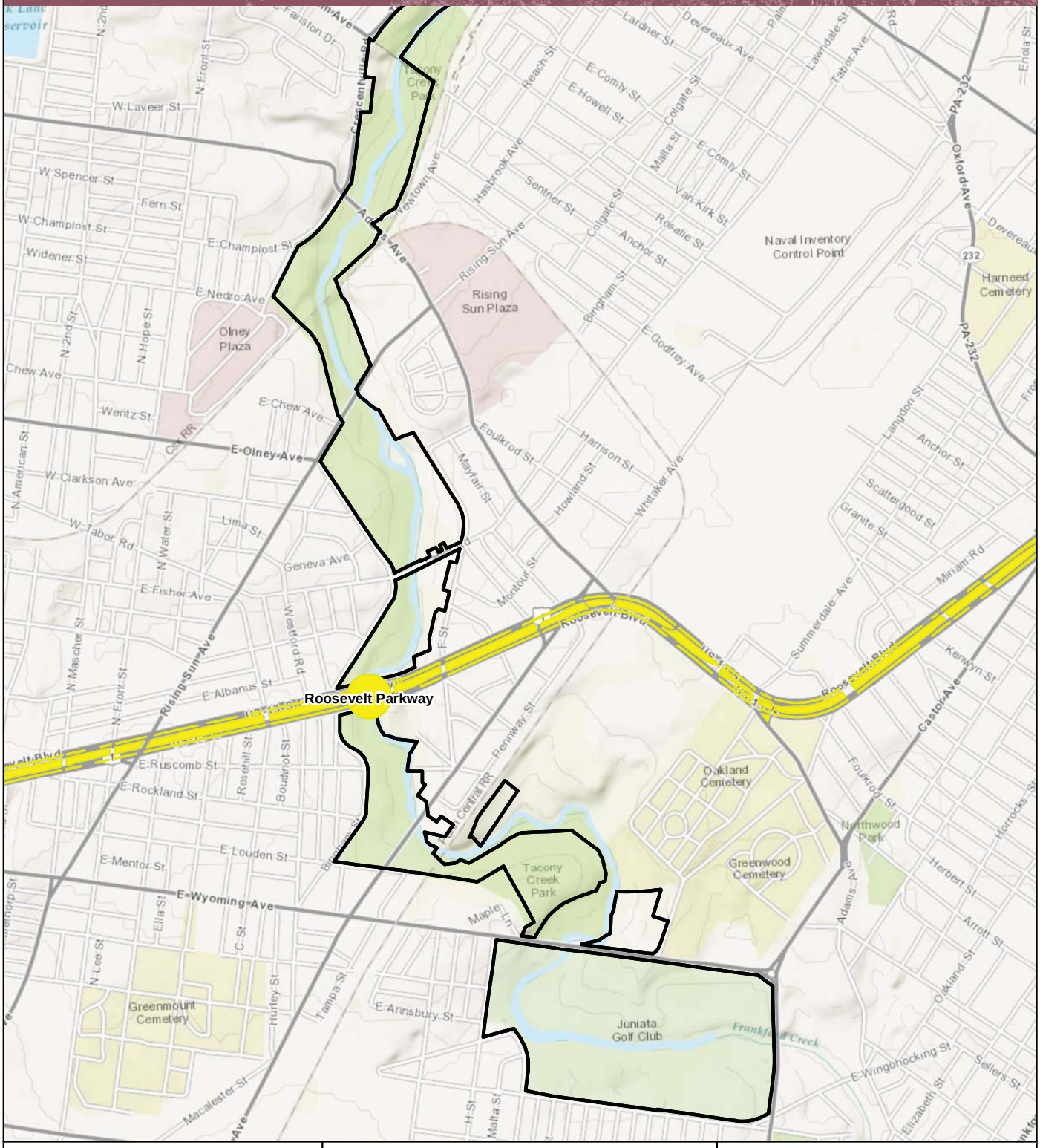
Figure IV–6



Pilot Projects

TACONY

PHILADELPHIA PARKS & RECREATION · Biohabitats

Pilot Project

0 1,000 2,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure IV–7

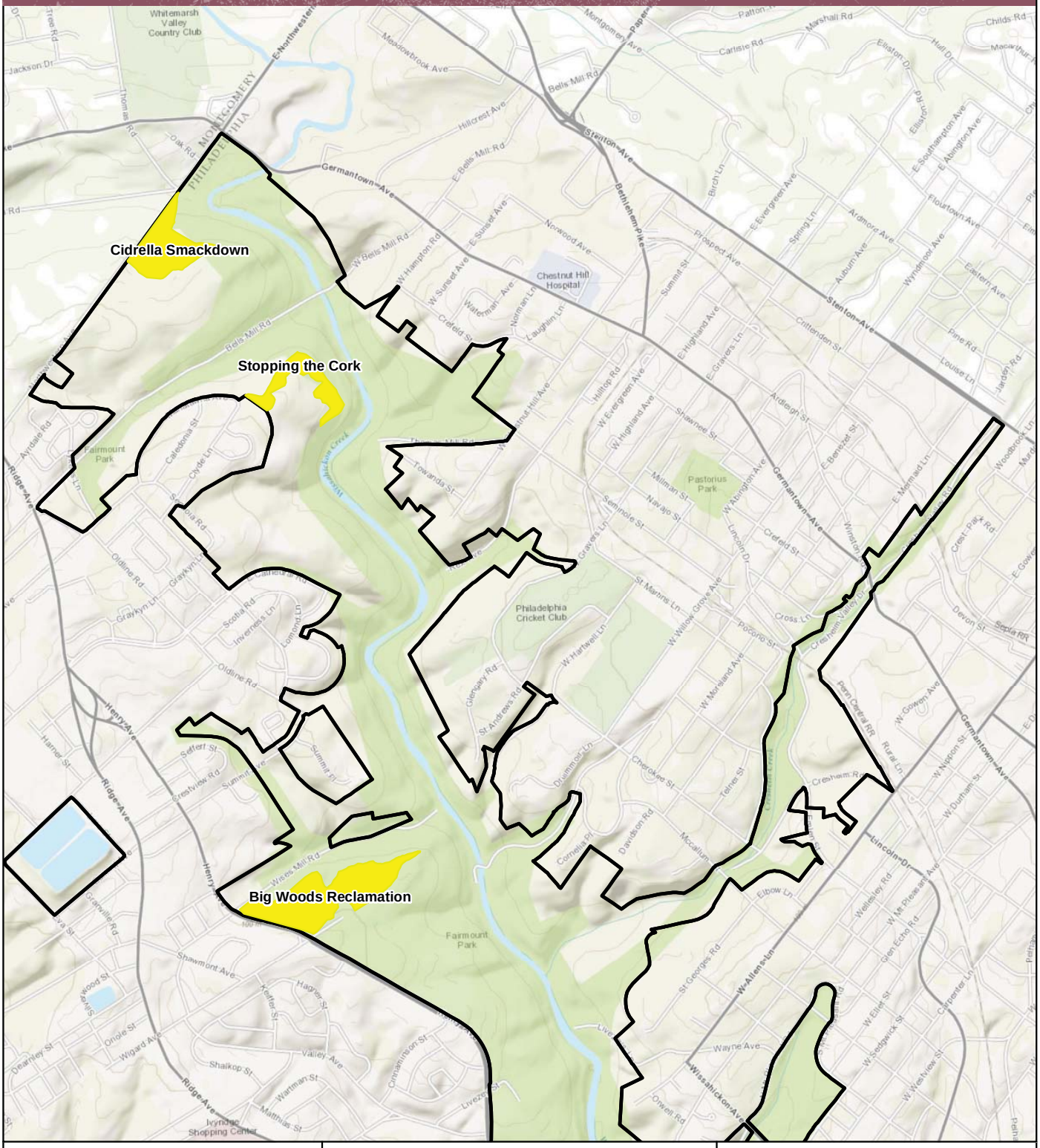


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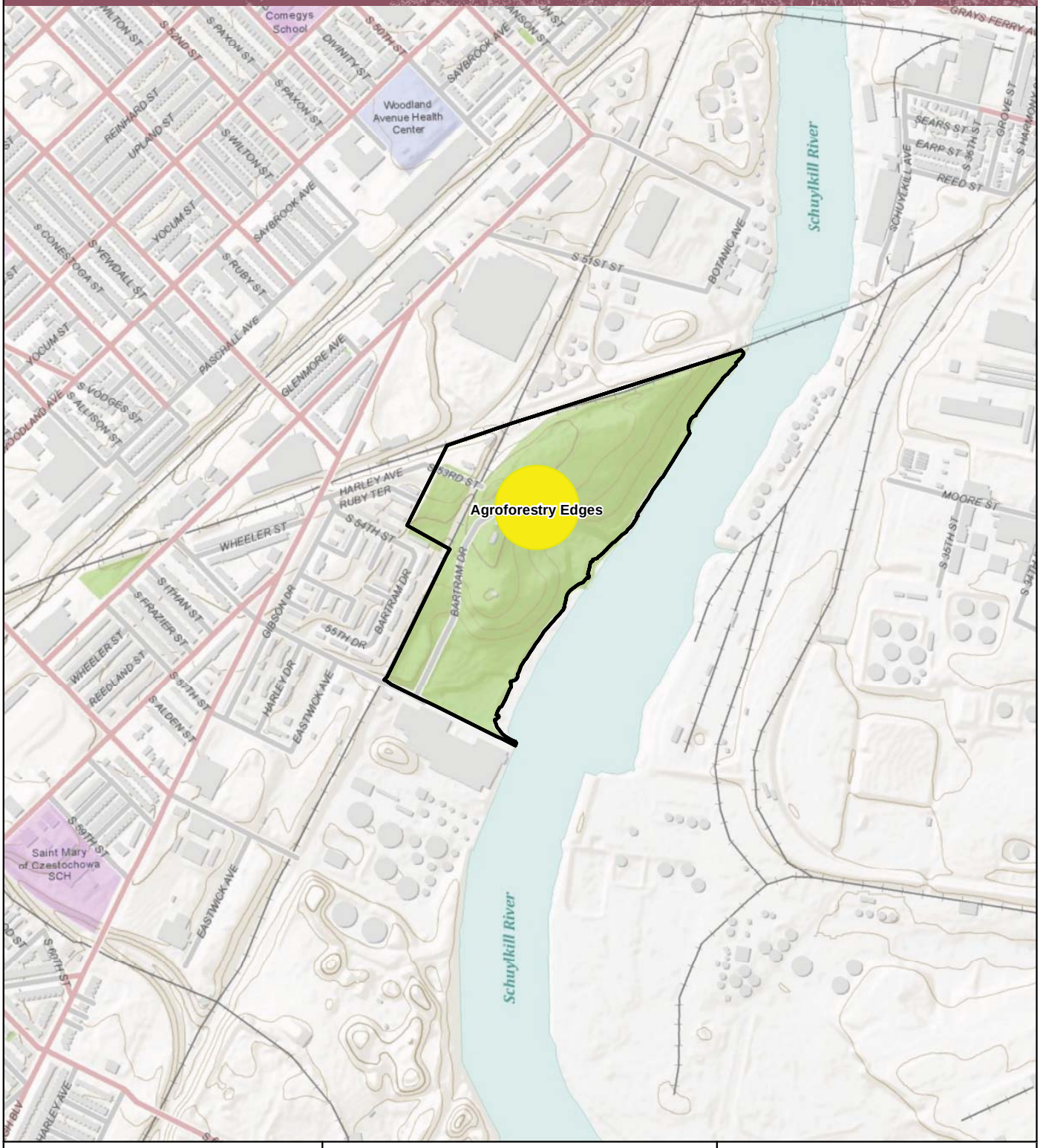
Figure IV–8



Pilot Projects

BARTRAMS

PHILADELPHIA PARKS & RECREATION · Biohabitats

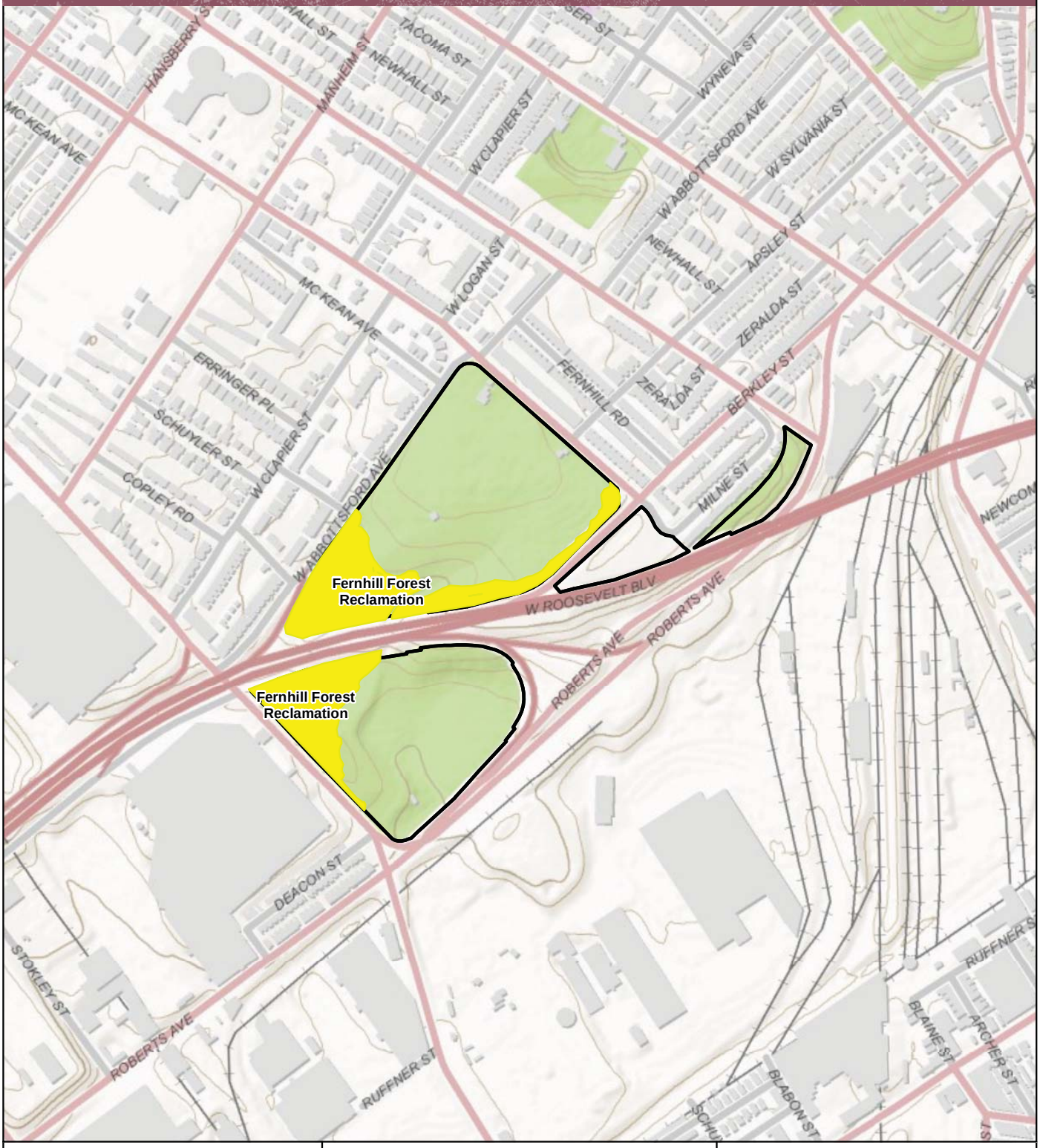
Pilot Project

0 500 1,000

Feet

Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure IV–9



Basemap Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, AND, USGS, NRCAN, and the GIS User Community

Figure IV–10

4.4 Funding Needs to Achieve Goals

Maintaining and operating a large municipal park system requires significant expenditures of capital for staff time, equipment procurement and contracting. The associated challenges of park management are particularly difficult in periods of challenging economic and fiscal spending reductions. As one of the objectives of PP&R, maintaining the ecological integrity of park system natural lands requires sufficient investments, in order to maximize natural capital or park use and program value. The following section describes some of the expenditure needs for restoration and care, in order to accomplish more effective parkland forest management.

Staff work on invasive tree removal

The current restoration project staffing and can be summarized as follows:

- For all the project sites in all the parks, the City has two staff people dedicated to full-time fieldwork in natural areas.
- Part of their responsibility is to oversee contract work (e.g., herbiciding).
- Having volunteer workers is very helpful, but staff is necessary for a variety of reasons–including their capacity to run power saws and other equipment, apply herbicides, etc.

4.4.1 Staffing and Equipment

Current Staffing and Equipment

The current Natural Resources staff is comprised of one each of the following positions:

- Division Director;
- Administrative Systems Manager;
- Director of Natural Resources;
- Project Manager;
- Restoration Field Supervisor;
- Land Steward; and
- Native Plant Nursery Manager.

The Restoration Field Supervisor and Land Steward are the only field staff. The total annual cost for all seven staff is $390,000. Volunteer Coordinators are within a different division of PP&R and are leading volunteer work projects in the wider park system, including recreation centers, as well as in natural areas.

Current equipment maintained by Natural Resources includes:

- Three 1998 Ford Explorers
- Kubota L4330 tractor with bucket, mower, and post-hole digger
- Truax drill seeder (owned by PWD)
- 15-hp walk-behind brush mowers (2)
- Chain saws
- Backpack sprayers
- Hand tools

Proposed Staffing and Equipment

Current natural resources staffing levels are inadequate to address the scope and diversity of required work in park natural areas. Not only are there a wide range of stressors that continue to impact these areas, but the number and collective acreage of restored sites has already exceeded the capacity of staff who can effectively monitor and maintain them. Staff have the expertise and willingness to restore and maintain sites, but do not have enough time to regularly address all sites. In short, the 5,400 acres of park natural areas calls for more than two full-time field staff.

Because of this deficit, at least one (ideally two) full-time field crew (3-4 people, including crew chief) needs to be dedicated to natural lands restoration and maintenance. Thus, a minimum of two additional full-time field staff need to be dedicated to natural lands restoration and maintenance in Philadelphia Parks. Combined with the two current field staff, this would allow for a regular 4-person crew. Such a crew would monitor and maintain hundreds of acres of previous project sites and conduct large-scale restoration projects on new sites. A crew could implement large invasive clearing projects, maintain plantings, repair trails, oversee contract work and perform a myriad of other needed tasks. They would utilize heavy equipment for natural lands projects. A crew would expand the capacity of PP&R to maintain its neglected forests, facilitate the work of Volunteer Coordinators, and reduce demands on already-stretched District Operations staff. Having at least one in-house restoration crew is a necessary way to fill an important "niche" in a comprehensive restoration strategy.

The initial cost for two additional staff members (to create a crew of four) is approximately $90,000 including benefits. Raising the annual budget for Natural Resources staff to $500,000 would allow for the addition of these two field work-

ers, and allow for salary adjustments as appropriate. Raising the annual staff budget to $580,000 would allow four field staff to be added to create two 3-person restoration crews.

The quantity, magnitude, scope, diversity and complexity of challenges in the natural areas require that a variety of means be utilized. In addition to labor needs, there is a need for equipment that is appropriate for the challenging conditions associated with resource management in park natural areas. Such equipment would significantly enhance staff capacity. The following table indicates the additional equipment needs (and associated costs) of a dedicated restoration crew.

Table 5. Additional equipment needs (and associated costs) of a dedicated restoration crew

ITEM	APPROXIMATE COST
Ford F250 Super Duty 4x4 Supercab pickup truck (2)	$90,000 ($45K each)
Caterpillar 299D Compact Track Loader w/ bucket	$ 85,000
Loader attachments	
72" mulcher	$ 32,000
BR166 Brush mower	$ 6,000
79" 6-way dozer blade	$ 6,000
66" industrial grapple forks	$ 6,000
Ripper/scarifier	$ 2,000
Flatbed equipment trailer	$ 4,000
John Deere XUV 4x4 utility cart	$ 10,000
Truck-mounted tank sprayer (200 gallon)	$ 4,000
Ford F550 single-axle dump truck	$ 50,000
Total	**$ 295,000**

Any of the equipment that can be obtained for PP&R Natural Resources would be a valuable asset, and further the ecological protection goals for parkland forests.

Other Costs

Funding is also used each year to purchase the following:

- Materials and supplies (e.g., herbicide, erosion control materials, safety supplies)
- Hand tools (e.g., pruning saws, shovels)
- Small equipment (e.g., chain saws, backpack sprayers)
- Nursery supplies (e.g., containers, growing media, fertilizer, irrigation)

Currently, annual costs for such materials and supplies are roughly $25,000. Natural Resources has been able to utilize budgeted PP&R funds for these purchases, and anticipates being able to do so in the foreseeable future.

A field crew ready to work

Contractor Project Costs

The scale of work needed in natural areas demands that a variety of tasks be done by contractors. For example, each year herbicide applications for invasive species control are done on more than 50 acres of natural lands. This far exceeds staff capacity. The work is done by a contractor, but overseen by Natural Resources staff. PP&R typically plants 5,000 or more trees and shrubs each year, which also exceeds staff capacity. Natural Resources staff identifies planting sites, map the sites, develop planting plans and work with contractors to both purchase and install most plants. Other types of work that necessitates contractors are projects that require large-scale invasive plant clearing; forestry mowing (shredding woody debris to prepare site for planning); removal of hazardous trees; extensive excavation or grading; deer fence installation; or use of specialized equipment. Some large projects also require consultants to develop design and permitting plans. Consulting fees must be paid from contract funding.

Funding needs for contractor projects vary widely year to year, depending on the particular projects that are planned and the availability of other funding (e.g., grants). From 2000-2012, annual spending on contract projects averaged about $700,000. The majority of this funding has come from grants, which are for specific types of work (e.g., stormwater management). In recent years, annual contractor project costs paid directly by the City have been roughly $100,000, with half this amount going to herbicide application and planting. It is recommended that regular annual funding for contractor work increase to $500,000 - $700,000. Additional dedicated funding for contract projects will give PP&R the capacity to implement projects that are highest priority in a predictable schedule, including demonstration projects identified in this report.

The following table summarizes current annual funding vs. proposed annual funding needs, based on the above discussion of both staff and contractor work:

Table 6. Current and proposed annual funding for park natural lands restoration

	CURRENT FUNDING	PROPOSED FUNDING	PROPOSED INCREASE
Staff	$390,000	$500,000 – $580,000	$110,000 - $190,00
Contract projects	$100,000	$500,000 - $700,000	$400,000 - $600,00
Total	**$490,000**	**$1 million - $1.28 million**	**$510,000 - $790,000**

The following table reflects average costs for typical contract restoration work in Philadelphia Parks:

Table 7. Average costs for typical contract restoration work in Philadelphia Parks

PROJECT TYPE	COST
Invasive plant clearing and stabilization (large sites)	$6,000/acre
Invasive plant clearing and stabilization (small sites)	$12,000/acre
Reforestation planting	$ 8,000/acre
Deer fence installation	$8/linear foot

V–Reference List

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VI–Appendices

Appendix A – Literature Review Abstracts in Chronological Order

As noted in the body of the report, a series of studies and restoration plans were completed between 2001 and 2012, providing a rich resource of assessments done in the parks, as well as planning guidance for future restoration and management of the parks as a whole.

2001

The Natural Lands Restoration Master Plan by the Academy of Natural Sciences of Philadelphia provides a detailed assessment of the restoration opportunities for the natural lands throughout the seven stream valley parks (Academy of Natural Sciences of Philadelphia, Patrick Center for Environmental Research and Biodiversity Group, Fairmount Park Commission2001). The first volume sets the context for the parks, their history and the importance of forest cover to the City of Philadelphia in considering a master plan for ecological restoration. "First established in 1855 in an effort to protect the city's water resources, the park system has grown to include 8,900 acres, constituting 10% of the area of the City of Philadelphia." Information on restoration, landscape ecology, and ecological principles of particular importance in restoration planning is followed by suggested restoration goals used to guide restoration planning and implementation. The next two sections describe the assessments of past and current conditions of the flora, including historic forest species and with small subsections devoted to each of the stream valley parks and fauna including some rare bird species and streams (Section 5) of the park system.

Forest-dwelling bird species decline in the park includes: ground nesters including hooded warbler, ovenbird, and Kentucky warbler (all of which have been adversely effected by the rise in deer population); broad-wing hawk; and Coopers hawk. Fifteen species noted as species of concern by the Carnegie Museum of Natural History are documented as breeders in the park system or nearby. "Management for some of the species (bluebirds, purple martins, and wetland specialists) would go far to improve the value of the Fairmount Park system as a refuge for endangered birds"(Academy of Natural Sciences of Philadelphia, Patrick Center for Environmental Research and Biodiversity Group, Fairmount Park Commission, 2001, I-57).

Exotic plants of note throughout the parks include: Norway maple, Japanese knotweed, multiflora rose, garlic mustard, common reed, purple loosestrife, ailanthus, mile-a-minute, paper mulberry, winged euonymous, wineberry, amur honeysuckle, lesser celandine, goutweed, Japanese hops, Japanese stiltgrass, Japanese honeysuckle, oriental bittersweet, and wisteria. Vines are noted both for their advantages and disadvantages: native vines provide an important food source for birds but the invasives are easily spread by the birds.

"Restoration may include establishing large habitat patches and allowing cycles of disturbance and succession within parts of these areas. It involves recognition of unusual habitat patches and both high quality late and early successional habitats. The high quality mature forests should be protected and enhanced, (e.g., by increasing size, reintroducing missing flora or fauna). Management of the early successional habitats will be necessary to maintain them. For many of the moderate quality forest

patches, management should aim at reducing disturbance. In the areas surrounding the natural lands, efforts should be made to work with managers to increase their natural value, e.g., by landscaping with native species and mowing open lawn areas less frequently" (Academy of Natural Sciences of Philadelphia, Patrick Center for Environmental Research and Biodiversity Group, Fairmount Park Commission, 2001, Page I-12).

One point of interest in the summary of forest goals is that there is a higher priority on those habitats that have seen a disproportionate habitat loss, including the Coastal Plain Forest. The park-specific studies include information on stresses and restoration activities considered in developing the plans, the list of recommended restoration activities, a short description of the overall restoration strategy, general recommendations relating to restoration, and summaries of each high priority site. Each section includes a brief historical summary. For each park description there is an existing conditions inventory that includes a description of vegetation and flora, as well as fauna and associated important habitats.

Restoration of forested uplands and riparian zones in each of the parks includes recommendations associated with forest management for the following: planting of native species, invasives control, trash removal, protection of high quality areas, repair of gullies, increased forest area, decrease areas of mowing, removal of problematic invasive species like Japanese knotweed, regrading or stabilization of stream banks, replanting with native forest corridors of at least 35', control of ATV use and other prohibited activities, alleviating stormwater pressures, removal of trash and abandoned cars, protection of high quality forest areas, and enhancing natural lands that provide important habitat for breeding birds,

The appendices contain supporting data, including information on each of the high priority restoration sites, technical information supporting the information in the assessments and other sections, and a glossary of terms. Data from this study and associated restoration plan has been used in this forest management framework assessment mapping.

The following appendices and tables are included in the third volume of the report:
Appendix A-1.1 – Inventory of plant occurrence in the Fairmount Park system.
Table A1.4 - Records of plants from Wissahickon Valley Park and adjoining areas.
Appendix A-2.2 Park-specific list of individual bird indicator species observed in 1998 in Fairmount Park System.
Appendix A-2.3 – Historical Accounts of birds in Pennypack Creek Park.
Appendix A-2.4 Historical account of birds in Wissahickon Creek Park.
Appendix A-2.5 Historic account of bird occurrence in Tacony Creek Park.
Appendix C – Plant lists.
Appendix C-2 Deer Browse Survey and Monitoring Protocol.
(Academy of Natural Sciences of Philadelphia, Patrick Center for Environmental Research and Biodiversity Group, Fairmount Park Commission, 2001).

2002

The **2002 manual of the NLREEP** program training is a synthesis and amalgamation of materials prepared for technical training session, as part of the restoration education known as the Natural Lands Restoration and Environmental Education grant (conducted between 1999-2002) (Munro, 2002). The focus is on ecological restoration and management of natural lands within Fairmount Parks. General assumptions about forested lands in the parks include: the primeval forest cannot exist in Philadelphia parks again; the Lenape will not return to provide their management methods; the balance has been severely tilted and will take much time to return; exotic species are always able to recolonize, if not removed; certain original natural factors cannot be returned to the system; human tending of the balance is both necessary and natural; human tending must be oriented toward maintaining a balance, not tilting it. Other sections include information on restoration of native plant communities, forest restoration, monitoring, and adaptive management, trails design and maintenance, definitions, management, removal techniques, a checklist and other resources for exotic plant species. The last section gives information on volunteer activities, coordination and management.

2005

The 2005 publication, **"Value of Trees Statistics Sheet",** published by the USDA Forest Service provides several statistics addressing the City of Philadelphia's woodland resources, as well as broader statistics that reinforce the importance of enhanced resiliency in our urban forests (USDA Forest Service, 2005).

- Philadelphia's 2.1 million trees currently store approximately 481,000 metric tons of carbon with an estimated value of $9.8 million
- Trees reduce runoff and erosion from storms by about 7% and reduce the need for erosion control structures. In urban areas with trees, the use of smaller drainpipes can save cities on materials, installation and maintenance
- Modest increases of 10% canopy cover in the New York City Area were shown to reduce peak ozone levels by up to 4 parts per billion or by nearly 3% of the maximum and 37% of the amount by which the area exceeded its air quality standard. Similar results were found in Los Angeles and along the East Coast from Baltimore to Boston.
- Leafy tree canopies catch precipitation before it reaches the ground, allowing some of it to gently drip and the rest to evaporate. This lessens the force of storms and reduces runoff and erosion. Research indicates that 100 mature tree crowns intercept about 100,000 gallons of rainfall per year, reducing runoff and providing cleaner water.
- Trees in urban parks and recreation areas are estimated to improve outdoor leisure and recreation experiences in the United States by $2 billion per year.

2007

The 2007 report **"Assessing urban forest effects and values"**, uses the UFORE model and data from a vegetation assessment completed in 1996. The report summarizes results and values of: forest structure, potential risks to forest from insects or diseases, air pollution control, carbon storage, annual carbon removal, changes in building energy use. One particularly interesting piece of data is Appendix

IV, Tree Planting Index Map, which shows the locations for priority tree planting. It is considered a type of 'environmental equity' index with areas with higher human population density and associated areas of lower tree cover (Nowak et al, 2007).

2008

The Trust for Public Land for the Philadelphia Parks Alliance published a report, **How much value does the City of Philadelphia Receive from Its Park System,** examining the value that the city gains from its Parks and recreation space (Trust for Public Land's Center for City Park Excellence, 2008). The report's goal was to address the issue of the parkland being undervalued in the City of Philadelphia. It relies heavily on USDA Forest Service data from Philadelphia and other cities with regard to forest canopy. The research undertaken for the Parks Alliance shows that the parks provide the city and its residents with $23 million in city revenue; $16 million in municipal cost savings; and $1.1 billion in cost-savings for citizens.

"The Philadelphia Parks Alliance is calling on the city to take three steps to fully and adequately fund the city's park network: Mayor Nutter's proposed 5 year budget increase of 46% for Fairmount Park should be fully realized, beginning with a $3 million increase for parks and trees in the coming year. Work must begin now to identify, secure and leverage new and diverse funding streams for the park. State and federal environmental and recreational funds must be aggressively pursued. Creative collaborations with local and national foundations are essential and revenue generated in the park must stay in the park. Work must also begin on a detailed inventory of all park properties and facilities. Park officials estimate that at least $30 million may be needed for annual operations, along with $85 million for capital repairs, but too little is known about the precise condition of our park infrastructure. Any serious fundraising effort must be guided by a clear understanding of the problems at hand. This inventory should be completed by May 2009" (Trust for Public Land's Center for City Park Excellence, 2008).

The **Natural Heritage Inventory of Philadelphia County** (Western Pennsylvania Conservancy, 2008) focused on enhancing the City of Philadelphia's understanding of existing and potential ecological resources, building on the work already done in the Fairmount Parks Master plan effort. The Pennsylvania Natural Heritage Program conducted surveys on public and private lands not included in the original Fairmount Park Master Plan and on lands not currently managed as parks. The survey efforts primarily focused on the discovery of new populations of plants and animals considered rare, threatened or endangered within the Commonwealth. The areas mapped support species of special concern, including natural communities of value and their associated ecosystem character. Overall, 29 sites were identified in 2007 and of them 22 were included in this inventory. Of the 22, 10 appear to be in the vicinity of Parks and Recreation Lands with associated species of concern: Cobbs Creek Park and Greenway (elephant's foot – *Elephantopus carolinianus*); Fairmount Park (pied-billed grebe – *Podilymus podiceps*); Franklin Delano Roosevelt Park (tidal species); Pennypack Park (nesting osprey – *Pandion haliaetus*, hallow pennant dragonfly – *Celithemis eponina, and* marsh wren- *Cistothorus palustris*); Poquessing Creek Greenway, Poquessing Creek Uplands and Benjamin Rush State Park; Tacony Creek Park; and Wissahickon Valley (meadow species of concern). Each of the sites is highlighted with some

mapping of opportunities areas. A theme that seems to emerge amongst different documents is the suggestion that maintaining and increasing contiguity and connectivity of forested lands is important for enhanced habitat value and function, as well as supporting and enhancing ongoing restoration. Issues of note include illegal dumping, deer, CSOs, stormwater management and non-native invasive species. Species of concern vary within each park (Western Pennsylvania Conservancy, 2008).

The **Stewardship Handbook for Natural Lands in Southeastern Pennsylvania** by the Natural Lands Trust, published in 2008, highlights major stewardship issues: deer overabundance, fragmentation and edge effects, invasive plant species, dead wood, and water resources (Steckel, David B.; Harper, Holly M. 2008). Forest management with a focus on invasive species is included under Stewardship Techniques and Procedures. There is also a whole chapter on Native Plant Materials that may be a very valuable reference for plant palettes already developed for the Philadelphia region.

2009

Connections: The Regional Plan for a Sustainable Future, adopted by the DVPRC Board on July 23, 2009, is a blueprint for the future growth and development of the Greater Philadelphia region, with an emphasis on the transportation system (DVRPC, 2009). The Connections Plan identifies four integrated principles to achieve a sustainable future by 2035. The four principles are managing growth and protect resources, develop livable communities, build an energy-efficient economy, and establish a modern multi-modal transportation system. Goals to manage growth and preserve open space, improve air quality, and manage stormwater each mention forest/woodland protection.

The Philadelphia Academy of Natural Sciences ornithologists have described the loss of early successional habitats as the "most important threat to bird populations in Philadelphia" (US FWS 2009). This threat is common to many natural areas in the eastern U.S. "Treaty funds have been set aside to help assist Fairmount Park in reclaiming fifteen acres of degraded grassland and shrub habitat in the Wissahickon section of the Park. It represents the beginning phase of reclaiming 45 acres of an area known as Houston Meadows, which was a 70-acre grassland as recently as 1970… Philadelphia is positioned at the intersection of numerous migration routes, making it a particularly important city in terms of the large number of migrants passing through. The need to ensure the availability of habitat where birds can quickly restore depleted energy is critical. Treaty funds are being used to provide support to the Migrant Stopover Ecology Study. This project, designed to assess the ecological value of habitat in the West Park section of Fairmount Park, is a collaborative effort involving the Philadelphia Zoo, Audubon Pennsylvania, Fairmount Park and researchers at the Wildlife Conservation Society/Bronx Zoo Department of Ornithology" (US FWS 2009).

2010

The 2010 **Natural Areas Stewardship Plan and Trails Recommendations for the Manatawna Farm and East 33 Properties** presents a plan for stewardship of natural resources at continuous properties along the border of the City of Philadelphia, and not far from Wissahickon Valley Park (Natural Lands Trust. 2010). It includes forest, farmland, meadow and is near the Schuylkill River. Manatawna Farm is actually

owned by the City of Philadelphia and managed by Parks and Recreation, as part of the 9,200-acre Fairmount Parks system. It provides guidance in management and restoration of natural areas based on the following priorities: restoring and managing native forests, meadows and wetland resources to benefit migratory wildlife; maintaining properties for passive recreational uses along sustainable trails; and continuing agricultural operations in a sustainable and wildlife-friendly way. There is a section on forest sustainability. There is a whole chapter on trails recommendations. Other key items of potential interest include: Appendix B – Pennsylvania Natural Diversity Inventory Environmental Review; Forest Habitat Management recommendations in Appendix C, from the Pennsylvania Game Commission (pages 2-7); and excerpts from the Natural Lands Trusts' Stewardship Handbook for Natural Lands in Southeastern Pennsylvania (2008) including invasive species management, native plant materials lists, deer management, meadow management, and hazard tree monitoring.

The Penn Praxis **Green 2015 Plan** provides an action plan for greening across the City of Philadelphia in the next 3 years, with the goal of addressing the first 500 acres of change. It wants to redefine the term "park space" (Penn Praxis 2010). It sets out goals for what is to be accomplished by 2015 and lists priorities for new parks across the city, including "environmental benefits of regional significance." Mapping includes school yards and park land as opportunities for connections. This relationship will be interesting in terms of future stewardship and educational partnerships. "The goal of Green2015 is to unite city government and neighborhood residents to transform empty or underused land in Philadelphia into parks for neighbors to enjoy. Most of the land that can be greened is already publicly owned and therefore requires no money to acquire. The planning, implementation, and maintenance of these parks will be a collaborative effort among many partners, including neighbors, businesses, nonprofits, developers, and the city" (Penn Praxis 2010). http://planphilly.com/green2015-action-plan-first-500-acres

In 2010 a collaborative effort between Temple University, Philadelphia Zoo, Fairmount Parks, PHS and Germantown Friends School was begun, in order to germinate new native tree seedlings and plant them as part of forest restoration strategy within the parks (Monheim, Eva, Grace Chapman, Mark Raczynski, Valerie Packham, Tyler Troxell, Lawton Atlee, and Andrew Kirkpatrick. 2010). The goal is to restore 8 acres of forest. Due to the loss of several rare specimens at the school, Temple University and Ambler Arboretum faculty and staff identified the need to preserve and restore the collections as well as enhance them for student learning. The first planting of seedlings was planned for sometime between August 2010 and August 2012.

GreenPlan Philadelphia, 2010, identifies a series of opportunities to help achieve a resilient urban forest and makes the case that an open space system, and its associated benefits provide essential function within a network of environmental, economic, and quality of life benefits (Wallace Roberts Todd, 2010). Two of the indicators used are habitat and productive land use. Objectives include improving the health of the watersheds, creative or sustaining a competitive economy, and providing convenient recreation access. The plan builds on the 2009 long-range plan to the year 2035, developed by the Delaware Valley Regional Planning Commission, which outlines a web of resources aligned with riparian

corridors, major historic and cultural corridors, and trail opportunities. The GreenPlan recommendations align with those in the plan.

The plan begins by laying out a framework of benefits within the environment, economy and quality of life, focusing on the elements of each that help to define Philadelphia. The key elements of Green Places in terms of the network of benefits that are identified in the GreenPlan are trees, stormwater management, meadows, trails and bikeways, wetlands, urban agricultural and community gardens, high performance surfaces, and renewable energy. The Green Places that they have focused on for future changes toward improved connectivity and function include Parks and Recreation at the top of the list.

With regard to trees, the long-term vision is for a forested city. The goal is to achieve 30% tree cover in every neighborhood and increase park space to ten acres of park space for every 1000 residents. Those neighborhoods closest to the stream valley parks are probably much closer to this goal than other parts of the city. Ideally this reforestation of the neighborhoods wouldn't just be piecemeal plantings but something more akin to strengthening forest connections to the existing forest in the stream valley and other public parks, reaching out from these resources and strengthening the interior through strengthened forest edges. It was noted that approximately 57% of the trees in the city are under the management of Parks. However in neighborhoods with smaller plantable areas on the residential properties the city needs to maximize street plantings in order to increase tree canopy. Key issues to the overall forest health and function of the urban forest stands in Philadelphia are deer, invasive plant species and other pests, and soil erosion. In order to achieve the 30% canopy cover within the city the Plan calls for one million trees to be planted. One key recommendation directly relevant to Park forests is to restore the city's forest and increase forested land to 7,200 acres, based on the current forested land acreage of 6,746, which would require 136,200 trees ((Wallace Roberts Todd, 2010, page 71). Two other key tools that are identified as important for urban forest management is a street tree inventory and a digitized tree-information management system, both of which may already be underway, as the Parks department continues to refine data sets associated with the urban canopy and await an i-Tree study currently being completed by the USFS. There is also a goal for 292 miles of waterway edges with riparian habitat, increasing from the current 248 miles.

Another important priority identified in the plan is for increased ecological diversity, particularly with regard to meadow habitats, which are identified as important edge and opening spaces within the forest ecosystem matrix. One of the listed goals is to improve existing meadows and create 220 acres of new meadows across the parks. It is apparent from recent visits to the Parks that there have been notable efforts toward this end in the last several years, including a number of the ARRA projects.

Another desire is to expand the trails and bikeways across the city, to improve connectivity and access. It is noted that a trail system is an essential component of an overall strategy for urban sustainability and open space. It will be important to make sure that any new trails suggested in this plan would not fragment interior forest patches of significance across the city's stream valley parks, as described and shown in this report.

Clean water is highlighted with regard to wetlands and their ecological benefits associated with ecological services as well as stormwater management, economic and recreation opportunities. Parks and Recreation is acknowledged both as a major landowner and a key opportunity for expanding park lands and opportunities for ecological diversity, habitat enhancement, recreation space and healthy waters. One target is to increase park space to ten acres of parkland per thousand residents. And a key recommendation is to acquire and develop new parks to form an integrated and interconnected system of parks, trails and habitats.

In December 2010 the University of Vermont Spatial Analysis Lab, working with the USDA Forest Service Northern Research station provided a report on the **City of Philadelphia's Existing and Possible Tree Canopy** (O'Neil-Dunne 2010). This report examines tree canopy throughout the city of Philadelphia, as it related to land use types and also how it fares within the parks. The assessment reveals potential opportunities to increase coverage in certain parks, including Pennpack on the Delaware, the lower portions of Fairmount Park (East/West) and FDR park. It also examines tree canopy by neighborhood, through planning districts, by subwatersheds, by zip code and socio-demographic variables (to start to tease out potential environmental justice opportunities). Conclusions included:

- Canopy improvement should be focused on parcels in the city that have large contiguous impervious surfaces
- Programs that educate residents on tree stewardship and provide incentives for tree planting are crucial.
- Socio-economic conditions and extents of tree canopy can be summarized to target tree planting and preservation efforts in different parts of the city.
- The city's rights of way contain 16% of existing canopy and 32% of possible canopy, suggesting that opportunities exist for increasing the number of street trees.

In 2010 Robert Loeb published the article, **Diversity gained, diversity lost: long-term changes in woody plants in Central Park, New York City and Fairmount Park, Philadelphia**, which examines changes in species diversity in Central Park and Fairmount Park from their beginnings (mid-late 1800's) to the 1970's. Loeb noted that species diversity was greatest in Fairmount Park in 1880. The change in species was "less than 50% increase in native trees, close to doubling of native shrubs, greater than 350% increase for alien trees; and more than four-fold increase in alien shrubs" (Loeb 2010, 126). By 1970 Fairmount Parks total species diversity was 2/3 less than it was at its height, through a combination of visitor abuse of the parks and natural calamity. Loeb's conclusion is that to maintain plant diversity in parks there must be a combination of education toward more conducive visitor behavior toward plants and soils; as well as supplemental/replacement plantings (Loeb 2010).

2011

The 2011 **Benefits of Trees and Urban Forests: A Research List** includes a few Philadelphia-specific stats of relevance for consideration of Woodland resources and need for conservation, restoration and resilience in function (Alliance for Community Trees, 2011).

- Philadelphia's $1.5 billion stormwater management plan focuses almost exclusively on eco-friendly solutions--bioswales, permeable pavement, street trees--as a way of reducing the city's 15 billion gallons of annual water overflow.
- The stormwater management value of Philadelphia's parkland and trees is $5.9 million annually.
- Trees and shrubs in Philadelphia removed 971 tons of air pollution annually at value to society of $4.8 million.
- Philadelphia's water management plan includes improved and built green areas to capture stormwater, which will increase nearby property values by $390 million.
- New tree plantings increased surrounding housing values by approximately 10%, in the Philadelphia neighborhood of New Kensington, which translates to a $4 million gain in property value through tree plantings.
- According to Time Magazine in 2007, San Diego lost a quarter of its tree cover; the tree cover in Michigan, North Carolina and Florida has fallen to 27% of what it once was; Chicago and Philadelphia are just 16%.
- Philadelphia lost 200,000 shade trees between 1976 and 2004, according to a 2004 study by forestry consultants.

Appendix B - Spatial Assessment Figures

Regional Landscape Ecology Mapping

Forests - Figure B–1

This figure presents existing forest and core forest habitat within the 50-mile radius zone described above. Landcover data was extracted from the National Land Cover Dataset (NLCD) provided by the USGS. NLCD is a 30-m resolution raster dataset, and is of a suitable resolution for analysis at this scale. All forest cover types in the NLCD were reclassified to a generic 'forest' type. This provided the basic distribution of forest cover. In order to determine core forest habitat, the forest cover was buffered 100-m inward from the edge of each polygon, any patches of forest existing more than 100-m from the edge of a forest patch were classified as core forest habitat and sorted by size. All figures include water body and stream data extracted from the NHD Plus hydrologic dataset, obtained from EPA/USGS.

Forest Gaps - Figure B–2

To identify isolated forest patches within Philadelphia, a gap analysis was conducted using the vector-based landcover dataset provided by PPR. A minimum threshold of 1 acre was selected, and all forest patches 1 acre or greater were initially displayed. Upon examination of the data subset, it appeared that some patches of forest were neighborhood street trees, which were being captured as true forest patches. This was due to the forest land cover type in this dataset being identified via canopy extent. In order to remove non-forest tree patches from the data, the Natural Heritage Inventory (NHI) potential green space layer provided by PPR was added to the model. All forest patches over one acre that intersected the NHI layer were retained, while all others were removed. Using ArcGIS the distance from each forest patch in the resulting dataset to its nearest neighboring patch was measured, and the results were sorted by distance. Additionally, the hydrological polygon and plotline data provided by PPR was buffered outward 100ft to illustrate riparian zones around hydrologic features (streams and creeks). Wetland data is taken from the National Wetland Inventory (NWI) provided by USFWS.

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FIGURE B-1 REGIONAL LANDSCAPE ECOLOGY: FORESTS

50-mile Buffer
Philadelphia City Limits
State Border
Forest

Core Forest

0-250 Ac.
250-500 Ac.
500+ Ac.
Water
River/Stream

N

0 2.5 5 10
Miles

Biohabitats
Incorporated

PHILADELPHIA
PARKS & RECREATION

FIGURE B-2
FOREST GAPS

Legend

Patch Distance (ft)

- 0-100
- 100-250
- 250-500
- 500-1000
- 1000+
- Study Area Parks
- Water
- River/Stream
- NWI Wetland
- 100m Hydro Buffer
- Streets

N

0 0.5 1 2

Miles

Biohabitats

Appendix C – Site Observations

The following are summarized observations made during the team's brief field visit hosted by Philadelphia Parks and Recreation.

Fairmount Park West

Greenland Nursery and Recycling Center: An area of heavy deer browse, the nursery production area enclosed in deer fencing (about 11 acres); significant invasive species are present including vines (mile-a-minute, oriental bittersweet, porcelain berry, English ivy, Japanese honeysuckle) and trees (including tree-of-heaven and paulownia); Recycling Center wood waste collection and recycling (including debris from hurricane Sandy) and potential opportunity for re-use of certain wood and mulch as part of forest restoration amendments).

Fairmount Park East

Prior management and restoration includes reforestation plantings, meadow release (including old fill area meadow, about 7 acres) and coordinated volunteer restoration efforts. Forest impacts include deer browse damage and invasive plant species, stressors include roadway vectors and disturbed forest edges); and needs & opportunities include the potential for some additional reforestation plantings in select open areas and additional woodland invasive species management.

Tacony Creek Park

Adams Avenue to Roosevelt Blvd., new recreation path south of Roosevelt Blvd: Stream valley floodplain includes riparian forest, meadow and wetland areas. The new recreational path was still being paved at the time of the site visit. Prior restoration and management includes stream restoration, volunteer riparian plantings, slope reforestation, and native meadow establishment. Forest impacts and stressors include deer browse damage, Japanese knotweed re-colonization, porcelain berry invasion into plantings, lack of native understory and excessive downed woody debris. Management and restoration needs and opportunities noted include deer management (culling), additional Japanese knotweed and porcelain berry control, vernal pool wetland enhancement and edge area trash and debris clearing.

Pennypack Park

Pennypack on the Delaware, recreation path from Algon Ave. to Welsh Rd., Verree Meadow, and Fox Chase Farm: Areas of successional to maturing mid-succession forest along the path and main stream valley and slopes, with narrower riparian woody vegetation, open fields (including mowed lawn) along the Delaware, and at Verree Meadow and Fox Chase Farm. Prior projects along the path valley area include planting along the floodplain (limited success), planting along slopes and openings (trees & shrubs) including floodplain to upland and with Friends of Pennypack Trees & Trails Committee. Impacts and stressors along the valley include deer browse, path vectoring of invasive species, legacy sediment terrace and invasive species colonization (Japanese knotweed and mile-a-minute); associated needs and concerns over future ash tree management as emerald ash borer moves in as well as need for additional deer management and understory diversification.

Pennypack on the Delaware has an established native meadow area and scattered trees. Impacts and stressors include unplanned mowing by others, some areas of debris; and there are needs and opportunities to expanded parts of the riparian buffer, manage common reed invasion, and provide an evergreen tree roosting grove (not on fill mound).

Verree Meadow is a newly established warm season grass meadow along with perimeter woodland edge plantings of trees. In terms of forest edge impacts and stressors, extensive invasive species were removed here and there is a need for follow-up monitoring and some additional control of Japanese stiltgrass and mile-a-minute).

Fox Chase Farm has open fields, pastures, specimen trees and variable woodland conditions along the riparian buffers. Repairs have focused on drainage impacts. A wetland restoration included removal of a parking lot and the creation of a wet meadow near the dam area. The area has forest resource impacts associated with historic clearing, agricultural use and grazing. There is an opportunity to improve and expand some areas of riparian buffer, along with the potential to demonstrate working lands best practices for riparian buffer management and water quality protection.

Fernhill Park

This park includes open field, parking lots, scrub-shrub depressions, wooded slope and highly disturbed forest stands. Prior projects include a Forest Service project with invasives control and native plantings, along with clearing of invasive species on slopes and revegetation. Non-native invasive species and impacts occur in the highly disturbed forest stand, particularly impacted by extensive porcelain berry invasion along the ground cover and climbing trees, and along with additional Japanese honeysuckle and English ivy. Needs and opportunities include a potential project to provide significant invasive plant control (minimum 2 seasons) followed by future reforestation plantings and management.

On December 6, 2012 Biohabitats, Inc. visited Wissahickon Valley Park (Northwest Headquarters, Andorra and Houston Meadows, Carpenters Woods, Forbidden Drive, and Bluebell Picnic Grove; Fairmount Park West (Chamounix Stables); and Cobbs Creek Park (Naylor's Run, 72nd and City Ave., Morris Park, Church Lane, and Bocce Woods).

Wissahickon Valley Park

The Northwest (District 4) Headquarters area, a regional PPR maintenance yard located off of Henry Avenue, includes open storage and yard areas, fields, pond and swale and forest. Prior projects include stormwater best management practices including retention pond with native marsh plantings and an infiltration swale with native woody tree and shrub plantings. Site impacts that have been addressed by the projects include stormwater run-off from the service yard and gully erosion; and current impacts include non-native invasive and weedy plants. One additional opportunity in this area is treatment to reduce the abundance of locust saplings and invasive species management for Japanese honeysuckle, oriental bittersweet and European privet.

The Andorra and Houston Meadow sites are predominantly established native meadow with tree groves and a forested perimeter. Houston Meadow occurs over a unique geologic formation that influences soil character and vegetation. These projects sites are extensive meadow community restoration areas dominated by native warm season grasses. These sites involved extensive non-native invasive plant species removal and herbicide treatment and an area of deer exclosure fencing to protect a portion of the forest to establish understory re-growth. Related forest impacts have included woody vines invasion (heavily along edges and open areas) and substantial deer damage including browse and rubs. The needs and opportunities include annual mowing management of the meadow grasses, follow-up spot spraying of invasives, extended monitoring and the potential to expand deer fence protection to more forest area.

Carpenter's Woods, in the Mt Airy Neighborhood on the northeast side of the Wissahickon Valley park, is a deciduous forest stand in a neighborhood and it has undergone a restoration and management project to treat a variety of heavily invaded non-native plants including English ivy, pachysandra, burning bush, oriental bittersweet, Norway maple and Japanese knotweed (edges). Impacts and stressors to this Woods have included the invasive species mentioned, some deer pressure, and stormwater gully run-off. Additional opportunities include volunteer planting and management, additional herbicide follow-up treatment, and controlling areas of English ivy climbing up trees.

Forbidden Drive traverses the scenic and extensive deep valley along the Wissahickon through the heart of this historic valley along the creek floodplain, past iconic features such as the Valley Green Inn, and framed by forested slopes of deciduous forest and grove of the evergreen eastern hemlock. Prior restoration and management projects include open grass area conversion with reforestation plantings, invasive species including Japanese knotweed, wineberry, oriental bittersweet and other invasive vine clearing (including efforts of the Friends of Wissahickon 'Vine Crew'), trail closures and re-routes by Friends of Wissahickon (FOW), stormwater BMPs (including Valley Green rain garden), and numerous slope erosion, major gully repair/stabilization and native plantings (with PP&R, FOW and the Philadelphia Water Department).

The Bluebell Picnic Grove area includes parking and picnicking facilities, open lawn and deciduous woods edge. This area was the subject of a prior stormwater gully repair and stabilization project. The stressors in this area (and prior impacts) include stormwater run-off from roads and parking. Additional needs for this area include invasive species monitoring, and follow-up treatment of invasive vines and mugwort.

Fairmount Park West

Chamounix Stables: An area of mixed deciduous wooded slopes. This area is part of the on-going deer management program, and there have been volunteer clean-up, invasive control and planting projects. Stressors include extensive deer browse on canopy species saplings and only browse-resistant shrubs are present. An opportunity exists here to augment and protect the missing regeneration of native seedlings to saplings in order to provide for future forest canopy.

Cobbs Creek Park

Naylor's Run, 72nd and City Ave., Morris Park, Church Lane, and Bocce Woods: Morris Park is a neighborhood park with open parkland lawn and trees, gardens and forested areas with paths. Prior projects include an ARRA dead tree and invasive removal effort, park edge tree plantings, and wood chip trail mulching. Opportunities exist to tap into and augment the extensive volunteer steward work in the park to removal invasive species and perform follow-up maintenance. Related opportunities include providing additional resources to cut and spray tree-of-heaven. The 72nd and City Ave. area of the park includes an extensive wet meadow prior restoration project establish with wetland grasses and forbs adjacent to forest. Impacts and stressors to the forest include invasive vines along the edges and some evidence of deer browse. This area is one of the park restoration monitoring sites that have been recently evaluated. This site has the opportunity to inform adaptive management for woods and meadow edge transition areas.

Naylor's Run is an area with deciduous woods, scrub-shrub and open field cover. A project was completed in this area addressing stormwater drainage and wetland restoration with marsh plantings. Deer damage and the re-invasion of non-native invasive vines, including on trees, are noted impacts. In addition to additional invasive vine treatment this area could also provide expanded environmental education opportunities for wetland studies of water quality, vegetation and wildlife.

Church Lane is an area of mowed lawn, street trees, woodland edge and native plantings. An ARRA project here included invasive species management of Norway maple, bush honeysuckle, and other invasive vines as well as native tree planting with tree protection shelters. Forest impacts and stressors include edge invasion and deer browse. Management opportunities include follow-up treatment of Japanese knotweed and stewardship-based plant care.

Bocce Woods is an area with deciduous woodlands, tree plantings and scrub-shrub edges. Prior projects include invasive tree management for tree-of-heaven, Norway maple and cork-tree, and native reforestation plantings. Impacts and stressors include urban neighborhood interface, deer damage, invasive plants and drought after plantings. Additional opportunities here include woody debris management and beneficial use, developing a follow-up maintenance plan, bush honeysuckle removal, and additional Japanese stiltgrass and mile-a-minute invasive species management.

Appendix D – Partial list of Invasive Plant Species present in Fairmount Park system

Trees

- *Acer platanoides* Norway maple
- *Acer pseudoplatanus* Sycamore maple
- *Aesculus hippocastanum* Horsechestnut
- *Ailanthus altissima* Tree-of-heaven
- *Albizzia julibrissin* Mimosa
- *Alnus glutinosa* European black alder
- *Broussonetia papyrifera* Paper mulberry
- *Catalpa bignoniodes* Catalpa
- *Eudoia hypenhensis* Bee bee tree
- *Kalopanax pictus* Castor aralia
- *Morus alba* White mulberry
- *Paulownia tomentosa* Princesstree
- *Phellodendron levallei* Cork-tree
- *Prunus avium* Bird cherry
- *Toona sinensis* Cedrela/ Chinese toon tree
  (formerly known as Cedrela sinensis)
- *Ulmus pumila* Siberian elm

Shrubs and vines

- *Acanthopanax sieboldianus* Five leaf aralia
- *Actinidia arguta* Hardy kiwi
- *Aesculus parviflora* Bottlebrush buckeye
- *Akebia quinata* Fiveleaf akebia
- *Ampelopsis brevipedunculata* Porcelainberry
- *Aralia elata* Devils walking stick
- *Berberis thunbergii* Japanese barberry
- *Celastrus orbiculatus* Oriental bittersweet
- *Deutzia scabra* Deutzia
- *Eleagnus umbellata* Autumn olive
- *Eunymous fortunii* Running euonymous
- *Euonymous alatus* Winged euonymous
- *Hedera helix* English ivy
- *Ligustrum obtusifolium* Border privet
- *Lonicera japonica* Japanese honeysuckle
- *Lonicera maackii* Amur honeysuckle
- *Lonicera tatarica* Tartarian honeysuckle
- *Pachysandra terminalis* Pachysandra
- *Philadelphicus coronarius* Mock orange
- *Rhodotypos scandens* Jetbead
- *Rosa multiflora* Multiflora rose

- *Rubus laciniatus* Cut-leaved blackberry
- *Rubus phoenicolasius* Wineberry
- *Symplocos paniculatus* Sapphireberry
- *Viburnum dilatatum* Linden-leaf viburnum
- *Viburnum plicatum* Doublefile viburnum
- *Viburnum sieboldii* Siebold viburnum
- *Vinca minor* Periwinkle
- *Wisteria sinensis* Chinese Wisteria

Herbaceous Plants

- *Aegopodium podagraria* Goutweed
- *Alliaria petiolata* Garlic mustard
- *Artemesia vulgaris* Mugwort
- *Cirsium arvense* Canada thistle
- *Clematis terniflora* Sweet autumn clematis
- *Hemerocallis fulva* Orange day-lilly
- *Humulus japonicus* Japanese hops
- *Lythrum salicaria* Purple loosestrife
- *Macleaya cordata* Plume poppy
- *Microstegium vimineum* Japanese stiltgrass
- *Miscanthus sinensis* Japanese plume grass
- *Perilla frutescens* Beefsteak plant
- *Phragmites australis* Common reed
- *Polygonum cuspidatum* Japanese knotweed
- *Polygonum perfoliatum* Mile-a-minute
- *Pseudosasa japonica* Bamboo
- *Pueraria lobata* Kudzu
- *Ranunculus ficaria* Lesser celandine
- *Urtica dioca* Stinging nettle

Appendix E – Friends Groups in the City of Philadelphia

Friends groups are community-led organizations primarily established to support and advocate for specific park areas. Friends groups work in close partnership with PPR staff to create welcoming community green spaces and positive experiences with nature at the neighborhood level.

(Source: http://www.phila.gov/ParksandRecreation/getinvolved/friendsgroups/Pages/default.aspx, accessed on February 7, 2013.)

Center City

- Cianfrani Park
- Clemente Park and Playground
- Delancey/Three Bears Park
- Fitler Square
- Julian Abele Park
- Louis Khan Park
- Moyamensing Point
- Rittenhouse Square
- Schuylkill River Park
- Seger Park Playground
- Shot Tower
- Starr Garden
- Weccacoe Playground

North

- Campbell Square
- Fairhill Square
- Fischer Park
- Historic Penn Treaty Park
- Hunting Park
- Lemon Hill Mansion
- Ned Wolf Park
- Shevchenko Park

Northeast

- Pennypack Park

Northwest

- Fountain Street Steps

- Germany Hill
- Gorgas Park
- Inn Yard Park
- McMichael Park
- Sedgley Woods
- Vernon Park
- Wissahickon Neighbors
- Wissahickon Valley Park

South

- Bardascino Park
- Beck Park
- Capitolo Playground
- Dickinson Square
- FDR Park
- Gold Star Park
- Hawthorne Park
- Jefferson Square
- Karen Donnelly Park
- Mifflin Square
- Stinger Square

West

- Bartram's Garden
- Ben Barkan Park
- Cedar Park
- Clark Park
- Cobbs Creek Park
- Morris Park

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