Fairmount Park System

Natural Lands Restoration Master Plan

V O L U M E I

General Observations

Meadow in the Wissahickon

For more information about the Fairmount Park System Natural Lands Restoration Master Plan,
please contact the offices of the
Natural Lands Restoration and Environmental Education Program
at 215.685.0274.

FAIRMOUNT
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1. INTRODUCTION

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Wissahickon Valley

Fairmount Park is one of the world's preeminent park systems. First established in 1855 in an effort to protect the city's water resources, the park system has grown to include over 8,900 acres, constituting 10% of the area of the City of Philadelphia. The mosaic of landscaped areas, recreation centers, playing fields, tot lots, historic houses and gardens, and natural lands of open meadows, streams and woods constitute a world-class park system which is accessible to most neighborhoods in the city, making this clearly a people's park. The variety of park resources is vast, extremely valuable, and often overlooked.

The Fairmount Park Commission (FPC), having jurisdiction over the park system, is charged with protection and enhancement of this valuable resource. The FPC consists of 16 members, ten of whom are appointed by the Philadelphia Court of Common Pleas for five-year terms and six ex-officio members who serve by virtue of holding public offices. They include the Mayor, the City Council President, the Commissioner of Public Property, the Recreation Commissioner, the Water Commissioner and the Chief Engineer and Surveyor. The FPC meets regularly to govern all aspects of the park system. The policies of the FPC and day-to-day management of the park system are carried out by a staff of approximately 225 full-time people, headed by an Executive Director.

In an effort to establish long-term stewardship policies, the FPC initiated preparation of the first comprehensive park master plan in 1983. The plan established goals, policies and guidelines for preservation, as well as strategies for land acquisition, finance and administration for the park system through the year 2000. This plan distinguished three types of areas within the park: the designed landscape, consisting of landscaped areas of different styles, and historic structures; recreational resources, focusing on programming and recreational needs of the resident; and the natural lands, lands not formally maintained. The master plan noted the extent and significance of these natural lands and highlighted areas of particular ecological importance. The plan also identified disturbance of vegetation in many areas of the park system (Rhoads 1983), trail erosion and widening, and erosion and other problems in many of the streams of the system (Wallace, Roberts and Todd 1983).

In 1996, the William Penn Foundation made a grant to the FPC of $26.6 million to restore areas of natural land and to build or enhance environmental education centers to both interpret the natural systems in the park system and build a larger constituency to help with its protection. The Natural Lands Restoration and Environmental Education Program (NLREEP) was created within the FPC to administer and implement the grant. The program consists of a group of interrelated activities, including restoring vegetation and streams, trail repair and improvement, building environmental education centers and developing educational and volunteer restoration programs, securing protection of adjacent undeveloped areas, and promoting programs to increase watershed protection outside the park.

The FPC and NLREEP selected the Academy of Natural Sciences of Philadelphia (ANSP) in August 1997 to formulate restoration plans for vegetation and stream channels in the natural lands of seven areas of the Fairmount Park system, including Wissahickon Creek Park, Cobbs Creek Park, Fairmount (East/West) Park, Franklin Delano Roosevelt (FDR) Park, Pennypack Creek Park, Poquessing Creek Park and Tacony Creek Park. This process included reconnaissance of existing conditions in the park, identification of areas in which restoration efforts would be concentrated, and recommendation of restoration activities. An ANSP team headed by Dr. Richard Horwitz of the Patrick Center for Environmental Research was formed which includes scientists, botanists, ecologists, zoologists, stream bioengineers, landscape architects and planners. In addition to staff of ANSP, the team has included staff of the Morris Arboretum of the University of Pennsylvania, University of Delaware, the Natural Lands Trust, and Munro Ecological Services.

Planning for the project began in August 1997 and continued through the spring of 1999. Tasks included development of restoration goals, compilation of existing information on park conditions, compilation of biological specimen data from the park system in the ANSP collections, generation of field survey protocols, implementation of field surveys, development of a database for historical and assessment information, development of a geographical information system (GIS) and production of maps. Historical and current conditions were compared to determine trends. The assessment information was used to define potential restoration activities at sites within the park system. These activities were prioritized to form the restoration recommendations. Throughout this process, the team interacted with the FPC staff, park users, scientists, engineers, ecologists, landscape architects and representatives of state agencies who have knowledge of the park system, so that the plans incorporate the viewpoints of the full community of stakeholders. While the primary goal of this process has been the development of recommendations for restoration to be done as part of the 5-year NLREEP program, it is anticipated that this plan will provide the basis for ongoing restoration and maintenance activities in the natural lands of the park system.

The assessments of existing conditions and analyses of trends were done in all seven park areas in 1997-1998. The comparison of conditions within and among different park areas was valuable in determining various stresses and restoration options among the parks. The restoration plans are being prepared on a staggered schedule. Master Plans and restoration recommendations were developed first for Cobbs Creek (Section 1 of Volume II) and Tacony Creek (Section 2 of Volume II) parks, followed by Pennypack (Section 3 of Volume II), FDR (Section 4 of Volume II) and Fairmount (East/West) (Section 5 of Volume II) parks, and then Wissahickon (Section 6 of Volume II) and Poquessing (Section 7 of Volume II) parks. This staggered schedule provides several benefits, including allowing earlier implementation in some of the parks and follow-up monitoring and remedial activities, if necessary. Subsequent restoration activities can then incorporate changes in protocols, thus providing greater efficiency. The Master Plans for each park represent these efforts, and the recommendations herein will guide the FPC and park staff in maintaining, protecting and enhancing the natural lands of the park system, for they are a precious resource in a busy city.

This document starts with general information relevant to the entire restoration process. This includes information on restoration and ecological principles of particular importance in restoration planning (Section 2). Section 3 contains the restoration goals used to guide restoration planning and implementation. The next two sections describe the assessments of past and current conditions of the flora and fauna (Section 4) and streams (Section 5) of the park system. Section 6 discusses the general process of nominating, ranking and selecting sites and projects which are recommended for restoration. The appendices contain supporting information. This includes 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. Each of the sections in Volume II contains park-specific information on existing conditions and recommended restoration projects. These sections 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.

Plants and animals in each section are referred to by their common name, followed by their scientific name upon first introduction in the text. Common names are used thereafter. Scientific names are consistent Latinized names of plants and animals. These consist of a genus (italicized and capitalized) and a specific name (italicized but not capitalized), which together form the binomial name of a species. A group of organisms within a species that shares distinguishable trends may be classified as subspecies (given a third name after the specific epithet) or variety (for plants). Common names are more easily recognized and are used in the text after presentation of the scientific name. For some groups, such as fishes, reptiles, amphibians, and birds, common names have been standardized, at least within the United States. As part of standardization, the first letter of each word in a bird's name is capitalized, and this convention is followed in the text. This convention is not used for other groups. Where common names have not been standardized, names follow those of relevant authorities, e.g., Rhoads and Klein (1993) for plants.

2. WHY RESTORATION?

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Restoration in progress with FPC Volunteer Coordinator and team.

Pennypack Park

2.A. Importance of Natural Lands Restoration to the Urban Landscape

The natural lands of the Fairmount Park system are important, as are all natural systems, because they support life. Natural lands are crucial to our survival as a species. First and foremost, they fulfill human biological needs by providing the basics: water to drink, air to breathe, and food to eat. The natural lands in the City of Philadelphia mitigate the effects of dense development and enhance the quality of the environment by tempering extremes in climate, reducing erosion and flooding by holding soil in place and slowing stormwater when it rains. The forests clean the air, water, and soil by filtering particles out of the air and soil, and trap sediments before they enter the rivers and streams. Thus, the natural lands of Philadelphia are, in an unobtrusive way, extremely important for lessening the environmental impacts of a highly developed and busy city, yet they are often unnoticed and taken for granted.

Although humans depend on natural lands to survive, people have controlled, reshaped and destroyed these lands as a means of supporting human life for thousands of years. Over the last millennium this control has greatly changed the natural lands of the world, evidenced by the landscape in and around the city. Currently, the trend of destruction of natural systems for development has expedited the loss of natural areas, increasing the importance of the ever-rarer remaining natural areas. The natural lands of the Fairmount Park system are a "land bank" of natural resources for the next generation. In an early example of environmental protection, the city fathers realized the association between development and natural resources and they responded by purchasing natural lands in order to protect the city's water supply.

Natural land areas have been recognized as important not only for lessening environmental impacts in the city but also for being historically touted for their restorative and medicinal qualities. This philosophy first surfaced in the 19th century when people began to notice how fast the country was changing. The rapidity with which natural lands and their resources were being depleted was startling to many writers, philosophers and planners. Downing, Olmstead and Emerson noted how the wilderness was disappearing at a rapid and alarming rate. They commented on the unprecedented growth of the city. They associated poverty, disease and overcrowding due to urbanization with the loss of natural lands. In the wake of progress were polluted rivers, unhealthy tenements, poverty and disease.

Emerson (Whitson 1976) perhaps best summarized the sentiment of the restorative potential of natural areas.

> *"To the body and mind which have been cramped by noxious work or company, nature is medicinal and restores their tone. The tradesman, the attorney comes out of the din and craft of the street and sees the sky and the woods, and is a man again. In their eternal calm, he finds himself."*

Natural lands were the prescription for the ills of the city. People were encouraged to go to natural areas and find solace, peace and redemption in the land. This notion reflects an ancient belief that green pastures restore health and still waters restore the soul. Parks with carefully designed natural areas were planned and implemented throughout the country in hopes of saving mankind from itself. Natural lands in the Fairmount Park system were conceived through such thinking, and today a park system with natural lands is accessible to most every Philadelphian. The Fairmount Park system offers a variety of restorative opportunities for contemplation and meditation, as well as active recreation. It provides an opportunity to observe and learn about the natural world and is intrinsically linked to all humans in ways which are not fully understood. The natural lands are important and need to be protected and enhanced.

2.B. GENERAL ECOLOGICAL PRINCIPLES

In prioritizing and planning the restoration of park sites, it is important to consider ecological processes of the park's ecosystems as they are affected by various types of disturbances. These processes determine which stresses are most critical, where stresses may be too great to overcome, and what activities are necessary to restore these ecosystems.

Ecological systems are dynamic, changing in both regular and unpredictable ways. For example, the success (i.e., survival, growth, reproduction) of many organisms depends on weather at critical times in the species' life cycle. Species will respond to weather patterns differently over the years. Consistent changes in climate can lead to shifts in species occurrence. Urban areas are typically warmer, which can shift ecological communities.

Plant communities shift in response to changes in environmental factors, biotic factors such as deer browsing and insects, and competition among plants. Such relationships are very complex, depending on the species, size of plants, and many environmental factors. Changes in plant community composition often reflect the outcome of plant competition for light, water and soil nutrients. Light competition influences plant establishment, survival and growth rates. In the open, fast-growing plants can shade out slower-growing plants. Shade-intolerant species may be unable to invade forests. Stands of shade-intolerant trees, unable to regenerate in their own shade, may be unable to sustain themselves over time. Competition for nutrients, based partly on development of root systems, may balance competition for light, based on development of leaves and stems. Plants able to grow quickly under high nutrient conditions may grow poorly in low-nutrient situations; whereas other species are able to sustain themselves by using organic nutrients through root-soil fungus interrelationships. Many exotic plant species do best where disturbance increases light and inorganic nutrient concentrations. In the Fairmount Park system, forests on poor, acid soils appear most resistant to invasion by exotics; patches of this habitat have a relatively large component of their native flora. These relationships can be used in restoration by promoting native species through shading and reduction of nutrients (e.g., by reducing nutrient input or availability), although these techniques have not been tested extensively.

Regular patterns emerge from these competitive interactions and the impacts of organisms, especially plants, on their environment. Succession is the typical pattern of change of plant and animal communities in response to internal dynamics which affect shading, soil chemistry and other factors. Old field succession is an example of changes in vegetation following abandonment of farming of an area. This pattern is central to the history of park lands, most of which were farmed before being set aside as parks. The typical pattern involves early dominance by annual grasses and forbs, which are then replaced by perennials. These in turn are shaded by shrubs and trees. The succession of forest communities represents transitions from short-lived, shade-intolerant species to long-lived, shade-tolerant trees. While changes in the species composition and size of canopy trees are the most obvious aspects of succession, changes in the herbaceous flora, the fauna, and soil chemistry are important as well. Analyses of old-growth forests and models of succession suggest that complete succession may take several hundred years. If so, most of the forests in the Fairmount Park system, which are probably 100 to 150 years old, are still in mid-successional stages, and changes may still be expected in these forests regrowing from early settlement clearing. The particular patterns of change depend on the physical nature of the site (e.g., slope, soil chemistry, moisture), availability of colonizing plants, and competitive interactions among plants. Succession is also sensitive to disturbances such as fires which can delay or alter the pattern of change, as well as suppress successional changes.

The most obvious symptom of stress on ecosystems is mortality of individual organisms. In urban parks, tree longevity is typically lowered by air pollution and soil compaction. Aquatic organisms may be killed by pollution such as low dissolved oxygen associated with sewage or other pollutants, ammonia, chlorinated water and pesticides. Trampling can kill small plants. The impact of such stresses depends on their frequency, magnitude and duration, but also on the integrity of the ecological systems such as the presence of refuges from mortality or sources of new organisms.

Reproductive success and mortality usually vary geographically. As a result, some areas may have high net production of organisms ("surplus production"), which serve as sources for surrounding areas. Conversely, reproduction may not balance mortality in some areas, and occurrence in these areas depends on immigration from source areas. While such "sink" areas may be important in some situations, these areas may be essentially insignificant to the population of organisms. In the worst case, individual organisms may be attracted to areas where they cannot sustain themselves. In these cases, the poor areas can be thought of as population traps. These processes are not well known and require large amounts of information to assess. Restoration should provide habitat sufficient to sustain target populations and should avoid creating small, isolated, marginal populations.

Fragmentation of natural areas can have a severe impact because of the importance of differences among sites and of colonization and movement between sites. Small areas of natural land are less likely to contain a diverse mix of habitat types such as different successional stages. As patches of vegetation change and become unsuitable for early successional species, there is less likely to be new, suitable early successional habitats available. Small total population sizes of moderate and large-sized organisms can make them more susceptible to extirpation due to fluctuations in survival and reproduction. While even small areas may contain large numbers of small organisms, restricted movement among fragmented sites can affect dynamics. For example, low colonization rates by organisms with short dispersal distances may prevent full development of late successional forest communities. Many species of animals will not travel across edges and habitat gaps.

Smaller patches also have large amounts of edge relative to interior habitats. While such edge habitats may be productive and favor some organisms, species requiring interior conditions may be excluded from small patches. This is important in the distribution of both forest and grassland bird species. Edges cause microclimate changes and provide corridors for dispersal of exotic plants. Plants growing in sunny forest edges can colonize part of the interior of the woods by seeds or vegetative growth. This is especially significant for forests in the Fairmount Park system, many of which are confined to narrow bands along the creeks or patches within landscaped areas.

Because of these processes, the impacts of disturbances also depend on the pattern of the landscape. Large areas can contain a mix of habitat types, including a few large patches of a single habitat type. In these situations, local disturbances such as fires can be important in maintaining habitat diversity by preventing succession to relatively homogeneous late successional habitats. Many native species occur primarily in disturbed or early successional sites, so maintenance of these is important in maintaining biodiversity. However, small, isolated patches can be vulnerable to disturbance because there may be no nearby source of native flora and fauna to recolonize the area, and the entire stand may become a single habitat type.

Natural lands in urban areas present a special landscape pattern in which much of the temporal variation is constrained. Control of large fires and tree cutting leads to forest development. However, these forests differ from rural late successional stages because of their size and shape, historical loss of species, and the presence of numerous stresses (e.g., air pollution, altered hydrology, soil compaction). The relatively small size of many of these park patches can make it difficult to sustain a pattern of mixed successional stages. On the other hand, these forests are often surrounded by various open habitats such as mowed lawns, residential and park landscaping, vacant lots and roadsides. These can be considered highly modified, early successional habitats. Thus, the natural pattern of successional changes over different areas is replaced by fixed habitats. The early successional stages are arrested by mowing, weeding and pruning and the late successional stages are preserved from cutting. Planning for restoration and management needs to account for these constraints in order to enhance the function, structure and biodiversity of the natural lands. 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.

Because of the complexity of management of natural lands in an urban setting, goals for restoration need to be established to ensure common understanding and continuity of activities undertaken. These goals are presented in the following section.

3. RESTORATION GOALS

Fairmount Park System
Natural Lands Restoration
Master Plan

Andropogon meadow in Tacony Creek Park.

3.A. SUMMARY

GOAL of Vegetation Restoration: Restore the composition and structure of vegetation native to the parks in order to establish self-sustaining ecological communities. These communities should be capable of typical function with respect to production, nutrient cycling, and age-structure, and able to support typical plants, plant-eating animals, and carnivores;

GOAL of Stream Restoration: Preserve streams that are currently in good health and restore/rehabilitate degraded streams by counteracting the effects of urbanization on hydrology (i.e., high peak flows, low base flows), geomorphology (i.e., scoured and enlarged channels) and aquatic ecosystems.

In the 1983 master plan for the Fairmount Park system, park lands were separated into three classes—designed lands, recreational areas and natural lands. Over half of the total area of the Fairmount Park system is managed as natural lands. The natural lands are not actively landscaped, and construction and maintenance of manmade features within these natural lands are largely restricted to those associated with access (i.e., trails, etc.), cultural features (e.g., dams and buildings), water management (such as storm sewer outlets and sewer pipes) and removal of hazards. Management and restoration of the natural lands is necessary because of: the mix of cultural and natural values of these areas; impacts from the surrounding areas; and the continuing effects of earlier land use practices.

In 1996, the Fairmount Park Commission received a grant from the William Penn Foundation to restore natural lands, promote environmental education, and increase stewardship within the park. This five-year (1997-2002) grant program, the Natural Lands Restoration and Environmental Education Program (NLREEP), is intended to serve as a catalyst for restoration, education and stewardship within the park. As part of this effort, this document outlines goals and principles to be used in restoration. These goals are principally designed to guide the NLREEP efforts, but it is expected that these goals can serve as a basis for future management and restoration of natural lands in the park.

3.A.1. **Guiding Principles**

The goals should guide planning and implementation of restoration and management. The goals should provide criteria for the selection of sites to be restored, for the specification of anticipated outcomes of the restoration, and for processes and methods of restoration. The goals document discusses a number of significant guiding principles for these planning and management tasks. Reference states, i.e., conditions providing a concept for the outcome of restorations, are also discussed. The NLREEP program is divided into vegetation and stream components, and separate goals for these components are presented. However, there are strong parallels between guiding principles for the two components, so that a single summary of principles can be presented here.

The overall goal of restoration is to enhance native species and natural processes, and several principles address this:

- Protect and enhance healthy systems;
- Use and promote natural processes to the extent feasible;
- Recognize the dynamic nature of natural systems;
- Ecological condition is the primary justification for restoration activities;
- Enhance terrestrial and aquatic organisms by habitat improvement.

The program is intended to provide real, long-term benefits, and several principles are adopted to further this objective:

- Address basic causes: attack problems, not symptoms;
- Address situations where restoration can make a difference;
- Define objectives to allow evaluation of restoration activities.

Because of connections between different parts of the system, the ecological setting must be considered, and restoration activities need to involve groups responsible for management of different parts of the system. Restoration needs to be linked to education about the values of natural lands and impacts of different disturbances:

- Recognize watershed-level effects, and seek watershed-level solutions;
- Link restoration of vegetation and streams;
- Coordinate with other groups;
- Increase public awareness of the scenic, inspirational and spiritual values of natural systems.

Fairmount Park has a number of uses, and these must be considered in managing natural lands:

- Respect other uses and values, including cultural resources and public uses.

3.A.2. Reference States

Reference states are conditions which represent the desired outcomes of restoration. Since natural systems are dynamic, a precise, single reference condition will not be defined. Reference states will include a range of conditions, along with typical ecological processes and patterns of change over time. Reference states may be conditions at some pre-existing time period, or may represent current conditions in less disturbed sites. For vegetation restoration, historical conditions are used to determine vegetation types which have been present, species which are native to Philadelphia County, and typical assemblages of plants and animals, but restoration to a single point in time will not be sought. For example, the absence of unlogged deciduous forests in the region makes forest restoration an important goal. However, restoration of other vegetation types, such as wetlands and meadows, is also important, since these types have become much rarer with urbanization than during earlier periods. For streams, current conditions in relatively undisturbed local watersheds (e.g., in Chester County, PA) are used as reference conditions to define differences between urban and rural streams, which is used to determine specific goals for restoration.

3.B. Goals For Management And Restoration of Natural Lands in Fairmount Park

3.B.1. Overview

Goal of Vegetation Restoration: **To preserve healthy communities and enhance ecological communities containing native species appropriate to the region.**

Goal of Stream Restoration: **To preserve healthy streams and counteract the effects of urbanization on flows and channel structure.**

Guiding Principles

- Address basic causes: attack problems, not the symptoms
- Address situations where restoration can make a difference
- Protect and enhance healthy systems
- Use and promote natural processes to the extent feasible
- Enhance terrestrial and aquatic organisms by habitat improvement
- Recognize watershed-level effects, and seek watershed-level solutions
- Link restoration of vegetation and streams
- Recognize the dynamic nature of natural systems
- Coordinate with other groups
- Respect other uses and values, including cultural resources and public uses.
- Define objectives to allow evaluation of restoration activities
- Increase public awareness of the scenic, inspirational and spiritual values of natural systems

3.B.2. **Introduction**

The Fairmount Park system was first established to protect the water supply of the City of Philadelphia. Additional park lands have been added, and numerous changes in land use have occurred as a result of natural processes, implementation of park designs, and accrual of various manmade structures. Currently, the lands of the Fairmount Park system are important as sites of recreation, as functioning ecosystems, and as representatives of the cultural history of the region. As ecosystems, the park supports a myriad of species and has effects on the entire city, such as storage and cleansing of water. In the 1983 park master plan, park lands were separated into three classes—designed lands, recreational areas and natural lands. Over half of the total area of the Fairmount Park system is managed as natural lands. The natural lands are not actively landscaped, and construction and maintenance of manmade features within these natural lands are largely restricted to those associated with access to natural areas (i.e., trails, etc.), cultural features (e.g., dams and buildings), water management (e.g., storm sewer outlets and sewer pipes) and removal of hazards. Before incorporation into the park, much of the natural land area was farms, fields, woods, and mills. A few areas may have had continual forest cover, while other woods were regrowth; in either case, virtually all woods were affected by livestock foraging, lumbering and wood cutting. The natural lands include areas never included in park designs (e.g., areas added to the system relatively recently), areas set aside as large wild areas crossed by roads and trails (e.g., much of the Wissahickon Valley and ravines in other parks), smaller areas set aside as parts of rustic landscapes (e.g., in East and West Parks), and formerly landscaped areas which have reverted to forest. The designed and recreational landscape includes buildings, formal plantings, ballfields, picnic areas and other frequently mowed areas.

Management and restoration of the natural lands is necessary because of the mix of cultural and natural values of these areas, and because of impacts from the surrounding areas and the continuing effects of earlier land use practices.

NLREEP is organized into several activities related to education, restoration, community involvement, and protection of adjacent lands. Restoration activities are divided into three components: restoration of vegetation, management of stormwater and trail repair. Vegetation restoration focuses on improvement of forest and other vegetation communities within the natural lands of the park. Consideration of park fauna is also included within this component, due to the integral relationship which exists between flora and fauna. Stormwater management involves amelioration of effects of disturbed hydrology of the park. This document discusses goals for the vegetation and stormwater components, which are being addressed through the work of the Academy of Natural Sciences of Philadelphia (ANSP). However, trail restoration is outside the ANSP scope of work. Separate restoration goals are outlined in this document for vegetation and for stream restoration and management, since they are managed separately with respect to implementation of restoration. However, both components reflect the same underlying philosophy of park management, since vegetation and hydrology are intimately linked. For example, vegetation on slopes and riparian zones affects erosion and hydrology, and hydrology is a critical factor controlling vegetation.

3.B.3. **Integration of Park Uses**

The distinction between the designed and natural landscape provides a useful separation of primary current uses of park land. However, the distinction is not absolute. Natural and cultural elements characterize both types of lands. How the designed lands are managed affects the entire park, including natural lands. Restoration and other activities on the natural lands can also affect recreational uses and cultural resources in natural and designed lands. Therefore, a broad policy of natural land management and promotion of ecological goals will require balancing different activities and uses throughout the park. This document presents principles which can be used as a basis for natural lands management. However, this document is designed primarily to guide restoration activities under NLREEP. It is anticipated that NLREEP sites can be chosen where conflicts with other park uses are minimal. Where such conflicts arise, discussions of alternative plans among stakeholders are encouraged to produce acceptable management plans.

The determination of desired conditions is a critical part of restoration, since these will affect priorities for restoration and restoration plans. In many cases, desired results can be defined using reference sites, i.e., existing communities in similar settings with desired attributes. Within the vegetation and watershed restoration goals outlined in this document, there is a discussion of both desired results and reference sites.

3.B.4. **Goals for Restoration of Vegetation and Determination of Reference Conditions**

GOAL: The goal of restoration is to strengthen the viability of self-sustaining ecological communities containing native species appropriate to the region. These communities should be capable of typical function with respect to production, nutrient cycling, and age-structure, and able to support typical plants, plant-eating animals, and carnivores.

3.B.4.1. **Guiding Principles**

1. **Address basic causes**. Restore the composition and structure of vegetation native to the parks in order to establish self-sustaining ecological communities. For example, if some invasive species are promoted by certain types of disturbance, restoration should focus on removing the disturbance as the basic means of controlling the invasive species, rather than removing the species without otherwise changing the environment. Even where control of these causes is within the scope of NLREEP or the Fairmount Park Commission, identification of effects within the park and advocacy of solutions may promote eventual control.

2. **Use and promote natural processes to the extent feasible**. Natural processes should be favored, since these are expected to have a broader range of ecological benefits, fewer negative effects on overall ecosystem health, and generally require less long-term maintenance.

For example, habitation by some hole-nesting birds may be encouraged by nest boxes. These would replace use of natural tree holes, which are often limited by age of the forest and removal of dead or diseased trees. In place of artificial habitat, restoration should encourage development of forest management procedures which allow the creation and retention of natural cavities.

3. **Use artificial processes to control basic causal factors where necessary**. Activities may be implemented which would not in themselves be considered restorative, if these activities promote desired conditions in the site or in adjacent sites. In particular, activities which reduce impacts of disturbed hydrologic regimes, soils or nutrient processes may be used. For example, such activities might include construction of basins, and wetlands in places where they did not occur historically.

4. **Protect against impacts which cannot be controlled**. Where basic causes of ecological impairment cannot be addressed by this program, restoration activities should be specifically designed to avoid failure due to these causes. Such protections may include:

   - Constructed/built elements to protect restoration activities (e.g., deer exclosures, tree tubes). Preference should be given to passive, low maintenance, protective activities;

   - Low-level maintenance may be recommended (e.g., annual removal of some exotics), although the prescribed maintenance should be considerably less than that typically used for horticultural, recreational and other designed landscapes.

5. **Consider short-term solutions**. Activities which are unlikely to be self-sustaining can be used to preserve species or communities where there is a reasonable expectation that the impeding factors will be addressed in the near future by other programs. These activities should not be considered as long-term solutions.

   For example, planting of tree species whose regeneration is currently prevented by deer could be considered under an expectation that deer populations will eventually be controlled. In contrast, planting or stocking of species whose reproductive requirements are unlikely to ever occur in the park should be avoided.

6. **Manage self-sustaining ecological communities, rather than single species**. The establishment and preservation of ecological communities and landscapes, rather than single species, should be the primary focus of restoration. Individual species which prove to have deleterious effects on natural communities should be managed. Such deleterious effects could include prevention of regeneration by grazing or browsing (e.g., by deer, squirrels, geese), inputs of nutrients (e.g., by geese), overgrowth of tree seedlings by exotic and native vines, and predation on rare animals. Similarly, protection of rare taxa may be an important basis for selecting restoration sites and activities.

7. **Restoration of vegetation should be linked to stormwater management and watershed restoration, where appropriate**. Restoration of vegetation on slopes and in riparian zones may reduce erosion, and restoration of wetlands and flood plains may be integrated with water holding systems.

8. **Consider significant topographic restoration**. Topographic restoration may be considered where historical topographic and other environmental factors have changed resulting in changes in the ecological community. For example, rebuilding of wetlands and flood plains which have been filled in may be considered. The decision as to whether

to implement such changes will depend on anticipated benefits, costs, potential impacts on adjacent areas, and competing uses.

9. **Ecological condition is the primary justification for restoration activities**. Improvement of ecological conditions should be the primary reason for any restoration activity. An activity which has some ecological benefit secondary to some other purpose should have very low priority. For example, control of invasive species in patches of natural areas within designed landscapes (e.g., surrounding ball fields picnic areas) would be of low priority if the primary purpose is enhancement of the aesthetics of the area. Conversely, improvement of manmade features which impact ecological conditions (e.g., artificial ponds, trails, parking areas) may be of high priority.

10. **Control native species only where necessary**. Native species should be controlled only where there is strong evidence of deleterious effects or where there have been major changes in the ecology of the species. For example, deer have major impacts on park vegetation, resulting from high densities of deer, low mortality from hunters and wild predators, and the availability of food outside park natural areas. The common reed grass (*Phragmites*) is considered native, but it has become a significant invasive species. This change has been ascribed to genetic changes in the species. The Canada goose is a native species. Formerly, it occurred as a migrant and wintering bird. It has become established as a common breeding species in this area, possibly following release of non-migratory captive stock. It has the potential for significant impacts due to grazing and nutrient enrichment, and management of such a species may be desirable to further project goals.

11. **Encourage natural regeneration and colonization of plants and animals, where feasible**. Regeneration is used here to mean the natural reproduction of species locally present (e.g., seedling establishment of canopy tree species). Colonization is used to mean the establishment of a species which is not locally present as a reproductive population. Where feasible, activities should encourage the natural colonization of fauna or flora. Such methods may include:

    - Improvements in local conditions, making them more favorable for colonists, for example, improvements in soil conditions (i.e., chemistry, water), light conditions, and establishment of food plants (e.g., butterfly weed for butterfly species). For many species (e.g., understory plants, many animals), development of appropriate vegetative structure will be an essential component of these conditions. The restoration of vegetative communities is in itself expected to encourage colonization and regeneration of species appropriate to these communities.

    - Improvements in access of organisms to sites, allowing dispersal of flora and fauna into sites with suitable conditions for habitation. Improvements may include restoration of now-fragmented habitats, removal of barriers to dispersal, and/or development of passageways.

    Re-introduction of species after thorough consideration of the likelihood of success and possible negative impacts, and under the following restrictions:

    - Determination that the species is not extant and that natural colonization is highly unlikely to occur.

    - Determination that appropriate conditions for the establishment of the species are present in the site. For newly restored sites the development of appropriate vegetation (e.g., canopy trees) may take years, and introduction of some component species (e.g., understory plants, animals) should wait until suitable vegetation has developed. However, rapid introduction may be feasible in some sites currently in good condition.

- Determination that the total area of suitable habitat is sufficient to support a viable population.
- Determination that suitable conditions can be maintained; for example, species requiring early successional habitats should only be introduced where a management plan is implemented to maintain these habitats.
- Determination that negative effects of the introduction on other organisms are highly unlikely. Such effects would include transmission of disease or parasites or predation on rare taxa.

It is expected that most or all re-introductions would be of species occurring within the region, but which are absent from one or more park units. For these species, their ecology in nearby sites would allow assessment of the likelihood of success and potential impacts. Assessments of existing conditions are expected to identify fauna and flora which have become rare or extirpated, and restoration plans may discuss candidate species for re-introduction. Introductions may require special permitting for collection, transport or stocking of organisms. Regulatory issues should be addressed in any introduction plan.

12. **Consider negative impacts of planting or stocking, and minimize potential impacts**. Planting and stocking have potential effects on remaining native elements, such as introduction of disease or pest organisms, and loss of local genetic adaptation by introduction of exotic genetic material. These effects have been documented in some systems, but are poorly known. It is unlikely that this program has the resources to generate the necessary information to evaluate such impacts definitively. The following guidelines should be used to minimize these potential effects:

- Existing information on diseases and pests associated with source material should be evaluated.
- Existing information on potential differences between source and native material should be evaluated (e.g., differences in form, flowering and fruiting time, etc.).
- Preference should be given to obtaining source material from local stocks. It should not be assumed that stock from local nurseries comes from local wild stock.
- Rare, native taxa should be identified. These taxa should be planted as a last resort, since the taxa which have not been extensively used horticulturally are most sensitive to stress. Reduction of stresses on these species and protection of remaining populations should be given preference.
- Active programs to develop plant material from local stocks (e.g., using local seed) should be encouraged.

Information on the history of existing vegetation in the area may be useful in determining such risks. For example, since much of the park consists of formerly cleared areas, existing vegetation may itself be a mix of native and horticultural stock, thereby minimizing stocking effects.

13. **Recognize human use and access**. Public access and use of each of the parks are an important purpose of the Fairmount Park system; therefore human use should be planned and encouraged in restoration sites, where use does not impede ecological goals. In areas where fragile ecological communities must be preserved, controlled access may be

recommended. Activities which advance both ecological goals and other uses may be given higher priority.

14. **Coordinate with other groups**. Coordination with other groups, including private groups and municipal, county, state and Federal public agencies is encouraged. For example, coordination could lead to more extensive restoration efforts than possible under NLREEP alone, or integrated management of restoration sites and adjacent areas.
15. **Assess cultural resources**. The presence of significant cultural resources in a restoration site should be assessed prior to restoration. At the least, assessment should involve search of the Fairmount Park Commission database and of the Federal registry of historical landmarks, and field survey for evident structures. If significant cultural resources are present, restoration plans should be reviewed by appropriate staff within the Fairmount Park Commission to determine the compatibility of restoration and cultural preservation. Potential conflicts may be resolved by modification of restoration plans where these do not compromise ecological goals. The presence of highly significant cultural resources may preclude ecological restoration. Where it is decided that damage or loss of cultural resources is acceptable, Fairmount Park staff should be given the opportunity to document the resources prior to restoration.
16. **Establish accountability**. Restoration activities should be accountable in:
    - Defining expected benefits of each type of activity in terms of specific outcomes. Specific definition of goals in terms of directions of change of potentially measurable quantities should be encouraged;.
    - Including design and implementation procedures to allow evaluation. Such procedures should include use of defined protocols, documentation of the tasks performed, controlling protocols, and records of deviations from these protocols. Baseline conditions should be documented.
17. **Restoration activities**. Activities which will promote restoration goals and are consistent with guiding principles include:
    - Planting native trees and shrubs in areas of disturbed forest.
    - Planting native herbs and grasses, as understory in forests, or in meadows and wetlands.
    - Planting native species of plants as larval or adult food sources for insects (e.g., butterflies) or other species of animals.
    - Creating or increasing the width of riparian zones around streams.
    - Periodic mowing to maintain meadows or other early successional habitats.
    - Prescribed burning to maintain meadows, change forest soil and nutrient conditions, favor some native species, etc.
    - Creation of wetlands or ponds.
    - Control of invasive, exotic species of plants, such as Norway maple, Japanese knotweed, Japanese honeysuckle, common reed (*Phragmites*), and mile-a-minute.
    - Removal of trees and shrubs to maintain meadows.
    - Removal of fill or sediment deposits (e.g., on flood plains).

- Addition of mulch or similar materials to increase water retention, promote soil fungus, etc..
- Alteration of soil chemistry (pH, etc.) to affect nutrient availability, etc..
- Mechanical soil aeration.
- Addition of logs to improve soil condition, provide wildlife habitat, etc.
- Construction of berms or other barriers to reduce slope or gully erosion.
- Limitation of access (e.g., to dumping, cars), to reduce trampling and soil compaction.
- Construction of exclosures to reduce grazing, browsing or trampling effects.
- Re-introduction of species of plants or animals locally extirpated from the park.

These activities should be evaluated for use in individual site restorations. Other activities which are primarily associated with trail or watershed restoration may have effects on vegetation and associated wildlife, as well.

By its nature, ecological restoration does not lead to a static endpoint whose success can be simply evaluated. For example, direct restoration activities may consist of ground preparation and planting of tree and shrub seedlings. It is anticipated that these plantings will grow and spread, and that additional species of plants and animals will colonize restoration sites. These changes will have consequences on ecological conditions, such as soil condition and water retention. Conditions will continue to change over long time periods, in response to aging and replacement of large trees, etc. Therefore, accountability should be examined at several time scales:

- Immediately after the initial restoration activities. This consists of development of the site-specific restoration plan and documentation of restoration. Evaluation at this scale consists of determining adherence to the project plan.
- Short-term (i.e., within the first or second growing season after restoration). Measures of restoration could include survival and growth of original plantings, density or cover of native seedlings, or density or cover of invasive species. Evaluation would be based on increases or decreases of these measures with respect to baseline or immediate post-restoration conditions.
- Long-term. Long-term measures might include some of the short-term measures, as well as measures of colonization by additional species.

The extent and timing of evaluation will depend on project resources and schedules. For example, short-term monitoring and evaluation activities may not be possible for NLREEP projects done near the end of NLREEP funding. However, restoration projects should be designed and conducted to enable evaluation.

3.B.4.2. **Reference States and Definition of Communities**

One of the most important decisions in designing ecological restoration initiatives is the restoration concept, i.e., the mix of habitat types, biological communities and component species to be encouraged. A restoration concept will need to account for uses of adjacent lands and activities within natural lands, since these affect the integrity and time trends of ecological communities. For a given site, the priority for restoration would depend on existing conditions at the site relative to the habitats within the restoration concept (how good or bad is the site now?), the priority for potentially restorable habitat within the concept (e.g., can the site be restored to an unusual or otherwise particularly significant habitat?), and the feasibility of long-term successful restoration. If the site is selected for restoration, a site-specific restoration objective would be developed as part of developing a restoration plan. This objective defines the habitat type or types which are to be promoted on the site, and any site-specific factors which would limit the extent of restoration which could be done. The following points discuss appropriate desired results and existing or historical models which can be used as models.

The goal of restoration is to strengthen the viability of communities containing native species appropriate to the region. Restoration activities may include planting of native species, control of exotic or invasive species, and reductions in conditions inimical to native species.

1. **Use historical and regional reference communities to develop the restoration concept**. Assessment of the level of degradation and desired improvements should be tied to reference conditions, i.e., conditions in areas with the desired state. Reference conditions should include both historical conditions and currently-existing regional, natural communities in similar environments.

   Historical information can be used to determine species native to the region, distribution and relative abundance of some species at various times, the occurrence of different habitat types (e.g., different types of forests; meadows, fields and savannahs; and wetlands), aspects of vegetation structure (e.g., density of undergrowth, size or age of canopy trees), and important factors and disturbances affecting the biota (e.g., fire, flood-drought cycles). Where available, information about the period of early European settlement will indicate conditions prior to extensive impacts of agriculture, urban development, and industrialization. However, precise restoration to any given historical condition is not a goal, since:

   - Climate and other environmental conditions have changed significantly since the pre-settlement period as a result of both natural and human causes. For example, recent climatic warming trends and local warming effects of cities may have led to increases in southern species and decreases in northern species.
   - Species ranges and abundances have changed dynamically throughout history, so that a single period for restoration cannot be justified ecologically.
   - Some keystone species, which existed in pre-settlement communities (e.g., canopy chestnut, passenger pigeon) cannot be re-established, therefore making complete restoration of historical conditions impossible.
   - Use of park and adjacent lands may constrain some natural patterns. For example, a variety of flood plain plant communities may be maintained naturally by stream meandering and channel abandonment. This pattern may not be feasible where roads, trails, buildings, sewer lines, etc., limit acceptable channel movement. Landscaped and mowed park and adjacent land creates a great deal of edge habitat, which affects the abundance of edge versus forest interior species of biota.

   Existing conditions in regional sites with less disturbance provide a model of what can be achieved under current climatic conditions and human impacts. However, the amount of disturbance in regional sites may be difficult to determine, and may in some cases be greater than that in the park. For example, parts of the park probably have lower densities of deer than many regional forest patches. Therefore, regional reference states cannot be the sole basis for comparison.

Compilation of information on historical and regional reference conditions is a necessary part of defining restoration activities. However, such work has to be done within the time limits and financial constraints of NLREEP.

2. **Choice of habitat types as site-specific objectives**. In choosing among different potential restoration sites or in selecting objectives for individual sites, it is necessary to prioritize among habitat types. Higher priority should be given to ecological communities representative of landscapes with minimal human disturbance. For the Philadelphia area, these communities include several types of deciduous forest, non-tidal and tidal wetlands. Persistent manmade landscapes will therefore receive less consideration for restoration. Such manmade habitats include both modified natural landscapes and former designed landscapes (i.e., agricultural, residential, horticultural and industrial) whose intended use has become obsolete. Many of these sites have historical associations for park users. Abandoned designed landscapes include mill dams and associated mill ponds, other abandoned structures, and gardens. Many of these sites support or supported characteristic assemblages of native plants and animals. Restoration of these sites to their modified historical condition will be a low priority of this program. Sites where modifications persist and remain important to park users will also be of low priority for restoration to natural conditions. However, restoration of manmade features to reduce impacts on ecological conditions (e.g., trail repair), to improve ecological functions (e.g., water detention) or to increase native biodiversity is expected to be an important part of restoration.

   Higher priority should be given to habitat types which have become the most uncommon or degraded in the region. For example, there has been disproportionate loss of some habitat types, such as wetlands and Coastal Plain forests. Priority should be given to creation or improvement of habitat types which have become the least common or the most degraded relative to their historical occurrence.

   For example, deciduous forest was a dominant vegetation type in this region, and forest restoration is a high priority. Most park lands have undergone huge changes in proportions of habitat types from settlement through park development and forest regeneration. In particular, early successional habitats have been prevalent during several time periods, e.g., during various phases of settlement, after industrial, agricultural or residential abandonment, and after being established as park lands. Maintenance of early successional stages is important to this program, since these are characteristic of natural, self-sustaining landscapes. These early successional stages are critical to maintenance of a number of species of plants and animals which prefer these habitats. Restoration activities such as maintaining some early successional stages may be performed (e.g. meadows). Early successional stages should be considered as appropriate site specific objectives for areas where sustenance of mature deciduous forest is not feasible or would conflict with other uses, such as some edge habitats. However, the extent of early successional stages in the natural lands should be small relative to mature forest, reflecting the corresponding relationship of these stages in areas of low human disturbance.

3. **Constraints on restoration**. In some sites, restoration to reference conditions is not feasible as a site-specific objective, because of other uses of the site or adjacent areas or because of the severity of disturbance to the site. Restoration may still increase the ecological value of these sites. Goals for restoration of such sites will include:

- Increasing native biodiversity. This could involve increases in the number of species using the site (i.e., increasing local biodiversity), or increases in a few locally rare species (i.e., increasing regional biodiversity).
- Hydrologic protection of streams which drain the site, for example, by increasing water-holding capacity.

4. **Consider different aspects of ecological communities in assessing disturbance and developing restoration plans**. Ecological communities may be defined in several ways, including overall aspect (e.g., canopy forest, gallery forest, meadow), dominant structural species (e.g., oak-hickory forest), overall plant assemblage (all plants present), or overall plant and animal assemblage. These definitions will have consequences in assessment of the condition of different sites which will affect prioritization of sites for restoration. For example, sites with a variety of canopy species might be considered relatively healthy by a structural definition, but could be considered very degraded based on loss of herbaceous plants, animals or other groups. These effects of designating community types will need to be considered in the selection of restoration projects, and assessment of existing conditions should consider biodiversity as well as structure.
5. **Consider the spatial arrangement of habitat types in developing restoration plans**. Landscapes typically consist of a mosaic of different habitat, and the size and arrangement of habitat patches greatly affects ecological communities. For example, many species of amphibians breed in wetland pools and use surrounding forests for most of the year. Many forest butterflies use wildflowers in adjacent meadows as nectar sources. A mix of habitat types is necessary to maintain these groups. On the other hand, proximity of open habitats (e.g., yards, parks and meadows) may increase parasitism of nests of forest birds by cowbirds. In developing restoration plans, the effects of size and pattern of different habitats on different organisms should be considered.
6. **Exotic species may be appropriate for some sites, such as those with habitual disturbance**. A number of exotic plant species have become well-established. These are prevalent in disturbed sites, and it may be very difficult or impossible to restore sustaining assemblages of native species in their place. Therefore, sites which represent these assemblages should be identified, as restoration would not be appropriate in these areas. Control of invasive, exotic species, such as Norway maple and Japanese knotweed, may still be warranted because of their ability to spread into restoration sites and less disturbed areas.

3.B.5. Goals for Restoration, Rehabilitation, and Preservation Of Streams and Determination of Reference Conditions

GOAL: Preserve streams that are currently in good health and restore/rehabilitate degraded streams by counteracting the effects of urbanization on hydrology (i.e., high peak flows, low base flows) and geomorphology (i.e., scoured and enlarged channels) And aquatic ecosystems.

Restoration activities may include:

Decreasing peak flows (e.g., detention basins and infiltration techniques).

Increasing base flows (e.g., infiltration techniques).

Improving riparian conditions (e.g., planting of native species, and removal of invasive/exotic vegetation).

Improving groundwater seeps/wetlands.

Creating wetlands.

Improving habitats for aquatic organisms.

Modifying stream geomorphology.

Restoring the interaction of channel and flood plain, where appropriate.

Bank stabilization.

Controlling outfalls (i.e., check dams, energy dissipation, etc.).

Daylighting streams (i.e., removing stream channels from underground culverts, pipes, etc.).

Removal of concrete stream channels and restoring natural contours, banks, substrates.

Trail modification to decrease runoff and erosion.

Modifying park management to decrease stormwater runoff (i.e., conversion from mowed grass to meadows).

3.B.5.1. **Objective**

The desired result is a system of streams that exhibits hydrologic and geomorphologic characteristics typical of less urbanized areas, and that provide healthy/diverse habitat for aquatic biota.

3.B.5.2. **Guiding Principles**

1. **Address basic causal factors**. In order to promote development of healthy/stable streams that are as self-sustaining as possible, restoration activities should address the primary conditions which impair the streams. The streams flowing within and through the Fairmount Park system boundaries and their watersheds exist in a highly urbanized landscape. The process of urbanization produces fundamental changes in the hydrologic, hydraulic, erosional, and depositional characteristics of fluvial (stream) systems. These changes often lead to stream instability which is characterized by abrupt, episodic, and progressive changes in the location, geometry, gradient, or planform of a river or stream. Urbanization typically causes increased peak flows, decreased base flows, increased channel size due to erosion of the bed and banks, scour of sand-sized sediment from the beds of small streams, and deposition of the eroded sediment in larger streams.
2. **Recognize watershed-level effects**. Ideally, the effects of urbanization on hydrology should be addressed in the upland watershed through best management practices that reduce runoff from impervious surfaces. The Fairmount Park system is made up mostly of stream valleys that were intentionally set aside to protect and buffer the streams in the City of Philadelphia. Unfortunately, 95% of the flows in these streams originate from outside the parks. Eventually, watershed restoration should involve coordinated efforts of the Fairmount Park Commission and agencies working outside the city. However, the areas outside the park are essentially beyond the control of the Park's restoration activities under NLREEP. Therefore, other than education and working with other City agencies (i.e., the Philadelphia Water and Streets Departments), there are few opportunities to conduct upland restoration activities that directly control watershed runoff at the source. Much of the restoration should involve activities in stream, flood plain, and riparian zones in an effort to reduce the impacts of upstream urbanization.

3. **Work with other city, regional, and Federal agencies to create watershed-level solutions.** Coordination with a variety of agencies to develop watershed-level solutions is essential to the health of the Park's streams and should be encouraged. However, such watershed-level solutions are beyond the scope of NLREEP. It is important that the Park consider partnerships with other city agencies (i.e., Philadelphia Water Department) and non-city governments (i.e., Montgomery County, Darby Township) to facilitate watershed-level controls of storm flows. For example, Cobbs Creek actually creates the border between Philadelphia and Darby Township. Therefore, it is not possible under this project to implement controls in the watersheds contributing to small streams that enter from the west that only have small stretches within the park and no contributing areas within Philadelphia. Watershed-level solutions for consideration include zoning, land use legislation, education, and stormwater management in the upper portions of the watersheds.

4. **Address situations where restoration efforts can make a difference**. Many streams have much of their channel and watershed outside of the Fairmount Park system (e.g., Wissahickon Creek), and much of these out-of-park areas are urban. This project may not be able to effect significant change in many systems under present conditions in these external areas. As a result, restoration should be concentrated on smaller tributaries, especially those with significant watershed areas within the parks. In particular, there should be less effort on the main stem tributaries (Schuylkill, Wissahickon, Pennypack, Cobbs, Tacony, and Poquessing), since conditions in these streams are controlled largely by conditions outside the park and actual restoration would require a watershed-level approach.

5. **Work with other agencies to influence on-going or soon-to-be engineering projects**. The FPC should work with the Philadelphia Water and Streets Departments, the Pennsylvania Department of Transportation (PennDOT), and other governmental agencies to ensure "environmentally sensitive" technology and maintenance activities (i.e., avoid using riprap, placing streams underground, channelizing streams, and increasing stormwater discharges on steep slopes). It is especially important to be aware of and prevent these activities from occurring during the restoration process. For example, a large section of Indian Run in Cobbs Creek Park was lined with riprap during the early phases of the project in order to protect an eroding sewer line.

6. **Recognize the benefits of cooperating with other Philadelphia agencies** (e.g., Philadelphia Water and Street Departments). There may be some excellent opportunities to leverage restoration efforts by partnering with other City agencies. For example, the Philadelphia Water Department has a priority list of capital projects in their efforts to control stormwater. Their list of priority projects should be considered an important factor in the selection of restoration projects to be undertaken by the FPC.

7. **Stream restoration activities should be linked to vegetation restoration**. For example, restoration of wetland seeps in flood plains will help mitigate flood flows, increase base flows, as well as provide a valuable landscape/vegetative feature and important habitats for terrestrial and aquatic fauna. As another example, the reduction in the amount of mowed land and subsequent conversion to open meadow will help reduce runoff as well as provide valuable terrestrial habitat.

8. **Stream restoration activities should be linked to trail restoration and development**. For example, many trails follow the main stream channels (Wissahickon, Cobbs, Tacony, Pennypack, Poquessing, Schuylkill) and the small 1st and 2nd order streams draining into

these main channels. It is important to reduce the impact that trails have on these small streams and to design trails in an ecologically sensitive manner. In addition, trails can cause stormwater and erosion problems. Therefore, the restoration of trails that cause these problems should be encouraged. However, planning and implementation of trail restoration is beyond the scope of ANSP's activities on NLREEP.

9. **Use techniques and materials approaching natural**. Restoration activities should utilize natural processes or bioengineering techniques. Bioengineering techniques emphasize the use of live vegetation or natural materials (e.g., fiber logs and mats) to stabilize and restore stream banks. The use of conventional bank armoring techniques such as concrete and riprap will be discouraged.

10. **Recognize the importance of small streams in the overall health of aquatic ecosystems**. The Fairmount Park system has an incredible variety of small 1st and 2nd order streams. Often, these small streams are ignored or overlooked by the public and by managing agencies. These small streams are often placed in underground culverts, filled, or disrupted by trail usage. It will be important to publicize the results of the ongoing assessment (i.e., streams and biota). For example, a map showing the small streams in the parks and the biota inhabiting them would be a strong educational tool.

11. **Recognize the importance of water quality to the overall health of aquatic ecosystems**. Although the NLREEP does not specifically address water quality, restoration activities that improve water quality should be encouraged and appropriate partnerships should be made to begin to address water quality issues.

12. **Recognize the dynamic nature of stream channels and systems**. Erosion and deposition are natural processes in streams. In addition, channel movement is natural and creates diversity of instream habitats and a mosaic of flood plain habitats. Change in hydrology and sediment supply due to urbanization may destabilize stream channels, change rates of channel movement, and result in channel widening and/or incision. Eliminating sediment or keeping stream channels in a fixed position should not be a desirable goal of restoration.

13. **Recognize that even though streams naturally move laterally, the control of lateral movement may be necessary to protect riparian or channel features (i.e., bridges, walls, trails, roads, buildings, ruins, sewer lines)**. Therefore, although little ecological benefit may be realized, such control (i.e., bank stabilization) should be recognized and considered under the restoration program when necessary.

14. **Recognize and restore flood plain function, where appropriate and feasible**. Many stream systems have flood plains which are periodically flooded. Under natural conditions, parts of the flood plain are flooded often enough to affect hydrology (i.e., water storage, water chemistry) and ecology. For example, flood plains in undisturbed systems often contain a mix of wetlands, seasonal ponds and backwaters which are important habitats for flora and fauna. These stream and flood plain systems have been highly disrupted by changes in hydrology, post-settlement deposition, channel incision, and exotic vegetation. Reestablishing the relationships between channels and flood plains that existed before urbanization should be considered as a restoration activity.

15. **Control high peak flows due to watershed urbanization**. Impervious cover (e.g., pavement, buildings.) directly influences urban streams by dramatically increasing surface runoff during storm events which can cause scour and enlargement of stream channels. Restoration activities should consider an array of methods to control these

excessive storm flows. For example, techniques such as detention/retention basins, infiltration techniques, and wetland restoration/creation should be considered.

16. **Increase base flows in order to improve aquatic habitat**. Since impervious cover prevents precipitation from infiltrating into the soils, less flow is available to recharge groundwater. This project should consider the use of infiltration techniques and wetlands restoration or creation to help store water during storm events, thereby allowing water to infiltrate into the ground.
17. **Modify stream geomorphology in order to ameliorate the effects of high flows/low flows where it is not possible to fix the problem**. For example, urban stream channels tend to be enlarged at the same time their dry weather channels (i.e., low flows) are reduced due the lack of groundwater recharge. For many urban streams, this results in a very shallow low flow channel that haphazardly wanders across a very wide stream bed, often changing lateral position in response to storms. This results in very poor habitat for aquatic organisms. It is possible to create/excavate new low flow channels within the new high capacity channels to improve/maintain low flow habitat. However, the actual excavation of channels should be considered only as a last alternative. If peak flows can be decreased and there is enough new sediment available, narrower channels should slowly develop through time by the deposition of sediment within the larger channel.
18. **Recognize that dams within stream channels are not ecologically "natural" and that improvements or modifications of them should not be considered restoration activities**. Most of the main tributaries in the park contain dams. These are non-natural elements of stream systems and they can significantly affect these systems. Potential effects include sedimentation in backwaters and reduction of sediment supply in downstream reaches, warming in the backwaters, and blockage of stream channels to migrations of organisms. Under present conditions, park dams have little water storage capacity, and the net effects on oxygen depletion in backwaters and aeration at spillways is unknown. Therefore, reconstruction or repair of dams is not considered a restoration goal for natural lands management. Dams and associated backwaters have cultural importance to park users as scenic and historical features. These values should be considered in any plans to restore natural conditions in these reaches. NLREEP should consider the removal of dams as a stream restoration activity. As discussed above, there are many dams within the parks that can cause undesirable conditions for streams. As an example, the PA Fish and Boat Commission is currently removing dams throughout the Commonwealth in order to restore the natural flow characteristics of streams and rivers for fish passage.
19. **Consider "daylighting" streams that have been placed underground in culverts**. This restoration activity involves the removal of culverts and fill material and the restoration of the stream channel and riparian zone. The purpose is to bring light back to covered reaches of small streams. It is also important to recognize that daylighting is not feasible under certain conditions (e.g., the small streams in West Park that are separated from the Schuylkill by lengthy culverts).
20. **Acknowledge uncertainty of urban hydrology and restoration techniques**. Hydrology (i.e., precipitation, infiltration, runoff, and groundwater) is stochastic in nature. In other words, from day-to-day or year-to-year we cannot be certain of the events that will occur. Therefore, it is difficult to "predict" the future amount or timing of rainfall or runoff in a stream and, therefore, it is difficult to "design" a restoration activity that will succeed under all possible conditions. Therefore, stream restoration

activities should be implemented in stages, with monitoring before, after, and during each stage. Stages can then be modified as the stream and flood plain evolve. This is particularly important for restoration activities that involve creation of new storage bars and flood plains. Because the hydrology and sediment supply of the parks' streams are largely undocumented, rates of "recovery" following reductions in storm runoff may be difficult to predict.

21. **Consider the impacts of restoration activities on water quality**. Direct effects on water quality are beyond the scope of NLREEP. However, improvements may be achievable by addressing riparian zones and wetlands (i.e., filtering, processing of nonpoint source pollution), control of erosion (i.e., reducing exposure, stress, breakage of sewers), riparian vegetation (i.e., affecting temperature and, therefore, dissolved oxygen), and improved habitat (e.g., riffles increase dissolved oxygen).

    Oxygen is the most fundamental parameter of aquatic ecosystems aside from water itself. Dissolved oxygen in the water column is essential to the survival of aquatic biota. However, dissolved oxygen concentrations can be depleted in polluted streams. Two important factors that influence the amount of dissolved oxygen in water are: a) the solubility of oxygen is affected by temperature and increases considerably in cold water and b) mechanical mixing or turbulence (such as flow through a riffle or over a cascade) can increase the amount of oxygen dissolved in water.

22. **Increase public awareness of the scenic, inspirational, and spiritual values of the streams in Fairmount Park (e.g., waterfalls)**. This should be accomplished through the cooperation between the assessment and restoration activities of this project with the educational component through the transfer of knowledge gained. In addition, public outreach via newspaper and other media (e.g., Internet, radio and television) can increase awareness of park features.

23. **Re-introduction of aquatic organisms**. Re-introduction of aquatic organisms to park waters may be considered after careful consideration of potential impacts, the likelihood of recolonization without introduction, and of the likelihood of sustained success of the re-introduction. These considerations should be similar to those discussed for re-introduction of terrestrial species.

3.B.5.3. **Reference Conditions**

In order to "restore" you must have a "reference" to compare to. However, there are no streams in "pristine" or "pre-settlement" condition in the area to use as reference examples since humans have altered all streams or their watersheds to some extent. As an example, French Creek is considered one of the healthiest and protected streams in the greater Philadelphia area. Much of the creek's watershed is in forest cover and protected by a state park and land conservancy acquisitions. However, the entire watershed was historically deforested to produce charcoal for iron furnaces. Deforestation caused extensive alteration of streams and flood plains—the deposits formed during this period are still evident in alluvial valleys of the creek. Therefore, the stream is not in "pristine" or "pre-settlement" condition, but does exhibit relatively healthy and stable stream characteristics for use as a reference for the current restoration project.

The "reference" streams selected as desired objectives for restoration are "rural" Piedmont streams (except for Coastal Plain streams, such as those in FDR Park) that have forested riparian zones, are biologically "healthy," and have not been extensively scoured and enlarged by erosion of the stream's bed and bank. Such streams are found in Chester, Montgomery, and Bucks counties in PA and Cecil County in MD.

4. HISTORY AND EXISTING CONDITIONS OF VEGETATION AND FAUNA

Fairmount Park System

Natural Lands Restoration

Master Plan

Fauna and Flora.

Cobbs Creek Park

4.A. INTRODUCTION

An assessment of current conditions was done as the first part of restoration planning. Vegetation, selected groups of animals, stream channels and disturbances to these resources were assessed. The assessment included review of various types of published data and maps, taxonomic collections, information from citizens, park staff and scientists, and a field inventory. Information on historical ecological conditions and trends was compiled. The objectives of this assessment were to determine:

- the status of the natural lands throughout the park system;
- trends in conditions, as part of identifying vulnerable resources, and causes of ecological degradation;
- threats to the natural lands; and,
- sites of exceptional value.

This assessment provided the foundation for selecting sites for restoration, specifying restoration activities at these sites, and making general recommendations for the management of the natural lands and adjacent areas.

The main components of the assessment are:

- Assessment of types and levels of disturbance of vegetation, including:
  - classification of natural lands, vegetation types and disturbance levels from aerial photographs;
  - extensive ground survey of vegetation and disturbance, with more intensive analysis of representative sites; and,
  - botanical surveys of the natural lands to determine the relationship between disturbance, vegetation and biodiversity;
  - Inventory of biodiversity of selected groups of animals, to determine relationships between disturbance, vegetation and faunal biodiversity;
- Analysis of watersheds and stream channels in the park, including:
  - screening-level survey of all stream tributaries in the park;
  - detailed assessment of representative stream reaches and comparison with reference sites in nearby rural areas;
  - analysis of characteristics of representative watersheds in the park.

This section describes the vegetation and faunal assessments. The stream channel assessments are described in Section 5. These discussions focus on conditions in the entire system. This is a powerful approach in demonstrating effects of different types of disturbance, since it allows contrasts between areas with different types and levels of disturbance. Park-specific conditions are described in more detail in Volume II. These park-specific assessments provide the basis for selection of restoration sites within each park.

4.B. VEGETATION AND LAND USE HISTORY

Knowing the history of the seven large watershed and estuary parks is essential in evaluating their current conditions, understanding how they reached these conditions and in developing models for restoration. The landscapes which greeted the Europeans when they began to settle in the 17th century were not primeval forests, but landscapes which had been much altered by the native Americans who had been living in the area for 20 to 50 thousand years. Pyne (1982, p. 46) states: "The virgin forest was not encountered in the sixteenth and seventeenth centuries; it was invented in the late eighteenth and early nineteenth centuries." The Delaware Valley was largely forest, and was home to the Leni Lenape, who primarily farmed openings in the forests, hunted in the woods and fished in the rivers and streams. It was wilderness only to the eyes of Europeans, who came from an urban society supported by intensive agriculture based on the iron ax and plow. This technology cleared the fertile plains of Europe into the farms, cities and villages, and contrasted sharply with the woodlands culture of the Native American. So it is not hard to imagine why the European settlers saw the land as a wilderness.

It is difficult to reconstruct a vision of the woodland landscape which greeted the Europeans. Journals, pictures, and travel accounts are wrought with projections of European cultural ideas. Native Americans are drawn with European likenesses. Travel accounts tend to paint a rosy picture and personal accounts often do not mention the common everyday details, since most writings were directed at encouraging Europeans to migrate. Travelers probably focused on what seemed most unusual to them, so readers may get an exaggerated view of the extent of the forest, the abundance of wildlife, etc. Many of the more detailed accounts are from the 18th century, by which time settlement had already greatly changed the landscape.

Native American culture was affected by European exploration and trade in the continent even before intensive settlement (Crosby 1994). Indian populations probably decreased radically from European diseases and some early settlers may have seen portions of a landscape in the process of reforestation following abandonment of Indian agriculture (Pyne 1982). Nonetheless, travel accounts, combined with information on the current vegetation and fauna, historical information on age and size of trees, and paleo-ecological studies, can be used to develop an idea of the history of the region.

One of the primary accounts is that of Peter Kalm, a Swedish traveler who spent time in the colonies from 1748 to 1751, much of that time in the Philadelphia area. The accounts of his travels (Benson 1964 edition of Kalm 1770) provide rather detailed notes on a variety of plants and animals. In addition to his own observations, he interviewed several settlers concerning conditions during early settlement. Kalm's local observations include a mix of general observations and notes about conditions along travel routes that were taken while visiting nearby areas (e.g., Germantown, Wilmington, Penns Neck, Raccoon Creek, Trenton). Although he made detailed observations, it is difficult to determine if statements within his notes apply to a single locality or are based on regional findings.

The woods of the Leni Lenape, a relatively closed canopy forest, appeared vast to the New World settlers. The climax forest had much larger trees than we find in the park system today. It is estimated that oak trees found by the settlers grew for 300 to 400 years (Wildman 1933). In a visit to Penns Neck, Delaware, Kalm observed many 200-year old trees, but few 300-year old trees. It is not clear within this discussion if this was a general regional observation or if it was site specific. Trees were an important resource for early development and accounts often mention common tree species. Kalm made a detailed list of trees and shrubs and their relative abundance and distribution (see Section 4.D). These observations indicate that the general composition of the forest was similar to existing forests, with many of the same species (oaks, hickories, maples, sycamore, etc.). There have been some changes, such as the decrease in chestnut following the chestnut blight in the early 20th century.

The early landscape is often pictured as an unbroken forest of mature trees which ran for miles. The non-forested uplands which did exist were probably maintained primarily by Native Americans either by burning or by actively farming the land. The extent of these non-forested areas and the precise conditions in forested areas are not well known. For example, the extent and nature of burning by Native Americans is not well characterized. Burning was a common practice by Northeastern Amerindians (Pyne 1982). When sailing into the mouth of Delaware Bay in 1632, a Dutch traveler noted smoke from Native American fires (cited in Bakeless 1961). Burning was used to create and maintain open fields or savannahs (i.e., meadows with scattered groves of trees), but burning was also used to control understory within closed woods. These practices could be used to increase growth of forage for deer, aid access into woods, and to maintain open vistas for security.

Many people of the time, documented in travel journals, commented on the openness of the understory, some describing it as “park-like” (Budd 1966). For example, in several places Kalm noted the ability to ride horseback through woods. This condition could be created by burning, although the shade in a continuous, mature canopy forest may restrict undergrowth without burning. By Kalm’s time, foraging of cattle and hogs in the woods could also have affected the forest understory.

The Philadelphia area was settled first by the Swedes and Dutch in the first half of the 16th century, and at the end of the century by the British. “Go yea out into the wilderness and seek” was the cry from the religious leaders of Protestant Britain, and William Penn did just that. He named his lands Pennsylvania and began a “Holy Experiment.” The vastness of the woods, coupled with the abundance of edible fauna and flora, and the availability of reasonable land for farming was in stark contrast to Europe, where hunting lands were controlled by the crown and wealthy landlords. For most Europeans, the New World represented unprecedented opportunity. The ensuing influx of European “farmers” commenced the cutting and alteration of the native American landscape. This process was vast, and ultimately settlement spread into the interior of the state and beyond. Philadelphia was a center for immigration and soon became a preeminent city in the New World, changing the landscape dramatically and rapidly. The forest was forever altered, first with hand tools and manual labor, then with the advent of steam powered with wood and later, coal. Initially, development centered along the edge of the Delaware River. But soon the trees were cut on its banks and piers were constructed along the shore.

William Penn’s Holy Experiment began in 1681, 60 to 70 years after settlement had begun in New England and the Tidewater area. Settlement of the area was influenced by the experience of a generation of New World settlers of multiple ethnic groups. Penn realized that agriculture did not need to rely on the common field, but could survive and flourish with families farming small plots of land (approximately 250 acres). Thus, the large landowners further subdivided their tracts and sold them to small farmers. The families, in turn, began the arduous task of clearing the forests and replacing them with fields, crops and orchards. This method of settlement not only cleared the land, but interrupted the Native American lifestyle which relied on the unbroken woods.

Because of their steepness, slopes of the Wissahickon and probably a few other areas (e.g., Chamounix in West Park) were spared from the plow. However, the trees on the slopes were cut for timber and fuel. The climax forest before European settlement does not exist anywhere in Philadelphia or, for that matter, on the east coast. This fact demonstrates how thoroughly eastern North America was cleared. However, aging of single trees in an ecological study of Fairmount (West) Park (McCormick 1971) indicated the presence of trees which sprouted in the 18th century, suggesting some continuity within the forest.

By 1720, plantations, the common term for farmsteads, dotted the countryside in and around Philadelphia. As people entered the city, a greater demand was placed on the nearby resources. As forests were cut for the plantation fields, there was a ready market in nearby Philadelphia for the wood. Houses needed to be built and heated. Local forest wood was needed for shipping crates, furniture, shingles, beams, floor boards, window sashes and doors. Clay was removed from fields, molded into brick and fired. Marshes were drained for agriculture and health reasons. In 1750, Kalm still characterized the landscape around Philadelphia as woods broken by clearings, in specific contrast to the more developed landscape around Princeton. The closer to the city, the more pressure on the local resources, and the less one would see patches of forests. Streams in and around the city were rerouted, covered or drained. Housing expanded westward. The huge appetite for lumber began to exhaust the local supply. The need for food and shelter put huge demands on the natural resources of the area, creating the need to clear more land, and plant more crops for the growing markets of the city. The plantation not only housed many families, it assured a steady and reasonable income for each family, creating a demand for land which was purchased for cash. What began as a Holy Experiment in 1681 resulted in a large English speaking city in the New World with a bustling economy.

Bartram perhaps summarized the rapidity with which the forest was cleared in his correspondence to Peter Collinson (1741, ANSP Archives):

> *"Indeed most of our curious native plants, shrubs and trees is destroyed for 80, 90, 100 miles back this year. I went up sculkil toward ye mountain to gather ye shugar maple seeds where grew a fine grove of them whose fallen tops lay so thick upon ye ground that I took another course 30 miles to gather some particular forest seeds I gathered there but ye trees was cut down and ye land cleared and clouthed with green corn..."*

A regional network of plantations connected to villages radiated out from Philadelphia. To support the growing population and commerce, a system of roads developed from what began as trails through the woods. Toll roads further fragmented the forests connecting the outlying areas to the city.

Further glimpses of the landscape can be gathered through letters and journals and pictures of the period (Bakeless 1961). The clearing of the forest happened quickly. In less than 100 years the landscape changed dramatically, especially in and around the city. Early 19th century views of the Schuylkill River show large estates among clumps of trees with lawns running to the river's edge (Foster 1997). The pictures show little understory and the landscape seemed to feature planted specimen trees. By 1800, both banks of the Delaware River were tamed and were active centers for transportation and commerce. Early pictures of the city viewed from Camden demonstrate how the landscape was cleared of its forest, and in its place grew the red brick city of Philadelphia (Foster 1997).

The agricultural development of the land had huge ecological consequences beyond the change from forest to field. Many European plant species were brought to the area, either intentionally for crops (e.g., white mulberry) or as ornamentals, or more often, inadvertently mixed in with seed. Many of the common old-field herb species are of European origin. Soil carried on ships as ballast was dumped on arrival in port, and numerous European species of plants grew in these areas.

The land clearing had tremendous effects on streams and rivers. The change in flow regime with clearing was noticed early. For example, Kalm noted the decrease in stream flows following clearing. Clearing also increased erosion, and there was a tremendous amount of sediment entering streams and rivers. This sediment was deposited on the flood plains and in the stream channel raising stream elevations. The soil horizon marking the presettlement soil surface and several feet of post-settlement deposition can be seen in many stream banks in the Piedmont. As streams now downcut through this sediment, the stream channels have become much lower than the flood plain banks, leading to the characteristic flood plain channel profile seen throughout the park system.

During the period between 1800 to 1900, the city and region experienced incredible growth. The early industrial part of the eighteenth century began with steam power. Steamboat ferries not only enabled people to cross the rivers more quickly and regularly, but they also provided a reliable and efficient means of taking products up and down the rivers, getting goods to outlying areas and growing markets. What began as a quiet country town circled by plantations became a busy commercial center for the entire Delaware Valley. The Schuylkill canal was built in the early 19th century, further changing the river's edge and was followed quickly by construction of the railroads, requiring more wood from the forests. The railroads provided the city with a new quick and reliable way to bring in raw materials necessary to supply the demands of the nation's largest city. Pressure for land in the city mounted, causing further demand for goods. Plantations which began as self-sufficient agricultural endeavors were now fully responding to market conditions and generated large revenues. Areas that were once open space were developed. The plantation system in the Delaware Valley which began in the 18th century reached its peak in the middle of the 19th century.

By 1860 the forest which was once Penn's wood was virtually clear and Pennsylvania was a dairying center. Milk was produced throughout the Delaware Valley and brought to the city for processing. The farmstead with its associated house, barn outbuilding and wood lots was the dominant feature outside the city while within the expanding city, row after row of houses filled the original street plan and began to stretch to the other side of the Schuylkill, displacing farmstead after farmstead. As long as horses were an important means of transportation, horse pastures were significant land uses.

An idea of the landscape in the latter part of the 19th century can be gleaned from Krider's *Forty Years Notes of a Field Ornithologist (*1879). Krider provides specific information on the Philadelphia region, along with general assessment of abundance in the eastern United States. Krider makes repeated references to the Meadows in South Philadelphia (which included the area now in FDR Park), an area of marshes and fields. His records of open country birds indicate the prevalence of pastures, fields and marshes in the city during that period. For example, the Marsh Hawk, which breeds and forages in grasslands and marshes, was said to be the commonest hawk. Other open country birds which were apparently more common then than now include the Rough-legged Hawk, Rails, Short-eared Owl, Bluebird, Horned Lark, Brown Thrasher, Marsh Wren, Savannah Sparrow, Swamp Sparrow. Many of these species have declined throughout the northeast as marshes and pastures have been replaced by crop fields, woods, or houses.

Many of the woodland birds which are now common were uncommon or absent (e.g., Red-bellied Woodpecker, Pileated Woodpecker, Tufted Titmouse). However, some of the woodland birds were common then, such as Screech Owl, Hairy Woodpecker, Downy Woodpecker, and Blue-gray Gnatcatcher (said to be common in some seasons along the Schuylkill River). Krider specifically noted some changes, such as decreases of worm-eating warbler (a forest species) with the cutting of woods. Weygandt (1930) provides information on the Wissahickon in the early part of the 20th century. Interestingly, he notes increases in some woodland species, such as Hooded Warbler, Kentucky Warbler and Louisiana Waterthrush. This is consistent with Krider's account, which does not list these as breeders in the Philadelphia area.

By the middle of the 19th century the city was a major center of immigration, supplying inexpensive labor to the factories which grew in response to regional demands. From Camden one did not see a shore line of reeds and trees, but wharf after wharf and brick buildings row by row. In the late 19th century, industrial developments were built along the Schuylkill and Delaware rivers, further restricting open lands and polluting the rivers. For example, the Schuylkill Fishing Company, a private club, had its clubhouse on the Schuylkill River near Gray's Ferry since the early 19th century. Meals were expected to be supplied by fish from the river. However, by the late 19th century, accounts indicate the building up of land around the club and pollution of the water (giving the fish a foul taste); members began bringing fish from elsewhere for meals (Schuylkill Fishing Company 1889). Around the turn of the century, the club moved to the mouth of the Wissahickon, but after a few years it moved to a site on the Delaware River in Bucks County.

The population increase led to further declines in stream conditions. Essentially, many streams became open sewers (Lewis 1924). In response, many streams were covered over. Combined sanitary/storm sewers carried sewage to treatment plants. With incomplete treatment, these plants polluted the main receiving rivers, and sewage overflows into streams occurred during storm events. More modern development incorporated separate sanitary and storm sewers, although leaks and illegal cross-connections have led to sewage spills. In recent years, there have been major upgrades of sewage treatment and there are ongoing efforts at remediating many of the stormwater water quality issues. Most historic information concerns the Schuylkill and Delaware rivers or the smaller tributaries (e.g., Mill Creek in West Philadelphia). Little information has been found on historic water quality conditions in the main park streams (i.e., Cobbs, Pennypack, Wissahickon, Tacony and Poquessing). Given the industrial use of these streams and general sanitary practices, it seems likely that these experienced highly degraded water quality.

In addition to the woodlands of Philadelphia's uplands, the area had extensive wetland habitats, primarily on the Coastal Plain along the Delaware and lower Schuylkill rivers. These included a variety of intertidal channels, marshes, mudflats, and gravel bars. Much of the south and southwestern parts of the city, including what is now FDR Park, was a mix of tidal channels and marshes. Nontidal wetlands were present inland from the tidal marshes and along streams (e.g., Morris 1915). Differences in extent and regularity of inundation, depth, substrate and other factors generated a diversity of habitat types, and these wetlands supported a variety of plants and animals. Parts of the Pennsylvania Coastal Plain supported acidic wetlands with a distinctive flora similar to that of the New Jersey Pine Barrens. These areas are best known from the vicinity of Bristol, PA, where remnants still exist. The occurrence of such habitats in Philadelphia is uncertain, but records of some of the plant species (Wherry 1968) in or near the city (e.g., Andalusia and Cornwell Heights) suggest that some of this habitat type was present.

These wetland habitats were modified or destroyed for a variety of reasons. Diking and filling of marshes was done to provide grazing areas and new croplands. The sediment influx generated by settlement in the watershed would have affected streamside wetlands and possibly the larger riverine wetlands. Diking of parts of south Philadelphia changed the area from tidal marshes to a mix of meadows and marshes. Naturalist's accounts of the 19th century (e.g., Krider 1879) frequently mention these habitats, and the "Neck," a part of South Philadelphia with marshes and vegetable farms. Most of these marshes have been filled in. Wetlands were probably present along many of the streams. There is little information on these, but records of species such as the bog turtle indicate their occurrence. Riverine wetlands were destroyed by sedimentation, down cutting, filling, and reduced base flows. Currently, there are almost no large riverine wetlands.

Recent demographic changes in the region have had significant effects on park natural lands. The city has decreased in population and abandoned factories and houses have increased the amount of open land in the city. In the same period, suburban populations have increased dramatically. Many of the suburbs have lower housing densities than the city, but many surrounding areas have preserved relatively little open space. Suburban development has occurred in the headwaters of all the major park streams, strongly affecting downstream hydrology. The increase in impervious surface in the watersheds has increased storm flows and reduced base flows. Increased water use has also reduced downstream water quantity. These changes in development in and outside the city have both increased the stress on park lands and waters and increased the value of these systems to the city and region.

In recent years, there has been an increase in occurrence and establishment of exotic plants and animals (i.e., plants and animals outside their native range). Introductions have occurred intentionally, to provide what was thought to be better wildlife habitat or food plants, as escapes from horticultural plantings, and accidentally from a variety of sources. While many of the exotic plant introductions of the 18th century were of European origin, many of the new introductions are of Asian origin. The occurrence of a very high diversity of Asian temperate plants, many related to North American taxa, provides a source fauna adapted to the eastern climate. Many of these species have spread into disturbed habitats, but many occur in relatively undisturbed areas as well.

While the ecological history of an urban area can be thought of as local human modifications of a static natural landscape, human impacts interact with effects of a variety of environmental changes. Climate change has had an important effect on the area. Over the long term, the geography, flora and fauna of the region have been shaped by effects of glaciation and glacier melt during and after the Ice Age. Although the Philadelphia area was not glaciated, the climate was strongly affected by the proximity of glaciers. These effects continue into the present as land levels change and as plants and animals recolonize northern areas. More recently, weather cycles have affected the region. For example, the period 1350 to about 1870 is often referred to as the "Little Ice Age" (Pielou 1991), since it was characterized by colder temperatures than the present. For example, Kalm (1770) noted frequent freezing of the Delaware River near Philadelphia in the 1748-1751 period, while such freezing is rare now. These differences would have profound effects on flora and fauna, with different groups of organisms increasing or decreasing in response. In addition to these natural weather cycles, recent global warming has been attributed to human activities. More locally, cities create "heat islands," or warming due to loss of vegetation and urban construction increases local temperatures. This combination of natural, global and local effects exemplifies the complexity of factors leading to the current environment of the city.

4.C. PARK HISTORY

By 1855 the city was experiencing problems associated with its rapid growth, including a seriously threatened water supply. A conscious attempt was made to protect the surrounding watersheds so clean potable water could be secured, while also providing for the increased recreational needs of a growing middle class. It was during this period that forward-thinking officials of the city began to purchase open space in the watershed, which marked the beginning of the present Fairmount Park system.

By City ordinance in 1855, Lemon Hill was purchased and dedicated for the use of the people to be enjoyed as a public common. This was followed soon after by the purchase of Sedgely and Georges Hill. By 1867, the Fairmount Park Commission (FPC) was formed and 2,648 acres had been purchased. Both the need to protect water resources and give people in the city a place to recreate fueled the development of the city park system. The promenade at the Water Works and the romantic sculptures at Laurel Hill were visited regularly by the city's new middle class. However, continued development in the Schuylkill watershed outside the park system continued to threaten the city's water supply.

The city acted by purchasing more park lands in and near the developing neighborhoods. By 1868, the Wissahickon Valley was purchased, increasing the park system holdings to 4,077 acres. The Wissahickon Valley had a number of mills, which were closed (and many torn down) following park establishment. The main road through the valley was closed to commercial traffic and became known as Forbidden Drive. As a park, the Wissahickon Valley became known regionally and nationally as a natural landscape, and poets, authors and artists widely circulated writings and pictures of this beautiful landscape.

The park continued to expand in the early days of the 20^{th} century with the purchase of the Pennypack, Cobbs, and Tacony Creek parks, followed by Franklin Delano Roosevelt (FDR) and later the Poquessing. Seven large parcels now form the backbone of the system. These are: Wissahickon Valley, Pennypack Park, Cobbs Creek Park, Tacony Creek Park, Fairmount (East/West) Park, Poquessing Creek Park and FDR Park. Throughout the 20^{th} century, there have been two parallel trends. Most open land in the city outside the park has been developed. Houses were constructed on almost all uplands and parts of stream valleys were filled, often with ash, construction waste and other garbage. Many streams were converted into storm/sanitary sewers and their valleys filled and developed. These sites have created huge problems, as subsidence and erosion of fill has destroyed houses. At the same time, there were forces in the city which intended to keep Philadelphia a “Greene Countrie Town.” Trees were planted in the parks, street trees accompanied the building of the rows of houses, and more land was acquired along stream corridors. Together with the numerous small parcels of park land acquired later, the park system grew to its present configuration of 64 parks encompassing 8,900 acres, ranging from small neighborhood parks to the larger watershed parks. More recently, decreases in industry and the population of the city have opened up new vacant land, though little of this has been incorporated into the park system.

The natural lands of the park have continued to change in response to various types of internal and regional influences. Much of the park land was established from farms (i.e., cropland and pastures) or former industrial sites (i.e., mills of various kinds). When set aside as parkland, these areas tended to undergo succession from old fields through shrub to forest. Since much of the park outside the Wissahickon and East and West Park was established in this century, forests are relatively young, even-aged stands dominated by early- to mid-successional trees like tulip poplar (which can maintain itself into late succession as well), ashes, box elder and red maple. Older stands occur on steep slopes or ravines. Scattered late-successional trees (e.g., oaks and hickories) do occur, even in younger forests. Some of these may have been left from earlier periods, when they were left as shade trees and rows along roads. As forests mature, early successional stages and their flora and fauna have decreased. In some areas, relatively recent park additions (the area west of Pennypack Creek and south of Verree Road) have added new early successional areas to the park.

Undeveloped areas adjacent to the parks have also served as important adjuncts to the natural lands. Maintenance of many of these areas stopped later than that of the park lands, so these areas contained early successional habitats adjacent to maturing woods in the park. Over time, many of these areas have been developed or have become forested, representing a loss in the total size of unmanaged lands, and especially of early successional habitats.

Landscaping, land use and maintenance practices within the park system have also affected natural lands. Recreational areas (e.g., ballfields, golf courses, picnic areas) have been built in most of the parks. In some parks, especially Cobbs, Tacony, East and West Park, recreational areas occupy much of the flat land at the tops of plateaus, leaving natural lands along slopes. Fields have also been built on many of the wide flood plain areas near creek bends, as in Cobbs and Pennypack parks. Many trees and shrubs have been planted near or at the edges of the natural areas. While many of these include native species (e.g., oaks, flowering dogwood, and mountain laurel), many exotic species were planted. For example, Norway maple is commonly planted as a street tree and seedlings often occur near the edges of woods with rows of planted Norway maples.

In some areas, landscaping has been stopped, with reversion to more natural vegetation. Canopy shade trees are often present from earlier plantings, which form the basis of a closed canopy forest, often with native species. However, the understory and herbaceous layers of these areas are often dominated by exotic species with relatively few native species. For example, the section of Cobbs Creek Park west of 63rd Street and south of Race Street (the bocce facility woods) has a canopy of mature oaks, hickories and other species, but a sparse understory. Aerial photographs from 1927 show this site to be an open grove of large trees, which established the canopy after mowing was stopped.

While the parks were originally established to protect water resources, most of the parks include strips of land along the lower reaches of the creeks. Most of the watershed is outside the park, and the majority of the watersheds are outside the city. Watershed development has had tremendous impacts on the park streams, as the increase in impervious surface leads to more rapid runoff, increased storm flows, decreased infiltration and decreased base flows.

Levels of disturbance in the park system have changed in response to local and regional factors. For example, increases in trash dumping within the park has been linked to the restriction of free dumping at municipal sites. Changes in recreational styles, toward activities like mountain biking, all-terrain vehicles (ATVs) and motorcycle use, have increased damage in the natural areas of the park system. Decreases in police presence in the parks has also been linked to increasing disturbance of park areas.

For over 140 years the park system has grown and expanded not only in area, but in terms of programs available to the public. During that time, many parcels were added to the original park and now those parklands are an integral part of the city, tied inextricably to the quality of life in its neighborhoods. As the park system has grown, it has encountered conflicting groups of demands. With decreasing financial resources, the park has had to make critical decisions affecting allocations among landscaped, recreation and natural lands. There are demands for additional recreational facilities and for maintenance of orderly landscaped areas. With demands for new facilities, the natural lands are once again seen as opportunities for development. The natural lands contain important historical resources, which could potentially conflict with natural resource management. Natural lands have been treated as being, virtually by definition, “able to take care of themselves,” even as they are recovering from past land uses and faced with a myriad of current threats. With lands being stressed, it is sometimes difficult to distinguish normal changes in vegetation and other aspects of the natural lands from drastic decline. Given these competing demands and threats, restoration of the natural lands, integrated with other park activities, is essential to the vitality of the Fairmount Park system.

4.D. EXISTING CONDITION AND TRENDS OF VEGETATION

4.D.1. **Ecological Assessment**

4.D.1.1. **Introduction**

Vegetation within the natural lands of the park system was surveyed as part of the 1983 Master Plan prepared by Wallace, Roberts and Todd (Rhoads 1983) and as part of the Natural Lands Restoration and Environmental Education Program (NLREEP) assessment in 1998 by The Academy of Natural Sciences of Philadelphia (ANSP). The present vegetative community composition of the seven parks evaluated as part of NLREEP can be described based on major habitat types such as wetlands, forested uplands, non-forested uplands, slopes, streambanks, riparian zones and shrub/meadow areas. These habitats have different plant communities and different types of environmental problems which affect restoration planning. Information and data presented here provide a synopsis of the current vegetation of the natural lands of the Fairmount Park system. It focuses on the overall community composition and health of the natural lands of the park system.

Locations of managed land, such as ballfields and other recreational areas, were mapped from aerial photographs, but were not surveyed as part of the vegetation assessment. The following sections give a summary account of the community composition and factors affecting the integrity of the ecosystems in each of the seven parks that were investigated. More extensive findings with detailed issues and precise locations are provided in the park-specific volume (Volume II).

4.D.1.2. **Methods**

Aerial Mapping of Vegetation Types and Disturbance Categories. Mapping of vegetation was done from aerial photographs. The mapping had four basic functions:

- It differentiated existing natural and maintained (e.g., mowed areas, recreation facilities) sites. This was necessary since existing maps, such as those developed for the 1983 Master Plan, differentiated only forest and nonforest areas, and since there have been some changes in use of specific land parcels in the park system. The total of all "natural lands," i.e., those not maintained, was used as the basic domain for site evaluation and restoration planning.
- It defined different vegetation types such as deciduous forest, flood plain forest, evergreen forest, old field, shrubland and wetland.
- It provided the basic information on disturbance within each vegetation type. Thus, each patch of natural vegetation was defined by its vegetation type and level of disturbance.
- It identified undeveloped areas adjacent to the parks. This information was used mainly in the stewardship program of NLREEP.

Delineation of patches from aerial photographs and initial ground-truthing was done by Munro Ecological Services. ANSP undertook the digitization of patch boundaries, rectification of aerial photographs with digital information, and subsequent ground-truthing (site visits to verify classifications done on maps) as part of mapping and vegetation assessment. Mapping was done from the 1995 Delaware Valley Regional Planning Commission black-and-white aerial photographs (scale: 1"-800'). Ground-truthing, which was done to validate interpretations of the aerial photograph, provided additional information on disturbance and vegetation and helped to determine conditions of a few sites which could not be interpreted from the aerial photographs. Corrections, modifications and standardization of class names were done as part of the mapping and database process.

Each of the vegetation patches defined by the aerial interpretation was numbered, and the boundary, identification number, vegetation type, and disturbance class were used to define polygons in the Geographic Information System (GIS). These polygons became the basis of the main field vegetation assessment.

Vegetation Assessment. An assessment of the community composition of the vegetation in each of the seven watershed and estuary parks was performed by a team at ANSP in the summer of 1998. Areas included in the survey were selected based on data obtained from the aerial mapping of vegetation types and disturbance categories. Based on the findings from the aerial survey, each section of the park was divided into the following categories; deciduous forest (FD), evergreen forest (FEV), herbaceous layer (OF), shrubland (SH), wetland (W) and forest flood plain (FFP). In addition, a numerical value ranging from one to three was assigned to each site. Areas which were designated a one were considered to be least disturbed. These sites were dominated by native species and did not appear to be impacted heavily by either human or natural factors. Lands designated as a three were considered heavily disturbed, as indicated by dominance of exotic species and other disturbance. Sites which were given a rating of two fell in the middle of these classifications. The classifications were then mapped for each park. Most of the natural lands of the park were visited during the survey. Ten percent of the natural lands within each of these categories were chosen as formal assessment sites for the 1998 survey, which included only park natural lands. Information on managed lands, such as recreational areas, was not included in the results of this survey. The assessment was performed from April through September 1998. At each site, vegetation associations (i.e., habitat type and major communities within each type) were noted, as well as abundance and diversity of native species in each layer (i.e., herbaceous, vine, shrub and tree). Exotic species occurring in these areas, canopy gaps, soil moisture and depth of litter layer were also documented. Disturbances such as ATV use, deer browse and trash dumping were recorded. Based on the 1998 data, some of the boundaries set by the aerial mapping were changed and the included maps reflect the most recent data.

The vegetation survey was complemented by a floral survey. The floral survey focused on occurrence of plant species, particularly uncommon species, while the vegetation survey focused on dominant vegetation types and the types of disturbance affecting them. The floral survey was conducted by Dr. A.E. Schuyler (primarily Cobbs, Pennypack, Tacony, East/West and FDR Parks), of the Department of Botany of ANSP, and Dr. A. Rhoads and T. Block of the Morris Arboretum of the University of Pennsylvania (primarily Wissahickon Park). Poquessing Park had been surveyed in 1997 (Rhoads 1997). Records of uncommon plants were also compiled during the vegetation survey, as incidental observations during other surveys and as part of the 1998 Bio-Blitz in East and West Parks. The primary goal was documentation of native plants associated with the natural lands of the park, and identification of undocumented introduced species. A complete flora of the parks was not attempted and some groups (widespread, introduced species such as many old field herbs) were not documented unless dominant or otherwise notable. No comprehensive survey of aquatic and intertidal macrophytes was made, although records were compiled from the tributary streams and ponds in the seven park segments.

4.D.1.3. **Results**

The Fairmount Park system supports many different plant species and vegetative communities of varied habitat types including meadows, riparian zones, flood plains, upland forests, slopes and wetlands. The vegetative communities in each of the surveyed parks reflect the level of overall disturbance and human impact in the area based on successional stages. Succession is defined as the progression of changes in plant community composition, from early colonization of an area by plants to achievement of a climax community. An ecosystem will go through various successional stages until this climax community is reached. This community is defined as a climax because it is self-sustaining, where all of the plant species are interrelated. An example of a climax community in the northeast United States would be a mixed oak, hickory, beech canopy with various heath species in the understory. Although there are several locations where this type of climax community can be found in the Fairmount Park system, it is not as common as mid-successional or exotic dominated communities, which are prevalent in disturbed areas (see Appendix C-1.1 in Volume III).

Wissahickon Valley. The Wissahickon Valley has a varied topography which provides habitat for a myriad of plant and animal species in Philadelphia. Since the 1983 survey was performed, the vegetative community of the Wissahickon has changed. It was noted in previous studies that hemlock (*Tsuga canadensis*) stands with an understory of mountain laurel (*Kalmia latifolia*), hemlock and native azalea species represented one of the healthiest forest types in the Wissahickon Valley. This type of forest community is typically found on steep slopes with thin soils and outcrops of bedrock. The presence of the hemlock woolly adelgid (HWA), an introduced insect pest, has led to cessation of growth, discoloration and premature drop of needles and the dieback of branches in hemlock trees. Presently, this community type is declining due to both slope erosion and the HWA. An increase in the deer population has affected the understory vegetation of the Wissahickon, as shown by the dearth of both oak (*Quercus*) and hickory (*Carya*) saplings. Tulip poplar (*Liriodendron tulipifera*) is one of the most abundant canopy species in all regions of the valley. Tulip poplar/beech (*Liriodendron tulipifera/Fagus grandifolia*) and beech/oak/tulip poplar (*Fagus grandifolia*/*Quercus* spp./*Liriodendron tulipifera*) are the two most common mature forest associations. Understory consisting of dogwood (*Cornus* spp.), shadbush (*Amelanchier* spp.), spicebush (*Lindera benzoin*) and *Viburnum* spp. are very common on slopes and plateaus throughout the valley. Overall, the herbaceous layer on the slopes is sparse due to deer browse, but the native species which are frequently found are Christmas fern (*Polystichum acrostichoides*), lady fern (*Anthyrium filix-femina*), Jack-in-the-pulpit (*Arisaema triphyllum*), and false solomon's seal (*Smilacina racemosa*), along with the exotic species goutweed (*Aegopodium podagraria*) and pachysandra (*Pachysandra procumbens*). There are several open field areas in the Wissahickon where the herb layer consists of mixed grasses and forbs, such as goldenrod (*Solidago* spp.), indian hemp (*Apocynum cannabinum*), milkweed (*Asclepias purpurascens*) and bluestem grass (*Andropogon* spp./*Schizachyrium scoparium*).

Fairmount (East/West) Park. The Fairmount (East/West) Park section is heavily landscaped and is fragmented by roads, highways and railroads. 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). In 1983, the major canopy trees found in this park were oak, ash spp., tree-of-heaven (*Ailanthus altissima*), black cherry *(Prunus serotina*) and black locust *(Robinia pseudoacacia*). The understory associated with this type of canopy is *Ailanthus*, box elder (*Acer negundo*) and invasive vines. Presently, there is an increase in the number of Tulip poplar and devil's walking stick (*Aralia spinosa* and/or *A. chinensis*). The understory of the forested areas of the park are represented by honeysuckle bush *(Lonicera mackii*), *Viburnum* spp., multiflora rose (*Rosa multiflora*), blackberry (*Rubus allegheniensis*) and pokeweed (*Phytolacca americana*). Some of the more common herbaceous species found are jewelweed (*Impatiens capensis*), may-apple (*Podophyllum peltatum*), and enchanter's nightshade (*Circaea lutetiana*). The forest north and west of the Chamounix Stables is one of the healthiest stands of woods in West Park. The canopy is composed primarily of oak-beech-tulip poplar association and the understory is a native mix of azalea, dogwood and *Viburnum*. The area located between Ormiston Mansion and Kelly Drive shows a very similar community association to the one identified in the Chamounix Stables area.

Pennypack Park. The most predominant community types of the upland forests of the Pennypack are tulip poplar/beech and beech/oak/tulip poplar, ash/cherry (*Fraxinus americana/Prunus serotina*) in the canopy and understory. Dogwood and spicebush are the most common shrub layer species in the upland community. Pennypack Park has been heavily impacted by deer, and this is reflected by the lack of abundance and diversity of the herbaceous layer. Those species found in the herbaceous layer of the wooded areas are trout lily (*Erythronium americanum*), spring beauty (*Claytonia virginica*), jack-in-the-pulpit, garlic-mustard (*Alliaria petiolata)*, and Japanese stiltgrass (*Microstegium vimineum)*. Tree communities occurring along the creek in the flood plain consist of box elder, sycamore (*Platanus occidentalis*) and silver maple (*Acer saccharinum*). Much of the shrub layer is dominated by Japanese knotweed (*Polygonum cuspidatum*) and the herbaceous flood plain species include stinging nettle (*Urtica dioica*), false nettle (*Boehmeria cylindrica*), clearweed (*Pilea pumila*), and lesser celandine (*Ranunculus ficaria*). This park contains several small wetlands dominated by skunk cabbage (*Symplocarpus foetidus*). The 1983 Master Plan identified the wetland in the bend of the creek crossing Rhawn Street as a significant habitat. This wetland, which contains lizard's tail (*Saururus cernuus*), is still in good condition.

Poquessing Creek Park. Poquessing Creek Park is very narrow, and recent developments adjacent to the creek in some areas have fragmented the natural lands even further. The effects of this disturbance are apparent in the prevalence of the exotic plant multiflora rose as an understory species in Poquessing**.** However, 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. The herbaceous layer in this wooded area includes Christmas fern, lady fern, New York fern (*Thelypteris noveboracensis*) and joe-pye-weed (*Eupatorium* spp.). In November 1997 Anne Rhoads surveyed the vegetation along Poquessing Creek and found 33 species of trees in the canopy. The species included the typical flood plain forest trees of silver and red maple, box elder, sycamore and American elm. Upland species identified included red oak, black oak, tulip poplar and American beech.

FDR Park. This park was designed by Olmstead and is a managed landscape. Recreational facilities (baseball fields, tennis courts, the FDR Golf Course) have been added to the site. The natural lands that do exist have been heavily impacted by their proximity to Interstate 95, trash dumping and a general overuse by humans. The three ponds in the central and southern parts of FDR contribute to the unique character of the park. The wet areas are dominated by common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). Catalpa (*Catalpa bignonioides*), elderberry (*Sambucus canadensis*), sweetgum (*Liquidambar styraciflua*), pin oak (*Quercus palustris*), European alder (*Alnus glutinosa*), and mulberry (*Morus alba*) are some of the species found in the wooded areas of the park. The shrub layer is dominated by multiflora rose and *Ailanthus* saplings. Wood aster (*Aster divaricatus*), mugwort (*Artemisia vulgaris*) and goldenrod are found in the herbaceous layer.

Tacony Creek Park. Tacony Creek Park consists primarily of forested slopes comprised of early to mid-successional species such as black locust, ash and black cherry. Slope erosion and gullies are commonplace on most of the slopes due to ATV use. Trash dumping and overall misuse of the natural park lands are obvious in almost every area of the Tacony Creek Park, but impacts of ATVs and discarded automobiles are especially severe in the areas south of the Roosevelt Boulevard. The creek is used for swimming and fishing, especially at the Adams Avenue bridge, and the impacts of heavy picnicking are obvious on the creek banks where the soil is compacted and there is little or no vegetation. Where riparian vegetation does occur along Tacony Creek, it exists as dense stands of Japanese knotweed. There are several small wetlands in Tacony Creek Park, but they are severely disturbed by stormwater runoff, invasion by exotic species and proximity to landscaped facilities such as the Juniata Golf Course. A highly diverse, relatively undisturbed wooded area with a mature canopy of mixed oak and hickory does exist at the northernmost end of the park. Open meadow habitat is found in the southern end of the park and appears to be one of the primary sites for vehicle dumping.

Cobbs Creek Park. This park contains habitats which include large forested areas, wetlands, disturbed streambanks and riparian zones, and small stands of woods. These small wooded areas, which have been fragmented by development and recreational facilities such as golf courses, are commonly inhabited by exotic plant species. A few stands of mature forest do exist within the park. Erosion of soils from stormwater runoff and ATV use has impacted the sloped forests of Cobbs Creek Park where exotic species and early to mid-successional native species are common. Early to mid-successional tree species such as box elder, ash and sycamore are commonly found in disturbed flood plains where dense stands of Japanese knotweed line the banks. Japanese knotweed can be found along most streambanks, but is particularly dense in Carroll Park and along the edge of the golf courses. Deer populations are low in this park which allows for regeneration of tree and herbaceous species in undisturbed areas. Dumping of large appliances and vehicles is common, as is vandalism.

Species found in the 1998 survey of all of the parks are listed in the Appendix A-1.1 in Volume III. This list includes trees, shrubs, vines and herbaceous species.

4.D.2. **Floral Changes**

Much of the historical vegetation data for the Philadelphia area is based on the notes of the following botanists and travelers: Peter Kalm, Benjamin Smith Barton, Ida Keller and Stewardson Brown, John M. Fogg, Jr. and Edgar T. Wherry. William C. Barton's *Compendium Florae Philadelphicae* was published in 1818, Ida Keller and Stewardson Brown published a *Handbook of the Flora of Philly and Vicinity* in 1905, John M. Fogg, Jr. compiled a list of plants in the Wissahickon Valley in 1953 which was published in the 1996 issue of *Bartonia*, and Edgar T. Wherry's checklist of *Flora of the Philadelphia County* was published in the 1968 issue of the same journal. A survey of the park system was performed by Wallace, Roberts and Todd in 1983. The most recent survey of the major vegetation associations as well as identification of rare taxa of the Fairmount Park system was performed in 1998 by the ANSP.

Appendix A-1.2 lists those species found by Peter Kalm in the Philadelphia area. Kalm noted many native herbaceous species as well as introduced species. In particular, he recorded European exotics. He quoted Bartram that white mulberries had been established but were rarer than red mulberries (he noted the absence of white mulberries on a visit to south Jersey). These herbaceous species are listed in Appendix A-1.3.

Overall, Kalm noted 47 different species of trees and approximately forty herbaceous species, fifteen of which he recorded as introduced. Peter Kalm's mid-18th century notes provide us with baseline information that can be used to compare to the checklists of subsequent naturalists. It is important to note how vegetative communities and natural ecosystems have been altered in response to both human and natural disturbance. By comparing these data sets, the ecosystem response to disturbance can be ascertained by documenting the presence and abundance of exotic species when compared to natives as well as noting the overall diversity among the native species.

Decreases in species diversity can also be obtained from analyzing and comparing historical and current data sets. In the 1818 publication of William C. Barton's *Compendium Florae Philadelphicae*, 900 plant taxa were listed for the Philadelphia County. It is estimated that 130 of these are introduced plants.

Some of the historical information that is available focuses on only one section of the park system, such as John Fogg's *Annotated Checklist of the Plants of the Wissahickon Valley*. The compiled list of species revealed that there were 36 native and no introduced species of Pteridophytes (ferns and fern allies), 5 native and 2 introduced species of Gymnosperms (Conifers), 37 native and 12 introduced species of monocots (grasses, arums, lilies, irises and orchids) and 417 native and 145 introduced species of dicots in the Wissahickon Valley. This list is important to incorporate into the historical data collected in the Fairmount Park system, but is not inclusive since collections focused on the Wissahickon Valley. Also, the list of Monocots does not include grasses, rushes or sedges and is therefore considerably smaller than Wherry's *Checklist of the Flora of the Philadelphia County*.

Wherry (1968) estimated 2,075 different plant species were recorded from the Fairmount Park system. It is estimated that 885 of these plants are introduced species. Prior to the 1983 survey of the Fairmount Park system by Rhoads and Mellon, most of the vegetation data collected were either limited to only one of the parks of the Fairmount Park system or the entire park was encompassed by one checklist. It is therefore difficult to accurately compare current data (1983 and 1998) to historical data, due to these information gaps.

Comparison of occurrence of species provides more detailed information on changes in habitats in the region, as well as suggesting species for planting and reintroduction. Comparisons of the existing forest types with those recorded by early floras and travelers indicate that the dominant native tree species are similar, with the exception of decreases in chestnut and hemlock. However, changes in occurrence of a number of less common species have occurred. These can be important in determining impacts of disturbance on the park and for selecting species for planting. The 1998 inventory data provide a basis for comparison with historical records of plants in the city and park. The main goal was to determine species formerly common or widespread which have greatly decreased in abundance.

The herbarium of the Academy of Natural Sciences of Philadelphia (ANSP) was used as the primary source of information on historical occurrence of plants. Herbarium records through 1997 were computerized and used as the basis of Rhoads and Klein (1993). Philadelphia County records from this database were filtered and compared with observations in this survey.

Wherry (1969) prepared a checklist largely from herbarium records, but included additional records that he considered reliable. These should probably be considered hypothetical (some were reviewed and rejected in Rhoads and Klein 1993). Comparisons were made principally on native species.

Comparisons of the inventory and herbarium records need to consider differences in the two types of data. The herbarium covers a great deal of collecting effort by a number of workers over a long time. Collecting for the herbarium was selective. Unusual species, and species in diverse groups which are difficult to identify are probably over-represented. Conversely, widespread, common species are likely to be represented in collections, but at lower frequency than their abundance in the field. Spatial coverage is variable, so that distribution over most individuals parks cannot be determined. The 1998 inventory was relatively brief in duration. It was done mainly in the spring and early summer, so that fall-blooming plants may be under-represented. The inventory concentrated on natural areas. Some habitats (intertidal marshes, old fields) are under-represented in the survey. The 1998 inventory covered most of the park system, providing more spatial information. In making comparisons, species represented by a number of herbarium sheets (5 or more) were considered frequent or common; these assessments were strengthened by distribution in adjacent counties (Rhoads and Klein 1983) and by assessments of abundance and habitat preference in regional floras and other literature (Keller and Brown 1905, Benner 1932, Hough 1983). Comparisons included species which would be expected in the inventory, based on the habitat and time of sampling.

Based on these comparisons, a number of species which were probably relatively common in the city are now rare or absent in the park system. Many of these may not have been common in park system habitats and still occur in the city outside the park system. However, a number of species which were not found would likely have been found in park system areas. Several shrubs, such as American strawberry bush (*Euonymus americanus*), speckled alder (*Alnus serrulata*), ninebark (*Physocarpus opulifoilius*) and several heaths (black huckleberry *Gaylussacia baccata*, fetter-bush *Leucothoe racemosa*, and maleberry *Lyonia ligustrina*), were not observed. These include species of wet swamps, bogs, stream and pond margins, and alluvial soils (alder, ninebark and strawberry bush). Several herbs typical of marshes, wet woods and/or wetlands were also not found, such as hyssop skullcap (*Scutellaria integrifolia*) and other skullcaps, turtlehead (*Chelone glabra*), monkey-flower (*Mimulus ringens*), arrow-leaved and halberd-leaved tearthumbs (*Polygonum sagittatum* and *P. arifolium)*, great lobelia (*Lobelia siphilitica*), golden ragwort (*Senecio aureus*), interrupted fern (*Osmunda claytoniana*), swamp saxifrage (*Saxifraga pensylvanica*), primrose violet (*Viola primulifolia*) as well as sedges and grasses. A number of species of fields, meadows and dry woods were not observed, although many of these are fall-blooming species and may not have been distinguished. Such species include several species of asters (*Aster*), goldenrods (*Solidago*), bone-set (*Eupatorium perfoliatum*), mountain-mint (*Pycnanthemum tenuifolium*), large twayblade (*Liparis liliifolia*) and Indian paintbrush (*Castilleja coccinea*). Only a few species typical of rich woods were not found Virtually all of the typical tree species are still present, although there may be decreases of rarer species. For example, no Allegheny plum (*Prunus americana*) were seen; this species was said to be common in the early 19th century in Delaware County, but virtually extirpated by mid-century (Smith 1862).

These changes are consistent with the history of vegetation in the area and current conditions. Changes in urban hydrology affect wetlands, marshes and stream edges, affecting habitat for a number of species. The amount of field habitat has decreased as park lands have undergone succession to woods and adjacent areas have been developed. Decreases may also be due to changes in conditions in open habitats, such as effects of grazing by deer, changes in fire regime, etc. Interestingly, clear losses in species of rich woods was not seen. Such losses could have resulted from the earlier deforestation of much of the park. Many species of rich woods could have been affected by early deforestation and already decreased by the time of botanical documentation.

4.E. FAUNAL ASSESSMENTS

4.E.1. Faunal Occurrence and Habitat Quality

The general findings of the faunal assessments are discussed in Section 4.E, and findings specific to individual parks and sites are discussed in the park-specific Volume II. Information on faunal occurrence is summarized in Habitat Quality Maps, Volume II, Section 1 (Cobbs), Volume II, Section 2 (Tacony)**,** allows comparison of some patterns across different faunal groups. Sampling of terrestrial insects was too limited in Cobbs Creek Park. This map shows points of observation of groups of taxa. The information is coded to show two different types of data. For some groups (i.e., aquatic macroinvertebrates, fishes and birds), standardized sampling was used to record a number of species from a site. Thus, each collection contains a number of species, which was used to define metrics of quality related to species richness and tolerance. These metrics were coded into different classes, which are displayed on the habitat condition map. The sampling units and metrics are:

> **Aquatic macroinvertebrates**. The metric was the number of taxa of mayflies, stoneflies and caddisflies (families Ephemeroptera, Plecoptera and Trichoptera), commonly referred to as the EPT metric. These groups are sensitive to aquatic degradation, and the EPT index is a commonly used component of measures of biotic integrity. Categories were low EPT (0-2 taxa), moderate EPT (3-6 taxa) and high EPT (greater than 6 taxa). These categories were chosen to reflect expected values in different types of streams given the level of sampling.
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> **Fish**. The metric was the number of native species in a sample. Based on the range of values observed, the classes defined were: a) No fish caught; b) 1-5 species caught; c) 6-12 species caught; and d) greater than 12 species caught. These metrics will reflect habitat and water quality within a site, the species pool within the drainage, and the size of the stream.
>
> **Birds**. The metric was the number of “indicator species” observed in 500-ft blocks. The indicator species are those species specific to natural habitats, i.e., this group excluded birds widespread in urban, residential and other landscaped areas. Blocks with more than 7 indicator species were rated high quality, those with 4-6 were rated moderate quality, and those with less than 4 were rated low quality.

The second type of information collected relates to individual observations. This type is relevant to highlight unusual occurrences and for groups where single observations were more typical than standardized samples producing a number of species. Coding was based on species attributes. Separate codes were done as follows.

> **Birds**. Specific occurrences of uncommon species (species only found once or twice which are linked with specific habitats) were mapped to highlight areas supporting these taxa. This

included 14 species, most associated with forests (Pileated Woodpecker, Yellow-billed Cuckoo, Prothonotary Warbler, Black-and-white Warbler, Cerulean Warbler, Hooded Warbler, Worm-eating Warbler, Rose-breasted Grosbeak), some associated with field and shrub habitats (Brown Thrasher, Blue-winged Warbler, Yellow-breasted Chat, Chestnut-sided Warbler and Willow Flycatcher), one with marshes (Swamp Sparrow), and one with clay banks for nesting (Bank Swallow). Some species which are wide-ranging (Osprey), probably poorly censussed (Great Horned Owl), or possibly not breeding (Coot) were not mapped. On the map, the sites are identified as the centroid of the block from which the species was recorded. This mapping supplements the species richness metric.

Reptiles. Different map symbols are used to separate introduced species (the red-eared slider), native widespread species which probably occur throughout the park, including the Eastern garter snake, brown (deKay's) snake, Northern water snake, snapping turtle, and painted turtle, and native uncommon species (other species).

Amphibians. Different map symbols are used to separate native widespread species (i.e., species probably occurring throughout the park system, including the redbacked salamander, green frog and bullfrog), and native uncommon species. No introduced amphibians have been found in the park system..

Mollusks. Different map symbols are used to separate terrestrial and aquatic mollusks, introduced species, Holarctic species (i.e., species found in Eurasia and North America; these species are usually tolerant of a range of habitat conditions), and Nearctic species (i.e., species found only in North America).

Terrestrial Insects. Sampling for crane flies, butterflies, skippers and moths was concentrated in Pennypack and Wissahickon parks, and their occurrence is mapped only in these parks. Metrics are based on the number of species of butterflies and skippers at sampling locations, and number of species of crane flies at sampling locations.

4.E.2. **The Wild Birds of Fairmount Park**

4.E.2.1. **Introduction**

The Fairmount Park system has long been a treasured resource for Delaware Valley ornithologists and bird-watchers. It plays an increasingly important role as a wildlife sanctuary in a regional context due to rapid and unplanned suburban development. The birdlife of the Fairmount Park system is one of its greatest, though least appreciated, attributes. While naturalists over the past century have documented occurrences of birds in particular segments of the park, no comprehensive census of the breeding birds of the Fairmount Park system has ever been done.

The ANSP conducted an assessment of the bird fauna of the Fairmount Park system as part of planning for restoration under NLREEP. During the summer of 1998, a breeding bird census took place in these seven areas of the park system: Cobbs Creek Park, Franklin Delano Roosevelt (FDR) Park, Fairmount (East/West) Park, Pennypack Park, Poquessing Creek Park, Tacony Creek Park and the Wissahickon Valley.

4.E.2.2. **Objective**

The objective of the 1998 breeding bird census was to assist in the determination of past and present natural conditions within the park's designated "natural lands." By understanding the diversity and abundance of breeding birds, an informed interpretation about the quality of natural habitats can be made. Consequently, certain birds were singled out as being important indicators of habitat health. The presence of these "indicator" species can be interpreted to mean either habitats with low levels of disturbance or of high quality. Indicator species are classified as distinct from those species that are common either throughout the parks or Philadelphia in general (common "back-yard" birds), and closer attention was paid to the location of observed individuals. For the 55 indicator species, observations of all individuals were recorded in the field and later plotted on Fairmount Park system base maps before being entered into the database. (Appendix A-2.1 in Volume III lists bird species observed during the census and highlights those that are considered indicator species.)

Prior to the census, a survey of historical documents was performed. This allowed for a comparison of past and present data on abundances of indicator species that can be used to interpret changes that have occurred over the past century. The compiled historic and census data will provide a benchmark against which to measure any changes brought about as a result of the actions taken under the NLREEP restoration project.

4.E.2.3. **Methods**

The disparate nature of the park areas and the relative isolation of the birds in each area from those of the other areas required that each of the seven natural areas be approached as separate ecological units when sampling the park's bird life. Simply stating that birds such as Phoebes breed in the Fairmount Park system would not have provided a fine-enough level of understanding to allow for effective management of either the bird or its habitat. Thus, both in the historical survey and in the breeding-bird survey, each of the seven natural areas were treated separately. As a consequence, results reflect with moderate accuracy the diversity and abundance of breeding birds for each area.

What Species Were Included? Only breeding birds were censussed. When assessing the park's historic and current importance as a refuge for wild birds, one could consider several categories of birds. These categories are: 1) year-round residents; 2) species that breed but do not winter in Philadelphia; 3) winter residents - species that winter but do not breed in Philadelphia; 4) transients - species that migrate through Philadelphia but which do not breed or winter there; and, 5) vagrants - species that normally do not occur in Philadelphia. For this project, the most appropriate group to study was breeding birds because their habitat requirements are narrower and more specific than they are for birds present at other times of the year. For the historical review, records for all species were included because the additional information could prove useful to future research and did not require significant additional work. As a result, while all birds that regularly occur, or previously occurred in the parks, are included in tables for historical records, the field research was limited to those species that use the parks during breeding season.

Historical Review. The first phase of the project included a thorough literature review to understand general and specific information about the historic (ca. 1890-1990) bird populations present within the park system. The lack of significant records prior to the formation of the Delaware Valley Ornithological Club (D.V.O.C.) in 1882 prohibits accurate interpretations of the abundances and distribution of those birds that were recorded in the parks prior to 1890. However, inferences can be made based on what is known about the habitats that were present in the park (or lands that became park) or lands adjacent to park boundaries. General regional information (e.g., Krider 1879) also provides information on past distribution.

Documents reviewed included published records on the birds of the Wissahickon, Pennypack and Tacony Creek areas, along with field notes taken from *Cassinia* and *The Oölogist*. Single specimen records from the Academy of Natural Sciences ornithological specimen collections were also included in our historic overview. In total, 12 published articles which took a comprehensive look at the birds of Philadelphia, or some segment of the Fairmount Park system were reviewed. An additional 11 published documents that dealt with single species or a more narrow research focus were also reviewed. Unfortunately, historic information on the bird life of Cobbs Creek, Fairmount (East/West) Poquessing and FDR parks is virtually lacking.

A spreadsheet was created for each of the three areas for which data were available that lists 190 species that either occurred in the parks, or were believed to occur in a segment of the parks at one time over the past 100 years. Voucher records for those species that have been recorded for a particular area are included along with any additional information, including date of observation/collection, collector, locality, breeding status, or other anecdotes.

In addition, the spreadsheets contain a column titled "State Conservation Status" that helps highlight those species of special concern: 1) endangered; 2) threatened; 3) vulnerable; or 4) undetermined. These categories were taken from a comprehensive study published by the Carnegie Museum of Natural History entitled, *Species of Special Concern in Pennsylvania* (Genoways et al. 1985). Another column, "Noted Regional Change," indicates any perceived *regional* changes in the species' population. This information is taken from Mellon (1990). He presents a number of different categories for bird population trends, but it was determined simply to interpret species as either decreasing (-) or increasing (+) during the past one hundred years, regardless of what their prior status was. This is perhaps the most subjective and difficult aspect of the data sheets because of the lack of long-term, quantitative studies of regional bird populations. But if interpreted with caution, it can also be the most instructive and useful piece of data when trying to understand how the park has changed.

Census Methods. To survey the park for the various groups of birds, two trained observers with extensive local birding experience visited the natural areas of the parks for a total of 28.5 person-days between 1 June and 3 July 1998. Most areas of the parks were visited. The typical field day started around 5:15 am, at which point a transect through a particular section of the park began. Generally, transects followed foot-paths or bike paths as these allowed for most birds within park boundaries to be heard or seen. From the beginning to the end of the transect, all birds observed were recorded in a field notebook. Up to as many as 11 point counts were done during a transect. A point count was simply a tool used to fix data to a very specific locality. This was done by taking careful note of the observer's exact location and then recording all birds heard or seen during up to as many as 20 minutes during the point count. Between point counts birds were recorded and any information that might help fix the bird to a locality was also recorded in the field notebook. Notes on habitat were also recorded for point counts and at other localities along the transects because habitat types and habitat quality can greatly affect the kinds and abundance of breeding bird species observed.

All seven major natural parks were visited between 1 June and 3 July 1998, during the peak breeding season for birds in the Philadelphia region. Nearly all portions of each park were visited and all birds observed were recorded (except for the most common birds) into field books. Observations about habitats, additional wildlife, and other issues pertinent to the overall restoration project were also noted in a daily log.

After finishing field work, which usually lasted for 5-7 hours, the Fairmount Park system base maps were used to fix particular individuals of indicator species to the map. This was an important step, and was completed within hours of finishing a particular transect. This allowed for correct locality data to be associated with each individual of the indicator species.

4.E.2.4. **Results**

Historical Data. Published voucher records or specimens from Philadelphia were found for over 175 species (105 breeding species), most of which were from locations within the Fairmount Park system. The data overwhelmingly demonstrate that certain areas of the parks have been extremely important to native breeding birds, including such songbirds as thrushes, vireos, flycatchers, wood-warblers, tanagers and orioles. Other important groups such as owls, hawks, swallows, ducks and woodpeckers have also been recorded consistently in the park. In fact, such a suite of birds is remarkable when considering the general isolation of the park segments due to urban and suburban development. While many species have been classified as occurring "abundantly" others have only been recorded as "rare breeders." Many of these have been relatively consistently documented throughout this century, but a strict comparison of our present records for 72 species with the 105 may not yield an accurate view of a reduction in diversity. In part this is due to the loss of species that required large tracts of open farmland (such as near Pennypack Creek at the turn of the century) where species like upland sandpiper, Eastern meadowlark and dickcissel were found. Also, the limited time that could be dedicated to each segment very likely left some species unrecorded (Appendix A-2.2 in Volume III gives summary tables of historic records for Pennypack, Tacony and Wissahickon creek areas.)

1998 Census Data. Observations of occurrences of the 55 indicator species totaled 1,149 records (1,430 Individuals), while there were well over 1,700 observations for all species. Of the 55 Indicator Species, there were singular to quadruplicate records for individuals of 17 species. Although populations fluctuate from year to year, this brings to 38 the total number of indicator species that have modest to well-represented populations. Table 4.E.1 illustrates the diversity of bird life observed in each of the park segments, along with those groups of birds that are particularly well-represented and areas where restoration activities could be focused for the benefit of wild birds (Appendix A-2.3 in Volume III gives a more complete inventory of species abundance by park segment).

Table 4.E.1. Diversity of breeding birds by park in 1998 inventory, with additional information.

Park Unit	Days Visited	Species Present (Prob. Breeders)	Well-represented habitats, based on bird fauna	Recommended Conservation Priority
Cobbs Creek	3	48 **(47)**	Parkland/Human-modified	Control human traffic
Fairmount	4	59 **(49)**	Parkland	Reduce fragmentation
FDR	2	44 **(38)**	Parkland/Wetland	Restore natural lands
Pennypack	4	56 **(55)**	Forest	Control deer browse
Poquessing	2	34 **(34)**	Shrub/Edge	Land acquisition and/or protection
Tacony	2	39 **(35)**	Riverine	Control exotics
Wissahickon	7	60 **(57)**	Forest/Riverine	Control deer browse
TOTALS	**24**	**80 (72)**	Forest; generalist	

Park-wide, species that show especially healthy populations are *forest*, *riverine* and *habitat generalists* (see Appendix A-2.4 in Volume III for a definition of these groups and a complete list of birds encountered in each habitat type) Within the first group, the following species (indicator and otherwise) seem to be well-represented, especially in the wooded valleys of the Wissahickon and Pennypack creeks: Eastern Wood-pewee, Acadian Flycatcher, Great-crested Flycatcher, Carolina Chickadee, Downy Woodpecker, Red-bellied Woodpecker, Hairy Woodpecker, Tufted Titmouse, Blue-gray Gnatcatcher, Veery, Wood Thrush, Yellow-throated Vireo, Red-eyed Vireo, Northern

Parula Warbler and Scarlet Tanagers. Riverine species are doing well in those two valleys, as well, with Louisiana Waterthrushes exclusively well-represented in the Wissahickon and Warbling Vireos well-represented at Cobbs, Pennypack and Fairmount (West) Park. Interestingly, Belted Kingfishers (a stream-bank cavity nester) were found in all five river valleys. Rough-winged Swallows are also common anywhere there is appropriate bridge habitat, while Wood Ducks were only found on the Wissahickon. As for human-modified habitat generalists, the golf courses at Cobbs, FDR, and Wissahickon, along with some areas of all other parks are providing fairly good habitat for such birds as Eastern Kingbirds, Northern Mockingbirds and Chipping Sparrows. The Eastern Screech Owl was not recorded in the inventory. However, it was reported during the survey period (in Cobbs Creek Park) and is known to nest in at least Wissahickon Park (and likely other areas).

4.E.2.5. **Conclusions**

After censussing all natural lands segments for breeding birds in June 1998, it is clear that the Fairmount Park system is an invaluable sanctuary for many wild species native to the Philadelphia region. Over 70 species are believed to breed in the park or to use it during the breeding season. Despite this encouraging finding, there are clear indications that the number of species currently using the parks is markedly lower than earlier in this century; and, that the downward trend in diversity will continue unless certain problems are corrected.

The Fairmount Park system probably harbors a greater diversity of breeding birds than any other urban park in North America. But, is this apparent diversity an inherent capacity of the park, or can management activities (either deliberate or *de facto*) increase or decrease the diversity? Clearly, passive management for much of the 20th century has changed the park's various habitats, and thus its birds. Historical records, when cautiously compared with the 1998 census bear out this truth.

Trying to determine which bird species lived in the area and how abundant they were is a speculative endeavor. Undoubtedly, the 19th century, and even the 18th century, were hard on birds native to the areas now considered part of the park system, and the bird diversity we see today is probably less than that of Pre-Columbian times. More difficult still is trying to assess the causes behind this loss of diversity. However, we can, with a good degree of certainty, note that significant clearing of the land for agriculture and fuelwood during the 18th and 19th centuries probably favored grassland species at the expense of many native forest species. Small urban centers that sprung up during the 19th century fragmented the existing landscape, and in all likelihood, the conditions observed by ornithologists at the turn of the century (when the first reliable published records exist) were drastically different than the conditions that would have been present 100 years earlier. Around the turn of the century, filling in of wetlands along the Delaware River and smaller tributaries further reduced diversity. Perhaps the differences observed were even more drastic than between what can be observed today when compared to 100 years ago.

Historical Comparisons. Comparing the present findings with historical records can shed some light on the current conditions for wild birds and what kinds of population trends have taken place or are ongoing for the various species. What species are now missing that were once present? What species are now present for which earlier records are scant or non-existent? Comparisons between historical documents and our current survey illustrate some general trends as well as more specific cases of species recently lost or gained in the park system.

Gains in bird species diversity: Generally speaking, the maturation of natural lands into mature, deciduous woodlands since the turn of the century has improved and increased the amount of habitat for many of the forest specialists like vireos, thrushes, some warblers, and woodpeckers. Concomitant with the increase in forestland species has been a loss of grassland and shrubland species such as Chestnut-sided Warblers, Yellow-breasted Chats, Bobwhite, Brown Thrashers and Eastern Meadowlarks, which were all once fairly common. This pattern is particularly evident in the extensive natural lands of the Wissahickon and Pennypack creeks. Although this process is natural, the inclusion of many exotic species into the native forests, such as Norway Maple and Japanese Knotweed, may have an impact on the quality of bird breeding habitat. Without reliable measures of abundances of many woodland species earlier in the century, it is difficult to say whether, for example, the Wissahickon holds more suitable habitat now than it did 80 years ago for birds such as Red-eyed Vireos and Wood Thrushes. Species that probably have recently (within the past 30 years) returned to the park after long absences because of more extensive and more mature forests include Pileated Woodpecker and Great Horned Owl. Species whose populations have increased as the forests have matured include Red-bellied Woodpecker, Carolina Chickadee, Blue-gray Gnatcatcher, Acadian Flycatcher and American Redstart. Other species may have increased, but insufficient data prevents accurate interpretations.

A species that has only recently become abundant in Philadelphia, in particular along the Schuylkill River and in FDR Park, is the Canada Goose. Traditionally, this species was a winter visitor to the area, spending its breeding season in the arctic tundra. For various reasons, populations have established themselves as year-round residents and breeders in the mid-Atlantic region. Essentially, mowed lawns adjacent to open water mimics in some ways their tundra breeding habitat, and as long as such conditions exist, Canada geese are likely to remain breeders in the parks.

Losses in bird species diversity: Many different factors have contributed to, and continue to contribute to an overall decline in bird species diversity within the Fairmount Park system. Various examples of species lost are outlined below.

The extinction of the Passenger Pigeon, which was once an abundant deciduous forest nesting bird in the region, is a well-documented natural history story. Though they did not become extinct until 1914, their population had already been significantly reduced in the latter part of the 19th century. One interesting Philadelphia record is a report of a flock of 50 birds in Holmesburg in 1878 (McNeil 1941). The Passenger Pigeon was certainly an inhabitant of the park system, although not necessarily a breeder, but their loss illustrates well how forces beyond the control of the park are often the cause for a particular species' decline.

The loss or severe reduction of such ground-nesters as Worm-eating Warblers (only one individual heard during census), Hooded Warblers (only one individual observed) and Ovenbirds illustrate the devastating effects of deer on the understory which these birds need for nesting. In fact, another ground-nester, the Kentucky Warbler, that was recorded as the most common warbler in the Wissahickon Valley as recently as 1951 (Pettingill) appears to be completely gone from the Fairmount Park system; not a single individual was recorded during the 1998 census. Local experts with years of birding in the Wissahickon, like Keith Russell and Robert Ridgely, remember the abundance of these species prior to the eruption in the deer population in the early 1980s. Although the effect of deer may be most acutely felt by ground and shrub-nesters now, their effect on canopy nesters will likely be felt if nothing is done to regenerate the aging canopy forest. Thrushes, however, which don't need dense understory, appear unaffected by these conditions and were recorded in considerable abundance.

For the song birds and game birds that require varying degrees of open fields and edge habitat for breeding, the maturation of fields into forest has been nothing short of devastating. In the Cresheim Valley section of the Wissahickon watershed, for example, as late as 1942, Tracy (1943) noted, "Woodland, meadow and swamp are well defined. On the hilltops, and occasionally on the valley floor itself are open meadows which afford good localities for field species." During the period while he was writing his account, the conditions of the valley were very likely undergoing profound changes as his records of two species typical of open areas, or edge habitat illustrate. Regarding the Ring-necked Pheasant (an introduced, Eurasian species) he notes, "An early morning walk in May seldom failed to show up fifteen or more cackling males. No young birds were seen, due probably to depredation by dogs and other natural enemies." For the Yellow-breasted Chat, he noted, "This past summer the chats deserted the valley except as visitors, although they have been found nesting there before." In both of these cases, the decline and eventual loss of the species as breeding birds may reflect a regional decline, but is probably also closely tied to the degradation and decrease of early successional habitat within the Cresheim Valley watershed.

Another group of birds which seems to have disappeared are the raptors such as Broad-winged Hawks, Coopers Hawks, and Kestrels. The apparent loss of the latter (although one was observed during the census near the mouth of the Wissahickon) is probably due to a loss of open habitat - its preferred foraging grounds. The loss of Broad-wings and reduction or extirpation of Coopers Hawks may reflect a reduction in the amount of quality forest habitat (particularly in the Wissahickon, where these birds have mostly been recorded in the past), or may reflect the relatively recent addition of the territorially-aggressive Great-horned Owls. Great-horned Owls were observed in East Park and are known to nest regularly in the Pennypack and Wissahickon valleys, although they were not observed there during this census.

The decline and eventual extirpation (local extinction) of American Bittern, Least Bittern, King Rail, Red-headed Woodpecker, Bobwhite, Vesper Sparrow, Savannah Sparrow, and Bobolink, among others, especially reflects a loss of habitat within Philadelphia. In the case of bitterns and rails, the wetlands along the river and at the mouth of the Pennypack in Holmesburg, prior to their filling in, were home. These wetlands were the most significant such habitat in Philadelphia; this habitat was a well-documented refuge for marsh birds that has been lost. Mill ponds may have also provided some wetland habitat for these species. Without creation (or re-creation) of large wetlands (i.e., greater than 10 acres), these species and other wetland-dependant species are unlikely to return to Philadelphia.

Status of species of special concern: The degree to which a natural area provides habitat for species that are recognized as threatened or endangered could be used as one measure of an area's usefulness in contributing to conservation. A comprehensive study published by the Carnegie Museum of Natural History entitled, *Species of Special Concern in Pennsylvania* (Genoways et al. 1985) classifies species as being either: 1) endangered; 2) threatened; 3) vulnerable; or 4) undetermined. Fifteen of these species have been recorded as breeders in the park system or nearby adjacent lands, but none is currently found within the park. Management for some of these species (i.e., Bluebirds, Purple Martins, and wetland specialists) would go far to improve the value of the Fairmount Park system as a refuge for endangered birds.

Current Threats. At the turn of the millennium, the diversity and abundance of wild birds breeding in the park system is under threat from several stresses. As these threats are likely to change, subside, or grow more severe, they are documented here for future reference.

Fragmentation: The negative effects of the loss and/or change of habitat, as illustrated above, have been further aggravated by habitat fragmentation and actual loss of parklands and/or adjacent open spaces to development. If one looks at the total species diversity for each park area, there is a fairly close correlation between an area's size and the number of species: the larger, more contiguous a park area, the greater its species diversity. Within each park area, only the largest portions of each significant habitat are able to attract what might be considered significant populations of the most significant of species. This tight connection between a park's size and its bird species diversity illustrates the importance of acquiring or protecting adjacent open lands (and minimizing development within the natural lands) to prevent a further loss of diversity.

Aside from development pressures, a significant cause of fragmentation in some segments of the park is heavy human use. Mountain bikers and ATV users trample plants, compact soil and generally degrade available habitat.

All of the factors that contribute to fragmentation leave a landscape that is less productive for those species of birds that still use them for breeding. Certainly for some species, much of the Fairmount Park system may support a higher mortality rate than reproductive rate.

Exotic plants and their impacts on native breeding birds: A number of exotic plant species are well-established in the park and some of these are clearly reducing the quality and abundance of appropriate habitat for our breeding birds. Chief among the most troublesome exotics in some sections is Norway maple. Although it only dominates in a few sections of the park, the ability of this tree to shade out competitors and understory vegetation, and its unattractiveness to nearly all breeding birds, means that, unless actions are taken to reduce its spread, bird diversity and abundance will probably be reduced in the Fairmount Park system. Areas dominated by Norway maple, such as Andorra in the Wissahickon, were considerably more quiet than comparably-sized forests of native tree species. Norway maples shade out all understory, and it is generally the only tree to regenerate in its own stands.

Another exotic that is having a significant effect on birds is Japanese knotweed. Patches of this plant are frequently used by catbirds for cover, and even nesting, but no other species was observed using this plant regularly. Along stream banks, the plant may be directly displacing the Louisiana Waterthrush by growing over their preferred foraging grounds along the rocks and shorelines of swift-flowing streams. In most areas, however, the plant most likely reduces plant and habitat structural diversity to the detriment of shrub, edge and ground nesters. In the long term, corridors of knotweed may be preventing the regeneration of forest such that even canopy nesters are impacted. Control of this species would help many bird species.

Multiflora rose is yet another invasive plant that impacts native bird populations. Although it can provide food, cover and nesting habitat for a variety of species, its ability to create a monoculture is not particularly attractive to most bird species. Certainly, where it occurs, a mosaic of native shrubs would provide more adequate habitat for birds. There are many exotic herbaceous plants that carpet sections of the park, such as garlic mustard. The impacts of these plants on birds is currently unknown.

Lastly, two plants that may not be a current problem because of the paucity of wetland areas, but that have disturbed some habitats (and could become a problem at the newly constructed wetlands of the Pennypack), are common reed (*Phragmites*) and purple loosestrife. Both species are invasive and form large monoculture expanses. They do not provide particularly good habitat for marsh birds like rails, blackbirds and swamp sparrows. An acutely impacted area is in the southwest corner of FDR Park. No birds were heard or observed in the core of this habitat. Both plant species are also invading the small marsh in the northeast corner of FDR Park.

Forest gaps and vines: Much attention has been paid to the pervasiveness of vines in some areas of the Fairmount Park system. Vines such as native grapes, native and introduced honeysuckles and bittersweets, Virginia creeper, and poison ivy are often targeted as problems. In fact, many bird species use the berries of these plants (both native and introduced) as significant food sources, especially during fall migration when the high sugar content of the berries are used to build up energy reserves. Additionally, some of these vines (like poison ivy) do not choke and kill trees, but instead keep most of their growth along the trunk and thus do not create “undesirable” openings.

The habitat diversity created by vines is a very important, natural component of the forest ecosystem that birds have adapted to (although some vines, especially exotics like oriental bittersweet, have the ability to greatly reduce available forested habitat). Just as a forest completely fragmented by large areas of vine-choked trees is unattractive to forest birds, a forest without gaps is also less attractive. Efforts to reforest all gaps in areas such as the Wissahickon, Pennypack and West Park should be done with the knowledge that bird diversity will be reduced as a result.

Feral, domestic and native predators: A number of species of birds and mammals prey on adults, eggs or nestling birds. Domestic cats may be particularly important. A number of native and introduced predators, such as opossum, raccoon, red fox, Norway rat, gray squirrel, blue jay and American crow, are likely to be more common in developed areas because of increased food (bird feeders, garbage, etc.). These predators are likely to be important in park areas adjacent to developed areas; in the smaller parks, this zone may constitute the entire park. The importance of this factor cannot be assessed, because of the difficulty of getting quantitative data on the abundance of predators and their consumption, and on possible counteracting effects of decreased abundance of other predators (such as breeding raptors, snakes, and skunks).

4.E.2.6. **Discussion**

The 1998 census of the Fairmount Park system's breeding birds provided an excellent opportunity to expand our knowledge of Philadelphia's breeding birds. The Fairmount Park system's natural lands are a tremendous local resource that, with proper management techniques, can be even more important to wild birds. If bird-friendly management techniques and other more ecologically-minded management practices are adopted, the park system can serve as a model for other urban communities wishing to live near an enriching natural environment. The park can in turn serve as a catalyst for improving the city's image and attractiveness to residents and businesses alike.

This census should serve as an excellent benchmark against which to measure the effects of future park activities. It should also serve as a stimulus to encourage follow-up activities such as bird-oriented education programs. Future research activities could include more detailed censusses of particular areas and monitoring programs for the productivity of particular bird groups (e.g., neotropical migrants) to determine reproductive success and viability of the bird populations in the park system.

4.E.3. **Mollusks**

4.E.3.1. **Introduction**

Mollusks, including snails, slugs, clams, and mussels, are the second most diverse group of animals after insects and their relatives. Mollusk species are excellent indicators of environmental health because they are sensitive to changes in their environment such as temperature, salinity, pH, moisture, and other variables. Most snails and slugs are not host specific, so their occurrence in an area will correlate more with general vegetational type, soil chemistry, and availability of moisture than with the presence of particular species of plants. Snails and slugs have low dispersal ability, so specimens collected at a site can generally be assumed to have spent their entire life at that site.

For the purposes of this section, mollusk species will be grouped in several ways for analysis: 1) by habitat preferences, including vegetational types, moisture, disturbance and calcium dependence; 2) by trends of increase or decline in Philadelphia; and 3) by distributional patterns, including native versus introduced, and extent of distributions outside the Philadelphia area.

This study had various limiting factors. Most importantly, sampling was much more intensive in terrestrial than freshwater habitats. Freshwater mollusk species were collected as encountered along shorelines and stream banks. Quantitative benthic sampling, however, was not done since this area was covered by the benthic macroinvertebrates survey. Analysis of the mollusk data is therefore restricted to the terrestrial samples. Many of the slugs collected early in the year proved too immature to identify, so they were not included in the study. Lack of soil chemistry data makes it more difficult to explain faunal changes.

Another limiting factor is lack of information about sampling methods used by previous workers whose material is represented in the collections at the Academy. It is unknown if they collected all the species found at a site, or only specimens of interest. It is also unknown how long was spent at a site, or how large the sites were.

4.E.3.2. **Historical Data**

Three primary sources of data were used for determining the historical molluscan fauna of Philadelphia County and the specific parks in the Fairmount Park system: 1) the specimen collections at the Academy of Natural Sciences of Philadelphia (ANSP), 2) papers by Gabb (1861), Ford (1887a, b) and Schick (1895) that detail the fauna of the Philadelphia region; and 3) papers by Pilsbry (1939-1948) and Hubricht (1985) that give county level distributions for mollusks of the eastern United States

Collection. Specimens are catalogued by lots, which are specimens of a species collected at the same time and place. The specimen collection at ANSP includes 621 lots and 9,019 specimens of mollusks from the Philadelphia area. Of these, 361 lots and 5,639 specimens are terrestrial and 260 lots and 3,380 specimens are freshwater. Fifty-nine species of terrestrial mollusks and 47 species of freshwater are recorded in the collections from Philadelphia. Of these, 44 terrestrial species (162 lots, 2,212 specimens) and 36 freshwater species (77 lots, 1,048 specimens) have been found in the Fairmount Park system.

Literature. The number of species known from Philadelphia County has increased with study of the region. Gabb (1861) listed 24 species, 20 of them native; Schick (1895) listed 39 species, 34 of them native; Pilsbry (1939-1948) lists 47 species, 37 of them native (however, he did not give county-by-county distributions for some widespread species, which would have given a higher total); and Hubricht (1985) listed 48 native species as occurring in Philadelphia County. Summed across all authors, 68 species have been reported in Philadelphia County, of which 58 are native. Two of the non-native species, however, have not been found outside of greenhouses: *Testacella haliotidea* and *Subulina octona*.

Schick (1895, p. 133) stated: "While many of the special localities herein recorded will be destroyed by the growth of the city, others situated in Fairmount Park, especially along the Wissahickon, will doubtlessly perpetuate within the city limits most of the species indefinitely; and the aquatic forms will survive at least as long as the Schuylkill furnishes the water supply of the city." He also noted (p. 134): "The west bank of the Schuylkill above Girard Avenue was a very good collecting ground...but this place has been destroyed this year by the laying out of a drive."

Historic Fauna. All of the species recorded in the ANSP collections have also been recorded from Philadelphia in the literature except *Oxyloma retusa*, a native species found in 1928, and *Arion subfuscus*, an introduced species found in 1984. Adding these two to the 66 species reported in the literature (excluding the two greenhouse species), the total historic faunal of Philadelphia is 68 species, of which 59 are native.

As noted above, 44 species from the Fairmount Park system are represented in the ANSP collection. Five species reported in the literature for the park system are not represented in our collection: *Catinella* sp., *Gastrocopta armifera*, *Nesovitrea electrina*, *Strobilops labyrinthica*, and *Vertigo ovata*. Thus a total of 49 species, 44 of them native, had been found within the boundaries of the Fairmount Park system prior to our survey.

4.E.3.3. **Current Survey**

Mollusks were collected at 95 sites throughout the Fairmount Park system. A total of 169 lots and 819 specimens were found. Of these, 146 lots and 712 specimens were land snails and slugs. A total of 29 species was collected, of which 22 are native. Thus half of the native species known from the park were not found during our survey.

Two introduced species not previously recorded from Philadelphia County were collected: *Cryptomphalus aspersus* and *Discus rotundatus*. One native species not previously recorded in the park was found, *Punctum vitreum*.

Habitat. Habitat preferences by species are summarized in Appendix A-3 in Volume III following data in Hubricht (1985). Data for some introduced species were taken from Kerney and Cameron (1979).

Several broad trends in habitat can be seen. Some species prefer upland, wooded or hilly areas; some prefer wetlands, and some prefer open areas (e.g., meadows, grasslands, roadsides).

Calcium dependence: Hubricht (1985) refers to some species as "calciphilic," meaning that they prefer areas where calcium is abundant. Pilsbry (1948, p. 804) notes that the Philadelphia area has mostly "crystalline metamorphic rock, deficient in lime," thus this region is not prime habitat for calciphilic snails. Nonetheless, historically, five such species have been recorded in this area (Appendix A-3 in Volume III), including three that were formerly common in local areas: *Pomatiopsis lapidaria*, *Gastrocopta armifera* and *G. corticaria*. None of these species was collected during the survey period. This might be a signal that acidification has occurred in some areas, decreasing the availability of calcium. However, because these species by nature have patchy distributions, it is also possible that they were simply missed during the survey.

Upland areas: Four of the species historically common in the park have a habitat preference for upland leaf litter according to Hubricht (1985): *Triodopsis tridentata, Ventridens suppressus*, *Haplotrema concavum* and *Stenotrema hirsutum*. All have declined significantly in abundance. The first was represented by a single specimen and the last two were not recorded at all during the survey. Only *Ventridens suppressus* could still be considered common. *Glyphyalinia rhoadsi* formerly uncommon, is now rare, represented by a single specimen.

Another group of species prefers leaf litter in wooded hillsides, ravines or talus slopes (Hubricht 1985). *Triodopsis juxtidens* and *Xolotrema albolabris* were historically common in the park and *Glyphyalinia burringtoni* and *Carychium exile* were uncommon. All were absent during the survey. *Anguispira alternata*, which prefers leaf litter in woods, might also belong under this heading, and was also absent during the survey.

Wetlands and flood plains: Among seven species formerly common or abundant in the park that prefer wetlands and flood plains, three were entirely absent: *Pomatiopsis lapidaria*, *Discus whitneyi* and *Hawaiia minuscula*; three were rare: *Novisuccinea ovalis*, *Zonitoides nitidus* and *Mesodon thyroidus*; and only one was stable: *Succinea* sp. C. This suggests a decline in the moistest habitats.

Meadows and grasslands: Of the six historically common species that prefer meadows and grassland, *Cionella lubrica*, *Vallonia costata*, *Vallonia* sp. *(V. pulchella* and/or *V. excentrica*, which are very hard to distinguish), *Vertigo pygmaea*, *Ventridens ligera* and *Discus whitneyi,* most seem still to have stable populations. Only *Discus whitneyi* was not recorded during the survey. It may have been replaced by *Discus rotundatus,* an introduced species. This group of species tends also to be found along roadsides (Hubricht 1985), suggesting that they are correlated with disturbance. With the exception of *Discus whitneyi* and *Ventridens ligera* these are Holarctic species.

Distribution Patterns. The native species of mollusks that occur in the Fairmount Park system can be divided into three categories of distribution: Holarctic species, which occur in Eurasia and North America; American species; and local endemic species.

Holarctic: Among Holarctic species are *Cochlicopa lubrica,* the three species of *Vallonia*, *Vertigo pygmaea*, *Zonitoides nitidus* and *Deroceras laeve*. *Zonitoides nitidus* declined greatly in abundance. The status of *Deroceras laeve* could not be assessed because probable specimens of this species were too juvenile for positive identification. The other species are associated with meadows and grasslands and have not declined.

American: All of the species historically present in the parks that were not recorded during our survey are American species. Only two of these species have relatively restricted distributions, *Triodopsis fallax* and *T. juxtidens*, so that their absence in the park might be cause for broader concerns about the conservation of the species.

Endemics: Only one species appears to be endemic to the Philadelphia region. This species has been reported from Wissahickon Park and Barbados Island, Schuylkill River, Norristown, PA by Hoagland and Davis (1987), as *Succinea* sp. C. It was found in Wissahickon Creek Park and Pennypack Park during the current survey. Schick (1895) reported the species as *Succinea obliqua* along the Wissahickon and in Westville, NJ. Populations do not appear to have declined from historical levels, but the extremely narrow range of the species makes it of special concern. It prefers very moist areas.

Succinea obliqua was first described by Thomas Say in 1817 from the Philadelphia area. It was later synonymized with *Succinea ovalis*, but this synonymy is incorrect (see Ford 1887b). Another species from the Philadelphia region has the same shell morphology but different anatomy (David Robinson, USDA, pers. comm.). Further study is needed to determine to which species the name *Succinea obliqua* applies. It is also possible that this species will turn out to have been introduced from Europe, but the taxonomy of European *Succinea* is in disarray. Therefore, this report uses the name *Succinea* sp. C, following Hoagland and Davis (1987).

Introduced species: Two introduced species not previously reported in the literature from Philadelphia have become the most abundant species in the Fairmount Park system: *Discus rotundatus* and *Arion subfuscus*. It is likely that both species have invaded since 1940. Pilsbry reported collecting *Arion subfuscus* in Haverford in 1940, but not in Philadelphia. It now is found throughout the park system in huge numbers. At many localities, such as Roberts Hollow in West Park, tens of thousands of specimens could be collected. *Limax maximus* was common in urban areas of Philadelphia 100 years ago, but had not been collected in the park. Since then it has become common in the park.

It is possible that these species are displacing native species. In particular, *Discus rotundatus* might compete directly with *Discus whitneyi,* and the slugs *Limax maximus* and *Arion subfuscus* could be displacing native slugs, and native polygyrid snails, since both feed on living vegetation (most snails feed on lichens or detritus). Introduced *Oxychilus* might have displaced native *Haplotrema* as both are carnivorous.

Another introduced species of concern is *Cryptomphalus aspersus*, which was found near the Poplar Street Bridge in East Park, just within the park boundary. The species had not previously been reported in Pennsylvania. It is a known agricultural pest and should be eradicated while the population is still areally restricted.

Individual Parks. Only two of the parks in the Fairmount Park system have been sampled extensively in the past: Wissahickon and East/West Park. Faunas and faunal changes in each park are reviewed below. In the following section, names of introduced species are underlined in the faunal lists. Names of species marked with an asterisk under "Current Survey" were also known historically from that park.

Cobbs Creek Park: Eight species are known historically from Cobbs Creek Park, all but one of them native. The current survey also found eight species, but only two of these, *Helicodiscus parallelus* and *Oxychilus* sp. were among those previously known. Five of eight of the newly recorded species are introduced and two, *Glyphyalinia indentata* and *Punctum minutissimum*, are native. Thus the fauna of the park, while still understudied, is shifting toward introduced species.

Historical	**Current Survey**
Gastrocopta contracta	*Arion subfuscus*
Hawaiia minuscula	*Deroceras reticulatum*
Helicodiscus parallelus	*Discus rotundatus*
Oxychilus sp.	*Glyphyalinia indentata*
Vallonia costata	*Helicodiscus parallelus**
Vallonia pulchella/excentrica	*Limax maximus*
Vertigo pygmaea	*Oxychilus* sp.*
Zonitoides arboreus	*Punctum minutissimum*

Fairmount (East/West) Park: Eighteen species are known historically from East and West Park, all but two of them native. One of the introduced species, *Subulina octona,* was recorded only in the greenhouse at the Horticultural Center. The current survey found only eight species, only three of which were among those previously known. The newly recorded species are all introduced. Two juvenile species of slugs were found, but these were too small for positive identification. A species of pupillid was found, but the shell was crushed before the specimen was identified; it may have been one of the *Gastrocopta* species previously recorded. The overall pattern in East and West Park is of great decline of native species and increase of introduced species.

Historical	**Current Survey**
Anguispira alternata	*Arion subfuscus*
Cionella lubrica	*Arion* sp.
Discus whitneyi	*Cionella lubrica**
Gastrocopta contracta	*Cryptomphalus aspersus*
Gastrocopta tappaniana	*Deroceras sp.*
Haplotrema concavum	*Limax maximus*
Hawaiia minuscula	*Mesodon thyroidus**
Helicodiscus parallelus	*Oxychilus sp.**
Mesodon thyroidus	Pupillid
Oxychilus sp.	
Pomatiopsis lapidaria	
Stenotrema hirsutum	
Subulina octona (greenhouse)	
Triodopsis juxtidens	

Vallonia costata
Vallonia pulchella/excentrica
Ventridens ligera
Zonitoides nitidus

FDR Park: The collection contains no historical records of mollusks from the area of FDR Park. Eight species were found during the current survey, of which three are introduced and the rest native. The native species, however, with the exception of *Helicodiscus parallelus* are all widespread Holarctic species associated with meadows and grasslands.

Historical	**Current Survey**
[no records]	*Arion subfuscus*
	Cionella lubrica
	Helicodiscus parallelus
	Limax maximus
	Oxychilus sp.
	Vallonia costata
	Vallonia pulchella/excentrica
	Vertigo pygmaea

Pennypack Park: Eleven species are known historically from Pennypack Creek Park, all but one of them native. The current survey also found 11 species, but only 4 of these were among those previously known. Of the seven newly recorded species, three are introduced and four are native. Although introduced species are increasing in Pennypack, other than Wissahickon, it has the best remaining native snail fauna in the Fairmount Park system. Two native species that historically have been found near the park might also occur in it: *Triodopsis tridentata*, in Bustleton, and *Nesovitrea electrina* at Valley Falls.

Of particular significance is that two of the newly recorded species are members of the family Succineidae, *Novisuccinea ovalis* and *Succinea* sp. C. *Novisuccinea ovalis* was formerly common in the Philadelphia area, but a single site along Rockledge Creek is the only place it was found during the current survey. *Succinea* sp. C. was found along the trail by Pennypack Creek near Rhawn Street. Both of these species live in wetland areas and their habitat should be conserved.

Historical	**Current Survey**
Anguispira alternata	*Arion subfuscus*
Carychium exile	*Discus rotundatus*
Gastrocopta contracta	*Helicodiscus parallelus*
Glyphyalinia burringtoni	*Limax maximus**
Glyphyalinia indentata	*Mesodon thyroidus**
Haplotrema concavum	*Novisuccinea ovalis*
Limax maximus	*Oxychilus* sp.
Mesodon thyroidus	*Succinea* sp. C
Ventridens suppressus	*Ventridens ligera*
Xolotrema albolabris	*Ventridens suppressus**
Zonitoides arboreus	*Zonitoides arboreus**

Poquessing Creek Park: The collection contains no historical records of mollusks from the Poquessing area. Seven species were found during the current survey, of which two are introduced and the rest native. One of the native species, *Zonitoides nitidus,* was formerly common in Philadelphia, but was recorded only at the one site in Poquessing during the survey. This is a Holarctic species however, so it is not of special conservation concern.

Historical	**Current Survey**
[No records]	<u>*Arion subfuscus*</u>
	<u>*Discus rotundatus*</u>
	Gastrocopta contracta
	Punctum minutissimum
	Ventridens ligera
	Ventridens suppressus
	Zonitoides nitidus

Tacony Creek Park: The collection contains only one historical record of a snail from the Tacony area. This species, a native, was also found during the current survey, along with two introduced species and two additional native species. *Glyphyalinia rhoadsi* was found just outside the park boundary during the current survey, and so probably occurs in the park as well. This native species was found nowhere else during our survey.

Historical	**Current Survey**
Zonitoides arboreus	<u>*Arion subfuscus*</u>
	Cionella lubrica
	<u>*Discus rotundatus*</u>
	Ventridens suppressus
	*Zonitoides arboreus**

Wissahickon Valley: Thirty-nine species are known historically from Wissahickon Creek Park, all but three of them native. The current survey found 19 species, only half as many as historically recorded. Only two species were found that were not previously reported, *Punctum vitreum*, a native species, not previously known in the park system and *Discus rotundatus*, an introduced species now widespread in the park system.

Wissahickon seems to be resisting the invasion of introduced species better than the other parks, and has retained more of the native fauna. That half of the native species known from the park were not found is alarming, especially in the case of formerly abundant species such as *Anguispira alternata* and *Discus whitneyi*. Also, abundance of the native species that remain appears to have declined significantly from historical levels, although this is hard to quantify because of different methods of collecting between then and now.

The best prescription for Wissahickon to increase snail diversity and abundance is similar to that for the park system in general: increase high quality habitat, particular forest and wetlands. One species of particular interest occurs in Wissahickon, *Succinea* sp. C., recorded near the bridge at Thomas Mill Road, along Wissahickon Drive near Gorgas Lane, at the Henry Avenue bridge at Gorgas Lane, and at the first tributary north of Ridge Avenue. Preservation of wetlands in these areas is essential for preserving the species.

Historical

Anguispira alternata
Arion subfuscus
Carychium exiguum
Carychium exile
Cionella lubrica
Deroceras reticulatum
Discus whitneyi
Euchemotrema fraternum
Euchemotrema leai
Euconulus chersinus
Gastrocopta contracta
Gastrocopta pentodon
Glyphyalinia burringtoni
Glyphyalinia indentata
Glyphyalinia rhoadsi
Haplotrema concavum
Hawaiia minuscula
Helicodiscus parallelus
Mesodon thyroidus
Novisuccinea ovalis
Oxychilus sp.
Philomycus sp.
Pomatiopsis lapidaria
Punctum minutissimum
Stenotrema hirsutum
Striatura meridionalis
Strobilops aeneus
Succinea sp. C
Triodopsis fallax
Triodopsis juxtidens
Triodopsis tridentata
Vallonia costata
Vallonia pulchella/excentrica
Ventridens ligera
Ventridens suppressus
Vertigo gouldii
Vertigo pygmaea
Xolotrema albolabris
Zonitoides arboreus

Current Survey

*Arion subfuscus**
*Cionella lubrica**
*Deroceras reticulatum**
Discus rotundatus
*Euconulus chersinus**
*Gastrocopta contracta**
*Helicodiscus parallelus**
*Mesodon thyroidus**
Philomycus sp.*
*Punctum minutissimum**
Punctum vitreum
*Striatura meridionalis**
Succinea sp. C*
*Triodopsis tridentata**
*Vallonia pulchella/excentrica**
*Ventridens ligera**
*Vertigo gouldii**
*Vertigo pygmaea**
*Zonitoides arboreus**

4.E.3.4. **Discussion**

The data suggest a lack of high quality woodland in the park, although it is not clear that forest quality was any better 100 years ago. One possibility is that the forests are drier now. This might result from deer browsing the understory, patchier forest with more canopy gaps, and channelization of streams, all of which would lessen moisture retention. Drier conditions would be less favorable to most species of snails. In addition, roads and trails along streams and rivers could create a zone inhospitable to snails and slugs, possibly cutting off migration towards moister habitat during dry spells or hindering dispersal outward from such refugia when conditions get better.

4.E.4. **Terrestrial Insects—Crane Flies**

4.E.4.1. **Introduction**

Insects comprise by far the majority of species of organisms that inhabit the Fairmount Park system's environments. Although their total diversity and ecological importance is still being documented, a conservative estimate would place the total number of insect species in the park system at 5000 species; although, the total may be more than 10,000 species. The size of this fauna prevented a full inventory of the insects in 1998 and required approaching this aspect of the inventory on a representative basis. During 1998, a few groups of insects were studied as representatives of important components of the environment, including benthic aquatic macroinvertebrates (aquatic), the Lepidoptera - butterflies, skippers and some moths (terrestrial), and crane flies (aquatic to terrestrial). This section covers the sampling and inventory program for crane flies within the Fairmount Park system in 1998.

Crane flies were selected as a representative indicator group for insects in general for the following reasons.

- Crane flies are exceedingly diverse, reflecting in general the extraordinary diversity of many groups of insects in the Fairmount Park system.
- The habitats used by crane flies are also diverse and range from aquatic to terrestrial, encompassing a broad span of wetland habitats not encompassed by stream macroinvertebrate sampling. Crane flies are particularly diverse in seeps and marshy areas, habitats that were not sampled in the aquatic macroinvertebrate study. Crane fly habitats also include streams, ponds, fungi, rotting wood, mosses, leaf litter and soil.
- Crane flies are not active dispersers and adults are generally found near the larval habitats.
- Crane fly feeding habits are primarily detritivorous (decaying plant material) or predatory (on other invertebrates), complementing data from the herbivorous feeding Lepidoptera.
- The Philadelphia crane fly records have been databased and there is local expertise for identifying and accessing published and unpublished information.

For all these reasons, crane flies serve in this study as an important indicator group for a range of other organisms in the same habitats that are not so easily sampled, or where local expertise is lacking.

4.E.4.2. **About Crane Flies**

Crane flies are long-legged, slender bodied flies and include the families Tipulidae, Trichoceridae and Ptychopteridae in the Order Diptera (the true flies including mosquitoes, gnats and house flies). The Tipulidae are the most species-rich family in this order, constituting nearly 20,000 species worldwide. Other common names for tipulids besides "crane fly" include "daddylonglegs (fly)," "leatherjackets" (due to the tough skin of some larvae) and "mosquito catchers" or "mosquito hawks" (a misnomer). Among the crane fly families Trichoceridae and Ptychopteridae, species of the genus *Trichocera* are known as "winter crane flies" and species of *Bittacomorpha* and *Ptychoptera* are commonly known as "phantom crane flies."

Although crane flies are ubiquitous, adults are most often noticed when they enter buildings accidentally, usually due to an attraction to an outside light at night or seeking a shaded area during the day. Larvae are usually not conspicuous, but larger species in streams may be noticed by fisherman or in soil by gardeners. The overall resemblance of adult crane flies to mosquitoes leads casual observers to consider them giant mosquitoes, although crane fly adults are completely harmless and do not carry disease.

The life cycle of all crane flies includes egg, larval (feeding), brief pupal and adult (usually non-feeding) stages. Larval stage is the longest in duration, ranging from a few weeks to nearly a year, with the adult stage usually lasting a week or two. Although many species have long adult emergence seasons, many others have comparable short ones (e.g., one month in spring or fall). Larval feeding varies among the species, including detritivores (i.e., leaf litter, fungi), predators on other invertebrates, and some herbivores on algae and moss. The impact of a few species has been well documented, but those that have been studied demonstrate that crane flies are important in breaking down leaf material in streams and forest soil. Both crane fly larvae and adults are well documented in the diets of a wide variety of organisms, including birds, fish, amphibians, other insects and even native peoples.

4.E.4.3. **Methods**

Sampling. Crane flies were sampled using a variety of methods. The predominant method was sampling of adults through aerial netting. This occurred in most parks at differing levels of effort. Adults were also collected by the use of stationary Malaise traps (see below) placed in several locations in Fairmount (West) and Pennypack parks. They were collected along with target Lepidoptera in the regular monthly light trapping which occurred in the upper Wissahickon Park and locations in Pennypack Park. Larvae were collected in sampling for the aquatic macroinvertebrate inventory and at times were collected during surveys of adults. In total, 36 localities in all the parks were sampled one or more times, using one or more methods. Each separate light trap or Malaise trap collection was counted as one sampling effort (see Appendix A-5.1 in Volume III for list of localities). This count does not include the larval material collected during the benthic macroinvertebrate sampling reported elsewhere, although crane fly specimens collected during that study are also referenced here. Level of the sampling effort is indicated on the species tables organized by individual park (see Appendices A-5.2-A-5.6 in Volume III).

Each method of sampling had its limitations and strengths. Malaise traps are large net traps, with a central baffle which insects intercept in flight. The trap design then funnels the insect up to a collecting bottle. Malaise trap sampling is ideal for use continuously over a limited area and often results in "rare" species, which for various reasons do not show up in aerial netting or light trapping. Once set, the traps can be maintained by anyone without specific insect expertise. Malaise traps can only sample what intercepts the netting, so placement of the trap is critical. The traps themselves are large and conspicuous and may be subject to vandalism or damage. In this study, two of the four Malaise traps used were lost, one by theft and one by deer damage.

Light traps using white or ultraviolet tubes can attract insects from a wide area reached by the lights. Full details are given in the Lepidoptera survey report. Light traps capture the insects that enter the trap and are set up and taken away after each night they are run. They are maximally useful only when there is no moon or competing lights. The traps can be set up and collected with only limited training. Although crane flies are attracted to light, currently designed light traps do not efficiently trap and hold these flies and so many never make it in the trap. The light traps are subject to theft. Losses also occurred during this sampling due to ants raiding the collected insects between the time the trap was set up at night and picked up the next morning.

Aerial sweeping can be most effective, and the collector can sample over a broader area, including specific microhabitats. An experienced collector will derive the most species and information while the efforts of less experienced collectors can be much more variable. An experienced collector can also note larval habitats, ecological interactions and other information that may be of use. Aerial sampling was done in 1998 primarily by experienced collectors. A drawback to aerial sampling is the length of time needed for sampling. Since sampling in 1998 was to maximize diversity, it generally occurred in an area until no new species were uncovered, often 1-2 hours per site.

Because of the seasonality of adult emergence in many species, a combination of methods has worked the best to estimate diversity at a site, particularly where the methods span the entire period of activity (April-October).

Because of the preliminary nature of this inventory, and the uncertainty of the species that might be found, identifications were based primarily on collected specimens. Although some species of crane flies can be identified reliably in the field, the vast majority is best identified authoritatively in the laboratory through microscopic examination of the wing venation, coloration, antennae and genitalia morphology and other features. Most specimens will be vouchered in the Entomology Collection of the Academy of Natural Sciences. Sufficient material exists to provide reference collections of common species for use in Fairmount Park instruction and education.

Sites and Samples. A total of 36 separate sites in all targeted parks was sampled (see Appendix A-4.1 in Volume III). These sites were not distributed equally among the six parks but were concentrated in Pennypack, Fairmount (West) and Wissahickon parks. No sampling was done in Tacony Park, and limited sampling occurred in Franklin Delano Roosevelt Park due to the scarcity of natural lands and the inability to secure collecting traps and other sampling equipment. Some sites had only a single sample taken, while others were repeatedly sampled, particularly by light and Malaise traps. Malaise and light traps also were comparably sampled by date, while dates of aerial sampling were more variable.

Preparation. The insects were preserved by both dry means and in fluid. Specimens in fluid were preserved in 70% ethanol and each species from a specific place and time was housed in a separate vial. Dry specimens of crane flies were taken from the killing jar or light trap to an envelope for short-term storage. They were then mounted on paper points attached to insect pins for study in the lab. Each pointed specimen or insect vial contains a detailed label(s) with identification, locality information and reference to collector field notes if available. With normal care given to the ANSP collections, the specimens should last for hundreds of years.

Identification. Specimens were identified using the scientific literature and making reference to authoritatively identified specimens in the ANSP's entomology collection. Some groups were not fully identifiable to species and remain in the tables as "sp.", "spp." or "sp. near." Some collections are based on larval specimens, which generally can be identified to genus or subgenus level only (e.g., *Tipula (Nippotipula*) sp.). Some species cannot be determined to species based on female specimens alone, particularly where more than one similar species occurs in the area. For example, female *Antocha* collected without accompanying male specimens, are left determined as "*Antocha* spp.," as two similar species of *Antocha* were sampled in the park system in 1998. In other cases, the understanding of the taxonomy of the species is not complete, and an authoritative identification may not be clearly possible or identification may change at a later date as an understanding of the species taxonomy progresses. Examples are the *Tipula (Lunatipula*) *submaculata* and *mallochi* species;

these are clearly two distinct species in the Fairmount Park system, but may not be the same species as applied elsewhere in the literature.

4.E.4.4. **Species Present in the Fairmount Park System**

1998 Survey Results. The 1998 sampling program for crane flies recorded 115 species among 6 parks in the Fairmount Park system, with total species per park ranging from no species in FDR to 85 species in Pennypack Park (Table 4.E.2). Tables of species and specific localities are presented for each park in Appendices A-4.2-A-4.6 in Volume III. Total species in a park were undoubtedly influenced by the level of collecting effort, as the lowest totals were in the three parks with the lowest effort. Single visits were made to FDR, Cobbs Creek and Poquessing parks, with corresponding low total species of crane flies of 0, 11 and 22 species, respectively. The other 3 parks had significantly more sampling sites and samples (from 5-14 sites and 36-50 samples), and species totals were also much higher. Along with the high of 85 species in Pennypack, 67 species were recorded in Wissahickon Park, and 75 species were recorded in Fairmount (West) Park. These species totals for each of these three parks were 58-74% of the total species collected in 1998.

Historical Occurrence. This study was able to benefit from an on-going project developing a database of the crane fly species of Pennsylvania. Previous to the inventory in 1998, the crane fly specimens in the collections of the Academy of Natural Sciences of Philadelphia and the Carnegie Museum of Natural History, Pittsburgh had been databased. In addition, a list of species potentially occurring in Pennsylvania had also been compiled.

A search of specimens with Philadelphia records prior to the 1998 inventory yielded a list of 52 species, 49 in the family Tipulidae, 2 in the family Ptychopteridae and 1 in the Trichoceridae. Of species historically recorded in Philadelphia prior to this study, only 14 were not encountered in the 1998 sampling (Appendix A-4.7 in Volume III). When the distribution area was expanded to include counties surrounding Philadelphia in Pennsylvania and New Jersey, then 105 crane fly species were known from or could be predicted to occur in Philadelphia based on museum records and literature citations. Nearly a third, 35 species, were not encountered during the 1998 sampling. Further discussion of the absence of these species is covered within the following sections on each habitat class (e.g., stream, marsh). Newly discovered and introduced species are identified and discussed in Appendix A-4.8 in Volume III.

Few of the Philadelphia specimens in the ANSP's crane fly collection specified any of the parks on the collection labels. This is in part due to the imprecision of data generally on the older specimens and probably also reflected the limits of space on an insect label for handling detailed locality information. All specimens collected in 1998 have been fully labeled, including detailed locality information.

Habitats. The species recorded in the 1998 sampling, as well as those species known to occur in the area historically, were grouped into their primary larval habitats: stream, edge of stream, vertical seeps/waterfalls, shaded marsh, open marsh, wet logs and forest soil (see Appendix A-4.9 in Volume III). This information was derived from published literature and from field observations of Dr. Gelhaus. Although a few larval rearings were made in the Fairmount Park system, the majority of information used to compile this table came from published and field observations in eastern and central North America. This grouping of regional species by habitat gives the potential number of species expected for a particular habitat.

Table 4.E.2. Species of crane flies recorded or potentially found in the Fairmount Park system in 1998. Park abbreviations are Fairmount (West) Park (FWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP) and Wissahickon Valley (WCP).

Species	FWP	WCP	PCP	PQCP	CCP	FDR	# parks Max.=6	Phil.	Southeast PA	Southeast NJ
Antocha spp.		X	X				2			
Antocha obtusa?		X					1			
Antocha saxicola		X	X				2			
Atarba picticornis	X	X	X				3			
Austrolimnophila toxoneura		X	X	X			3			
Brachypremna dispellens	X	X	X		X		4		X	
Cheilotrichia (Empeda) stigmatica		X	X				2			
Cladura flavoferruginea	X	X	X				3	X	X	X
Ctenophora (Tanyptera) dorsalis							0		X	
Dicranoptycha germana?				X			1			
Dicranoptycha winnemana?				X			1			
Dicranota (Paradicranota) eucera			X				1			
Dicranota (Rhaphidolabis) cayuga			X				1		X	
Dicranota (Rhaphidolabis) sp.	X						1			
Dicranota sp.			X							
Dolichopeza (Oropeza) carolus		X	X				2	X		
Dolichopeza (Oropeza) johnsonella		X					1			
Dolichopeza (Oropeza) obscura		X	X		X		3			
Dolichopeza (Oropeza) tridenticulata		X	X				2			
Dolichopeza (Oropeza) walleyi	X	X					2			
Dolichopeza sp.	X	X					2			X
Elephantomyia westwoodi	X	X	X	X			4	X		
Epiphragma fasciapennis	X	X	X	X			4	X	X	X
Epiphragma solatrix	X	X	X	X	X		5		X	
Erioptera (Erioptera) chlorophylla			X				1	X		X
Erioptera (Erioptera) chlorophylla group	X		X				2			
Erioptera (Erioptera) chlorophylla gp.sp 2			X				1			
Erioptera (Erioptera) megopthalma	X	X	X				3			
Erioptera (Erioptera) septemtrionis	X	X	X				3		X	
Erioptera (Hoplolabis) armata							0		X	
Erioptera (Mesocyphona) caliptera	X	X	X	X	X		5	X		
Erioptera (Mesocyphona) needhami	X	X	X				3			
Erioptera (Mesocyphona) parva			X				1			
Erioptera (Psiloconopa) venusta			X				1	X	X	
Erioptera (Symplecta) cana	X	X	X	X			4		X	X
Erioptera (Trimicra) pilipes							0			X

Table 4.E.2 (continued). Species of crane flies recorded or potentially found in the Fairmount Park system in 1998. Park abbreviations are Fairmount (West) Park (FWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP) and Wissahickon Valley (WCP).

Species	**FWP**	**WCP**	**PCP**	**PQCP**	**CCP**	**FDR**	**# parks Max.=6**	**Phil.**	**Southeast PA**	**Southeast NJ**
Gnophomyia tristissima	X	X	X	X			4	X	X	
Gonomyia (Gonomyia) subcinerea		X	X				2			X
Gonomyia (Lipophleps) manca	X						1			
Gonomyia (Progonomyia) ?	X						1			
Helius flavipes	X		X				2			X
Hexatoma (Eriocera) albitarsis			X				1			
Hexatoma sp. (stream species)							0		X	
Leptotarsus (Longurio) rivertonensis							0			X
Leptotarsus (Longurio) testaceus							0	X		
Limnophila (Dicranophragma) fuscovaria	X	X	X				3	X		
Limnophila (Eloeophila) solstitialis			X				1		X	
Limnophila (Lasiomastix) macrocera	X	X	X				3	X	X	X
Limnophila (Phylidorea) auripennis							0			X
Limnophila (Phylidorea) fratria							0	X		
Limnophila (Phylidorea) similis group	X	X	X				3			
Limnophila (Prionolabis) rufibasis							0	X		X
Limonia (Dicranomyia) brevivena	X						1			X
Limonia (Dicranomyia) divisa		X	X				2			X
Limonia (Dicranomyia) fusca	X	X	X				3		X	
Limonia (Dicranomyia) gibsoni							0			X
Limonia (Dicranomyia) globithorax	X		X				2			
Limonia (Dicranomyia) humidicola	X	X	X	X			4			
Limonia (Dicranomyia) immodesta							0		X	
Limonia (Dicranomyia) liberta	X		X				2		X	X
Limonia (Dicranomyia) longipennis			X				1			X?
Limonia (Dicranomyia) macateei	X						1			
Limonia (Dicranomyia) sp. wing-open discal			X				1			
Limonia (Dicranomyia) sp. near *pudica*	X		X				2			
Limonia (Dicranomyia) sp. near *stulta*		X					1			
Limonia (Discobola) annulata	X		X		X		3	X	X	
Limonia (Geranomyia) "canadensis"	X		X				2			
Limonia (Geranomyia) communis							0			X
Limonia (Geranomyia) distincta?		X					1			
Limonia (Geranomyia) diversa			X				1			
Limonia (Geranomyia) rostrata		X	X				2			X
Limonia (L.) sp.	X	X	X				3			

Table 4.E.2 (continued). Species of crane flies recorded or potentially found in the Fairmount Park system in 1998. Park abbreviations are Fairmount (West) Park (FWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP) and Wissahickon Valley (WCP).

Species	**FWP**	**WCP**	**PCP**	**PQCP**	**CCP**	**FDR**	**# parks Max.=6**	**Phil.**	**Southeast PA**	**Southeast NJ**
Limonia (Limonia) indigena indigena	X		X				2	X		
Limonia (Limonia) sp. near *fallax*	X	X	X				3			
Limonia (Limonia) tristigma		X	X				2			
Limonia (Metalimnobia) annulus cinctipes	X	X	X				3			
Limonia (Metalimnobia) immatura	X	X	X				3			
Limonia (Metalimnobia) sp. unidentifiable		X					1			
Limonia (Metalimnobia) triocellata	X						1	X		
Limonia (Neolimonia) rara	X		X				2			
Limonia (Rhipidia) bryanti		X	X				2			
Limonia (Rhipidia) domestica	X		X				2			X
Limonia (Rhipidia) fidelis	X	X	X				3			
Limonia (Rhipidia) lecontei	X	X	X	X			4			X
Limonia (Rhipidia) shannoni	X	X					2			
Limonia (subgenus?) defuncta		X					1	X		
Liogma nodicornis							0	X	X	
Molophilus cramptoni (dark species)	X	X					2			
Molophilus focipulus							0			X
Molophilus sp. (dark species)		X	X				2			
Molophilus sp. (yellow species)	X	X					2			
Molophilus spp.	X		X	X			3		X	
Neolimnophila ultima							0			X
Nephrotoma alterna	X	X	X	X			4			
Nephrotoma calinota							0		X	
Nephrotoma cingulata	X		X				2		X	
Nephrotoma cornifera					X		1			
Nephrotoma eucera	X	X	X	X	X		5	X	X	
Nephrotoma ferruginea	X						1	X	X	X
Nephrotoma gnata	X	X					2		X	
Nephrotoma macrocera	X	X	X	X	X		5	X(FP)	X	
Nephrotoma polymera	X	X		X			3			
Nephrotoma sodalis							0		X	
Nephrotoma species		X					1			
Nephrotoma subalterna		X					1			
Nephrotoma tenuis							0	X		
Nephrotoma urocera	X		X				2			
Nephrotoma virescens	X	X	X		X		4	X(FP)	X	

Table 4.E.2 (continued). Species of crane flies recorded or potentially found in the Fairmount Park system in 1998. Park abbreviations are Fairmount (West) Park (FWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP) and Wissahickon Valley (WCP).

Species	FWP	WCP	PCP	PQCP	CCP	FDR	# parks Max.=6	Phil.	Southeast PA	Southeast NJ
Ormosia (Ormosia) meigenii							0	X		
Ormosia (Ormosia) nigripila			X				1	X		
Ormosia (Ormosia) rubella							0			X
Ormosia nigripila group	X	X	X				3			
Ormosia pygmaea	X						1			
Ormosia romanovichiana	X	X					2	X	X	
Pedicia (Pedicia) albivitta	X		X				2		X	
Pedicia (Tricyphona) inconstans	X	X	X				3	X	X	X
Pedicia (Tricyphona) vernalis							0	X		X
Pilaria imbecilla imbecilla			X				1			
Pilaria quadrata							0	X		
Pilaria tenuipes	X	X	X	X			4	X	X	
Pseudolimnophila contempta			X				1		X	
Pseudolimnophila luteipennis	X		X				2	X(FP)		X
Shannonomyia lenta							0		X	
Teucholabis spp.	X	X	X	X			4			
Tipula (Arctotipula) williamsiana							0		X	
Tipula (Beringotipula) borealis	X						1	X	X	
Tipula (Lunatipula) bicornis							0		X	
Tipula (Lunatipula) duplex							0		X	
Tipula (Lunatipula) fuliginosa			X				1	X	X	X
Tipula (Lunatipula) georgiana		X					1			
Tipula (Lunatipula) sp. near *mallochi*	X	X	X	X			4			
Tipula (Lunatipula) sp. near *submaculata*	X	X	X				3	X		
Tipula (Lunatipula) submaculata group	X	X	X	X			4			
Tipula (Nippotipula) abdominalis			X				1	X	X	
Tipula (Nippotipula) metacomet	X	X					2	X	X	
Tipula (Nippotipula) sp.	X	X	X				3		X	
Tipula (Nobilotipula) collaris			X				1	X	X	
Tipula (Nobilotipula) sp.		X	X				2		X	
Tipula (Platytipula) paterifera			X				1			X
Tipula (Platytipula) spenceriana			X				1			
Tipula (Platytipula) tennessa							0			X
Tipula (Platytipula) ultima	X	X	X				3	X	X	X
Tipula (Pterelachisus) sp. near *trivittata*	X		X				2	X	X	
Tipula (Schummelia) spp.	X				X		2	X	X	X

Table 4.E.2 (continued). Species of crane flies recorded or potentially found in the Fairmount Park system in 1998. Park abbreviations are Fairmount (West) Park (FWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP) and Wissahickon Valley (WCP).

Species	**FWP**	**WCP**	**PCP**	**PQCP**	**CCP**	**FDR**	**# parks Max.=6**	**Phil.**	**Southeast PA**	**Southeast NJ**
Tipula (Trichotipula) oropezoides			X				1			
Tipula (Trichotipula) stonei	X						1	X(FP)		
Tipula (Trichotipula) unimaculata	X						1		X	
Tipula (Triplicitipula) "undulata"							0		X	
Tipula (Triplicitipula?) valida							0	X	X	
Tipula (Vestiplex) longiventris							0	X	X	X
Tipula (Yamatotipula) aprilina							0	X		
Tipula (Yamatotipula) caloptera		X	X	X			3	X		
Tipula (Yamatotipula) dejecta							0	X	X	X
Tipula (Yamatotipula) eluta							0		X	X
Tipula (Yamatotipula) furca	X	X	X	X	X		5	X	X	
Tipula (Yamatotipula) iroqouis							0		X	
Tipula (Yamatotipula) jacobus		X		X			2			
Tipula (Yamatotipula) sayi	X	X	X				3		X	X
Tipula (Yamatotipula) sp. nr. *dejecta*		X					1			
Tipula (Yamatotipula) strepens	X		X				2			
Tipula (Yamatotipula) subeluta?			X				1			
Tipula (Yamatotipula) tephrocephala			X				1			
Tipula (Yamatotipula) tricolor	X		X				2	X		X
Ula elegans	X	X	X				3			
Ulomorpha pilosella	X	X					2			
PTYCHOPTERIDAE										
Bittacomorpha clavipes							0	X		
Ptychoptera rufocincta	X		X				2	X		
Ptychoptera sp. 1			X				1			
TRICHOCERIDAE										
Trichocera (Metatrichocera) sp.	X	X					2	?	?	?
Trichocera annulata	X	X	X				3	?	?	?
Trichocera bimacula		X					1	X		X
Total Crane fly species sampled 1998	77	69	88	22	11	0	115	51	56	39
Total Tipulidae species historically recorded in region, but not seen in 1998							35			
Total Tipulidae species historically recorded for Philadelphia only, but not seen in 1998							13			

Streams: Stream species are grouped among several categories. The most fully aquatic species, such as *Antocha*, occur on rocks, in the bottom substrate, or in the leafpacks of streams and are exposed to the stream current constantly. Approximately 15 regional species were classed in this group. Of these, five species were not found during the 1998 sampling. Most notable are the absence of *Hexatoma* spp. and *Leptotarsus testaceus* which have been found in nearby areas in recent years. For example, *Leptotarsus testaceous* was collected in 1997 in the nearby Schuylkill Environmental Education Center. Both groups, although they could be missed as adults, are conspicuous as larvae in benthic sampling and did not occur in the 1998 macroinvertebrate sampling.

Of those species that were found, few streams were found with a full complement of species. *Dicranota* was absent (as larva and adult) from all but a few small streams. The *Tipula* species in this habitat were also not common or absent entirely except in a few smaller streams, generally where *Dicranota* was also present. Although *Antocha* was found in both Wissahickon and Pennypack creeks, the numbers of individuals were much lower than has been recorded in comparable or even smaller streams elsewhere.

A larger group of species is known to develop in the "edge" stream habitats such as sand or mud flats, stream banks, edge mosses or algal mats and accumulations of leaf material. Just over 30 regional species were classed in this group. Of these, eight species were not encountered during 1998 sampling. In 1998, only a few small streams cultured a typical complement of stream edge species. In the larger creeks such as Wissahickon and Pennypack, edge species were nearly entirely absent.

Taking the above two stream groups combined, the stream crane fly fauna differed tremendously among streams. Most streams sampled had few species, and only a few streams had high diversity. Streams with low crane fly diversity include all the larger main creeks (including Wissahickon, Cobbs and Pennypack creeks), and a multitude of smaller tributaries (including West Tributary 2 in Fairmount (West) Park, Tributary 20, Wise's Mill Creek, Tributary 15, and Bell's Mill Creek in Wissahickon Park, and Tributary 12, Tributary 13, Sedden's Run, Ballard Run and Rockledge Brook in Pennypack Park).

Streams with relative high diversity, and thought to be representative of less impacted water quality, are unfortunately few. Three Springs Run in Pennypack Park showed both high adult diversity and good larval densities of the stream and edge species and was the stream that produced the highest species totals overall. Tributary 15 in Pennypack Park also showed good larval densities and potentially good adult diversity, including the presence of *Dicranota*. Thomas Mill Creek in the Wissahickon Valley had high larval densities assessed qualitatively during a visit by Dr. Gelhaus. The diversity of habitat indicates a probable diverse fauna, although the macroinvertebrate study did not corroborate high numbers of larval crane flies. Tributaries 3 and 4 of the Wissahickon were not sampled at peak times for adult diversity. However, habitat assessment and the limited sampling indicates possible high quality habitat for crane flies not seen in other parks. Important features include a high gradient slope on Tributary 3, and a braided, marshy course of Tributary 4.

Eleven aquatic species were classed as using the specialized vertical seep or waterfall habitat, of which manmade examples occur in Pennypack (Rhawn Street and Environmental Center dams) and natural examples (Tributaries 3,4) sampled in the Wissahickon. All except *Dactylolabis* spp. were found in the 1998 sampling. *Limonia canadensis* and *L. diversa* were found around the Rhawn Street dam face, the only site where *diversa* was found in 1998. One species, *L. defuncta*, was collected only along Tributary 3, which has a rock streambed and high gradient slope.

Shaded Marsh: The largest number of species of crane flies develops in or surrounding forested, shaded marshes most notably dominated by skunk cabbage. Over 40 regional species were classed in this habitat, with only three of these not found during 1998. In contrast to the stream habitats sampled, nearly all marshes looked to have high diversity, with similar shaded marshes sampled in middle and upper Pennypack, Wissahickon and West Park. The numbers ranged from 10 species found around the marsh at the pond at the Andorra Natural Area in the Wissahickon (site 17) to 25-56 species in sites 20, 23, 27 and 32 in Pennypack, and 64 species from site 2 in Fairmount (West) Park. Although these species were derived from various habitats, most were classed as inhabiting forested marsh.

Another class of species develops in saturated wood, often logs and branches laying in marshy areas, but also those found laying in or along the edge of streams. Of the eight regional species classed in this group, all were found in the 1998 survey and most were found in several parks. Two species, *Epiphragma fasciapennis* and *solatrix*, often the most abundant crane flies, were widely distributed, and found far up the wooded slopes.

For crane flies and other insects with similar tolerances marsh habitats are important areas of production of adults and larvae as food for wildlife. The high percentage of observed species versus potential species indicates that, in general, the shaded marsh habitats are in good condition. As such, these habitats may serve as refugia for some insects expected to be found in streams, particularly where conditions in the area streams are not tolerable. The comparison of the samples from site 2 in Fairmount (West) Park and site 32 in Pennypack Park clearly show that the vast majority of aquatic/semi-aquatic species are derived from the marsh habitats and not from the nearby stream (West Tributary 2 and Rockledge Creek, respectively).

Open Marsh: Only site 20, in Pennypack Park was classified in this category. Although surrounded by woodland, the area is large enough to be relatively open and was not vegetatively dominated by skunk cabbage. Another open marsh area was in the upper reaches of Three Springs Run (Pennypack), although significant shaded marsh habitat occurred nearby. Of 14 regional species classed here, all but two were found during the 1998 survey. A related class of species inhabit temporary pools or streams or marshy areas which dry considerably in the summer. Six regional species were classed here with one, *Shannonomyia*, not being found in 1998.

Thirty-two species were recorded from site 20, many derived from the marsh. Most striking at this site was the abundance in the fall season of adults of several species of *Tipula*, all of which have larvae which develop in vernal aquatic habitats which dry considerably or completely in the summer. These include *T. sayi, ultima*, *paterifera*, and *spenceriana*, this last species unknown previously from the mid-Atlantic region. Although all the species, except *spenceriana*, were found elsewhere in Philadelphia, these species were particularly abundant at this site and the adults probably serve as important food for late fall insectivorous migrant birds.

Vernal Aquatic Habitats: As discussed under open marsh, there is a distinctive small component of species (six spp.) that develop in vernal habitats which fill with water in fall through spring, and dry in summer. The larvae are adapted for remaining inactive in the dry soil during the summer, then pupate and emerge in the fall. These species may be found around shaded marshes and streams and were particularly abundant in the open marsh (site 20). One species, *Tipula paterifera*, can develop in low-lying areas of turf or meadow. The habitats may not be sizable and may consist of flood troughs or pools along streams, rain pools which exist in the forest, and even manmade sites such as the pool at site 9 in the Wissahickon Valley. The intermittent stream at Valley Green may also be an important habitat, although no species were found in the one late-fall sample taken.

Meadows: Meadow habitats in Wissahickon and Pennypack parks were sampled as part of the Lepidoptera survey efforts. Six regional species were classed in the meadow habitat, with three of these encountered in 1998. Of interest, none of these is restricted to this habitat, while the three species not found are more tightly tied to meadows. Most species found in meadows (e.g., sites 13 and 14 in Wissahickon, site 26 in Pennypack) appeared to have spread here from nearby creeks, forest or marsh habitats. One species, *Tipula georgiana*, was only collected at site 13. This species has terrestrial larvae and has been reared elsewhere from the ecotone of meadow and oak hickory woodland.

Woodland: A large number of crane flies develop in woodland soil, leaf litter and rotting wood, ranging from flood plain to upper slope situations. Over 30 regional species were classed in forest soil habitat, with the majority of these in the species-rich genera of *Nephrotoma* and various subgenera of *Tipula*. An additional 13-15 regional species were classed in the rotting wood habitat. Although there is overlap with those species developing in saturated wood, the habitat here is not associated with wet habitats. All but 4 of the over 30 forest soil species and all but 2 of the 14 rotting wood species were sampled during 1998.

Several species of *Nephrotoma* were surprising additions to the Philadelphia and Pennsylvania region, the park locations now the most northern points for these species with southeastern U.S. distributions. The absence of *Tipula longiventris*, *valida* and species of *Tipula (Triplicitipula*) were perplexing as these species occur in the region and can be common. Both *Tipula mallochi* and *submaculata* were the characteristic spring woodland *Tipula* found throughout the wooded areas. Highest diversity occurred in areas with mature forests with well developed understory, such as sites 2, 3 (West Fairmount), site 6 (Wissahickon), sites 23, 28-29, 32 (Pennypack) and site 35 (Poquessing).

In late fall, *Cladura flavoferruginea*, a characteristic yellowish fly, is abundant in most areas sampled. Along with the winter crane flies, *Trichocera* spp., are the dominant flying insects of the woods at this time of year. *Trichocera annulata*, an introduced winter crane fly common in urban and suburban neighborhoods, was also abundant in most areas of the park, but not all. For example, at site 9 in the Wissahickon Valley, two native species of *Trichocera* were present and *annulata* was not sampled.

Species inhabiting rotting wood were widely distributed and diversity was highest where forest soil species were most diverse. Populations appeared particularly abundant in the woodland sites not near heavily trafficked areas directly surrounding the Pennypack Environmental Center.

4.E.5. **Terrestrial Insects—Lepidoptera**

4.E.5.1. **Introduction**

Terrestrial insects represent the single most diverse group of organisms on the planet. As such, they are in many respects an ideal target group for sampling and assessing biotic diversity in many terrestrial ecosystems. Lepidoptera are probably the best known and most thoroughly documented insect order, and the availability of extensive historical data and comprehensive reference collections made them a logical choice as one of the two main terrestrial insect groups to be studied as part of the terrestrial insect survey. The three target groups of Lepidoptera examined as part of the terrestrial insect survey were the true butterflies (Superfamily Papilionoidea), skippers (Superfamily Hesperioidea), and the inchworm moth (Subfamily Ennominae). These groups were chosen to encompass diverse lineages of phytophagous insects with differing host-plant requirements. True butterflies feed as larvae on a broad range of trees, shrubs and herbs. Skippers feed predominantly on monocots (especially grasses and sedges). Inchworm moths feed primarily on trees and shrubs. Historical records from the scientific literature of the past century, together with data from the ANSP research collection, provide a fairly good picture of the faunal composition for these groups in the Philadelphia region since the mid-19th century.

4.E.5.2. **Materials and Methods**

Five lunar cycles of light-trap sampling were conducted at 13 different sites in Wissahickon Park, Pennypack Creek Park, and Fairmount (West) Park. In addition, six diurnal sampling trips were made to four different sites in Wissahickon Park and Pennypack Creek Park, exclusive of incidental diurnal sampling during the setting and collecting of light-traps. Light traps consisted of battery-powered 15-watt "BLB"-type long-wave ultraviolet fluorescent tubes surrounded by stainless steel vanes arranged to guide insects into a plastic bucket as they are attracted to the light. These traps were equipped with photocell switches to automatically turn the light on at dusk and off at dawn. Three Malaise (flight intercept) traps were set in Fairmount (West) Park and these traps collected insects continuously since June 12-13th, 1998 with traps emptied at 2-4 week intervals. Three additional light-trap samples were taken from sites in Fairmount (West) Park. Diurnal insect sampling used aerial nets, and survey data from the resulting voucher specimens have been supplemented with a limited number of "sight records" for easily identified species that could not be captured. Bait traps were used during June - September 1998 at two deciduous forest sites in an attempt to sample species attracted to rotting fruit.

All voucher specimens of taxa in the three target groups, as well as samples of other insects collected in light traps and Malaise traps, have been deposited in the collection of the Department of Entomology of the ANSP.

4.E.5.3. **Major Habitat Types**

The major habitats sampled during the course of the survey include:

1. Late Successional Habitats
    - Mixed deciduous forest understory in the Schuylkill, Wissahickon, and Pennypack valleys. [AND-1; BMR; trail from Tabor to RR-MDW; PPE-2; WP-YH/STBLS]
    - understory of deciduous forest with *Liriodendron* -dominated canopy and *Lindera* –dominated understory [PPE-1]
2. Early Successional Habitats
    - old field/shrub habitats [PPE-MDW; WP-HORT]
    - meadows dominated by native bluestem grasses (*Andropogon/Schizachyrium* sp.) [CTHDRL-1; CTHDRL-2; RR-MDW (a.k.a. "Tabor Meadow")]
3. Ecotones
    - deciduous forest margins at interface with old fields/meadows/seeps [CTHDRL-1 (light-trap site); CTHDRL-2 (light-trap site); GRG-MDW]
4. Other Habitat Types
    - seep/wetland in deciduous forest understory [GRG-LT (a.k.a. "Three Springs Hollow")]

4.E.5.4. **Patterns of Species Diversity**

The habitats with the highest species diversity for a given target group varied depending on the larval host associations of the group in question. The occurrence of target-group species by sample-site is summarized in Appendices A-5.1 and A-5.2 in Volume III. The sites with highest skipper diversity were the bluestem-dominated meadows [e.g. CTHDRL-1 (40°04'09.6"N 75°13'37.8"W) CTHDRL-2 (40°04'12.1"N 75°13'46.1"W)]. This is to be expected for a predominantly grass-feeding group such as the skippers.

High butterfly diversity occurred in meadow/old field ecotones along deciduous forest margins [e.g., CTHDRL-1 (40°04'09.6"N 75°13'37.8"W), CTHDRL-2 (40°04'12.1"N 75°13'46.1"W), RRMDW (40°04'21.0"N 75°03'46.0"W), and GRG-MDW (the PECO powerline cut adjacent to "Three Springs Hollow")].

High inchworm moth diversity occurred at sites in mixed deciduous forest understory [e.g., PPE-1 (40°05'20.4"N 75°03'50.4"W), BMR (40°04'41.9"N 75°13'39.4W) and AND-1 (40°04'52.0"N 75°13'51.7"W)] as well as at some deciduous forest/old-field ecotones where light traps were positioned at the edge of the forest (e.g., CTHDRL-1 and CTHDRL-2).

4.E.5.5. **Threatened Habitats**

Bluestem (*Andropogon/Schizachyrium*)- dominated grasslands are a key habitat for many Lepidoptera species with small, isolated remnant populations in the Fairmount Park system. Two of the light-trap sampling locations are located in the "Cathedral Road Meadow," and global positioning system (GPS) data, together with a park boundary acetate overlay associated with maps on file at ANSP, suggest that one of these light-trap sites (CTHRD-2 at 40°04'12.1" 75°13'46.1"W) is actually just outside the Fairmount Park boundary, although it falls well within the "Critical Environmental Area" highlighted in the 1983 Master Plan. This area is extremely important as a "hot spot" of plant and insect diversity within the park system, and any areas of the meadow that technically fall outside the park boundary should be a top priority for either acquisition or "co-management." It is absolutely essential that this bluestem-dominated meadow be carefully managed to preserve this "island" of early successional habitat that supports many plant and insect species that are rare or absent in other sections of the Fairmount Park system. The only other meadow with a similar grass flora ("Tabor Meadow" along a railway line in Pennypack Creek Park) was surveyed for two grass-feeding skipper species unique to Cathedral Road Meadow, (see Section 4.E.5.7) and they appear to be absent. Both the Cathedral Road Meadow and the Pennypack site could be enhanced as butterfly and skipper habitats by supplemental planting of crucial adult energy resources that may be a limiting factor for many such small, isolated Lepidoptera populations. A prime candidate nectar source that could be easily cultivated in the Native Plant Nursery and transplanted at Cathedral Road to enhance the area for a broad range of butterflies and skippers is "Butterfly Weed" (*Asclepias tuberosa*). This plant occurs sparingly in the section of the Cathedral Road Meadow that appears to lie outside the park boundary, and it seems to be absent from the bluestem-grass meadow in Pennypack Creek Park. A scattered population of *A. tuberosa* also occurs on the south side of Ridge Avenue at the Schuylkill Environmental Education Center. The tiny population of *A. tuberosa* at the Cathedral Road Meadow site may be the only one remaining in the Fairmount Park system. Other milkweed species that are key nectar sources and can be easily propagated and/or transplanted to enhance these important butterfly habitats are *Asclepias syriaca* and *Asclepias incarnata*. Management via controlled burning is not recommended, as the skipper species feeding as larvae on bluestem grasses would be vulnerable to extirpation as a result of fire.

4.E.5.6. **Habitat Rehabilitation Recommendations**

Recommendations for maintaining and enhancing early successional plant communities apply here for the Cathedral Road Meadow and Tabor Meadow sites. Maintaining these two sites as early successional bluestem-meadows is a high priority if terrestrial insects of special concern and limited distribution within the park are to be conserved.

4.E.5.7. **Species of Special Concern**

Two species of skipper (Lepidoptera: Hesperiidae) appear to be restricted to a single locality within the Wissahickon section of the Fairmount Park system. These two grass-feeding species, *Atrytonopsis hianna* and *Hesperia metea*, have been previously documented from the upper

Wissahickon Creek (they were no doubt more widespread when native bluestem-dominated grassland was more extensive in early successional habitats of this region). Documented larval hostplants of *Atrytonopsis hianna* include: *Schizachyrium scoparius* and *Andropogon gerardii*. Documented larval hostplants of *Hesperia metea* include: *Schizachyrium scoparius*, *A. gerardii*, and *A. virginicus* (Shapiro 1965, Heitzman and Heitzman 1974). Both *Atrytonopsis hianna* and *Hesperia metea* are univoltine and have life cycles in which mature larvae hibernate (Shapiro 1965).

While neither species is globally or regionally endangered, both of these skippers are probably only found at this single remaining site within Philadelphia County, and may only be found at a handful of other localities in the Greater Philadelphia region. The locality in question, commonly known as "Cathedral Road Meadow," has already been highlighted as a "Critical Environmental Area" in the 1983 Fairmount Park Master Plan Summary (p. 9, site 13). While they appear to be absent from the Pennypack site (Tabor Meadow), this may be a suitable site for future reintroduction attempts. A third bluestem-feeding skipper, *Nastra l'herminier*, was recorded from the Pennypack site in mid-summer, but has not yet been documented from the Cathedral Road Meadow. While this bivoltine species is likely to be more widespread than our present records indicate, it represents another skipper whose continued presence in Philadelphia County will ultimately depend on the successful management of remnant bluestem-grass meadows in the Fairmount Park system.

4.E.5.8. **Recently Introduced Species of Potential Ecological/Agricultural Importance**

Fifteen individuals of the European noctuid moth, *Noctua pronuba*, were recorded from three trap sites (the Rhawn Street Buttonbush-Spatterdock swamp; a site north of the Pennypack Environmental Center; and the Andorra Natural Area) in August 1998. These represent the first known records of this invasive moth species from southeastern Pennsylvania. This moth was first documented from northeastern Canada in 1979 and has been spreading through North America at the alarming rate of 80 miles per year (Passoa and Holingsworth 1996). Based on recent records from southern New Jersey (Schweitzer, pers. comm.) it appears likely that this species reached the Delaware Valley in 1996 or 1997. The larvae of *N. pronuba* are polyphagous and will likely attack vegetable gardens and other cultivated crops.

This species apparently exhibits migratory behavior in western Europe, so it is likely to spread rapidly throughout the eastern United States and may pose a danger to indigenous noctuid moth species with similar ecological characteristics.

4.E.5.9. **Extirpated Species/Species Reintroduction Recommendations**

An overview of the historical occurrence of putative extirpated species is provided in Appendix A-5.3 in Volume III. Of the species listed in this table, the taxa discussed below are particularly well suited to reintroduction as part of restoration activities (due primarily to ease of laboratory culture, propagation of larval host plants, and habitat requirements).

Viable projects for the near future include:

- *Graphium marcellus* ("Zebra Swallowtail"). This species occurs in flood plain forests where *Asimina triloba* is abundant. It has been recorded historically from the Fairmount Park system but is not known to breed in Philadelphia County at the present time. The small population of *A. triloba* in the Pennypack sector of the park would be a suitable site for attempting a reintroduction of this species.
- *Speyeria idalia* ("Regal Fritillary"). This species was last recorded in Philadelphia in the late 1920s. It has completely disappeared from most of its former range in the northeastern United States, and only a handful of populations remain in Pennsylvania.

There are no recent records of this species from the Delaware Valley. The only remaining potentially suitable habitat might be "Cathedral Road Meadow" and similar nearby habitats at the Schuylkill Environmental Center and Manatawna Farm, but reintroduction of this species would require careful planning and management for both suitable *Viola* spp. as well as adult nectar sources.

Key to habitat rehabilitation/management: introduce and maintain larval host and nectar sources at target sites (see Appendix A-5.4 in Volume III). The larval host plant suitable for remnant *Schizachyrium* grassland is *Viola pedata* (Birdfoot violet). Nectar sources include: *Asclepias tuberosa*, *Asclepias viridifolia*, other *Asclepias* spp., *Apocynum androsaemifolium* (already abundant), *Prunella vulgaris*, *Vernonia glauca*, *Cirsium discolor*, *Cirsium pumilum* (+ European *Cirsium* spp., especially *C. vulgare*; other non-native nectar sources include: *Trifolium pratense*, *Achillea millefolium*) (Iftner et al. 1992).

Viable projects subsequent to successful future wetlands restoration in the Pennypack valley:

- *Lycaena hyllus* ("Bronze Copper"). This species was recorded as recently as the early 1960s from areas immediately adjacent to the upper Wissahickon sector of the park (wet meadows near the Morris Arboretum). The only recent records for Philadelphia County have been from the John W. Heinz National Wildlife Refuge at Tinicum (late 1980s).While still locally common in the Susquehanna Valley, this species is now very rare or absent from the lower Delaware Valley and adjacent areas with one small population known from Cumberland County, New Jersey. The larval hostplants are present at a number of sites in Pennypack (notably near the Rhawn St. Buttonbush-Spatterdock swamp). Captive breeding of this trivoltine species with release of adults at suitable sites subsequent to rehabilitation should be attempted in the Pennypack valley.
- *Euphydryas phaeton* ("Baltimore"). This species was recorded as recently as the mid-1960s from Pennypack Park and perhaps more recently from the John W. Heinz National Wildlife Refuge at Tinicum. It now appears to be extirpated from Philadelphia County, (but small isolated populations may still exist at Tinicum). This species would be suitable for reintroduction to Pennypack subsequent to restoration of flood plain wet meadow habitats where the larval host plant (*Chelone glabra*) is established. There are extant Delaware Valley populations in the Brandywine Creek drainage of Delaware County, as well as further north in the marshes around Trenton, NJ.
- Other butterfly and skipper species.

The following five species (listed with larval host plant/habitat type in parentheses) all occurred historically in Fairmount Park and are potential candidates for future reintroduction projects subsequent to wet meadow and wetlands restoration:

Satyrodes eurydice (Sedges [*Carex* spp.]/very wet meadows and marshes)

Poanes massasoit (Sedges [*Carex* spp.]/very wet meadows and marshes)

Poanes viator (*Phragmites communis*/tidal marsh and inland fresh-water marshes)

Euphyes conspicuus (Sedges [*Carex stricta*]/very wet meadows and marshes)

Boloria selene (Violets [*Viola* spp.]/wet meadows).

4.E.6. **Reptiles and Amphibians**

4.E.6.1. **Introduction**

Since amphibians and reptiles are cold blooded, they can maintain themselves with relatively low food intake, allowing populations to become very abundant. For example, woodland salamanders such as the redbacked salamander can be among the most common vertebrate in many woodlands. Turtles are potentially long-lived and may be very significant consumers of aquatic vegetation. However, reptile and amphibian populations can be sensitive to mortality of adults (e.g., moving to breeding pools or winter hibernaculation sites), eggs and juveniles. Collecting for pets or the pet trade has impacted several species, such as the bog turtle. Conversely, release of unwanted pets such as the red-eared slider is a source of introductions, especially in urban areas.

Terrestrial amphibians and some species of snakes are good indicators of the health of ecosystems because they require specialized microhabitats. For example, several species of snakes (e.g., worm snake, smooth earth snake, redbellied snake) require woods with high invertebrate densities and intact humus or uncompacted earth for feeding and burrowing. Some species have specialized food habits, tying them to these resources. For example, toads are a primary food of hognose snakes and crayfish are a primary food of queen snakes. Reptiles lay eggs in terrestrial nests, so that aquatic reptiles require adequate terrestrial nesting sites accessible from pond and stream habitats.

Aquatic amphibians and reptiles are especially sensitive to moisture, hydrologic conditions, pollution and loss of habitat. Many species of frogs and toads and some salamanders breed in ponds; vernal pools (i.e., pools which fill with rainwater in the spring and dry out later) and other fishless ponds are important habitats for these species. Many of these pond species, such as the gray treefrog and American toad, are terrestrial or arboreal outside their breeding period, so they require continuous areas with breeding ponds and woods. The worldwide decline in amphibian populations has received international attention. Several state endangered species (e.g., red-bellied turtle) have been documented in the area, and their presence is important for prioritizing protection as well as for minimizing risks during restoration.

4.E.6.2. **Existing Information**

Very little has been written on the distribution of the herpetofauna (reptiles and amphibians) of Philadelphia. A few field notes and very early historic accounts of descriptions of species, accompanied only by a vague locality, have been located. McCoy (1982) cites that “Philadelphia, near Philadelphia, in the vicinity of Philadelphia” has been used for the locality in 39 type species accounts, that is, the original collection upon which the species was scientifically described. Many of the type descriptions were written in the early 19th century. Very few mention any habitat information, and when present, this information is typically brief. Little information was written in late 19th and 20th centuries about the herpetofauna of the city. Dr. Roger Conant, past curator of the Philadelphia Zoo, published on the Red-bellied turtle (Conant 1951) and the European Wall Lizard (Conant 1959). His other works with "Philadelphia" in the title (Conant 1937, 1940) were mostly accounts of reptiles and amphibians of the Delaware Valley, with the emphasis on the New Jersey Pine Barrens. In 1982, C.J. McCoy of the Carnegie Museum of Natural History compiled data from museum collection, literature, and type locality designations for the distribution of Pennsylvania amphibians and reptiles. McCoy (1982) lists 17 amphibian species and 22 reptile species occurrences within Philadelphia County. Conant and Collins (1991) mapped 49 reptile and amphibian species distribution ranges to include Philadelphia. Historic information of herpetofauna within the Fairmount Park system was difficult to find and the reluctance of individuals with data was frustrating. Tables 4.E.3 (amphibians) and 4.E.4 (reptiles) list the herpetofauna within

Table 4.E.3. Species of amphibians found during ANSP 1998 inventory (*) and observations (O) of other ANSP groups during 1998-1999. Park abbreviations are East-West Park (EWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP), Tacony Creek Park (TCP) and Wissahickon Valley (WCP).

Common Name	Scientific Name	EWP	CCP	PCP	FDR	PQCP	TCP	WCP
Dusky salamander	*Desmognathus f. fuscus*		O					*
Redbacked salamander	*Plethodon cinereus*	*	*	*		*	*	*
Red salamander	*Pseudontriton r. ruber*	O					*	
Two-lined salamander	*Eurycea bislineata*	*	*	*				*
Long-tailed salamander	*Eurycea l. longicauda*							*
American toad	*Bufo americanus*							*
Spring peeper	*Pseudacris crucifer*			*				
Bullfrog	*Rana catesbeiana*	*	*	*	*	*	*	*
Green frog	*Rana clamitans melanota*	*	*	*	*	*	*	*
Pickerel frog	*Rana palustris*							*

Table 4.E.4. Species of reptiles found during ANSP 1998 inventory (*), the ANSP 1999 inventory (B) and observations (O) of other ANSP groups during 1998-1999. Park abbreviations are East-West Park (EWP), Cobbs Creek Park (CCP), Pennypack Park (PCP), Franklin Delano Roosevelt Park (FDR), Poquessing Creek Park (PQCP), Tacony Creek Park (TCP) and Wissahickon Valley (WCP).

Common Name	Species Name	EWP	CCP	PCP	FDR	PQCP	TCP	WCP
Snapping turtle	*Chelydra serpentina*	*	*	O	*			
Wood turtle	*Clemmys insculpta*						*	
Bog turtle	*Clemmys muhlenbergii*							
Stinkpot	*Sternotherus odoratus*	*						
Painted turtle	*Chrysemys p. picta*	*	*	*	*			*
Red-eared slider	*Trachemy scripta elegans*	*		*	*			
Red-bellied turtle	*Pseudemys rubriventris*	*		*	*			
Box turtle	*Terrapene c. carolina*	*	O	*				
deKay's (brown) snake	*Storeria dekayi*	*	O	B	*		*	*
Northern water snake	*Nerodia s. sipedon*		*	O		O	O	*
Eastern garter snake	*Thamnphia s. sirtalis*	*	O		*			*
Black racer	*Coluber c. constrictor*		*					
Milk snake	*Lampropeltis t. triangulum*			B?				

Philadelphia and its parks compiled from literature, museum records, personal accounts, and ANSP field visits.

Based on the range of habitats in the park, most or all of the species recorded from the city are likely to have occurred in the park. The historical sources document 17 species of native amphibians, 23 species of native reptiles, and 2 species of introduced reptiles in the city. An additional five species of salamander, one frog species and one snake species have been recorded in adjacent counties in Pennsylvania, but not in Philadelphia.

4.E.6.3. **Inventory of Reptiles and Amphibians**

To determine the current status of amphibians and reptiles in the park system, an inventory was performed as part of this assessment. The inventory started with initial park tours in the fall of 1997 and concluded in August of 1998. Sampling was done by observing animals, searching under rocks, logs and other cover, by listening for frogs and toads, and by setting hoop nets for turtles. Records from this inventory were supplemented by records from other ANSP inventory teams. For example, electroshocking for fish is also effective in catching salamanders and frogs.

4.E.6.4. **Results of Inventory and Comparison with Historical Accounts**

A total of 11 reptile species (10 native) and 10 amphibian species (all native) were observed during the study. This is less than 50% of the number species of Conant and Collins (1991) or of McCoy (1982) which are in range or have been documented in Philadelphia (Table 4.E.5). The distribution of herpetofauna throughout the parks tended to be scattered with the exception of the redbacked salamander, which was widespread within all the parks except FDR Park. Green frogs and bullfrogs were found in all parks, although locally (i.e., in scattered locations) in several of the parks. The two-lined salamander, snapping turtle, painted turtle, Eastern garter snake, deKay's (brown) snake and Northern water snake were found in a number of parks, though generally locally or in small numbers. The long-tailed salamander, American toad, spring peeper, pickerel frog, wood turtle, musk turtle and the Northern black racer were also found exclusively in one park (the northern red salamander was found in only in Tacony Park in the inventory, but was also recorded in West Park). A few other species may occur in the parks. A milk snake was reported from Pennypack Park, but this record needs confirmation, and there are anecdotal accounts of ring-necked snakes in Wissahickon Creek Park and the northern part of Pennypack Park as well. One introduced species, the red-eared turtle, was found. It was noted in West, Pennypack and FDR parks.

The inventory results clearly indicate a decrease in abundance and diversity of amphibians and reptiles in the park. For example, the ANSP herpetology collection contains a fair number of specimens of Northern red salamanders and Northern dusky salamanders collected over 75 years ago in the Fairmount Park system and other locations within Philadelphia. The survey was able to locate only one place in Tacony Creek Park for the Northern red salamander. They have been reported from Wissahickon Creek Park and near the Horticultural Center in West Fairmount Park. The Northern dusky salamander was located in several tributaries in Wissahickon Creek Park and one tributary in Cobbs Creek Park. They are known to occur in Fairmount and Pennypack Creek parks. Toad specimens also have a larger representation in the city historically. The only place where American toads were found was in the northeastern portion of Wissahickon Creek Park.

Most of the species which are still widespread in the park can use a variety of habitats. The redbacked salamander occurs in a variety of types of woods, and is less sensitive to low soil moisture than other woodland salamanders. The snapping turtle, water snake, bullfrog and green frog occur in or near a variety of stream and pond habitats. The green frog and bullfrog do not depend on small breeding ponds like toads and other frog species. The painted turtle is typically common in a variety

Table 4.E.5. Historic data of Philadelphia Reptiles and Amphibians. Sources of information are the ANSP Herpetology collection (A), Barton 1804 (B), Conant (1951), Kauffeld 1931 (J), McCoy 1982 (K), R. Horwitz pers. comm. (Q), E.S. Gilmore pers. observations (R), Odell 1995 (S), McNeil 1963 (T), Bonnaterre 1789 (C), Conant 1959 (F), Daudin 1803 (G), Harlan 1826 (H), Mondrosch 1986 (L), Rothman (1964 (M), Say 1825 (N), Schoepff 1792 (O), Welsh, et al. 1959 (P). Species without an entry have been recorded in nearby counties (see McCoy 1982), but no Philadelphia records have been located. See Table 4.E.3 for park abbreviations.

Common Name	***Species Name***	**EWP**	**CCP**	**PCP**	**FDR**	**PQCP**	**TCP**	**WCP**	**PHILA**
AMPHIBIANS									
Salamanders									
Spotted salamander	*Ambystoma maculatum*	A							B,K,G
Marbled salamander	*Ambystoma opacum*								K
Northern dusky salamander	*Desmognathus f. fuscus*	A		A		Q			K
Redbacked salamander	*Plethodon cinereus*	A,S	A	A		Q		A	A,K
Northern red salamander	*Pseudontriton r. ruber*	A,S		A		Q			K
Two-lined salamander	*Eurycea bislineata*	A,S	Q	A,R		Q			A,J,K
Long-tailed salamander	*Eurycea l. longicauda*							A,Q	K
Frog & Toads									
American toad	*Bufo americanus*					Q			A,K
Fowler's toad	*Bufo woodhouseii fowleri*								A,K
Northern cricket frog	*Acris crepitans*								A,K
Gray treefrog	*Hyla versicolor*								A,K
Spring peeper	*Pseudacris crucifer*					Q			A,K,L
Bullfrog	*Rana catesbeiana*	S	Q	A		Q			A,K,L
Green frog	*Rana clamitans melanota*	A,S	Q	A,R		Q			A,H,K,L
Pickerel frog	*Rana palustris*	S		A					A,H,K,L,M
Southern leopard frog	*Rana sphenocephala*								A,H,K,M
Wood frog	*Rana sylvatica*								L

Table 4.E.5 (continued). Historic data of Philadelphia Reptiles and Amphibians. Sources of information are the ANSP Herpetology collection (A), Barton 1804 (B), Conant (1951), Kauffeld 1931 (J), McCoy 1982 (K), R. Horwitz pers. comm. (Q), E.S. Gilmore pers. observations (R), Odell 1995 (S), McNeil 1963 (T), Bonnaterre 1789 (C), Conant 1959 (F), Daudin 1803 (G), Harlan 1826 (H), Mondrosch 1986 (L), Rothman (1964 (M), Say 1825 (N), Schoepff 1792 (O), Welsh, et al. 1959 (P). Species without an entry have been recorded in nearby counties (see McCoy 1982), but no Philadelphia records have been located. See Table 4.E.3 for park abbreviations.

Common Name	*Species Name*	EWP	CCP	PCP	FDR	PQCP	TCP	WCP	PHILA
				REPTILES					
Turtles									
Snapping turtle	*Chelydra serpentina*	A,S	Q	A		Q			A,K,L,M
Wood turtle	*Clemmys insculpta*					Q			K
Bog turtle	*Clemmys muhlenbergii*								A,K
Spotted turtle	*Clemmys guttata*								K,M,O
Stinkpot	*Sternotherus odoratus*	S							A,K,L,M
Eastern mud turtle	*Kinosternon s. subrubrum*								A,K,M
Painted turtle	*Chrysemys p. picta*	S				Q			A,K,L,M
Red-eared slider	*Trachemy scripta elegans*			R					L
Red-bellied turtle	*Pseudemys rubriventris*	E,S			Q				A,E,K,L,M
Box turtle	*Terrapene c. carolina*		Q			Q			C,K,L,M
Lizards									
Firve-lined skink	*Eumeces fasciatus*	D							D,K,P
European wall lizard	*Podarcis sicula*								F,J,K
Snakes									
Red-bellied snake	*Storeria o. occipitomaculata*								K
Brown snake	*Storeria dekayi*	R,S	Q	A, T					A,K,L,M
Northern water snake	*Nerodia s. sipedon*	R,S	Q	T		Q		R	A,K,L,M
Queen snake	*Regina septemvittata*								A,K,N
Eastern ribbon snake	*Thamnophis s. sauritus*								A,K
Eastern garter snake	*Thamnophia s. sirtalis*	S	Q	T	Q	Q			A,K,L,M
Northern hognose snake	*Heterodon platirhinos*								K
Worm snake	*Carphopis a. amoenus*								K
Ring-necked snake	*Diadophis punctatus edwardsii*	A,S						A,R	K
Black racer	*Coluber c. constrictor*								A,K

Table 4.E.5 (continued). Historic data of Philadelphia Reptiles and Amphibians. Sources of information are the ANSP Herpetology collection (A), Barton 1804 (B), Conant (1951), Kauffeld 1931 (J), McCoy 1982 (K), R. Horwitz pers. comm. (Q), E.S. Gilmore pers. observations (R), Odell 1995 (S), McNeil 1963 (T), Bonnaterre 1789 (C), Conant 1959 (F), Daudin 1803 (G), Harlan 1826 (H), Mondrosch 1986 (L), Rothman (1964 (M), Say 1825 (N), Schoepff 1792 (O), Welsh, et al. 1959 (P). Species without an entry have been recorded in nearby counties (see McCoy 1982), but no Philadelphia records have been located. See Table 4.E.3 for park abbreviations.

Common Name	*Species Name*	EWP	CCP	PCP	FDR	PQCP	TCP	WCP	PHILA
Black rat snake	*Elaphe o. obsoleta*	S							K
Milk snake	*Lampropeltis t. triangulum*	A							A,K
Copperhead	*Agkistrondon contortrix mokasasen*								K

of ponds, while the two-lined salamander occurs in rocky streams. The deKay's snake occurs in a variety of habitats and is known to maintain populations in urban areas.

The majority of the known herpetofauna of the city was rare or not found in the park inventory. This change reflects decreases in several different types of habitats and probably reflects effects of mortality within suitable habitat as well. Species breeding in small ponds were rare (e.g., American toad and spring peeper) or were not found (e.g., spotted salamander, marbled salamander, cricket frog, gray treefrog), showing the impact of the reduction of this habitat type. Some of these species can use artificial ponds, so that habitat restoration could aid these species. Several woodland species (e.g., the redbellied snake, worm snake, and smooth earth snake) were not found. Several other wetland species (e.g., bog turtle, spotted turtle, queen snake, and ribbon snake) are apparently extirpated from the city. There are not many historical records for these species. They may have always been rare, or they may have been reduced during the early period of settlement with accompanying deforestation and forest modification. Some species, like the New Jersey chorus frog, redbellied turtle and southern leopard frog, are found mainly on the Coastal Plain. The Coastal Plain wetlands have been greatly reduced in the city. Some species like the black rat snake, black racer, and box turtle can use a variety of habitats; their absence or rarity suggests mortality as factors.

The decline of much of the herpetofauna most likely happened during the late 19th and early 20th centuries. The loss of additional Coastal Plain wetlands in the southeastern portion of Philadelphia and the urbanization of the northeastern corner of the city has reduced streams, wetlands, and critical uplands.

4.E.7. **Fish**

4.E.7.1. **Introduction**

Fish are important components of aquatic communities and provide links to terrestrial systems via fish-eating wildlife. Fish are excellent indicators of environmental degradation because of their sensitivity to changes in hydrology, habitat, temperature, dissolved oxygen and other water quality parameters, and the construction of dams. In particular, fish are sensitive to many of the changes in stream bank structure, channel morphology and substrate types which are caused by stormwater flows and the loss of riparian vegetation.

Fish distribution varies across river drainages (a river and its tributaries) in response to the long-term history of the drainages and systematically within river drainages in response to habitat differences. Drainage basins differ in species composition. For example, there are a number of species in the Susquehanna River drainage which are not in the Delaware River drainage. The Delaware River drainage has a relatively low number of mainly freshwater species, although it has a relatively high number of species which use fresh and brackish or salt water (e.g., anadromous species, which spawn in fresh water and use estuaries or the ocean during other periods). These differences need to be considered in making comparisons of fish diversity and species composition.

Different habitats support different species, although many species can occur in a variety of habitats. Most of the Fairmount Park system streams are predominantly "pool-riffle" habitat, which are characterized by alternation of shallow areas with rapid current and coarse substrates with deeper pool with slow currents. These streams typically support a number of fish species, including several species of minnows, white sucker and the tessellated darter. Most of these stream fishes are small, although large individuals (e.g., eels, suckers, and sunfish) are often present. Ponds and similar habitats, including impoundments behind dams, often support sunfishes and bass. Marshes and vegetated streams may support many of the same stream and pond species, but there are a number of species which are found most commonly in these vegetated habitats. In the Delaware Basin, there is frequently a contrast in fish communities in sites on the Piedmont versus those on the Coastal Plain.

Piedmont rivers and streams tend to have higher gradients with a better developed pool-riffle structure, so that the pool-riffle species are well-represented. The flatter Coastal Plain tends to have marshes and wetlands, and streams often have lower gradients. Many of the vegetation-associated species are found largely on the Coastal Plain. In Pennsylvania, the Coastal Plain occupies a narrow band along the Delaware River, including portions of Philadelphia and the Fairmount Park system.

Fish distribution varies along streams with changes in habitat structure. Fish communities consistently change with stream size; the number of species typically increases downstream. There are also changes in which species are present, although many species found in headwaters typically occur far downstream as well. In looking at fish communities from the headwater to the mouth of a stream, the predominant pattern is of a progressive addition of species, with a few species dropping out. The species found in more downstream reaches are often larger species typical of more pondlike habitats, such as sunfishes and bass. The species found only in headwater or mid reaches (such as trout or sculpins) are often associated with springs or other cool water sites. Because of this progressive change in species composition and diversity along a stream, comparisons need to consider stream size.

The assessment of fish communities in the Fairmount Park system compiled historical information from specimen collections and historical accounts, and compiled more recent surveys. These compilations indicate major gaps in information. Sampling was done in 1998 and 1999 to provide current information and fill in data gaps.

The assessment of existing fish communities integrated several approaches. The historical data were used to define the probable species composition of fish communities in Fairmount Park waterbodies. For the most part, data were too sparse to allow detailed reconstructions of the fauna of individual sites. However, data on some Pennypack tributaries do provide site-specific information on fishes. After development of the regional fish fauna, recent information, including the new inventory data and existing information, was used to assess the overall occurrence of fishes in park drainages. This indicates the overall fauna of the area and shows the source fauna for individual stream sites.

The results of the new inventory were used to indicate condition of fish communities with respect to individual stream reaches. These studies demonstrate relationships between the fish fauna of individual sites and land use, watershed condition, and habitat at the sites.

4.E.7.2. **Existing Conditions and Historical Conditions**

Sampling Fairmount (West) Park
June 1998

Sources of Information on Historical Fish Communities (Before 1931). Historical information consists of general historical accounts, faunal compilations (Cope 1881, Bean 1892), and specimens (largely in collections of ANSP, with some in collections of Cornell University and University of Michigan). The historical accounts deal almost entirely with sport or commercial species (mainly trout, shad, white perch and sturgeon) and focus on the Delaware and Schuylkill rivers. The faunal compilations are more comprehensive, though they are often vague on specific locations. These faunas provide good information on the regional distributions of fish, but little specific location information on fishes in Fairmount Park system streams. A few specimens are present from the early to mid-19th century, mainly from the large rivers. These are invaluable in showing distribution of a few species which are now much restricted or extirpated. A number of specimens from the region were collected in the 1895-1930 period, mostly by H.W. Fowler of ANSP and associates of his. Within Philadelphia, most of these are from the vicinity of Holmesburg, including the main Pennypack Creek, Sandy Run, Willit's Run, a tributary of Willit's Run, and the Delaware River in the vicinity of Holmesburg. There are a few specimens from the Wissahickon and from Walton and Byberry creeks (Poquessing tributaries), but no records from the Cobbs or Tacony drainages.

Sources of Information on Recent Fish Communities (After 1931). Little specific information on fishes has been located from the 1930s to 1950s. This probably reflects decreased scientific activity during the Depression and World War II, but may also be due to poor water quality in many streams and rivers during this period. Because of sewage and industrial effluent, water quality was severely degraded in a major portion of the Delaware River in the vicinity of Philadelphia. At its worst around the mid-1940s, there was essentially no dissolved oxygen in the river for a 37-km (22-mile) stretch in summer (Kowalchik 1944, cited in Kiry 1974). Fish kills were noted in the Schuylkill River above Flat Rock Dam (i.e., between Roxborough and Montgomery County) in the 1950s, and concurrent sampling found few fish (ANSP 1959).

More thorough sampling began in the 1950s because of environmental concerns and for fishery management. These data are mainly from larger rivers and creeks. Data on specific areas include:

- Wissahickon. The mainstem of Wissahickon Creek has been sampled by a number of groups. The Pennsylvania Fish and Boat Commission (PFBC, formerly the Pennsylvania Fish Commission) sampled a number of sites in 1976 and 1990, PADER/DEP sampled a number of sites in 1980, 1992 and 1996. Other records are provided by R. Horwitz (unpublished records from 1980, 1986 and 1997). Gephardt (1998) provides comprehensive information on fishes in the creek and some tributaries.
- Pennypack Creek. The main creek was sampled at several sites by the PFBC in 1983 and 1995. Additional records are provided by collections of R. Horwitz (1981). McNeil (1963) provides a fish list for the park, apparently derived from Fowler's earlier collections.
- Tacony Creek. A few records from the Tacony outside the city were provided by PADER, from samples taken in conjunction with fish kills. No other information on Tacony Creek was found.
- Fairmount (East/West) Park. No records from East and West Park were found, excepting records from the Schuylkill River (see below) and a few records from a pond in the Philadelphia Zoo taken by ANSP in 1981.
- Cobbs Creek. The only information located on Cobbs Creek was samples taken by Normandeau Associates for the Philadelphia Suburban Water Company in 1997, and a series of samples taken by R. Horwitz in the 1990-1997 period.
- FDR Park. Sampling was done in the main ponds in FDR Park by the PFBC in 1987 and 1991, and by PADER in 1989. Information on sites along the Delaware River in Philadelphia and Delaware Counties has been collected by PADER. These provide reference information for this area.
- Poquessing Creek. The PFBC sampled several sites in Poquessing Creek in 1993. PADER sampled tributaries of the Poquessing in 1995. A number of collections were made by R. Horwitz in the 1979-1986 period, mostly in the reach above Roosevelt Boulevard.

- Schuylkill River. A large number of specimens have been collected in the Schuylkill River. ANSP sampled several sites above the mouth of the Wissahickon in 1956, 1958, 1960, 1966 and 1969. Harmon (1980) summarizes extensive sampling in the river both above and below the Art Museum Dam. Additional information is provided by PFBC samples below the Art Museum Dam and by samples near the mouth of the Wissahickon Creek (1993) and observations in the Fish Ladder (1980) by R. Horwitz. Fairchild et al. (1998) summarize a number of collections in the Schuylkill River drainage, including some on the mainstem of the river.
- Reference areas. Reports on fishes in nearby streams provides information on the regional fish fauna and on habitat-species relationships. Many of these streams are less urban and less disturbed than streams in the parks, so that these streams provide reference conditions for Fairmount Park system streams. The PFBC sampled a number of sites in the Darby Creek drainage, which is outside the city. These records are from suburban areas and provide a reference condition for Cobbs Creek and other city tributaries. The data on small streams in the Schuylkill drainage in Fairchild et al. (1998) provides additional faunal information. Collections by ANSP in a number of streams in the Schuylkill and Brandywine drainages provide data on abundance and species composition of fishes in streams ranging from those in relatively undisturbed agricultural areas through urban sites.
- Delaware River. The mainstem of the Delaware River has a relatively rich fish fauna, consisting of a variety of mainly freshwater species, anadromous species (species which spawn in freshwater and otherwise live in estuaries or oceans), and mainly estuarine species which can tolerate freshwater. However, poor water quality limited fish occurrence in the region immediately around Philadelphia, at least through the 1980s. At the period of worst water quality, the area was uninhabitable by fish during periods of no dissolved oxygen. Fish abundance presumably improved with improvements in water quality starting in the 1960s. Concurrently, a number of sampling studies have been done on the Delaware River. Species occurrence in the tidal freshwater Delaware is summarized in Horwitz (1986). The intensity of sampling and use of gear not available or commonly used earlier (e.g., electroshocking, fine-mesh nets for larval and postlarval fish, collection of fish caught on screens at industrial water intakes) has indicated the occurrence or abundance of a number of species not previously known in the freshwater part of the river. Since NLREEP restoration activities are not focused on the Delaware River, a thorough compilation of Delaware River fish information was not done for this assessment. Information is compiled to indicate the general source pool for Fairmount Park system streams and indicate the status of anadromous and other species which are relevant to NLREEP restoration activities.

4.E.7.3. **Fish Occurrence**

Native Fauna. The various collections document about 50 native species occurring in the vicinity of Philadelphia. Many of these occur mainly or entirely in the Delaware River, or Delaware and Schuylkill rivers.

Before 1931 (Appendix A-6.1 in Volume III), 30 species were documented from the Schuylkill River drainage (29 by specimens, and one by literature), of which 3 were noted only from the main river. The various samples from the Pennypack drainage contained a total of 15 species. All of these are also frequent in the smaller Schuylkill River tributaries, and these can be considered as typical small stream species. About six additional species (i.e., spotfin shiner, bluntnose minnow, creek chub, comely shiner, cutlips minnow and banded killifish) were also relatively frequent in streams in the Schuylkill drainage.

Several species are historically and/or currently highly restricted in distribution within the region. It is likely that these species were once much more widespread, but declined in abundance before the late 19th century when comprehensive collecting started. However, some of these may have been restricted by other factors. These include:

- Brook trout and slimy sculpin, which are recorded from a few spring heads. Early accounts suggest that the brook trout was very widespread in the early settlement period. The slimy sculpin is generally northern and may typically have been limited to springheads. Such spring habitats have been reduced in the area. For example, McNeil (1963) notes a decrease in the Pennypack from Frankford Avenue to Pine Street from at least 20 springs to 3 between the 1920s and time of writing. The decrease was attributed to deforestation and homebuilding. Confinement of springs for water sources, construction of storm sewers and contamination of springs may also have decreased the availability of this habitat to fish and other aquatic organisms.
- Margined madtom, which is now common in the upper Delaware River and occurs in scattered sites in the region.
- Eastern brook lamprey, which occurs commonly in a few drainages in Chester and Camden counties.
- Cutlips minnow, which is relatively common in the region (from Darby Creek and west), but is unrecorded in the city.
- Ironcolor shiner, which was recorded from a tributary to the Schuylkill River in Conshohocken, PA. The species was formerly common in the Pine Barrens and present in a few sites in southeastern Pennsylvania, but is apparently now localized in the region to a few sites in the Pine Barrens.
- Shield darter, which is common in the upper Delaware River and is also found in a few small streams (Beaver Creek, Schuylkill River drainage, ANSP data). It is unknown whether its current primary occurrence in large rivers reflects changes in conditions in the smaller streams.

A number of species were recorded mainly from marshes at the edges or near the Delaware River. These include the Eastern mudminnow, mummichog, fourspine stickleback, threespine stickleback, pirateperch, bluespotted sunfish, and banded sunfish. Accounts (e.g., Cope 1881) indicate that some of these were abundant in ditches in Philadelphia. The mummichog and sticklebacks are largely estuarine species, while the others are typically marsh species which are currently common in the Pine Barrens, but rare elsewhere.

The historical collections from the Pennypack drainage give some idea of the numbers of species and species composition at individual sites (Table 4.E.6). Three species were recorded from a tributary of Willit's Run, while seven species were caught at Willit's Run. Both of these are small tributaries. A total of 12 species was recorded from Sandy Run, and 14 from the mainstem of the Pennypack Creek in the same vicinity.

There is very little specific information for the period 1930-1960. As in the Delaware River, the 1930-1960 period is likely to have been a period of poor water quality in these streams. While the smaller streams did not have the same large inputs of municipal sewage and industrial waste that the Delaware and Schuylkill rivers had, the smaller streams were probably affected by combined

Table 4.E.6. Numbers of fish existing in the Fairmount Park system and nearby areas after 1931. Numbers in parentheses correspond to the 1998-1999 inventory.

Common Name	Scientific Name	Native/Int	Cobbs	Darby	Delco	FDR	Mill	Pennypack	Poquessing	S. Phila.	StU Schuylkill trib	Tacony	Wissahickon
bowfin	*Amia calva*	I? S US							1				
American eel	*Anguilla rostrata*	N	4 (2)	15	1	3 (1)	2	5 (5)	11			1 (1)	23 (1)
Herrings													
blueback herring	*Alosa aestivalis*	N				1							
alewife	*Alosa pseudoharengus*	N											
gizzard shad	*Dorosoma cepedianum*	N				3		(1)					
Minnows													
common carp	*Cyprinus carpio*	I Europe			1	3		2 (2)	2	1			5
goldfish	*Carassius auritus*	I Europe	4	3	1	2	2	1	5	1			5
eastern silvery minnow	*Hybognathus regius*	N		1				2 (2)					
cutlips minnow	*Exoglossum maxillingua*	N		14			1				1		
creek chub	*Semotilus atromaculatus*	N	8 (1)	9			2	5 (3)	8			1	1 (1)
fallfish	*Semotilus corporalis*	N	2	7					6				1
common shiner	*Luxilus cornutus*	N	8 (2)	12			1	2 (1)	20			(1)	28 (1)
blacknose dace	*Rhinichthys atratulus*	N	9 (3)	13			2	7 (3)	22		2	2 (1)	14 (2)
longnose dace	*Rhinichthys cataractae*	N					2	1 (2)	13		1		18 (1)
satinfin shiner	*Cyprinella analostana*	N		4				3 (3)	14				12 (1)
spotfin shiner	*Cyprinella spiloptera*	N		2		1		4 (2)	10			(1)	8 (1)
golden shiner	*Notemigonus crysoleucas*	N		4		1			5	1			10 (1)
comely shiner	*Notropis amoenus*	N		1					3				
spottail shiner	*Notropis hudsonius*	N	(1)	8				7 (3)	17			(1)	20 (1)
swallowtail shiner	*Notropis procne*	N	1 (2)	4				3 (2)	19			(1)	13
bluntnose minnow	*Pimephales notatus*	N		5									3
fathead minnow	*Pimephales promelas*	I Mid US			1			(2)					4 (1)
Suckers													
creek chubsucker	*Erimyzon oblongus*	N											
white sucker	*Catostomus commersoni*	N	8 (2)	14			2	8 (5)	19		2	1 (1)	18 (1)
Catfishes													
yellow bullhead	*Ameiurus natalis*	I? Mid US		1				1			1		1
white catfish	*Ameiurus catus*	N				1		(1)					
brown bullhead	*Ameiurus nebulosus*	N		1	1	2 (1)	2	2	5	1			1
channel catfish	*Ictalurus punctatus*	I				1		(2)					
Pikes and Mudminnows													
redfin pickerel	*Esox americanus*	N			1			3					
eastern mudminnow	*Umbra pygmaea*	N								1			

Table 4.E.6 (continued). Numbers of fish existing in the Fairmount Park system and nearby areas after 1931. Numbers in parentheses correspond to the 1998-1999 inventory.

Common Name	Scientific Name	Native/Int	Cobbs	Darby	Delco	FDR	Mill	Pennypack	Poquessing	S. Phila.	StU Schuylkill trib	Tacony	Wissahickon
Trout													
rainbow trout	*Oncorhynchus mykiss*	I W US		3			2	(1)					7 (1)
brown trout	*Salmo trutta*	I Europe		9			2	1 (1)					12 (1)
Killifish													
banded killifish	*Fundulus diaphanus*	N		1	1			6 (5)	14		2		13
mummichog	*Fundulus heteroclitus*	N	(2)	1	1			2 (3)	6	2		(1)	3
Livebearers													
eastern mosquitofish	*Gambusia holbrooki*	I S US								2			
Sticklebacks													
fourspine stickleback	*Apeltes quadracus*	N											1
threespine stickleback	*Gasterosteus aculeatus*	N											
Sculpins													
slimy sculpin	*Cottus cognatus*	N									1		
Temperate Basses													
white perch	*Morone americana*	N				3		(2)					
striped bass	*Morone saxatilis*	N						(1)					
Sunfishes and Black Basses													
rock bass	*Ambloplites rupestris*	I Mid US		5				(1)			1		4 (1)
redbreast sunfish	*Lepomis auritus*	N	(1)	8			1	8 (4)	7		2	(1)	26 (1)
green sunfish	*Lepomis cyanellus*	I Mid US	1 (1)	5	1	(2)	1	3 (1)	12		1		12 (1)
pumpkinseed	*Lepomis gibbosus*	N	7 (2)	9	1	3 (3)	2	4 (2)	14	1		1	16 (2)
bluegill	*Lepomis macrochirus*	I Mid US		5		3 (2)		1	3	1	1		4
smallmouth bass	*Micropterus dolomieu*	I Mid US		8				(1)			2		8 (1)
largemouth bass	*Micropterus salmoides*	I Mid US		3	1	3 (2)		3 (1)	1		1		4
white crappie	*Pomoxis annularis*	I Mid US				1				1			
black crappie	*Pomoxis nigromaculatus*	I Mid US				2			2				
Perches and Darters													
tessellated darter	*Etheostoma olmstedi*	N		13			1	7 (3)	19		2	(1)	15 (1)
shield darter	*Percina peltata*	N					1						
yellow perch	*Perca flavescens*	N											

sewer overflows (CSOs), inputs from leaking septic fields, and other waste inputs. Most information on fish is from after 1970. For the best-sampled tributaries (Pennypack, Poquessing and Wissahickon creeks in Philadelphia, and Darby Creek west of Philadelphia), 18-21 native species were recorded during this period (Appendix A-6.2 in Volume III). Most species were widespread across drainages, although a few (e.g., cutlips minnow, comely shiner, bluntnose minnow, redfin pickerel and fourspine stickleback) were local. Redfin pickerel was recorded in Pennypack Creek and there is a single record of fourspine stickleback from the Wissahickon Creek at the Morris Arboretum.

Sampling was done in 1998 and 1999 on the mainstem of Cobbs and Tacony creeks, in the tidal part of the Pennypack Creek, in a number of the smaller tributaries in the Cobbs, Wissahickon, Pennypack creeks and West Park part of the Schuylkill drainage to provide information on areas poorly covered by previous sampling (Appendices A-6.3 and A-6.4 in Volume III). FDR Park and the Concourse and Centennial Ponds in West Park were also sampled.

Most sampling was done using a backpack electroshocker, which temporarily stuns fishes. Most sites were blocked with nets at the upstream and downstream ends of the sampling site, and fish were collected using dipnets by the operator of the shocker and a second individual. Additional individuals assisted in collection at some sites. Most fish were identified, enumerated and released. The mouth of Pennypack Creek and the created wetland at the mouth were sampled using a boat-electroshocker, which is more powerful than the backpack electroshocker.

The new inventory information increases knowledge of the fauna of each stream in several ways. The sampling in the tidal portion of the Pennypack Creek demonstrated the occurrence of several more riverine species (i.e., gizzard shad, channel catfish, white catfish, white perch, striped bass), which are typical of the tidal Delaware River. The Pennypack sampling also showed the occurrence of a few previously unrecorded introduced species (i.e., rainbow trout, fathead minnow and rock bass). The sampling in Cobbs and Tacony supplemented considerably the limited existing information. However, even with the additional sampling only 11-12 native species (or 12-13 species including those which are introduced) were found in Cobbs and Tacony creeks, which is much lower than that of the other streams. While some of this difference is due to the lower total sampling effort and smaller size of Cobbs and Tacony relative to Pennypack and Wissahickon, several species were not recorded in Cobbs and/or Tacony which are widespread in the other drainages, even in small streams. These include satinfin shiner, spotfin shiner (found in Tacony but not in Cobbs), longnose dace, brown bullhead, banded killifish and tessellated darter (found in Tacony but not in Cobbs). Basic conditions such as water temperature, dissolved oxygen and habitat appeared suitable for these species, and their absence may reflect loss during former periods of poor water quality. However, undetected or episodic water quality problems could also affect the current distribution.

There were several differences in occurrence between the more recent (after 1931) and earlier (before 1931) periods. Decreases in frequency of occurrence were noted for the bridle shiner (not recorded in the study streams and regionally nearly extirpated), creek chubsucker (not recorded in the study streams, though still present in other streams), and redfin pickerel (still present in Pennypack Creek in the recent samples). All three species typically occur in slow-moving streams with abundant plant cover. Increases in frequency were noted for spotfin shiner, mummichog (found in non-tidal sites in the more recent samples), and banded killifish (not recorded in the Pennypack in earlier samples). The mummichog is an abundant species in brackish tidal marshes, and it is able to thrive under the rapidly changing flows in tidal situations. It is tolerant of a wide range of salinity, temperature and dissolved oxygen. Mummichogs, especially adults, eat algae and detritus. Their common occurrence in freshwater, nontidal streams suggests changes in hydrology (e.g., more fluctuating flows), water quality (e.g., greater load of dissolved salts, higher temperatures), and/or ecosystem structure (e.g., high algal biomass from nutrient enrichment and low invertebrate densities) in the urban streams. Some of the species recorded from marshes near the Delaware River (e.g., pirateperch, banded sunfish, bluespotted sunfish, fourspine stickleback and threespine stickleback) are very rare or absent in the more recent samples.

Introduced Species. A number of species have been introduced into the Philadelphia area (Appendix A-6.2 in Volume III). Most species were introduced as food or game fish. Others derive from release of bait fish (fathead minnow), probable incidental introduction with sport fish (green sunfish), release of aquarium fish (goldfish), or release to eat mosquito larvae (mosquitofish). Brown and rainbow trout are stocked annually. Some reproduction of brown trout probably occurs in the Wissahickon, although this is probably not sufficient to sustain the species without stocking. Although introductions of most of the sport fish started in the late 19th century, there are few records of these species until after the 1950s. Bean (1892) reported that the goldfish was common in the Philadelphia area, but did not mention the occurrence of the other species. Introduced species are now widespread in the area (Appendix A-6.2 in Volume III). While most of the introduced species have been established or stocked for a number of years, a few species have only recently been recorded in the city. The mosquitofish was reported in the 1920s in the area, but was not known from the city. It was found in this survey (1998) in the vicinity of the Japanese Garden in West Park. Flathead catfish (*Pylodictis olivaris*) was noted in a cleanup of the Schuylkill River fish ladder at the Art Museum Dam in May 1999 (three specimens were noted by John Pedrick of the PFBC, Pat Ford of the PWD, and Paul Overbeck of ANSP). This species is native to the Mississippi drainage, but has been stocked outside its range.

The introduced species differ in habitat requirements and their tolerance to impaired water quality. For example, some species such as the carp, goldfish, fathead minnow, mosquitofish and green sunfish are highly tolerant to high temperature and low dissolved oxygen. In the Midwest, the green sunfish is often used as an indicator of degraded water quality. Several species (e.g., largemouth bass, bluegill, white crappie, black crappie) are often dominant in lakes, ponds and impoundments in this region and they have become successfully established in many relatively undisturbed lakes in northeastern Pennsylvania. The trout generally require cool, highly-oxygenated water. Smallmouth bass and rock bass, though not as sensitive as trout, are also relatively intolerant of high temperatures and low dissolved oxygen.

Anadromous and Catadromous Species. Anadromous species are those which spawn in fresh water but spend much of their life in estuaries or the ocean. Catadromous species spawn in the ocean but spend most of their life in freshwater or estuaries. While most anadromous species spawn in larger rivers (e.g., Delaware and Schuylkill rivers), there is potential for spawning or feeding in the smaller Fairmount Park system streams. In the Delaware River basin, the sea lamprey (*Petromyzon marinus*), Atlantic sturgeon (*Acipenser oxyrhynchus*), shortnose sturgeon (*A. brevirostrum*), American smelt (*Osmerus mordax*), American shad (*Alosa sapidissima*), alewife (*A. pseudoharengus*), blueback herring (*A. aestivalis*), white perch (*Morone americanus*) and striped bass (*M. saxatilis*) were historically common anadromous species. Most of these species were affected since early settlement by damming and pollution of streams and by fishing. For example, McNeil (1963) noted that thousands of dead alewives were seen in the Delaware River in the 1930s, resulting from industrial pollution. The American shad has increased in the Delaware River in recent years, though there have been apparent fluctuations in abundance. The alewife and blueback herring have been common as well, although the blueback herring may be declining in abundance. The white perch is also common, and the striped bass has shown a dramatic increase in abundance in the Delaware River in the last few years. The shortnose and Atlantic sturgeons are classed as endangered in Pennsylvania and New Jersey. The smelt is presumably extirpated as a reproducing fish, although some were caught in the Delaware River in 1972.

These species differ in spawning habitat. The striped bass and sturgeons typically spawn in large rivers, mainly in the mainstem Delaware River in this area. Juvenile striped bass may use streams for feeding. The American shad also typically spawns in rivers. The Upper Delaware has been a major spawning area for the species. Before construction of what is now the Art Museum Dam, there was a major run in the Schuylkill River. Historical accounts also suggest spawning in other local rivers. The alewife and blueback herring often spawn in small streams, and there are accounts of spawning in local streams. However, no records of spawning in the Fairmount Park system streams has been found. Alewives were recorded in Edgewood Lake in FDR Park in 1989. These fish presumably came from the Schuylkill River through the tidal gate connecting the FDR ponds and streams and the Reserve Basin on the Schuylkill River. In May 1999, adult alewife and blueback herring were caught in the Delaware River just downstream from the mouth of Pennypack Creek. However, neither species was collected in the lower Pennypack Creek on the same date. The construction of the fish ladder at the Art Museum Dam in 1979 has allowed for upstream movement of anadromous fish to Flat Rock Dam. Plans to build fish ladders or remove dams to make much of the Schuylkill accessible to shad were announced in 1999. However, there is little quantitative data on the numbers of anadromous fish using the ladder or on the amount of spawning above the dam.

The American eel is the only catadromous species in the area. It has been reported commonly in streams in the region, including many in the Fairmount Park system. Young eels (elvers) are able to ascend or bypass rapids, small falls and dams so that they can occur upstream of such barriers. For example, eels have been collected in Cobbs Creek above both dams on the stream. Nonetheless, dams may decrease upstream movement of elvers, affecting population dynamics of the species. Citing a 1916 report by Fowler, McNeil (1963) noted that eels were "formerly abundant" in the Pennypack Creek or adjacent Delaware River.

Condition of Fish Communities in Stream Reaches. The compilation of fish species occurring in each drainage highlights broad differences among the streams; the comparison of individual sample sites provides more insight into local impacts on fish communities. In particular, the 1998-1999 inventory, which focused on smaller tributaries of the Fairmount streams, demonstrates differences among streams. More detailed analyses of fish communities at specific sites are presented in Volume II.

As noted above, the samples from the main channels of Cobbs (Appendix A-6.3 in Volume III) and Tacony (Appendix A-6.4 in Volume III) creeks suggest the absence of several species, suggesting past or present impairment of these streams. The single sample from the main stem of the Wissahickon Creek produced a variety of species (Appendix A-6.4 in Volume III); this is consistent with other samples from the creek showing a diverse fish community. The sample from the tidal portion of Pennypack Creek also indicates use of the stream by a variety of species characteristic of freshwater tidal streams in the basin.

There is a large range in diversity and species composition of fishes in the smaller tributaries. These differences are correlated with stream size and with watershed characteristics of the streams, particularly land use in the watershed and stormwater or combined sewer overflow (CSO) inputs.

No fish were found in several of the streams: Gorgas Lane tributary and Carpenter's Woods tributaries in the Wissahickon drainage, and the Roberts Hollow and Chamounix tributaries in West Park. No fish were collected at two sites on Wise's Mill Creek, but a few blacknose dace were observed in the upper part of the creek, above Summit Road, in 1999. Although small, these streams appear large enough to support fish (Appendix A-6.5 in Volume III). The Gorgas Lane tributary and the two West Park streams have high storm flows from the adjacent watershed. These streams are relatively steep and several have steep drops near their mouths (Wise's Mill Creek) or have drops where the streams cross under the Schuylkill Expressway (the two West Park tributaries). These streams might also be affected by occasional spills from broken water or sewer mains or contaminants in storm sewer runoff. We heard an anecdotal account of such a spill in the Carpenter's Woods tributary. It is plausible that the steep slope of these streams, high storm flows, and poor habitat complexity (lack of refuges) make fish sensitive to occasional mortality in these streams, and that barriers near the mouth prevent or slow down recolonization.

In contrast, one species of fish, the blacknose dace, was found in the West Park tributary north of the Horticultural Center. This stream has much of its drainage in the park and storm flows are moderated by upstream wetlands. Several species were collected in Cresheim Creek, which is larger than the other Wissahickon tributaries which were sampled. Several species were collected in the Japanese House tributary, but these were pond species which probably came from Centennial Lake or the Japanese House pond.

The larger tributaries (e.g., West Branch Indian Creek, Naylor's Run, Paul's Run, Rockledge Creek, Wooden Bridge Run) had more diverse fish communities, especially those in the Pennypack drainage (Appendices A-6.3 and A-6.4 in Volume III). Based on channel morphology, these sites appeared less affected by stormwater erosion.

The relationship between stream size and fish occurrence and species richness is shown in comparisons of the data from the ANSP 1998-1999 inventory, and local streams in watersheds ranging from rural to urban (Appendix A-6.5 in Volume III). Drainage area is used as a measure of stream size, since stream width and depth depend critically on watershed use and riparian land use (e.g., urban streams tend to be wider and shallower). These comparisons show that while many of the Fairmount Park system streams from which no or few fish were caught are small, fish are found in similar-sized streams with less disturbed watersheds. Streams the size of the Gorgas tributary typically have several species, while no fish were found in the Gorgas tributary. Notably, several of the larger tributaries (e.g., Rockledge Run and Wooden Bridge Run) have high species richness in comparison to similar-sized reference streams. This may be attributed to the proximity of the sampling sites to the main Pennypack Creek, which may provide a source of additional species. The comparison of drainage area and species richness also shows the paucity of the fish faunas of Tacony Creek and the Cobbs Creek tributaries (e.g., West Branch Indian Creek).

Sandy Run (also known as Sandy Ford Run) in the Pennypack drainage presents a special case. Much of the stream has been covered and converted into a stormwater channel, which opens just below Roosevelt Boulevard. The remaining open channel downstream to the mouth appears highly scoured by storm flows, and sanitary-storm sewer connections had degraded water quality. In 1979, R. Horwitz observed no fish in the stream. In 1998, the PWD temporarily diverted most flows from the stream to reduce sanitary inputs. At the time of sampling, there was a slight flow, apparently from smaller storm sewer outlets. Only a few juvenile redbreast sunfish were collected at this time (one other fish, probably a sucker, was observed), indicating severe impairment of the fish community.

Centennial Lake, Concourse Lake, and the sites in FDR Park have a different fish fauna than the streams. While the FDR sites are in remnant channels of Hollander and Sheldrake streams, these sites are wide, moderately deep and have virtually no current, so they are pondlike in habitat. These sites were dominated by sunfishes and bass. A few other species (i.e., brown bullhead, mosquitofish, eel) were also collected in the various ponds.

4.E.7.4. **Summary and Conclusions**

Although there is a good historical record and much existing information on local fishes, determination of long-term changes is complicated by several factors:

- A number of species may have decreased in the area prior to thorough scientific collecting and documentation of their occurrence.
- Most early collections were in the larger rivers, and no records exist from many sites.
- Collecting techniques used in earlier times were not effective on a number of species.
- Pollution of small streams was likely to have severely impacted fish communities during various periods, but there is little documentation of these effects.
- Much information is derived from specimen records, but there is little documentation of collecting effort and what specimens were captured but not kept.

Nonetheless, existing information provides a good idea of changes in fish communities over time. The data suggest the following conclusions:

- Much of the native fish fauna of the area is still present within the city, particularly in the main rivers (Schuylkill and Delaware) and larger streams (Wissahickon and Pennypack). Many of these species have probably increased from historic low abundances following improvements in water quality.
- A number of species have decreased in abundance, and a few have been locally extirpated. These species are mainly associated with vegetated streams or vegetated marshes.
- Coldwater species such as brook trout and slimy sculpin are rare in the region, not known in the city, and have probably decreased greatly over time. However, the decrease probably occurred by the 19th century or earlier and the former distribution of the species is poorly known. Some other species may have also decreased too early for good documentation.
- Starting in the 19th century a number of species have been introduced to the area. These species have become widespread in the last 50 years. Their increase is partly due to more intensive stocking and increased amount of pond and impoundment habitat. Some of the introduced species are highly tolerant of poor water quality and other disturbance, and their increase indicates habitat degradation. However, many of the other species are not notably tolerant.
- Despite the regional occurrence of many of the native species, local impairment of fish communities is evident at a number of sites. These sites are typically associated with disturbed hydrology from storm flows. However, the complete causes of impairment are not clear, since these sites have a variety of interrelated disturbances, including reduced habitat diversity, high storm flows and low base flows, a disturbed food supply (aquatic macroinvertebrates), and some probably experience episodic toxicity. Natural and artificial barriers affect some sites, especially small, steep tributaries, which increase the susceptibility of fishes in these streams to disturbance.
- Several species which are regionally widespread were not recorded in Cobbs Creek and/or the Tacony Creek drainages, although appropriate conditions seemed to be present. These absences may reflect episodic effects or unknown impacts. However, they may also reflect losses of the species during periods of lower water quality, with no subsequent recolonization.

4.E.8. **Benthic Macroinvertebrates**

4.E.8.1. **Overview**

Organisms lacking internal back bones (invertebrates) that are large enough to be observed with the unaided eye (macro) and live near the bottom of a body of water (benthic) are classified as benthic macroinvertebrates. This definition is usually followed by the condition that an organism must occupy "benthic" habitats or be "macro" for only a portion of its life. Thus, although near-microscopic larval dragonflies and mayflies are considered benthic macroinvertebrates, bacteria, salamanders, and fish are not. In healthy freshwater ecosystems, the benthic macroinvertebrate community is typically dominated by aquatic insect species, but worms, snails, clams and crustaceans may also be abundant.

Invertebrates represent a tremendously diverse species assemblage, which has been estimated to comprise approximately 95% of all animal species. Although individual organisms are small, arthropods are so numerous that they account for about 85% of all living animal biomass (Wilson 1992). They account for a tremendous amount of biomass as well as performing key functions in nutrient cycling and interacting at the base of most food webs. The streams within the Fairmount Park system are no exception.

Each of the more than 750,000 known insect species has a unique set of habitat preferences and physiological requirements. Some aquatic insects, such as mayflies and stoneflies, require clean, cool, oxygen-rich, flowing waters, whereas some larvae of aquatic diptera (true flies) inhabit exceptionally harsh habitats, such as Great Salt Lake, or water droplets on the surface of tar pits. Between these extremes, invertebrate species represent a diverse continuum of tolerances and habitat preferences. Thus, as environmental conditions change, the invertebrate species found in a given ecosystem are expected to change. For this reason, studies of macroinvertebrate communities have been used to describe and monitor the environmental "health" of aquatic ecosystems for many years. Recently, advances in methodology have pushed macroinvertebrate biomonitoring to the forefront of all comprehensive monitoring studies (Plafkin et al 1989, Rosenburg and Resh 1993, Barbour et al. 1997).

Although the terrestrial insect survey data of the Fairmount Park system dovetail nicely with the benthic macroinvertebrate data, the purpose and scope of the investigations are different. The focus of this section of the ANSP's work is to examine the functional role of invertebrates in the streams of Philadelphia parks and to establish baseline conditions for future monitoring efforts. The establishment of pre-restoration conditions is essential if the effectiveness of restoration efforts is to ever be described as well as to support the selection of "good" restoration sites. Thus, although the field work resulted in the collection and tabulation of macroinvertebrate taxa, the most valuable contribution of the macroinvertebrate studies is the descriptive metrics summarizing environmental conditions of the streams studied.

4.E.8.2. **Methods**

Historic Benthic Macroinvertebrate Surveys. Existing benthic macroinvertebrate data from streams in Philadelphia was searched to determine the amount of information available and to further understanding of the condition of urban streams in the area. Several data base services (Biological Abstracts, BIOSIS, AGRICOLA, Aquatic Sciences and Fisheries Abstracts, Water Resources Abstracts, Dissertation Abstracts and others) were used. Additional data were sought from the Pennsylvania Department of Environmental Protection (PA DEP) and Philadelphia Suburban Water Company. By far, the most useful information was PA DEP surveys of the area and these data were provided by Steve T. Schubert and Alan Everitt of the DEP's Southeast Regional Office.

Study Sites. Benthic macroinvertebrate communities from 31 streams within the parks of the Fairmount Park system were surveyed (Appendix A-7.1 in Volume III). The study sites will be described in more detail in the section addressing specific findings.

During the stream-walk phase of the study (see Section 5.C.3. Assessing Current Conditions, about the screening level assessment), unnamed tributaries were assigned a name. These names usually included the name of the park where the stream occurred and a tributary number corresponding to the order in which the tributaries were surveyed. For example, "West Tributary 6," " Cobbs Tributary 12," or "Wissahickon Tributary 9 " could have been used to refer to unnamed streams. Tributaries are labeled on the base maps for each park.

Field. At each of the 31 stream reaches studied, three quantitative samples were collected using a Surber sampler (sample area = 1 ft^2). A Portable Invertebrate Box sampler (PIBS, sample area = 0.05 m^2) was used to sample Pennypack Creek, Tacony Creek, and East Branch of Indian Creek, because the PIBS performs better in deeper streams. Both devices enclose a known quantity of substrate from which macroinvertebrates are washed through a fine mesh net. One particular habitat, cobble riffles, was targeted because this is where most stress-sensitive invertebrate species live in streams. Riffles are the rapidly flowing, turbulent parts of streams that resemble little rapids. Cobbles are stones that range in size from about the size of a fist to about the size of an adult's head. Hence, "cobble riffle" describes general substrata and flow characteristics in the sample sites.

Sampling one representative habitat is a common practice in aquatic ecology and helps maximize the sensitivity of ecological investigations. For example, nothing can be concluded about the environmental "health" of a stream if no sensitive species occur in a naturally harsh habitat within the stream, such as an organic, mucky seep. Although the species that occur there may be interesting or important from a conservation point of view, the absence of sensitive taxa such as mayflies from such a habitat does not provide relevant information because they don't usually occur in mucky seeps. Thus, to best describe the "environmental health" of streams, samples were taken specifically where the sensitive taxa should be most abundant: in cobble-riffles.

All of the rocks enclosed in the sampler were scrubbed with a brush to dislodge invertebrates, which were washed into a capture net attached to the downstream side of the sampling device. After scrubbing, the rocks were examined for missed specimens, which were removed with forceps or by additional rock scrubbing.

The sample consisted of all material washed into the net portion of the sampler by the stream's current, including invertebrates, silt, small stones, leaves and other debris. All the material was rinsed to the end of the net and transferred to 500-ml jars. After sample collection, the net was removed from the water and rinsed to concentrate fine detritus in the end of the net to facilitate transfer to the sample jar. The net was rinsed several times with additional material and specimens transferred to the sample jar. A standard label was added to the sample, defining the study, sample location, collection date, replicate number, and collection gear. The lids of sample jars were also marked with this information in solvent-resistant ink. The contents of the jar were preserved with 95% ethanol for subsequent analysis in the laboratory.

Laboratory. One of the three replicate samples collected from each stream was analyzed in the laboratory. The others are archived where they would be available for future analysis. At the beginning of the laboratory analysis procedures, it was randomly determined (by rolling a die) that replicate #2 would be the sample processed for each of the streams. Samples were transferred from jars to a standard 125-μm sieve and rinsed with tap water. The sieve was placed in a shallow water bath to allow the sample to "float" and be mixed evenly across the sieve. The sieve was divided by a quadrant partition and removed from the water bath. A quarter of the sample was randomly (again, with a die) selected for transfer to a quadrant petri dish. A randomly selected (with a die) portion was transferred to another quadrant petri dish for processing. The selected portion was sorted under a dissecting microscope at 9-12x magnification to remove all invertebrates. If the section contained fewer than 100 organisms, another portion was randomly selected and processed until the total number of organisms exceeded 100. The number and size of portions processed were recorded and used to estimate the total number of organisms per square meter. Thus, each sample represents a standardized amount of sampling effort regardless of the field gear used.

Throughout this report, the term “taxa,” or its singular form, “taxon,” is commonly used. This is a common practice in macroinvertebrate studies for several reasons. First, most of the specimens collected from water are immature, or larval. Most insect species have been defined based on the morphology of adult sexual structures and organs. Thus, species-level taxonomy is simply not possible for most aquatic insect species, and the next best thing, genus-level taxonomy, must be used. Secondly, to identify some species, biologists must mount tiny body parts, such as individual hairs, on microscope slides and examine them under extremely high magnification. For example, for some oligochaete worms, it is necessary to determine if the tip of a worm’s hair has 2 or 3 teeth. Such analysis of specimens is very time consuming, expensive and often not worth the cost. Thirdly, quantitative sampling is hard on the specimens. Scrubbing the rocks in the field may result in the loss of legs, gills, or other taxonomically important features on the creatures. Despite the most rigorous efforts of the taxonomist, the condition of the specimen often precludes species-level taxonomy. Thus, the terms “taxa” and “taxon”are used where ecologists in other sections use the term “species,” because organisms are identified to the lowest practical taxon (species, genus, family, order, or class), which may not be species.

All specimens were identified to the lowest practical taxon using the keys of Merrit and Cummins (1996), Pecarsky, (1990). Most aquatic insect taxa were identified to genus or species, except the chironomid midges, which were identified to family. Most annelids were identified to class.

Analysis. The abundance of data on invertebrate taxa were assembled into taxa-abundance matrices and used to calculate several descriptive metrics commonly used in aquatic ecological studies (see Rosenburg and Resh (1993) for a more thorough discussion of the use of these environmental measures). For the sake of discussion, the metrics are categorized into three classes of functionally similar metrics:

- Ecological Community Metrics;
- Community Stress Metrics;
- Functional-Feeding Group Analysis.

Ecological Community Metrics: The metrics utilized can be defined by three major categories based on the type of information represented. The class of ecological community metrics includes: Invertebrate Density (individuals/cm^2), Taxa Richness, Shannon-Wiener Diversity, and Evenness. These metrics class are commonly used by ecologists studying many different types ecological communities.

Density is the abundance of macroinvertebrates per unit area. It may be reduced by environmental disturbances, or elevated if a disturbance provides resources for tolerant organisms. Density is subject to a large amount of natural variability and is sometimes considered an insensitive indicator of disturbance.

Macroinvertebrate taxa richness is the number of different types, or taxa, of invertebrates occurring in a given ecosystem or sample. It is usually not as variable as density and typically is depressed in disturbed environments.

Diversity incorporates the number of taxa and their relative abundance and usually decreases with decreasing water quality. The Shannon-Wiener diversity index is a commonly used index. It increases with both the number of species and the evenness of relative abundance of species. We calculated the Shannon-Wiener diversity index according to the formulas in Ludwig and Reynolds (1988), using natural logarithms.

Community evenness is a numerical representation of the relative abundance of all taxa. We calculated Evenness (J') according to Pielou (1975). If all taxa collected from an environment had exactly the same abundance, evenness would equal 1. Conversely, evenness values approaching zero are indicative of communities lacking an equitable distribution of taxa. Typically, disturbance causes a decrease in the evenness of aquatic communities.

Community Stress Metrics: Community stress metrics incorporate biological information about the taxa collected and the relative abundance of taxa, allowing more sensitive evaluation of disturbance than Ecological Community Metrics. This group of metrics includes the EPT-Index, Percent Chironomidae, Percent non-insect dominance, EPT:Chironomidae Ratio, and Modified Hilsenhoff Biotic Index (HBI (Hilsenhoff 1987)).

EPT Index is the taxa richness of the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). These orders are generally considered pollution sensitive and values are usually depressed in polluted ecosystems.

The relative abundance of the family Chironomidae (midges) is used to calculate several metrics because insects in this group are largely considered pollution tolerant. The percent Chironomidae is expected to increase in perturbed ecosystems.

Percent non-insect dominance is the percent contribution of the all non insect taxa. In most "natural," "healthy" freshwater streams, aquatic insects typically dominate the benthic macroinvertebrate community; both in terms of density and biomass. Some disturbances may cause the relative of non-insects to increase by reducing the abundance most insects.

The modified Hilsenhoff Biotic Index (HBI) (Hilsenhoff 1987, Plafkin 1989) uses the relative organic pollution tolerance of all taxa and their relative abundance to assign a numerical value to aquatic communities. This value ranges between 0 and 10, with lower values indicative of a community dominated by highly sensitive organisms and high values indicative of dominance by pollution tolerant organisms.

Functional Feeding Group Analysis: The premise of this analysis is simple. Aquatic invertebrates identified in the semi-quantitative samples were assigned to functional-feeding group categories based on their primary method of gathering food. The proportional contribution of invertebrates from different functional feeding group categories was then calculated. The major functional feedings groups represented in streams of the region are: collector-gatherer, collector-filterer, predator, and scraper groups as defined by Merritt and Cummins (1996).

Some disturbances may cause shifts in the overall trophic function of aquatic ecosystems by affecting an invertebrate food source. For example, if a disturbance increased the availability of suspended organic particles, several taxa from the collector-filterer group might respond by expressing increased success (i.e., survival, biomass, fecundity, etc.). Due to the proportional nature of this analysis, increases in the contribution of one group are accompanied by decreases in contribution of other groups.

4.E.8.3. **Results**

Park-specific sites, results, and concerns for each park are discussed in Section II.C.8 of the park-specific volumes. Here, overall findings and trends that extend beyond individual parks, across all the streams we studied, are discussed.

Existing Benthic Macroinvertebrate Information. Most of the benthic macroinvertebrate data in the area have been generated for environmental investigations, rather than structured, routine, biological monitoring. The result of this is that the data were not developed with the intention of comparison with other studies, nor with the intention of being used in determining long-term trends. The earliest records are from the mid-1970s and consist of data from ecological investigations, often upstream and downstream, of a disturbance. Most of these studies focused on the larger streams in the city, such as Wissahickon Creek, Cobbs Creek, Tacony Creek, Poquessing Creek and Pennypack Creek, but some smaller tributaries were also sampled.

In 1997, the PA DEP initiated a program to assess all unassessed streams in the state (Paluh and Kime 1999). In the fall of 1998, they sampled some streams in Philadelphia. Although this could not help direct the ANSP's initial survey efforts (which occurred in June, before the state's survey) the data represent a valuable augmentation to these findings. The study is basically designed as a screening process, employing U.S. Environmental Protection Agency's (EPA's) Rapid Bioassessment Protocol I (RBP-I, Plafkin et al. 1989, Barbour et al. 1997). This design identifies most benthic macroinvertebrates to the family-level, and should initially prove to be quite sensitive to improving environmental conditions. However, as conditions improve, this method's sensitivity can be expected to decrease. For example, most streams currently have only one mayfly, (Baetidae (*Baetis* sp.)). If conditions improve, and the stream is colonized by two or more genera of Baetidae, investigators will not notice the improvements.

There are several problems in using data from different sources. These are generally unavoidable because studies with different goals may employ different methods. It is difficult to ensure these investigations represent a standard amount of collecting effort or level of taxonomy. Additionally, the abundances of many taxa are estimated by rough classification schemes of "abundant," "present" or "rare." These subjective terms make comparisons over time difficult. An additional deficiency is timing. Most of these surveys were specifically designed to evaluate the effects of a suspected disturbance at various times of the year. The abundance of different insect taxa is highly seasonal and a survey conducted in winter should describe a different community than a survey in summer.

Despite these difficulties, there are certain trends that persist. The data are condensed into tables of Taxa Richness and the number of EPT taxa (recall that EPT refers to the orders Ephemeroptera, Plecoptera and Trichoptera, generally sensitive orders). The most apparent trend was that, in all surveys, many fewer types (or taxa of aquatic insects) were found in city streams than typical "healthy streams." Additionally, all streams had fewer EPT taxa than expected. If the parks of Philadelphia were not subjected to urban impacts, one would expect to find about 15-60 taxa (depending on methods and habitats) and 10-25 EPT taxa. What was actually observed was taxa richness usually below 10 and EPT usually less than 3 or 4 taxa. Although these ranges are very coarse, it is evident that the streams of Philadelphia have been impaired from the first records in the 1970s through the present.

1998 ANSP Current Benthic Macroinvertebrate Surveys. This section deals exclusively with the results of the 1998 benthic macroinvertebrate survey. The benthic macroinvertebrate communities of the 32 streams were examined from three different analytical perspectives. As discussed above, Ecological Community Metrics, Community Stress Metrics and Functional Feeding

Group analysis were used to describe the condition of benthic macroinvertebrate communities in the Fairmount Park system. The list of taxa is provided in Appendix A-7.2 in Volume III.

Ecological Community Metrics:

Invertebrate Density. The total density of invertebrates ranged from about 134 organisms /m^2 at West Branch of Indian Creek (Cobbs Creek Park) to about 5500 organisms /m^2 at a small tributary draining Fox Chase Farm (Pennypack Park) (Appendix A-7.2 in Volume III). The mean of all 32 streams was 938 organisms/m^2 (± 360 /m^2 (95% CI)). Disturbances may reduce density through mortality, or increase density through resource additions or reduction of competition.

Taxa Richness. Macroinvertebrate Taxa Richness ranged from a low of 3 taxa (Poquessing Creek sample) to a high of 17 taxa (Three Springs Run, Pennypack Park). The average number of taxa from all parks was 8.3 (± 0.95 (95% CI)). This is a much more sensitive measure of ecosystem health than density and is usually depressed in perturbed ecosystems. Thus, it may be used to rank streams in order of increasing quality (Appendix A-7.3 in Volume III).

Shannon Wiener Diversity Index. Community Diversity ranged from 0.41 (Poquessing Creek site) to 2.2 (Three Springs Run, Pennypack Park). The mean diversity of all streams was 1.32 (± 0.14 (95% CI)). Although it is more difficult to interpret an integrative measure such as diversity, experience suggests that healthy streams similar to the streams studied should have diversity scores above 2. Only a few sites (Appendix A-7.4 in Volume III) had diversity values close to 2 (Ballard Run, Sedden's Run and Three Springs Run in Pennypack Park, and Bells Mill Run in the Wissahickon).

Community Evenness. Community Evenness ranged from 0.30 (West Park Tributary 5) to about 0.83 (Ballard Creek, Pennypack Park). Typically, values below about 0.70 indicate a high dominance by a few taxa, but this is a highly variable measure. The mean level of community evenness at all streams was 0.63 (± 0.05 (95% CI) Appendix A-7.5 in Volume III).

Community Stress Metrics:

EPT Index. The number of EPT taxa ranged from 0 (Poquessing Creek, Cobbs Tributary 12) to 5 (Three Springs Run, Pennypack Park). The average number of EPT taxa at all streams was 2.1 (± 0.38 (95% CI)). Previous experience suggests that EPT values should be above, or near, 10 for similar streams. Thus, although Three Springs Run had the greatest EPT score, it appears somewhat below "normal." Like Taxa Richness, the EPT index is an excellent criterion for ranking stream quality and identifying the streams with the healthiest invertebrate fauna. Clearly, all the Fairmount Park system streams scored well below the desired level for EPT (Appendix A-7.6 in Volume III).

Percent Chironomidae. The percent dominance of Chironomidae ranged from about 1% (Wises Mill, Wissahickon) to about 87% (Poquessing Creek). The mean contribution of chironomid midges to the communities studied was about 47% (± 7.6% (95% CI)). Values over 50% are usually obtained in stressed ecosystems, and values over about 60% are usually severely stressed. Like the other Community Stress metrics, the dominance of chironomid midges may be used as a rating criterion to identify high- (or low-) quality streams (Appendix A-7.7 in Volume III).

Percent Non-Insect Taxa. The percent dominance of non-insect taxa ranged from about 3% (West Park Tributary 3) to about 73 % (Thomas's Mill Run, Wissahickon Park). The mean contribution of non-insects was about 23% (± 7.0% (95% CI)). Typically, values expressing more than about 1/3 (33.3%) dominance of non-insects indicate some kind of disturbance. However, values above this may result from natural phenomena, such as spring sources with high mineral content. Four streams were identified with non-insect dominance above 50% (Appendix A-7.8 in Volume III).

Biotic Index. The Biotic Index (HBI) values ranged from 3.37 (Pennypack Tributary 12/13) to 6.21 (Poquessing Creek). The mean HBI score for all streams was 5.3 (± 0.22 (95% CI), Appendix A-7.9 in Volume III). Previous experience with “natural” streams of this type suggests that scores between 3 and 4 could be expected for “healthy” streams. Higher scores suggest a dominance by organisms highly tolerant to organic pollution. Thus, scores at the higher end of the spectrum are usually caused by organic enrichment, such as caused by sewage. Certainly, small streams with scores over 6 (excluding “mucky” spring seeps), should be suspect of contamination by sewage.

Functional Feeding Group Analysis. The functional feeding groups collected were primarily collector-gatherers and collector-filterers. Other groups included scrapers, shredders and predators. Other functional feeding groups, typically macrophyte piercers accounted for less than 5% of the population when they occurred, and they occurred only rarely. Discussion is focused primarily on the collector-gatherer, collector-filterer, shredder, and scraper functional groups.

The Dominant Functional Feeding Group in most streams was the collector-gatherer. These organisms are generalists and, although their occurrence in streams does not indicate perturbation, a dominance by this group may be caused by disturbance. Levels of collector-gatherer contribution were observed to be from about 53% (Gorgas Lane) to about 99% at Poquessing Creek. The average collector-gatherer dominance was about 83% (± 5% (95% CI), Appendix A-7.10 in Volume III), well above “normal.”

The next most abundant functional feeding group was the collector-filterer. They contributed from 0% (Cobbs Tributary 12 and West Park Tributary 12) to 47% at Gorgas Run (Wissahickon). The mean contribution was about 13% (± 4% (95% CI), Appendix A-7.11 in Volume III). Typically, collector-filterers are more abundant than collector-gatherers in riffle areas, so these results may represent a shift in the trophic structure of the area’s streams. Moreover, if both collector-gatherers and collector-filterers are pooled into a group representing all collectors, we find between 72% (West Park Tributary 3) and 100% (Gorgas Lane, Monoshone, Poquessing, Thomas Mill, Valley Green, Wises Mill, and Wissahickon Tributary 7) contribution. Moreover, 29 of the 32 streams had greater than 90% (24 ≥95%) dominance by collectors (Appendix A-7.11 in Volume III).

The dominance of the community by collectors is accompanied by reduction in both the contribution of shredders and scrapers. The lack of shredders is particularly noteworthy since they are usually most abundant in small streams and perform key roles in the natural break down and cycling of coarse organic particles.

4.E.8.4. **Discussion**

The results of the Ecological Community Metrics, Community Stress Metrics and Functional Feeding Group Analysis support the overall conclusion that the streams of Philadelphia’s parks support impaired benthic macroinvertebrate communities. This is perhaps most strongly supported by the functional feeding group analysis, which, although generally considered to be an insensitive measure, found that for many streams the entire community is composed of collectors.

There are no reference streams in this study and therefore reliance on personal experience for evaluation of the metrics is necessary. Although comparisons of this kind are subjective, most of the metrics underscore poor environmental “health” of most streams surveyed. This, in conjunction with the findings of the previous investigations, supports the conclusion that the benthic communities of Philadelphia streams are impaired.

The health of benthic communities in the Fairmount Park system has been compromised since the earliest surveys. Although the results emphasize the negative attributes of Philadelphia streams, they should not be too surprising. Trends of this sort are typical of major metropolitan areas world-wide. Allen (1995) succinctly summarized this trend, "Degradation of the ecological health of running waters is commonplace wherever significant human settlement has occurred." Perhaps, more importantly, the results should not be discouraging. There is no need to restore unimpaired environments. Moreover, many of the small streams should respond quite well to restoration efforts. The specific streams will be discussed in the sections addressing specific parks.

4.E.9. **Mammals**

Mammals are among the most recognizable groups of organisms, containing many familiar, sport and pest species. As a result, there is extensive historical information on a number of species. Two species (meadow vole and meadow jumping mouse), were described to science from Philadelphia specimens. However, many species are nocturnal and difficult to distinguish in the field, so there is a paucity of information on these. Anecdotal accounts of other species provide an ample, but questionable, data source. Mammal inventories are difficult, requiring a variety of sampling techniques and repeat sampling. As a result, a mammal inventory was not performed as part of this assessment. However, several sources of data provide good historical information on mammals in the region, the city and the parks, and incidental observations of mammals were made during the various assessment activities. Information was also sought from park staff and park users.

Rhoads (1903) described historical information and status of mammals of the area at that time. He compiled many records of the larger species which have been locally extirpated. Fred Ulmer, of the Philadelphia Zoo and Academy of Natural Sciences of Philadelphia, kept notes on mammal observations throughout the city and region. These date from 1942-1994, although there are relatively few after 1970. A few other historical references were compiled. Where there was precise location information, these were used to assign records to parks or city regions. Species recorded in a neighborhood adjacent to a park were considered to have been likely to have occurred in the park; in many cases, observations were actually from the park. For instance observation in western West Philadelphia were associated with Cobbs Creek Park, and records from Olney were associated with Tacony Creek Park.

The early records indicate that about 38 species of mammals were recorded in the area (Appendix A-8.1 in Volume III), plus some marine species that occasionally wandered up the Delaware. Notes of Cassin on mammals of Delaware County (in Smith 1862), are generally consistent with those of Rhoads, except that the gray fox is not listed. Philadelphia is currently within the range of another 10 species, mainly bats and rodents, which have not been recorded (Merritt 1987). As with other components of the fauna, smaller species may have been extirpated early in settlement before they were documented. The large predatory species (wolf, black bear, mountain lion, bobcat), fur species (beaver), and game species (white-tailed deer and elk, which was marginal in this area) were extirpated locally (and in much of the east) by the end of the 19th century. The Norway rat and house mouse were introduced during early settlement. The red fox was native to parts of North America, but was not found in the mid-Atlantic. The red fox was introduced by the mid-18th century from Europe for fox hunting.

In the more recent samples, Ulmer and others recorded 30 species in the city (Appendix A-8.2 in Volume III). Since most of his observations were from incidental observations, including road kills, his observations are biased toward larger and diurnal species. The most common species he noted were gray squirrel, opossum, raccoon, woodchuck and muskrat. Deer were recorded in a number of areas, but mainly in the Wissahickon. Both red and gray fox were noted, but red fox were relatively uncommon. The meadow jumping mouse was recorded from many parts of the city, while the masked shrew and star-nosed mole were local. For the most part, these are species that can do well in nonforested habitats or meadows with scattered trees (e.g., voles, mice, woodchuck, raccoon), in stands of large trees (gray, red and flying squirrels), or in wetlands (muskrat). A number of these species, such as opossum, raccoon and gray squirrel, do well in suburban areas, where trash, gardens and bird feeders provide food. A few have more specialized habitat requirements, such as the gray fox and chipmunk (usually in woods) and star-nosed mole (usually in shallow, marshy wetlands). Some species, such as woodchuck and meadow jumping mouse, had probably increased during early development as pastures replaced forests. The white-tailed deer re-established itself from re-introductions in the early 20th century. Beavers have spread more recently, and there are a few recent records, probably of wandering individuals.

Anecdotal information and incidental observations from the last few years suggest that the mammal fauna remains similar to that recorded by Ulmer, with some changes. The most obvious species–gray squirrel, opossum, raccoon, woodchuck, and cottontail, are still widespread. There are fewer records of the smaller species, but short-tailed shrew, meadow vole, house mouse, white-footed mouse, and Eastern mole are present within the park system. The most notable changes are in the abundance of deer and red fox. Deer are common in Wissahickon and Pennypack parks, as evidenced by sign, tracks, browse evidence and observations. NRC (1993) conducted a survey of browse damage and a population survey of deer in the Wissahickon, and found high densities and clear evidence of browse. The vegetation assessment noted deer damage in both Wissahickon and Pennypack parks. Deer were recorded in the other parks as well, but apparently at lower densities. Recent increases have been suggested for some parks, e.g., Fairmount (East and West Parks) and Cobbs Creek Park, although the numbers are still low and it is difficult to assess any trends.

Residents and park staff noted the occurrence of red fox in virtually all the parks. Red fox has apparently increased in suburban and urban situations in recent years; it is not known whether this reflects a shift in behavior of the species or response to changing conditions in these environments. Fox forage not only in park lands, but in adjacent streets and yards. No recent records of gray fox have been noted, although it apparently had been more common than the red fox. Gray fox typically use wooded areas more, and might be expected to increase with the afforestation of park lands. However, it appears to use adjacent developed areas less than the red fox. Competitive interactions between the two have suggested; for example, Barton (1792) noted that the gray fox disappears when the red fox enters an area, but this could be explained by differences in habitat. An otter was reported in 1998 or 1999 in the created wetland at the mouth of the Pennypack. Coyotes have spread throughout the eastern United States in recent years. Coyotes have been reported in the city, but they can be difficult to distinguish from dogs, so their status is unknown.

No recent records of several species, such as star-nosed mole, meadow jumping mouse, and masked shrew, were noted. Since these may take specialized trapping programs to document, they may be present, but decreases or extirpation resulting from loss of wetlands (star-nosed mole), meadows and pastures (jumping mouse) are plausible. The fox squirrel has decreased in the entire region, and no recent records are known.

Domestic dogs and cats are common in the park. Dogs have particularly been noted as a problem in West Park where they are fed by humans.

Mammals are often significant in ecosystem function, because the group includes top predators which can affect abundance of lower trophic levels, browsers and grazers which can have great impacts on vegetation, and mid-level predators, which can be critical in transferring food chain effects from top predators to small herbivores. Although many of the native species of the park are still present, the trophic structure of the park ecosystem is highly modified. The top wild predators (wolf, bear, and mountain lion) are extirpated, and hunting is restricted, although mortality by automobiles and other manmade sources compensates for some of this reduction in predator mortality. Reductions of top predators have two types of effects: 1) predation is reduced on large herbivores, white-tailed deer in this case; 2) predation is reduced on intermediate-sized predators, such as raccoons. While the first effect has received much attention, the second may be very important. Intermediate-sized predators are further aided in urban systems by alternate food sources. These sources may make these predators largely independent of wild prey, so that they can sustain themselves on these sources even as they reduce abundance of wild prey. A variety of prey taxa can be affected by these changes. Some groups, such as ground-nesting birds, reptiles (eggs and young are very vulnerable to predation), and some small mammals may be particularly sensitive to these impacts. These effects exacerbate effects of fragmentation, since predation may be greater near the edges of park land.

While it is virtually certain that these urban effects have profound effects on the structure of park ecosystems, it is difficult to ascertain the actual impacts. This is because of the complexity of trophic relationships of many of these predators (they eat multiple foods; for example even large predators eat small rodents), interactions among predators, the presence of other predators (e.g., hawks and owls), and the importance of other mortality effects (e.g., rabies epidemics and trapping of raccoons and other species to control rabies).

5. STREAM ASSESSMENTS AND RESTORATION

Fairmount Park System

Natural Lands Restoration

Master Plan

Japanese knotweed volunteer control site.

Tacony Creek Park

5.A. INTRODUCTION

The Fairmount Park system is made up mostly of stream valleys that were intentionally set aside to protect and buffer the streams in the City of Philadelphia. Unfortunately, 95% of the flows in these streams originate from outside the park and, therefore, are beyond the control of the Fairmount Park Commission. However, there are over 60 miles of stream within the Fairmount Park system (Fig. 5.A.1). These streams range from the small headwater streams that originate within the Fairmount Park system to the mainstems of Cobbs, Pennypack, Poquessing, Tacony and Wissahickon creeks as well as the Schuylkill River.

The streams flowing within and through the Fairmount Park boundaries and their watersheds exist in a highly urbanized landscape. When a watershed is urbanized, the supply of water and sediment to stream channels changes dramatically (Fig. 5.A.2). Peak discharges and total runoff increase as water quickly runs off of paved surfaces. Because less water infiltrates into the ground, less water reaches the stream through the groundwater, reducing the amount of water during low flow periods.

Stream channels in urbanized areas respond to these changes in several ways. Reduced sediment supply and increased storm discharges promote erosion, increasing the width and depth of the stream. As the stream incises, or cuts deeper into the valley, the flood plain becomes progressively more isolated; the water table is lowered and floodwaters are less able to interact with the streamside (riparian) forest ecosystem. Scour also causes reduced development of pool/riffle topography that provides important habitat features for aquatic organisms. These changes often lead to stream instability which is characterized by abrupt, episodic, and progressive changes in the location, geometry, gradient, or pattern of a river/stream. Unstable channels can destroy property, damage structures, reduce water quality, diminish aquatic (and terrestrial) habitat, and degrade aesthetic quality.

5.B. GOALS AND GUIDING PRINCIPLES

The overall goal is to preserve streams that are currently in good health and restore/rehabilitate streams by counteracting the effects of urbanization on hydrology (e.g., high peak flows, low base flows) and geomorphology (scoured and enlarged channels). The desired result is a system of streams that exhibits hydrologic and geomorphologic characteristics typical of less urbanized areas, and that provide a healthy, diverse habitat for aquatic biota.

Many streams have much of their channel and watershed outside Fairmount Park (e.g., Wissahickon Creek), and much of these out-of-park areas are urban. The NLREEP may not be able to effect significant change in these external areas. As a result, restoration should be concentrated on smaller tributaries, especially those with significant watershed areas within the park. In particular, there should be less effort on the main stem tributaries (i.e., Schuylkill, Wissahickon, Pennypack, Cobbs, Tacony, and Poquessing), since conditions in these streams are controlled largely by conditions outside the park and actual restoration would require a watershed-level approach.

In order to “restore” you must have a “reference” to compare to. However, there are no streams in “pristine” or “pre-settlement” condition in the area to use as reference examples since humans have altered all streams or their watersheds to some extent. The “reference” streams selected as desired objectives for restoration are “rural” Piedmont streams (except for Coastal Plain streams, such as those in FDR Park) that have forested riparian zones, are biologically “healthy,” and that

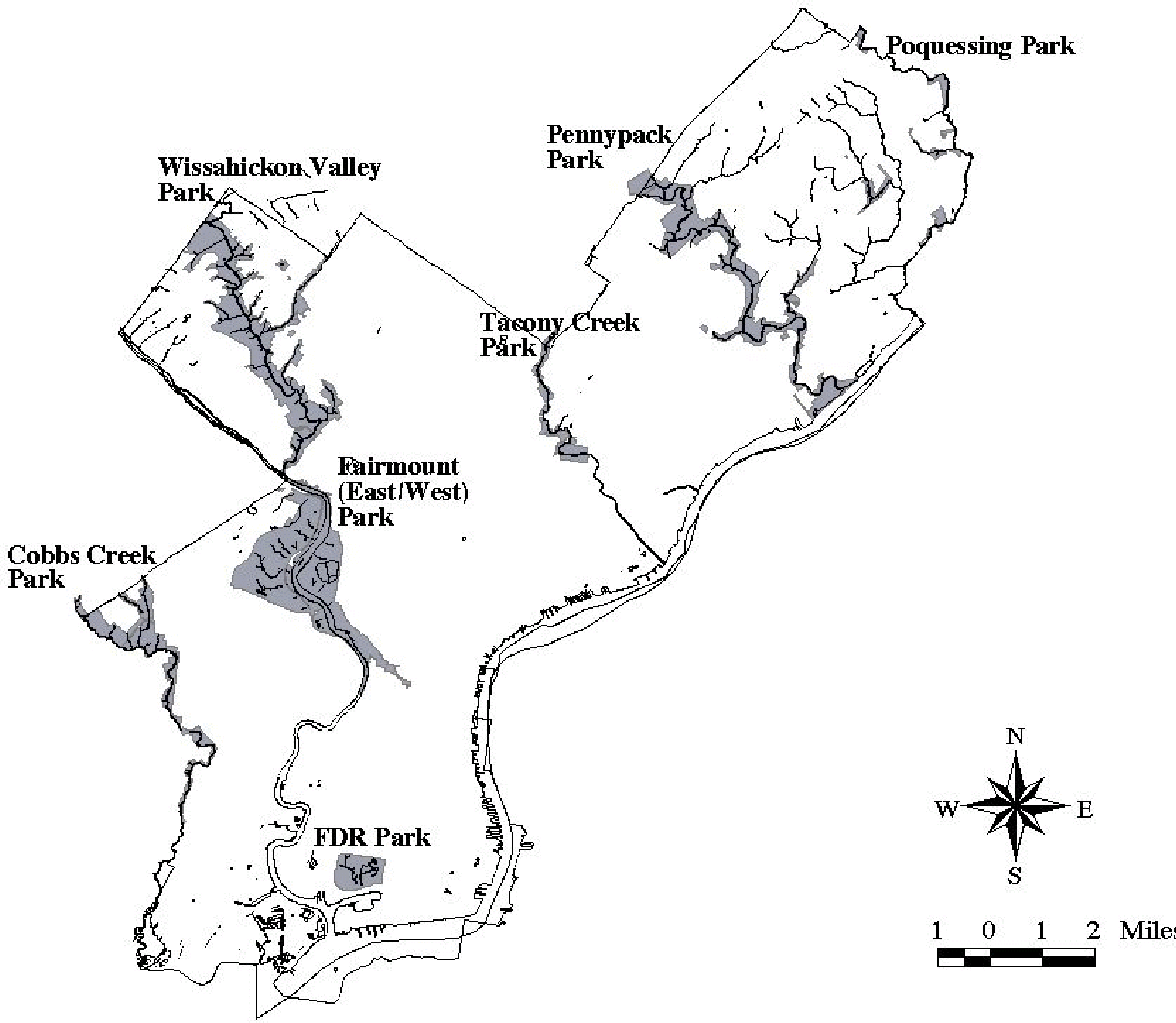
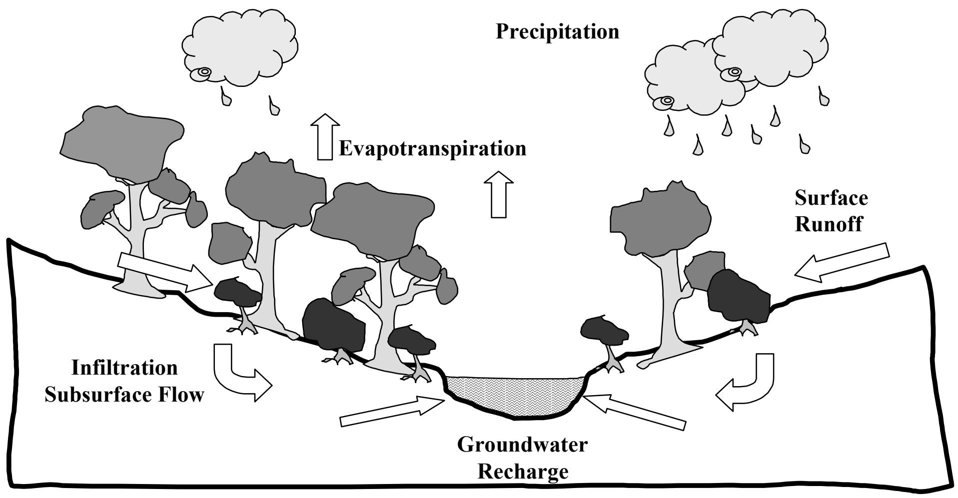


Figure 5.A.1. Fairmount Park system boundaries with individual parks identified.

(a)



(b)

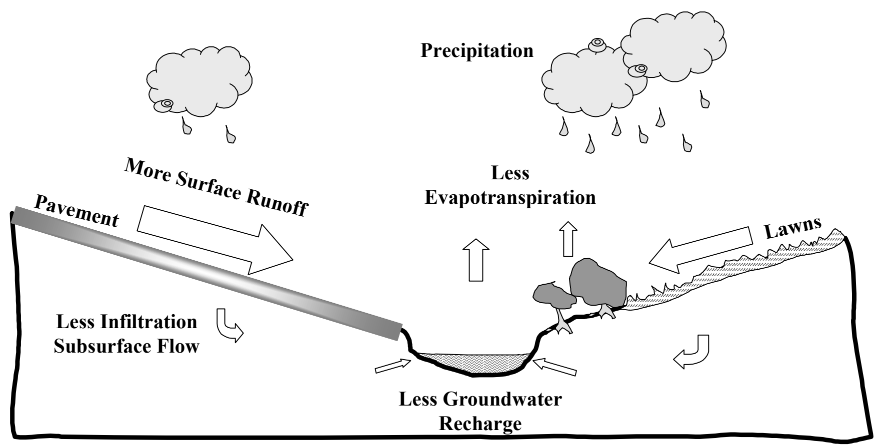


Figure 5.A.2 Hydrologic changes due to urbanization: a) a natural hydrologic cycle and b) a hydrologic cycle altered by urbanization.

that have not been extensively scoured and enlarged by erosion of the stream's bed and bank. Such streams are found in Chester County, PA and Cecil County, MD.

5.C. APPROACH

5.C.1. Initial Review and Data Collection

We initially reviewed general stormwater and stream restoration issues, methods, regulations, and current techniques and philosophies. An important aspect of this review was to meet with Fairmount Park Commission engineers and the Philadelphia Water Department to solicit their input and perceptions concerning priority or problem areas, possible solutions, and information gaps. Initial data gathering involved the incorporation of storm sewer locational data from the Philadelphia Water Department into a geographic information system (GIS).

5.C.2. Watershed-Level Characterization and Mapping

The watersheds of the streams within the park extend beyond the park boundaries, so ANSP developed watershed-scale maps showing the watershed boundaries, streams, Fairmount Park boundaries, and county boundaries for each of the major streams (Schuylkill River, Wissahickon Creek, Cobbs Creek, Tacony Creek, Pennypack Creek, and Poquessing Creek). Understanding the watershed context of these streams is essential to assessment and restoration planning. Some important information obtained from the watershed-level characterization are provided in Table 5.C.1, including: 1) watershed size; 2) percentage of watershed under various land uses; 3) percentage of watershed within park boundaries; and 4) percentage of watershed within Philadelphia city limits.

Table 5.C.1. Summary of watershed characteristics for Fairmount Park.

Park Name	Watershed Name	Watershed Size	Area in City	Area in Park	Watershed Land Cover (%)				
		(mi^2)	(%)	(%)	Urban	Grass	Forest	Agriculture	Other
East/West	Schuylkill River	1848	2	<1	10%	0%	48%	39%	3%
Wissahickon	Wissahickon Creek	64	17	5	47%	4%	40%	12%	1%
Pennypack	Pennypack Creek	56	32	5	68%	6%	28%	3%	1%
Cobbs	Cobbs Creek	22	60	6	84%	7%	15%	0%	1%
Tacony	Tacony Creek	35	61	1	84%	5%	15%	0%	2%
Poquessing	Poquessing Creek	22	25	2	69%	2%	19%	10%	2%

5.C.3. Assessing Current Conditions

The assessment program was specifically designed to test hypotheses about what is happening in the stream channels of the park and to help guide restoration. Two levels of assessment were developed, screening and detailed. The screening-level assessment was specifically developed to provide cursory data that could be collected for a majority of the streams within the park. These screening-level data allow us to evaluate the condition and rank most stream lengths within the park. This is a valuable tool for prioritizing restoration activities and for educating the public. In addition, the screening-level assessment was used to identify areas or stream reaches to be included in more detailed stream surveys. The detailed assessment or surveying involved quantitative measures of channel morphology and sediment characteristics on 20 stream reaches throughout the Fairmount Park system. The results of the detailed surveys were used to compare the Fairmount Park channels to 16 rural stream reaches in Chester County, PA and Cecil County, MD to help in understanding the impacts and causes and to develop goals for restoration.

5.C.3.1. **Screening-Level Assessment of Streams**

A screening-level assessment was developed that allowed ANSP to quickly assess the conditions of streams within the park (more than 60 miles). The goal was to cover 2 miles of stream per day. The purpose of the screening-level assessment (or "streamwalk") was two-fold: 1) to help identify areas or stream reaches to be included in the more detailed stream surveys, and 2) to allow assessment of the condition of the stream lengths within the park as a tool for planning, restoration prioritization, and public outreach.

The purpose of the streamwalk was to classify the streams into unique geomorphic types as well as identify the level of impact due to various disturbances. In particular, distinct stream reaches were assessed for geomorphic condition, aquatic habitat, and riparian zone condition. As a result, a variety of rankings can be developed depending on the impact of interest.

Due to the sheer length of streams to be screened, the streams were sampled using a reach length that varied with the width of the stream and only every fifth reach along a stream was characterized unless there was an obvious change in condition or characteristic. The reach length to be characterized/classified was approximately 20 times the bed width. This methodology was used only on smaller streams (with the exception of Tacony Creek since this park has few smaller streams). ANSP walked the entire length of the larger streams within the park system in order to document specific problems or restoration activities, but no formal assessments were conducted. A detailed description of the screening-level assessment and the data sheets used can be found in Appendix B-1 in Volume III.

5.C.3.2. **Detailed-Level Assessment of Streams**

The detailed assessment or surveying involved very specific measures of channel morphology and sediment characteristics. The results of the detailed surveys were used to compare the channels according to some desirable standard ('less' urbanized or otherwise non-impacted channels, for example). Comparing the characteristics of the highly urbanized stream channels of Fairmount Park to "reference" streams in less-impacted rural areas provides valuable information concerning the relative health and stability of the streams as well as quantitative goals for restoration.

A detailed assessment was conducted on 20 sites distributed among the parks. The number of sites per park was determined based on the total stream length of each park. The distribution was as follows: Pennypack, 5; Wissahickon, 5; Cobbs Creek, 4; Fairmount East-West, 2; Poquessing, 2; Tacony, 2 .

Reach lengths of 100- to 200-m were surveyed to develop a longitudinal profile and cross-sectional profiles using a laser level. For the longitudinal profile, water surface and channel bottom elevations were recorded at important features such as top of pool, deep point of pool, and top of riffle along the entire reach. Typically, five cross sections were surveyed within each study reach, equally spaced along the length of the reach. One cross section per study reach was chosen as a permanent site and rebar markers were installed to allow for assessing channel change over time. Finally, the stream substrate particle size distribution was sampled. A complete description of the detailed-level assessment methodology is provided in Appendix B-2 in Volume III.

Similar data were previously collected for rural streams in Chester County by the Patrick Center as part of a separate research study. Therefore, most of the data for comparing Fairmount Park streams with less-impacted rural streams already existed for 16 streams, although some additional field work was required at these sites.

5.C.4. **Assessment Results**

5.C.4.1. **Screening-Level**

The condition of distinct stream reaches was assessed in terms of stream morphology, aquatic habitat and riparian condition. First, the urban streams in the Fairmount Park system, and streams in rural watersheds of southeastern Pennsylvania/northern Maryland were classified using a 'checklist' of typical geomorphic features. Streams of urbanized watersheds differ from those of agricultural watersheds in dominant sediment size, flood plain type, bed morphology, type and presence of bars, channel form, and channel cross-sectional area scaled by drainage basin area. Differences in dominant sediment size, flood plain type, and cross-sectional area are statistically significant, while differences in other categories are not statistically significant. All the classification measures appear to be reliable: measured data reflect similar trends to those indicated by the classification measures.

The screening-level stream morphology data were used to create an "index" of urbanization effects that could be used to map the level of disturbance of stream channels. ANSP combined several measured or observed attributes into a single index of urbanization effects. A cumulative index, PCRUDS (Patrick Center Regional Urbanization Delimiter for Streams), was developed by combining and weighting classification observations of bed morphology, planform, bar type, flood plain morphology, and channel cross-sectional area. PCRUDS is scaled so values range from 0 to 1, with 0 reflecting no urbanization effects, and 1 reflecting large urbanization effects. PCRUDS is also positively correlated with the percentage of impervious surfaces in a watershed. The detailed description of the PCRUDS analysis are provided in Appendix B-3 in Volume III.

The task of habitat assessment was approached from two perspectives: 1) physical condition of the habitat (physical habitat) and 2) the "condition" or "health" of benthic communities (habitat function). For physical habitat, a modified version of the Environmental Protection Agency's (EPA) Rapid Bioassessment Protocols (RBP) for Habitat Assessment (Barbour et al. 1997) was used. The habitat function is based on the health of the benthic communities as a coarse measure of ecosystem function. The biota attached to rocks, logs, and leaf packs was examined. The rationale for assessing both physical habitat and the health of the aquatic community is that if the habitat appears near-optimal, but the function appears severely degraded, there may be other influences impairing the development of a "healthy" biota. This is important information from a restoration point of view, because habitat restoration may not improve the function of streams with very poor water quality. Both "physical habitat" and "habitat function" assessments described eight characteristics. The scores for each characteristic were summed to provide ranking criteria. ANSP ranked the streams into four equally-sized rating categories: severely-impaired, impaired, moderately impaired, and slightly/non-impaired. The detailed description of the habitat assessment methodology is provided in Appendix B-4 in Volume III.

The riparian, or streamside corridors were assessed based on three characteristics: 1) vegetation type and condition; 2) width of vegetated corridor; and 3) level of human disturbance. Each of these characteristics was classified as poor, marginal, sub-optimal, or optimal for each stream reach and given a numerical score. The evaluation was based on the assumption that the best-case in terms of stream health is a wide streamside forest consisting mostly of native vegetation.

Finally, a Stream Quality Index (SQI) was developed by scaling each of the scores obtained for stream geomorphology, aquatic habitat and riparian condition to values ranging from 0 to 100. The three scores were then summed, resulting in a final stream quality index ranging from 0 to 300 for each stream reach. The final SQI scores were then grouped into severely impaired (0 to 75), impaired (76 to 150), moderately impaired (151 to 225), and slightly or non-impaired (226 to 300). It is important to note that the final impairment classification based on the SQI is meant to provide an overall picture and basis for comparison of the condition of streams within the Fairmount Park system. However, the classification of streams may be modified based on additional information or special circumstances that may not be addressed with the assessment methodology. For example, some of the very small streams originating as wetland seeps within the park may score low for habitat and geomorphology due to their size, but they may be in excellent condition and be important ecologically.

5.C.4.2. **Detailed-Level**

To quantify the changes in Fairmount Park stream channels, 19 channels in the Fairmount Park system were compared with 16 channels in undeveloped, rural areas of southeastern Pennsylvania (Fig. 5.C.1; Table 5.C.2). The results are dramatic (Figs. 5.C.2 and 5.C.3): the urbanized Fairmount Park channels are, on average, 110% wider and slightly shallower than rural channels. Bank angles of Fairmount Park channels are steeper, suggesting increased erosion and incision caused by urbanization. Only 20% of the channels of Fairmount Park have active flood plains, while 60% of the rural channels have active flood plains. Sixty-four percent of the rural channels have well-developed pool/riffle topography, while only 44% of the Fairmount Park system channels have well-developed pool/riffle topography. Pools in rural channels are 130% deeper than pools in Fairmount Park system channels. As a result of the changes in morphology, urbanized Fairmount Park system channels can transmit an order of magnitude more water and two orders of magnitude more sediment at flood stage than corresponding rural channels.

Table 5.C.2. Detailed stream assessment sites (see Figure 5.C.1).

Urban Sites		Rural Sites	
ID	**Name**	**ID**	**Name**
1	Wise's Mill	1	Buck and Doe Run
2	Bell's Mill	2	Doe Laurels Run
3	Cresheim Creek	3	Sharitz's Run
4	Wissahickon Trib 26	4	Jock's Run
5	Carpenters Creek	5	Hannum's Run
6	West Trib 4	6	West's Run
7	East Trib 3	7	Fisher's Run
8	Cobbs Trib 3	8	Moorehead's Run
9	Indian Run	9	White Clay Creek
10	Indian Creek	10	Teeter's Run
11	Bocci Tributary	11	Big Springs Run
12	Tacony Creek	12	Doe Run
13	Tacony Trib 1	13	Pocopson Run
14	Rockledge Run	14	Grammies Run
15	Sedden’s Trib 1	15	WP White Clay Creek
16	Pennypack Trib 15	16	Birch Run
17	Three Springs		
18	Wooden Bridge Run		
19	Poquessing Trib 3		
20	Poquessing Trib 1		

Additional analyses were performed by pairing eight of the Fairmount Park system streams with eight of the rural streams based on watershed or drainage area. The basic assumption is that streams with similar watershed size in the Piedmont Physiographic province should exhibit similar

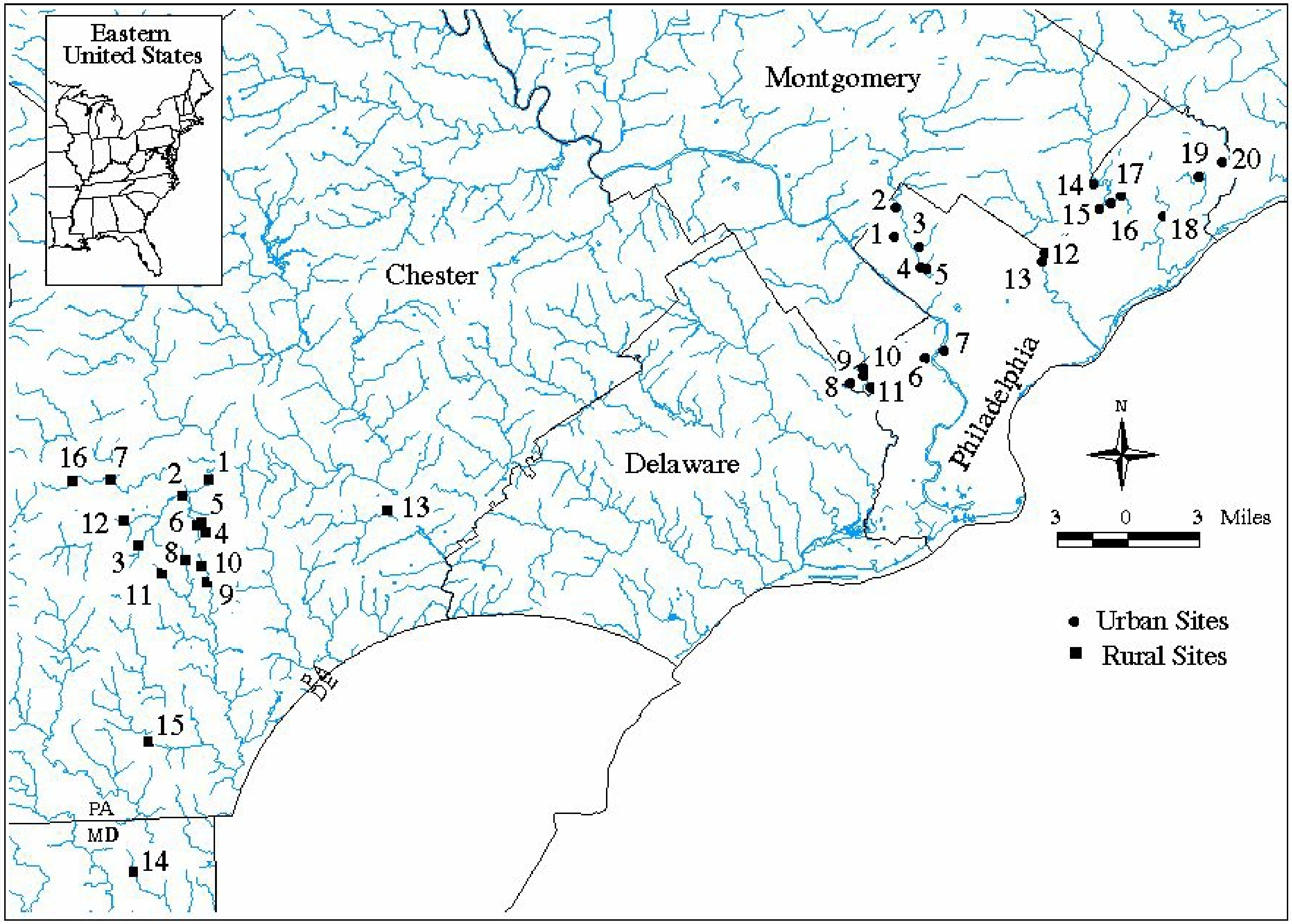


Figure 5.C.1. Location of detailed study sites in the Fairmount Park system and the rural study sites used as reference streams.

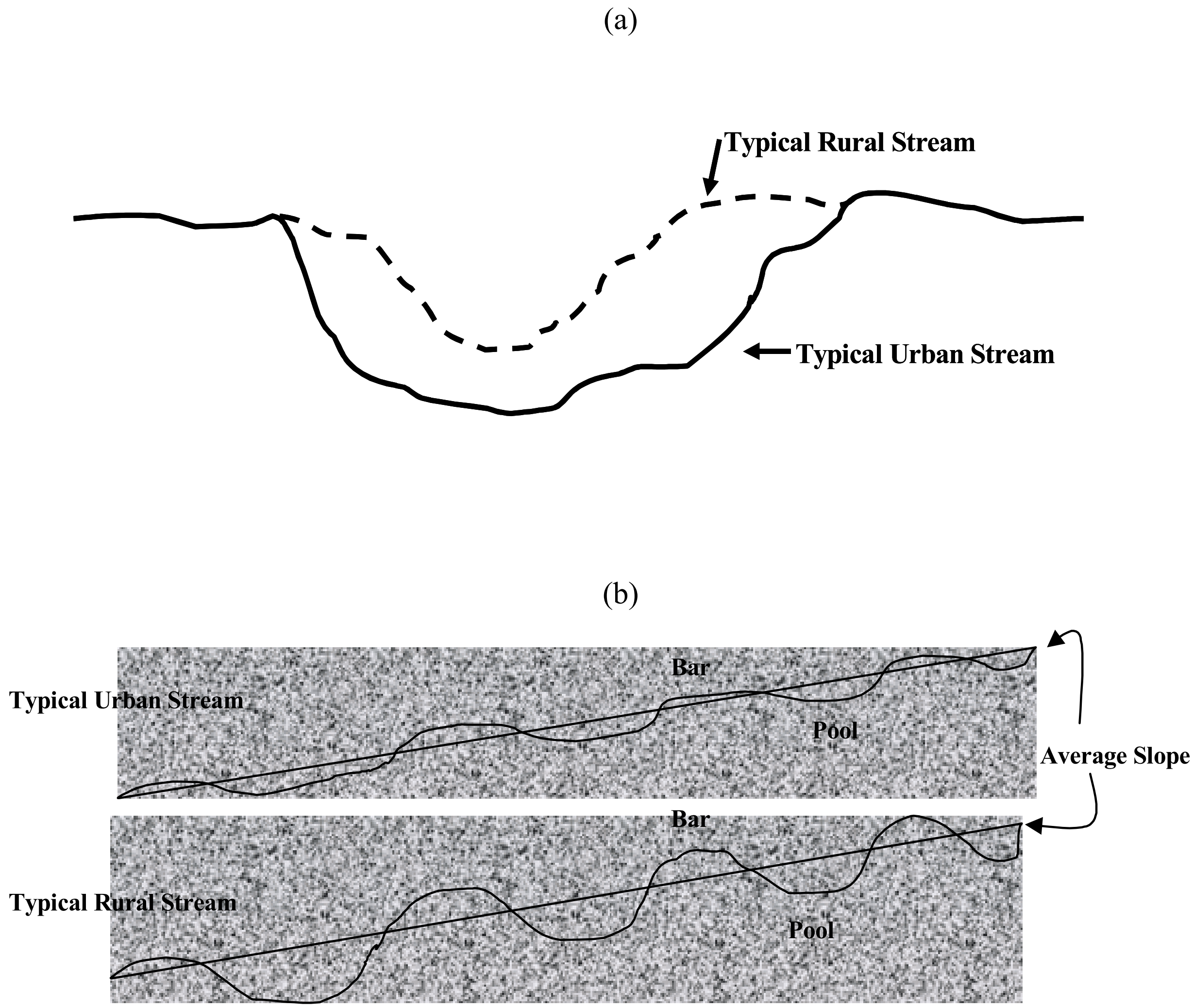


Figure 5.C.2. Illustrated comparison of typical rural and urban stream channels: a) cross-sectional view and b) longitudinal profile showing riffle-pool structure. This comparison assumes that the streams have a similar watershed size and are in a similar geologic setting.

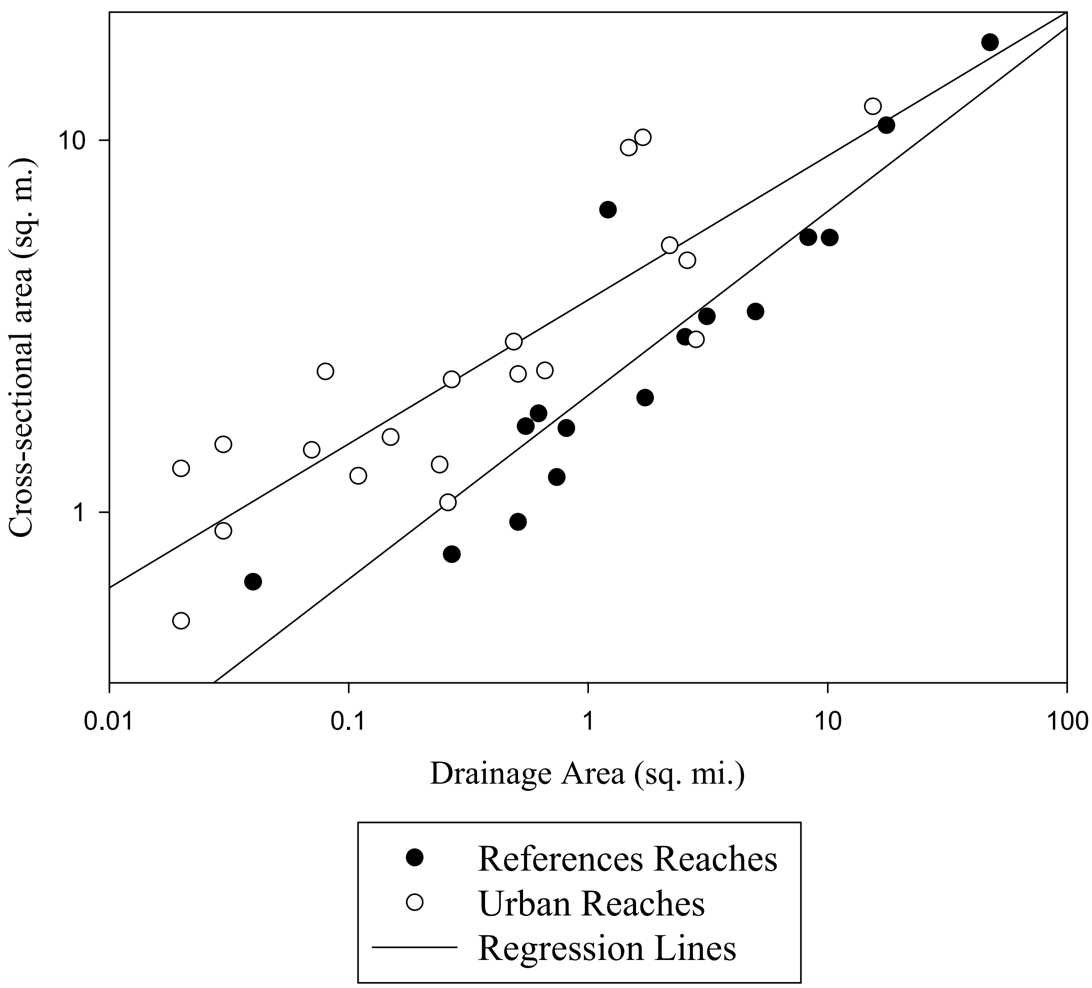


Figure 5.C.3 Bankfull cross-sectional area versus watershed size for Fairmount Park detailed sites and rural reference sites.

channel characteristics unless impacted by man-induced stresses (such as urbanization). Figure 5.C.2 illustrates the difference in important stream characteristics between the urban and non-urban streams. Knowing the differences between these important characteristics provides essential information for restoration activities.

Bankfull (the level of the flood plain lying along each bank) depth, reach-averaged bed slope, and median grain size are similar in urban and rural watersheds. Urban channels are wider and have larger cross-sectional areas than corresponding rural channels. Urban channels have lower pool depths and sinuosities than rural channels. A composite Manning's *n* (representing channel roughness or friction) value based on median grain diameter, pool depth, and channel sinuosity is used to assess differences in resistance to flow. Estimated Manning's *n* values are significantly lower in urban channels than rural channels, indicating that urban channels respond to increased peak discharges by reducing resistance. Dimensionless bankfull discharges, computed using the Manning equation and scaled by drainage basin area and the acceleration of gravity, are significantly higher in urban channels than rural channels. Histograms of bed sediment size distributions in urban channels lack a secondary peak in the size range 2-64 mm characteristic of rural channels, indicating that these sizes tend to be selectively removed from urban channels. However, bankfull Shields stresses (which provide an estimate of the ability of stream flows to erode channel sediments) in urban and rural channels exceed typical threshold values at most sites, indicating significant bedload transport at bankfull stage. Apparently, decades of urbanization-related peak discharges have not removed all the transportable sediment from urban stream channels. It is speculated that the supply of sediment to urban channels from hillslope processes and channel erosion remains significant, even though much of the upland surfaces of these urban catchments are covered with inerodible impervious surfaces.

These data clearly suggest that the Fairmount Park system's channels have been strongly influenced by urban stormwater runoff. The data quantify these changes and provide useful, quantitative goals for restoration and mitigation. Restoration or enhancement of Philadelphia's streams requires an understanding of the changes in fluvial morphologic variables as well as the causal factors. The results of this study serve as an important empirical basis for restoration or rehabilitation.