

6.0 PROMOTING A SUSTAINABLE LANDSCAPE

6.1 Introduction

Sustainability is a goal best stated as a direction rather than a destination. Is our society becoming more or less sustainable? As an absolute, sustainability may not be currently achievable in our modern society, but we can take incremental steps towards that goal. Every improvement, however small, however slow, is an important step in the right direction. Hopefully, this Conservation Plan will help to pave the way for a sustainable landscape in the Schuylkill River watershed.

The goal of promoting a sustainable landscape focuses on: creation of an integrated, connected natural lands vision for the Schuylkill River watershed, incorporating existing and proposed greenspace nodes; and, recognition that protecting a quorum of natural lands will promote landscape sustainability and help preserve water quality. The following issues related to landscape sustainability were highlighted during the public opinion poll and the public meetings.

- Loss of critical natural lands to development due to rapid urban/suburban sprawl
- Need to encourage responsible growth and offset associated losses of farmlands and wetlands
- Need for open space preservation to assist in water quality preservation
- Need to create and maintain linear parks and greenways as biodiversity connectors and riparian corridors to preserve water quality
- Lack of guidance on ecological management of protected natural lands
- Lack of strategic regional planning for identifying and conserving the watershed's ecological resources

This chapter provides a summary of the Schuylkill River watershed's existing natural and biodiversity resources based on publicly available geographic information systems (GIS) data and landscape modeling. Data gaps and issues needing further study are identified, and recommendations for protecting and improving the sustainability of the landscape are given. In addition, the issues noted above, as well as many other critical conservation and land use topics, were documented and discussed in the Report of the 21st Century Environment Commission (1998) an excellent resource for reviewing issues of sustainable landscapes and development throughout the Commonwealth (<http://www.21stcentury.state.pa.us>).

6.2 Summary Recommendations

Recommendations for sustaining the landscape of the Schuylkill River watershed are summarized in the table below. Each recommendation is assigned a unique code number (e.g., **R6.1**) and name, and is cross-referenced to the key landscape or land use issue(s) it addresses. These recommendations are described in more detail in **Section 6.8 Detailed Recommendations for Landscape Sustainability**, and the page number where the detailed description of that recommendation can be found is listed in the *Page* column of this table.

<i>Code</i>	<i>Recommendation</i>	<i>Summary Description</i>	<i>Issues Addressed</i>	<i>Page</i>
<u>R6.1</u>	Establish a Watershed Land Protection Collaborative (WLPC) to Proactively Protect Greenspace	More than 200,000 acres of potential greenspace across the watershed need to be protected within the next 20 years, to serve as the framework of a sustainable landscape and to ensure the health of the Schuylkill River watershed. A Watershed Land Protection Collaborative composed of watershed conservation groups working together needs to be established, to promote strategic land conservation and efficient resource use.	Loss of natural lands Need for greenspace Strategic conservation	6-23
<u>R6.2</u>	Refine Prioritization of Watershed Natural Lands using a Standardized Relative Assessment Tool	The watershed conservation community must take proactive steps to further prioritize high priority, sensitive lands according to their ecological value and degree of threat. Conservation groups should use established relative assessment tools to refine land prioritization and to conserve the high priority potential greenspace identified in this plan.	Loss of natural lands Need for greenspace Strategic conservation	6-24
<u>R6.3</u>	Support Outreach and Education Programs Providing Landowners with Land Preservation Options	Private citizens, who may have little understanding of the land preservation and ecological management options available to them, own the vast majority of lands proposed for preservation in the watershed. Outreach and education efforts should provide landowners with viable options and guidelines for land preservation and ecological management.	Loss of natural lands Need for greenspace Guidance on ecological management	6-25
<u>R6.4</u>	Proactively Protect PA Natural Diversity Inventory (PNDI) Sites	Protecting these identified high-value sites will help maintain the rare species biodiversity reservoir in the watershed. Protection of PNDI areas should be implemented in order of priority and threat, and to ensure a balanced portfolio of species and community biodiversity.	Loss of natural lands Need for greenspace	6-25
<u>R6.5</u>	Proactively Protect Identified Greenspace Nodes	Greenspace nodes (e.g., important bird areas, wetlands, floodplains, blocks of contiguous forest cover over 500 acres, and other priority habitat subwatersheds) need to be protected since they represent the biodiversity reservoirs in the watershed. Protection should be implemented in order of priority and threat.	Loss of natural lands Need for greenspace	6-26
<u>R6.6</u>	Proactively Protect, Restore and Create Identified Greenway Corridors	Greenway corridors will link greenspace nodes to help maintain environmental viability and connectivity in the watershed. In many cases, they can also serve a dual purpose as riparian buffers. Action should be taken according to priority and threat, where possible.	Loss of natural lands Need for greenspace Landscape connectivity	6-26

<i>Code</i>	<i>Recommendation</i>	<i>Summary Description</i>	<i>Issues Addressed</i>	<i>Page</i>
<u>R6.7</u>	Develop Strategic Protection Plans for Identified Subwatersheds in Habitat Zones	Site-specific plans must be developed for each priority habitat subwatershed to identify appropriate land parcels for permanent protection. Protection should be implemented in order of priority and threat, where possible.	Loss of natural lands Need for greenspace Guidance on ecological management Strategic conservation	6-27
<u>R6.8</u>	Develop Strategic Restoration Plans for Identified Primary Restoration Subwatersheds	Site-specific plans must be developed for each priority restoration subwatershed to identify appropriate land parcels for riparian buffer installation and/or reforestation. These efforts should be reinforced with permanent protection where possible, and be implemented according to priority and degree of threat.	Loss of natural lands Need for greenspace Guidance on ecological management Strategic conservation	6-28
<u>R6.9</u>	Develop and Adopt a Strategic Protection Plan for Watershed-wide Agricultural Land Resources	Develop a watershed-wide plan based on site-specific data (soils, agricultural security districts) and funding, to prioritize agricultural land parcels for protection. Agricultural preservation can serve a supporting role in maintaining landscape sustainability if ecological BMPs and NMPs are implemented and enforced.	Need for greenspace Guidance on ecological management Strategic conservation	6-29
<u>R6.10</u>	Reactively Protect Natural Resources in the Watershed as Opportunity Arises	Whenever an unsolicited, high quality, cost-effective natural land protection opportunity arises (i.e., maximum natural land acreage for minimum financial and time resources), it should be evaluated for protection regardless of greenspace and subwatershed priorities.	Loss of natural lands Need for greenspace	6-29
<u>R6.11</u>	Promote Development of Forest Resource Management Plans on Privately-owned Forest Lands	The majority of the watershed's forest resources are found on private lands, and owners should be provided guidance on maintaining or restoring these lands to their natural health and viability.	Loss of natural lands Guidance on ecological management	6-30
<u>R6.12</u>	Control Invasive Species and Deer Densities to Enhance Forest Regeneration of Native Plants	Demonstration projects, particularly at environmental education facilities, should be developed and supported to address these concerns, especially where the human community is demonstrably engaged in proposed demonstration land management projects.	Loss of natural lands Guidance on ecological management	6-30
<u>R6.13</u>	Develop Watershed-wide Adaptive Ecological Land Management Guidelines for Protected Lands	Provide a detailed, standardized tool-kit for adaptive ecological management plans that includes the use of BMPs and NMPs on protected lands. Make this available to the watershed conservation community through a watershed service center.	Guidance on ecological management Strategic conservation	6-31

<i>Code</i>	<i>Recommendation</i>	<i>Summary Description</i>	<i>Issues Addressed</i>	<i>Page</i>
<u>R6.14</u>	Establish Community-Based Programs to Implement Adaptive Ecological Management Plans on All Protected Lands by Priority	By developing Adaptive Ecological Management Plans that can be implemented by community volunteers, neighborhoods can reconnect with the local ecosystems on which they depend. A watershed-wide program should focus on the Urban/Suburban Zone.	Guidance on ecological management Strategic conservation	6-32
<u>R6.15</u>	Develop and Adopt a Strategic Resources Plan for Watershed-wide Land Protection, Restoration and Ecological Management	A watershed coalition of interested groups needs to build capacity (funding, personnel, expertise and leverage strategies) and develop a strategic funding plan to ensure sufficient resources to implement the land protection, restoration and management recommendations.	Strategic conservation	6-32
<u>R6.16</u>	Develop an Interactive GIS Resource for the Watershed Community	Capitalize on the investment made in GIS mapping and analysis for this Plan by making these data available through an interactive tool for use by the watershed conservation community and government agencies.	Strategic conservation	6-34
<u>R6.17</u>	Establish a Funding Base, Schedule and Distribution Protocol for Updating and Upgrading GIS Mapping	To address data gaps identified in this Plan, ensure that critical new or updated GIS data are added to the watershed GIS data set as necessary. Mandatory annual GIS data reviews should assess and address update/upgrade needs. Ensure distribution of upgraded GIS database to the watershed conservation community.	Strategic conservation	6-34
<u>R6.18</u>	Develop Local-Scale Comprehensive Subwatershed River Conservation Plans	Comprehensive subwatershed plans should be completed for areas in the Schuylkill River watershed not currently covered by local-scale River Conservation Plans.	Guidance on ecological management Need for greenspace Strategic conservation	6-36
<u>R6.19</u>	Support the Schuylkill River Heritage Corridor Management Action Plan	The Schuylkill River Greenway Association should be supported by government and watershed nonprofits in its efforts to develop a comprehensive Management Action Plan for the Schuylkill River Heritage Corridor and the National Heritage Area, addressing a full range of cultural, historic, scenic and recreational resource needs.	Need for greenspace Strategic conservation	6-36
<u>R6.20</u>	Encourage Smart Growth Policies	A number of smart growth programs exist at the federal, state and local levels, to help guide the development process to ensure sound environmental and economic growth.	Loss of natural lands Need for greenspace	6-37

<i>Code</i>	<i>Recommendation</i>	<i>Summary Description</i>	<i>Issues Addressed</i>	<i>Page</i>
R6.21	Support Brownfield Redevelopment Initiatives	As the complimentary strategy to land preservation, a model redevelopment incentive ordinance with BMPs should be developed. Montgomery County Planning Department would be an ideal choice for developing this text, which could subsequently be distributed to municipalities throughout the watershed.	Loss of natural lands Need for greenspace Strategic conservation	6-38
R6.22	Support Development of Standardized Demographic, Transit, Infrastructure and Land Use “Change Indicators” for the Entire Watershed	In order to adequately characterize levels of threat in the watershed so as to better direct conservation, a collaboration of county planning agencies could address the need to develop and maintain periodic updates for critical data that will assist in tracking the development pressure and human population impacts throughout the watershed.	Loss of natural lands Need for greenspace Strategic conservation	6-38

6.3 Background and Procedure

Landscape analysis is a process of considering interrelated spatial features, defining patterns, identifying regional issues and/or ecological and human processes that are likely to cause those patterns, and then recommending solutions to solve the identified problems. In this Plan, the focus is on identifying and conserving landscapes that will help to sustain the watershed ecosystem: by defining the pattern of greenspace and protected natural areas that can function as an interconnected network to protect the ecological and hydrological processes of the watershed.

Specific steps taken to achieve the goal of promoting a sustainable landscape in the Schuylkill River watershed were:

- Identification and mapping of existing greenspace components;
- Analysis and mapping of proposed greenspace components based on natural resource values;
- Mapping population projections to establish potential “threat” to watershed resources; and
- Providing recommendations and implementation tools, focusing on the need for strategic planning and institutional capacity building to ensure implementation of these recommendations.

6.3.1 Sustainable Landscape Analysis

A *sustainable landscape* is defined in this Plan as a matrix of natural lands that function together within a defined area, to maintain the essential ecological processes that support life, and to maximize and sustain natural biodiversity across a region.

Within the Schuylkill River watershed, a fabric of ecologically significant lands remains in a more or less natural, undeveloped condition (see the map: [Regional Land Cover](#)).

Maintenance of this ecological fabric can provide a critical quorum of land for preservation of good water quality, healthy functioning of the hydrological cycle and mitigation of non-point source pollution

throughout the Schuylkill River watershed. A sustainable landscape is also critical to ensuring human health and quality of life, through source water protection, prevention of floods, and provision of natural/recreational areas and greenspace amenities. However, at present growth rates (see the map: [Estimated Population Change](#)) many of these natural areas could disappear within the next twenty years, primarily lost to development, unless decisive, large-scale, proactive steps are taken to protect, maintain and/or restore these natural resources as soon as possible.

Within the context of a River or Watershed Conservation Plan, the primary ecological process to consider is the hydrologic cycle, with the unit of land for assessments being the watershed, or subwatershed (see the map: [Watershed Orientation](#)). Landscape analysis within the Schuylkill River watershed has been completed on the basis of the 37-subwatersheds shown in this map. Identifying components of the landscape within the Schuylkill River watershed that support sustainability of the hydrological cycle is the primary focus of this Chapter of the Schuylkill River watershed Conservation Plan.

In the context of watershed conservation, a sustainable landscape plan can be initiated by identifying high quality natural lands that already have been preserved, or sensitive natural lands that should be protected, and designating them as green nodes and greenways (linking corridors) within a networked landscape system.

Lands requiring habitat creation or restoration also may be identified and proposed as part of a sustainable landscape matrix, but these are considered secondary components in this Plan due to the site-specific nature of these sites and the reduced level of detail that this regional analysis affords. The discussion below therefore focuses on identifying areas of existing, intact natural landscape for protection, although some general recommendations for restoration have been included where possible.

While the resulting greenspace plan provides for a skeleton of ecologically significant lands to support healthy functioning of the hydrological cycle in the watershed, these proposals should be considered a functional minimum. Proposed greenspace should be protected through proactive methods: conservation entities should take active steps to promote the protection of the proposed core greenspace lands. However, additional reactive land preservation efforts should always be considered if cost-effective opportunities arise.

6.3.2 Data Sets and Analysis Components

From the available data for the Schuylkill River watershed, the following components were selected for analysis to define the potential greenspace nodes and corridors of a watershed-wide sustainable landscape plan. These components were selected as the best available data on which to develop a networked plan of sensitive natural lands worthy of protection and of direct utility in sustaining ecological-hydrological processes and/or biodiversity in the watershed. The components supporting this landscape sustainability analysis included the following types of data.

Locational Data

- Protected Lands
- Pennsylvania Natural Diversity Inventory (PNDI)/County Natural Area Inventories
- Pennsylvania Important Bird Areas (IBAs)
- Primary Sensitive Lands: Steep Slopes; Wetlands; and Floodplains
- Secondary Potential Greenspace Nodes and Corridors

Subwatershed Data

- Habitat Value (by taxa group and based on land cover)
- 1st order stream frequency in highly forested landscapes

Where possible, an attempt has been made to prioritize watershed lands within each data type. In many cases, however, due to the scale of this project and the limitations this implies on gathering site-specific data, such prioritization has not been possible. As new GIS data becomes available providing comprehensive and scale-consistent data coverage for the entire watershed, additional analysis of priorities can be undertaken (see Recommendations **R6.2** and **R6.17** in **Section 6.8** below).

A discussion outlining each component and how it informs the sustainable landscape analysis follows. A detailed summary of recommendations and implementation tools is provided at the end of this Chapter in **Sections 6.8 and 6.9** respectively. Notes on additional analyses that could facilitate future preservation efforts also are provided in **Section 6.10**.

6.4 Locational Data Analysis

6.4.1 Existing Greenspace - Protected Lands

Digital data layers representing government-owned lands available from the Pennsylvania Spatial Data Access (PASDA) website (<http://www.pasda.psu.edu>) were collected and compiled in a GIS database. These data included the following map layers.

- National Parks (4,340 acres ~ 0.35% of watershed area)
- National Forests (none in watershed)
- National Wildlife Reserves (none in watershed)
- State Parks (13,952 acres ~ 1.14% of watershed area)
- State Forests (5,260 acres ~ < 0.43% of watershed area)
- State Gamelands (31,697 acres ~ 2.6% of watershed area)
- County Parks (acreage and percent watershed area unavailable due to imprecise nature of publicly available data)

Note there are additional protected lands within the watershed for which watershed-wide data are not yet available in watershed-wide compiled GIS format, including agricultural easements held by State or County agencies and lands owned by local municipalities. In addition, Pennsylvania Environmental Council (PEC) is compiling a GIS data layer of all available, known locations of privately protected lands, including lands held in fee or under conservation easement by non-government organizations (NGOs): i.e., land trusts, watershed associations and other conservation and environmental education facilities. However, as of May 2001, the privately protected lands data layer was still incomplete and unavailable for inclusion in this Plan. This map layer also will be geographically limited to a five county region of Philadelphia, Chester, Montgomery, Bucks and Delaware Counties. Any of the data layers mentioned here could be very helpful when building the greenspace network for the watershed and should be incorporated into future versions of the watershed greenspace analysis if and when updates are available. See Recommendations **R6.2**, **R6.16** and **R6.17**.

Results and Discussion

The available data sets were compiled and combined to produce one GIS data layer. See the map: [Existing Greenspace](#).

Excluding acreage for the county parks (since no acreage data are available with this GIS data set, and other GIS data sets that include these data are not yet available for the entire watershed), the existing government-owned protected lands represent approximately 4.5% of the area of the entire watershed, which is insufficient for promoting a sustainable landscape. Recent Pennsylvania Department of Conservation and Natural Resources (PA DCNR) Bureau of Forestry guidelines for the entire Commonwealth, which are under development as part of a strategy to establish a Pennsylvania Bioreserve system, estimate that natural lands protection could be in the order of 10-20% (Jim Grace, *pers. comm.*). This appears to be a reasonable goal, as long as protected lands are distributed throughout the watershed and are not located all in one region.

Much has been written in the scientific literature to support the concept that connectivity and large preserve areas are required for maintaining biodiversity (see Noss 1997, Peck 1998 and other biodiversity conservation references). While there is still debate about the specifics of bioreserve size and shape, the general consensus is that a system of greenspace nodes and connecting corridors is a necessity to foster landscape sustainability. A good layman's introduction to the subject, with additional technical references other than those provided in this Plan, can be found in Quammen (1996). More discussion on this topic can also be found on The Wildlands Project web page at <http://www.twp.org>.

The existing greenspace pattern in the Schuylkill River watershed reveals a very uneven distribution of protected lands across the watershed. Most of these lands are concentrated along the Kittatinny Ridge, the majority of which is under the jurisdiction of the Pennsylvania Game Commission. As with the total acreage, the current distribution of existing protected greenspace is insufficient to provide for a sustainable landscape, since there are no connections between these large natural areas and greenspace nodes to foster biological exchange or "cross-fertilization" of natural resources between preserved areas. Without connections and biological exchange (e.g., migration, pollination, and colonization), the greenspace nodes act as isolated "habitat islands," where ecosystem processes and genetic biodiversity could be seriously impacted.

Finally, it should be noted that although "existing greenspace" implies that these lands currently receive adequate conservation protection, in reality their status provides protection mostly from the threat of land conversion and development. This status does not protect these areas from other secondary, cumulative, or random effects and ecological degradation associated with fragmentation, isolation, and incompatible land use on adjacent lands. Adaptive ecological land management that considers natural areas within their larger context of potentially developed and degraded lands is a critical requirement to facilitate sustainability and viability of natural resources in any greenspace plan. This topic is reviewed in more detail in Recommendations **R6.13 and R6.14**, and in **Section 6.9**.

6.4.2 Proposed Greenspace

6.4.2.1 Pennsylvania Natural Diversity Inventory (PNDI) and County Natural Area Inventories

Data was gathered in April 2000 from the Pennsylvania Science Office (PSO) of The Nature Conservancy for records of rare, threatened or endangered "elements" that are currently existing or recorded within the

last 10 years within the Schuylkill River watershed. These data are an equivalent or improved/updated version of what has already been published through the County Natural Area Inventories for the region.

An element can be a species, a natural community, a managed area or an important geologic feature. The county data has been compiled and merged using a GIS to produce a single mapped layer for the entire watershed. PNDI data was unavailable from PSO for Philadelphia County. Also, Dr. Ann Rhoads and other staff of the Morris Arboretum have compiled data for Bucks County rare species and communities. These data have been included in the analysis, but due to differences in data collection and evaluation with PSO's data, cannot be used comparatively. See the map: [PNDI - Site Types](#).

Each polygon placed on this map is based on the presence of one or more tracked elements. The shape of each mapped polygon represents a generalized location rather than a precise boundary in order to guard against illegal species collection or disturbance. The results of this analysis can be viewed by element type (e.g., geological feature, rare animal, rare plant, natural community, etc.) in the above map.

In addition, the value of each rare animal or plant element has been determined for the PSO data using a scoring system from low to high. Using a rapid ecological assessment methodology developed as part of an allied project of the Natural Lands Trust (details can be found at <http://www.smartconservation.org>), the most important information about a PNDI element can be combined into one aggregate score. Essential components considered in the scoring are: global rarity rank and state rarity rank (the rarity of the element on a statewide and global level); and the element occurrence rank (a score assigned to represent the quality of the species occurrence based on its health and viability). The number of elements within one polygon is also a component of the assessment, where polygons with more elements receive higher scores than polygons with fewer elements. See the map: [PNDI - Site Scores](#).

Scores for geological, managed area, locally significant and natural community elements were not generated due to inconsistencies or inadequacies in the available data, so no ranking or prioritization for these polygons was provided.

Results and Discussion

The result of the PNDI elements analysis is a clear prioritization for protection of rare or threatened species. Higher scoring sites should be targeted for protection before lower scoring sites, where possible. Sites with the highest scores ideally should be proactively pursued for protection by fee or conservation easement by conservation entities throughout the watershed. Care also should be taken to conserve sites that are representative of the biodiversity pool across the watershed. A biodiversity portfolio should be developed around these priority areas (see Recommendation **R6.4**).

The pattern revealed by both PNDI Type and Score Maps offers a major contribution to the proposed greenspace network, since these sites represent the most critical components of the watershed biodiversity pool. However, it must be emphasized that the polygons are purposefully imprecise, for reasons of confidentiality. It is hoped that ranking the PNDI data through this scoring process will aid watershed conservation entities determine their priorities when considering land and watershed protection over the next twenty years.

If a bona-fide conservation entity is interested in preserving one of these sites, it is recommended that the PNDI representatives at The Nature Conservancy's Pennsylvania Science Office, Middletown, PA be contacted for up-to-date and site-specific data. The NatureServe website (<http://www.natureserve.org>) also may be useful. Since the global, state and viability ranks of elements are reviewed and adjusted each year by PNDI, it is essential that these ranks be verified prior to making binding commitments to

preservation. It also will be critical to obtain more precise locational information since the polygons shown on these maps are purposefully imprecise. An approved conservation entity should be able to obtain more detailed site-specific data that will help refine land protection goals. Finally, the PNDI scientists also may be able to provide some data on the habitat requirements of the element so that a management plan can be developed to ensure element viability over time.

6.4.2.2 Important Bird Areas (IBAs)

Pennsylvania Audubon has spent several years documenting bird ‘hot-spots’ within Pennsylvania. While detailed conservation plans have yet to be developed to determine exact site boundaries and acreages for these locations, general areas of interest have been delineated within the Schuylkill River watershed. Sites within the Schuylkill River watershed were located based on mapping provided in the PA Audubon report *A Guide to Critical Bird Habitat in Pennsylvania* compiled by Gary Crossely (1999). Further information regarding the development of the IBA Site Conservation Plans can be obtained from Steve Hoffman, Pennsylvania Audubon Society, <http://www.audubon.org/chapter/pa/pa/>.

Results and Discussion

The IBA data are part of the proposed watershed greenspace network and are shown as a component of the map: [Sensitive Lands](#). There are six IBA sites within the Schuylkill River watershed.

- Hawk Mountain Sanctuary
- Lake Ontelaunee
- Blue Marsh Lake
- Green Lane Reservoir
- Unami Creek Valley
- Great Marsh

These areas are proposed for protection and are shown on the ‘proposed greenspace’ plan. Precise acres associated with each location are unavailable at this time.

6.4.2.3 Primary Sensitive Lands: Steep Slopes; Wetlands; and Floodplains

Steep Slopes

US Geological Survey (USGS) topographic data were collected in the form of Digital Elevation Models available from the PASDA website, which were then converted in ArcView™ GIS to maps of slope using Spatial Analyst™. The results were digitally combined and converted to show slope categories of 0-8%, 8-15%, 15-25% and those greater than 25%. These categories were selected since they match many municipalities’ zoning codes that place certain development restrictions on steep slopes (slopes greater than 15% or 25%).

Results and Discussion

Slopes greater than 25% have been mapped as a primary component of the proposed greenspace plan for the watershed on the map: [Sensitive Lands](#).

Many municipalities recognize steep slopes as sensitive habitats, primarily due to their erosion potential, and have adopted steep slope ordinances to protect these sensitive habitats. Due to the historic difficulty of developing these areas, steep slopes also can be some of the least disturbed and most healthy habitat in a township. Despite typically thinner soils on the steeper slopes, these areas usually are dominated by forests which have grown up slowly over time and developed their own pockets of humus and soil to sustain the slope ecosystem. If a complex structure of vegetation layers is present (e.g., intact leaf litter, herbaceous, understory trees and shrubs as well as canopy trees), stormwater runoff and soil erosion can be less than expected given the slope steepness. If vegetation is absent, these areas of steep slope are the prone to erosion damage and subsidence resulting in flood and mudslide hazards, increased runoff volume and velocity, and sedimentation of streams.

Wetlands

National Wetland Inventory maps define different types of federally recognized mapped wetlands in the watershed and are now available digitally from the U.S. Department of the Interior. GIS theme coverages for the entire watershed, with the exception of the Valley Forge USGS quad, have been obtained and combined.

Results and Discussion

National Wetland Inventory locations within the Schuylkill River watershed were mapped as a primary component of the proposed greenspace plan for the watershed in the map: [Sensitive Lands](#). In addition, a map: [NWI Types](#) showing types of wetlands is available in the online Reference Documents.

Where they have been mapped and are of sufficient size, many of these wetland features already are protected through federal wetland laws administered by the US Army Corps of Engineers (US ACE) and the Pennsylvania Department of Environmental Protection (PA DEP). However, not all watershed wetlands may have been mapped on the NWI layer. US EPA estimates indicate that on the order of 50% of wetlands many remain unmapped in Pennsylvania (A. Spingarn, *pers. comm.*). In addition, some mapped wetlands may be too small to receive protection under existing federal wetland laws; for example, wetlands less than 1/3-acre in size are unregulated as of the date of this Plan.

Certain small wetland features in the landscape such as vernal pools, that can be very significant in maintaining local biodiversity and water quality, are usually much less than 1/3-acre in size. Mapping at this regional scale therefore can easily miss them. Since any wetland system less than 15 square meters is unlikely to be identified by the MRLC land cover or NWI wetlands mapping, users should be aware of the likelihood for under-representation of these important wetland components in the GIS analysis. Local groups should be prepared to augment this Plan's assessments with more detailed local data to document small wetlands requiring protection (see Recommendation **R6.17** below and **R5.8** in **Section 5.6** of *Chapter 5.0 Water Quality*). This is also necessary for assessing the quality of those wetlands, which cannot be ascertained through this regional analysis.

Floodplains

Digital data for designated floodplains, as defined and mapped by PA DEP, have been collected and compiled from the PASDA website. These data are considered the best representation of the Federal Emergency Management Agency (FEMA) maps, but are not as accurate as a map of a Global Positioning System's floodplain coordinates. The data are from 1996.

Results and Discussion

Floodplains were mapped as a primary component of the proposed greenspace plan for the watershed (see the map: [Sensitive Lands](#)). These areas are susceptible to major, regular flood events that could endanger human life. Maintaining sufficient vegetation and healthy hydrology in the floodplain is essential to decreasing flood hazards and to ensuring watershed health.

6.4.3 Secondary Potential Greenspace Nodes and Corridors

A variety of additional digital GIS data are available that can be used to compliment the primary sensitive lands discussed above. These are considered “secondary” components of a potential greenspace plan, since, for the first three at least, political considerations may have been as important as environmental evaluations in their designation.

- Exceptional Value Subwatersheds
- Scenic Rivers
- National Historic Landmarks
- Inactive Railroads

Note that GIS data for long-distance trails also could be an appropriate component in this category, and is generally included in greenways mapping projects. However, it has not been included here due to lack of watershed-wide GIS data and concerns about misrepresenting the value of some of the trails as wildlife habitat connectors.¹

Each digital data set used for this component of the assessment was obtained from the PASDA website, was published in 1996, and is provided as-is. Additional information on each data layer used in this analysis of secondary greenspace is provided below.

Exceptional Value Watersheds

This digital data represents information from 1992. It shows watershed boundaries for exceptional quality streams, as designated by PA DEP. It should be noted that several comments were obtained during the public meetings indicating that the data layer may not be comprehensive or completely up-to-date. Several people felt that some designated exception value stream watersheds were not represented, e.g., Valley Creek, near Valley Forge Park, and the upper section of French Creek, west of route 100. However, further specific information about which exceptional value watersheds may be missing from the available public data was unavailable. If corrections or updates become available, they should be incorporated in the GIS database and the secondary greenspace analysis for the Schuylkill River watershed (see Recommendations **R6.16** and **R6.17**).

Scenic Rivers

This digital data set represents Scenic Rivers, as designated by PA DCNR, and was generated with data from USGS hydrology data layers and tax parcel maps.

¹ GIS data for existing and proposed long distance trails in the Schuylkill River watershed is difficult to obtain. Even if it were available, it would require careful evaluation to assess each trail’s contribution to greenspace connectivity. For example, the Cross-County trail that runs along Plymouth Creek in Montgomery County is essentially a bike path that crosses shopping mall parking lots and mown grass for at least some of it’s length. In these areas, it provides no real benefit as a natural areas connector, when compared to the Horseshoe Trail in northern Chester County which is a much more valuable conservation corridor.

National Historic Landmarks

This digital data set represents National Historic Landmarks, as designated by the National Park Service and adopted by PA DEP, and was generated from 1:24,000 USGS topographic maps.

Inactive Railroads

This digital data set represents the location of inactive rail lines digitized from 1:24,000 USGS topographic maps on a stable mylar base and has been adopted by PA DEP.

Results and Discussion

All of the above data sets were mapped as secondary components of the proposed greenspace plan for the watershed in the map: [Sensitive Lands](#).

Some components, the inactive railroads for example, may not necessarily be high quality natural lands, but could be important greenway corridor opportunities that may require ecological restoration to provide viable habitat function.

6.4.4 Contiguous Forested Land Cover

The map: [Regional Land Cover](#) shows land cover conditions for the Schuylkill River watershed and its immediate regional surroundings. This data layer was compiled and classified by the Multi-Resolution Land Characteristics Interagency Consortium (MRLC) using Landsat Thematic Mapper satellite imagery from 1991, 1992, and 1993 (Vogelmann et al. 1998). MRLC satellite imagery has a resolution of 30m, meaning that each pixel in the satellite scene measures 30m by 30m, with the raw satellite data being classified into fifteen different land cover categories.

While it is important to know exactly how much area exists as forest within the watershed, it is also important to know the quality and configuration of that forest. Large, contiguous patches of natural forest are able to support higher numbers and different types of species than small fragmented patches.

A wealth of conservation biology literature documents the importance of patch size for ecosystem function and species preservation (Quammen 1996, pp 385 - 498). In this Plan, a simple attempt was made to identify the largest forest patches existing within the Schuylkill River watershed: specifically, blocks of contiguous forest greater than a certain acreage. This information may be significant in identifying lands for potential preservation and protection.

Results and Discussion

The map titled [Composite Proposed Greenspace](#) shows contiguous forest patches larger than 500 acres. These patches were isolated using a coarse filter and the MRLC Landsat land cover data. The largest forest patches are in the northern subwatersheds, which are the most forested. Some significant patches also can be seen, however, in the subwatersheds along the southwest border of the watershed, including Schuylkill River 5, Hay Creek, and French Creek.

This is the final data layer added to the potential greenspace plan. It provides the “glue” by which the skeleton of greenspace begins to form a cohesive pattern. This clearly helps to identify the major patterns of preservation that could help to sustain the Schuylkill River watershed landscape.

6.4.5 Additional Greenspace GIS Data

During the Public Meetings, it was noted several times that various other data could be added to the potential greenspace analysis. For example, the unused US ACE desilting basins, already largely in public ownership along the Schuylkill River, were highlighted as wetland restoration opportunities. If restored, these basins could provide terrestrial and aquatic habitat, particularly for bird migrations. A network of restored wetlands could be created in close proximity to the Schuylkill River that would link Hawk Mountain Sanctuary at the Blue Mountain/Kittatinny Ridge and Tinicum Wildlife Refuge in Philadelphia, for example. However, most other suggested components are not yet available as vector-digitized GIS components, and so mapping of such site-specific details could not be easily accomplished for this project. It is recommended that a GIS database be established and upgraded on a regular basis so that such additional GIS data sets can be included in future analysis. See Recommendations **R6.16** and **R6.17**.

6.4.6 Overview of Locational Data Analysis Results

After analysis of the components discussed above, it was calculated that more than 200,000 acres, (approximately 15%), of the Schuylkill River watershed represent sensitive lands that are a high priority for protection. A [Sustainable Landscape Vision](#) map was developed based on the [Sensitive Lands](#) map and [Composite Proposed Greenspace](#) map, as a simplified, conceptual example of a potential greenspace network for the watershed.

Despite the fact that many of the proposed greenspace components currently receive a certain amount of protection under Federal and/or State laws, in reality, policies that afford this protection can change at any time. The goal should be, wherever possible, to provide additional protection for these sensitive habitats and proposed greenspaces by securing them for permanent protection as part of the greenspace network in the Schuylkill River watershed. To do this, several land protection options are available (see **Section 6.9**).

6.5 Subwatershed Analysis

For analysis and comparison purposes, the Schuylkill River watershed was analyzed using 37 subwatersheds (see the map: [Watershed Orientation](#)). As mentioned previously, a number of criteria were used in delineating the size of watershed selected for use. The scale had to be fine enough that trends could be seen throughout the watershed and comparisons made, yet the analysis could not exceed the resolution of the data. Consideration was also given to the scale of subwatersheds for which watershed conservation plans have been, or are being, developed. A subwatershed scale was selected to facilitate integration of those plans with this project. It was therefore decided that a subwatershed size of about 31,000 acres (i.e., 125 square km or 12,500 ha) would suffice.

Some of the subwatershed maps used and generated in this section, as well as in the water quality modeling section, follow the format used in the report *An Ecological Assessment of the United States, Mid-Atlantic Region: A Landscape Atlas* (Jones et al. 1997). Each subwatershed is color coded to show the relative condition for a given parameter.

As mentioned earlier in Chapters 3 and 5, satellite data showing land cover is available for the southeast PA region, including the Schuylkill River watershed, and dates from the early 1990s. The raw satellite data sets are too large for use with standard desktop computers. Instead, a processed version of the data by MRLC can be used more easily within a GIS. These data has a 30-meter resolution, and within this area spectral signatures for each pixel are averaged and classified by dominant land cover. In other words, if a pixel contains portions of a one-lane road at 10%, a small house and yard at 30% and a deciduous forest at 60%, the pixel will be classified as 100% deciduous forest. This means that large landscape features, such as forest cover, are likely to be overemphasized at the expense of smaller landscape features, such as vernal pools, etc. Although not a perfect solution, this is probably the best, most cost-effective land cover data set currently available for completing the watershed GIS analysis.

Even with the limitations set out above, the MRLC land cover data still gives a good sense of general trends in land cover conditions throughout the watershed area, as shown in the map: [Regional Land Cover](#). Forested lands are most prevalent in the upper, northwestern part of the watershed and to a lesser extent as a band in the central part of the watershed. Agriculture is most concentrated in a band across northern Berks County, and is otherwise dispersed throughout the middle and lower portions of the watershed. Urban/residential land use is greatest in and between the cities of Reading and Philadelphia. In aggregate, the maps [Forested Land Cover](#), [Agricultural Land Cover](#), and [Urban/Residential Land Cover](#) imply a regional pattern of three distinct zones of land use across the watershed. These areas are referred to as Habitat, Agricultural and Urban/Suburban Zones (see the map: [Sustainable Landscape Vision](#)).

6.5.1 Habitat Value Based on Land Cover

Each of the fifteen MRLC land cover classes can be valued according to habitat potential. During Natural Land Trust's *Smart Conservation* project these fifteen land cover classes were assigned habitat values ranging from very poor, poor, adequate to good for each of 6 taxa classes (i.e., mammals, birds, herpetofauna (i.e., reptiles and amphibians), invertebrates, plants and aquatics). A panel of regional experts and scientists assigned the habitat values. Information at <http://www.smartconservation.org> and in the online Reference Documents shows how these habitat evaluations then were applied to each of the 15 MRLC land cover classes, with different evaluations for each of the six taxa groups. These habitat evaluations were converted into analysis maps (see the maps: [Aquatics Habitat Value](#); [Birds Habitat Value](#); [Herpetofauna Habitat Value](#); [Invertebrates Habitat Value](#); [Mammals Habitat Value](#); and [Plants Habitat Value](#) in the online Reference Documents). Each land cover class was weighted according to its assigned habitat value and the cumulative average habitat score for each taxa group was generated by subwatershed. A generalized habitat value map was produced, which incorporates the habitat values from each of the contributing taxa maps. This composite of all of the habitat values of the six different taxa groups is shown on the [Summary Habitat Value](#) map.

Since these assessments are based on land cover data, and since forest and wetland cover types generally were valued higher as habitat than other land cover types, the resulting habitat patterns are somewhat predictable. However, the value of this analysis is to simplify the complexity of the 15-class land cover maps into a habitat map that displays a clearer pattern and summarizes the relative importance of land cover types as natural habitat.

The PA Gap Analysis Project (PA GAP) has used a similar technique, but also has incorporated wildlife range and elevation data into their analysis for Pennsylvania vertebrate assessments (e.g., bird, mammal, herpetofauna and aquatic vertebrates). Since PA GAP's effort was concurrent with this watershed conservation planning project, the simplified version generated by the project team was used rather than

PA GAP’s more complex assessments. More on the PA GAP assessment techniques is available at <http://128.118.47.95/erri/projects/gappage.htm> by following the links for *Wildlife Habitat Relations*. It is recommended that these improved habitat analyses be incorporated into future GIS updates, as they become available (see Recommendation **R6.17**).

Results and Discussion

Based on the resultant map of [Summary Habitat Value](#), the following appear to be the highest priority subwatersheds for habitat protection in the Schuylkill River watershed (**Table 6.1**). These areas are focused in two geographically distinct areas, which will be referred to as the Kittatinny Habitat Zone and the Reading Horseshoe Habitat Zone.

Table 6.1 Priority Habitat Zones in the Schuylkill Watershed

<i>Priority</i>	<i>Kittatinny Habitat Zone</i>	<i>Reading Horseshoe Habitat Zone</i>
<i>Highest (1)</i>	Little Schuylkill River – Lower Little Schuylkill River - Upper Schuylkill River Headwaters	Hay Creek
<i>Medium High (2)</i>	Schuylkill River Eight	
<i>Medium Low (3)</i>	West Branch Schuylkill River	Unami Creek Upper Perkionmen Creek Upper Manatawny Creek Schuylkill River Five Schuylkill River Four French Creek
<i>Lowest (4)</i>	Upper Maiden Creek	Pickering Creek Swamp Creek Lower Manatawny Creek

At the other end of the spectrum, the most impacted subwatersheds that have the lowest habitat value, according to this analysis, are Schuylkill River Tidal and Upper Tulpehocken Creek. The cost of restoring good quality habitat in these areas may not be as cost-effective or as critical in conserving watershed habitat as conserving or restoring lands in some of the higher priority habitat subwatersheds.

6.5.2 Habitat Value by Region

After assessing the pattern of subwatershed habitat values within the Schuylkill River watershed, these results were reviewed as part of the regional pattern that extends beyond the boundaries of the watershed. As mentioned above, the subwatershed analysis indicates two primary regions of habitat value:

- The Kittatinny Habitat Zone
- The Reading Horseshoe Habitat Zone

These two landscape units not only create habitat opportunities within the Schuylkill River watershed but are integral components of more extensive, contiguous habitats of regional significance that extend in a broad southeast-northwest direction beyond the Schuylkill River watershed boundaries.

The Reading Horseshoe, in the central portion of the watershed, is effectively an extension of the Highlands province. The Kittatinny in the upper part of the watershed ties into the larger geologic feature of the Ridge and Valley province. Maintaining the integrity of these habitat zones in the Schuylkill River watershed therefore will have the added benefit of supporting these two larger regional corridors that are significant landscape features and wildlife dispersal corridors for the East Coast.

The key differences between these two habitat zones are that the Kittatinny Zone is probably more ecologically valuable, as compared to the Reading Horseshoe Zone. It is important to note for future funding possibilities that extension of the Highlands Province to include the Reading Horseshoe is under consideration for adoption by the Highlands Coalition (T. Dillingham, *pers.comm.*). The Highlands Province may obtain special standing with several federal programs, such as the Land and Water Conservation Fund and the Forest Legacy Program, which may qualify conservation projects in this area for preferential funding. Attaching additional lands in Pennsylvania to those already designated in New Jersey and New York could result in similar preferential treatment from several potential funding sources.

In addition to these two habitat zones, two other landscape zones stand out from the subwatershed analysis: the Agricultural Zone, that lies north of Reading and south of the Kittatinny Ridge, and the subwatersheds at the south end of the river corridor; and the Urban/Suburban Zone, that is experiencing the most dramatic land use changes and impacts due to decentralization of population from the Philadelphia metropolitan region.

6.5.3 First Order Stream Frequency and Forested Land Cover

“Protecting our water supplies is in large part done through protecting forests. The highest quality water comes from forests: the older the forest, the better the water quality,”(Franklin 1990, in Drengson 1997).

The purpose of this analysis was to establish conservation priorities that will help protect water quality from non-point source pollution by preserving open space. This analysis does not take into account point source pollution such as acid mine drainage or municipal sewage treatment outfalls. It seeks to correlate the health of land cover with stream water quality within each subwatershed of the Schuylkill. The satellite data used was not of sufficient detail to consider specific riparian conditions in the subsequent analysis, but considers the average land cover conditions for each subwatershed.

6.5.3.1 First Order Streams

Stream order is a “measure of the position of a stream in the hierarchy of tributaries,” (Leopold 1994). Stream orders provide a way to organize and analyze stream networks. Often stream order is associated with stream and watershed size, where first order streams are the smallest; however this relationship does not always hold true. First order streams have no tributaries; second order streams only have first order tributaries and so on (see **Section 3.4.2** of *Chapter 3.0 Watershed Characterization* for a discussion of stream order).

The map: [Stream Order](#) shows the orders for all the streams in the Schuylkill River watershed. **Table 3.1 Stream Orders and Stream Lengths** in *Chapter 3.0* summarizes the lengths for each stream order throughout the watershed. First order streams comprise 56.56% of the stream length in the entire watershed, on average. These first order streams are the headwaters streams and often are the most susceptible to human impacts. These also are the streams that may have the best chances of being preserved, protected, or restored by proper watershed management and planning.

Stream order for the Schuylkill River watershed was generated in Arc/INFO™ GIS software using the networked stream data layer from PA DEP. All stream orders were then visually quality-checked, and first order streams were extracted into a separate GIS data layer.

6.5.3.2 Analyzing Protection Priorities

Using the contiguous forest and first order stream data layers developed for this Plan, as described above, a correlation was run to determine which subwatersheds in the Schuylkill River watershed have the best forest cover relative to the highest frequency of first order streams. This analysis can help prioritize which subwatersheds should be targeted for protecting both forest and water quality resources. Priorities were established by determining the subwatersheds with the highest forest cover and correlating these with subwatersheds that have the highest percent-length of 1st order stream. While this analysis was not detailed enough to determine the health or requirements for restoration of riparian corridors, the general consensus is that forested landscapes promote better hydrologic regimes, reduce nutrient and sediment loads, and help mitigate thermal pollution of water resources.

The 37 subwatersheds within the Schuylkill River watershed were classified by percent of forested land cover and by percent of first order stream frequency (see the map: [First Order Streams & Forest Cover](#)). The forested land cover analysis was based on MRLC Landsat imagery generated in the early 1990s and was classified as a percentage for the entire land cover within a subwatershed. The first order stream frequency is an index that measures the first order stream's length as a percentage of the total length of streams within each subwatershed.

Results and Discussion

A comparison of the five most forested land cover subwatersheds with the eight subwatersheds having the highest first order stream frequency, shows an overlap of only two subwatersheds (see the map: [Primary Protection Subwatersheds](#)). These two subwatersheds, Hay Creek and the Lower Little Schuylkill, both have more than 70% forested land cover and 60% first order stream frequency. These areas are generally well forested and have high ecological value for sustaining biodiversity and water quality.

It is known that there are significant impacts from acid mine drainage in the Lower Little Schuylkill. However, because the terrestrial habitat is apparently fairly intact in this subwatershed, it still should be a priority for protection on the assumption that acid mine drainage issues can be addressed at a future date and point sources of pollution may be successfully mitigated.

The second priorities for protection based on this analysis are the Schuylkill River Headwaters and the Upper Little Schuylkill River subwatersheds. These two subwatersheds both have more than 70% forested land cover and between 57.5% and 60% first order stream frequency.

Third priority is the West Branch Schuylkill River subwatershed, which has more than 70% forested land cover and between 55-57.5% first order stream frequency. At this point, a natural break in the analysis makes further prioritization for protection less obvious. **Table 6.2** summarizes the first order stream and forest protection priorities.

Table 6.2 Protection Priorities Based on First Order Stream/Forest Analysis

<i>Stream/Forest Protection Priority</i>	<i>Kittatinny Habitat Zone</i>	<i>Reading Horseshoe Habitat Zone</i>
Highest (1 st)	Little Schuylkill - Lower	Hay Creek
Medium (2 nd)	Schuylkill River Headwaters Little Schuylkill – Upper	
Lowest (3 rd)	West Branch Schuylkill	

6.5.3.3 Analyzing Restoration Priorities

Using the same analysis procedure, there also was an opportunity to prioritize the subwatersheds for restoration: by analyzing the subwatersheds that have more than 60% first order stream frequency and the lowest levels of forested land cover. These areas would be highly susceptible to habitat and water quality degradation.

Results and Discussion

The map [Primary Restoration Subwatersheds](#) shows that Upper Tulpehocken subwatershed is a clear priority from a restoration perspective. This subwatershed has more than 60% first order streams but less than 33% forested land cover.

Secondary priorities for restoration are four additional subwatersheds that have greater than 60% first order streams and only 33-55% forested land cover. In order of priority for restoration, these are:

- Little North Kill subwatershed (36% forested cover);
- Skippack Creek subwatershed (37.6% forested land cover);
- Ontelaunee subwatershed (41% forested land cover); and
- Upper Maiden Creek subwatershed (51% forested land cover).

Within these subwatersheds, an assessment of the riparian conditions would further inform prioritization. Local conservation entities could collect the necessary detailed riparian data, and/or localized aerial photography could be reviewed by consultants developing the proposed Strategic Restoration Plans (see Recommendation **R6.8**).

Restoration priorities (primarily in the form of reforestation) could begin with riparian buffers immediately along waterways, and extend into upland areas as the opportunity arises. Upland reforestation could focus initially on marginal agricultural lands and/or steep slopes currently in row crops or other human-influenced land uses. If carried out on private lands, reforestation should be encouraged particularly where permanent protection can be guaranteed to ensure that good returns on this investment.

6.5.4 Overview of Subwatershed Analysis Results

Map: [Watershed Priorities](#) summarizes the habitat conservation and restoration analysis results discussed above. In addition, at the landscape level, the GIS mapping has revealed several patterns of significance for a greenspace network and landscape sustainability.

- The dendritic pattern of the riparian corridors throughout the watershed, which when combined with riparian buffer creation and protection, offer one of the best opportunities to address the need for landscape connectivity across the watershed.
- The primary importance of the east-west forested landscape-scale feature of the Kittatinny Habitat Zone, both within the Schuylkill River watershed, and as a connecting link in the larger Ridge and Valley province that is integral to habitat connectivity on the East Coast.
- The secondary importance of the east-west forested landscape-scale feature of the Reading Horseshoe Habitat Zone, which is also under the greatest threat from population growth in the next decade.
- The valley in the upper-mid watershed, between the Kittatinny Zone and the Reading Horseshoe, dominated by agriculture. The subwatersheds in this Agricultural Zone become priorities for greenspace corridor and riparian buffer assessment, to maintain ecological connectivity between the Kittatinny and Reading Horseshoe habitat zones. This will encourage ecosystem viability, while agricultural preservation and best management practices also are critical to maintaining environmental health.
- The Urban/Suburban Zone in the lower watershed, south of the Reading Horseshoe, impacted primarily by urban sprawl. Opportunities for open space protection and habitat restoration/creation in this area are unlikely to cause a significant improvement the overall ecological health of the watershed. However, securing riparian buffers (particularly on first and second order streams) while preserving the identified potential greenspaces and managing existing protected lands in this zone will provide scenic, recreation and environmental education benefits to the watershed population that is primarily concentrated in this area.

6.6 Threat Assessment – Population Change

An analysis of population change was performed in the Schuylkill River watershed for the years 1990 to 2010. Population data were obtained from the 1990 Census Bureau for each municipality in the watershed. The geographic municipal boundaries for the state of PA were downloaded from the PASDA website.

A linear regression was performed on the 1990 population of each municipality to project the populations for 2010.² The population forecasts were then added to the GIS coverage of municipal boundaries. After finding the 2010 population forecasts for each municipality, a density was calculated, expressed as number of people per unit area. The population density was used to calculate the total number of persons per subwatershed. Note that where only a portion of a municipality was contained in a subwatershed, the density reflects the population for only that portion of the municipality contained in the subwatershed. A few important assumptions were made in calculating the population forecast.

- Population density is assumed to be uniform within each municipality.
- Population densities are assumed to remain constant through time.

² Both Montgomery County Planning Commission and the Delaware Valley Regional Planning Commission noted during the comment period for the draft Plan that municipal population projections, which they felt might be more accurate than the linear regression, are available from each County and DVRPC. There were also concerns that the population density assumptions used in this technique could lead to inaccuracies in identifying growth. Please note, therefore, that the data presented in this plan is a rough estimate of growth. Users are encouraged to contact their local County Planning Commission and/or to check DVRPCs website (<http://www.dvrpc.org>) to obtain growth projections *by municipality* (note that growth projections by subwatershed are not currently available from these agencies).

Results and Discussion

Population change values for each subwatershed for 1990-2010 can be seen in map: [Estimated Population Change](#). The results of the population forecast suggest that approximately 75% of the municipalities in the watershed will experience continued growth in population through the year 2010.

The most notable exceptions are Philadelphia County (Tidal Schuylkill River, Schuylkill River 1 and Lower Wissahickon subwatersheds) and the surrounding municipalities, as well as the three most ecologically valuable subwatersheds of the Kittatinny Habitat Zone (Schuylkill River Headwaters, Little Schuylkill River – Upper and Lower). The decentralization in urban populations is a prime factor in the dramatic rise of suburban populations, as is the out-migration typical of more rural, economically challenged areas like Schuylkill County.

For the Kittatinny Habitat Zone, the following table (**Table 6.3**) highlights the threat/habitat issues, based on population growth, habitat value, and protection priority. In this table as in **Table 6.4** below, a value of “1” represents a high priority.

Table 6.3 Threat Issues, Habitat Value and Protection Priorities for Kittatinny Habitat Zone

<i>Medium Threat Subwatersheds (11-20% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
West Branch Schuylkill	3	3
Upper Maiden Creek	4	-
<i>Low Threat Subwatersheds (1-10% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Schuylkill River 8	2	-
<i>No/Negative Threat Subwatersheds (-22 - 0% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Little Schuylkill Lower	1	1
Little Schuylkill Upper	1	2
Schuylkill River Headwaters	1	2

Meanwhile, the municipalities in Chester County, directly northwest of Philadelphia (Lower Maiden and Lower Perkiomen subwatersheds), are projected to increase by as much as 55-60% between 1990 and 2010. Montgomery, Chester, Bucks and Berks Counties are expected to experience the effects of urban sprawl most extensively.

Of the 10 subwatersheds that comprise the Reading Horseshoe Habitat Zone, all are projected to experience population growth. Factoring this threat in with habitat value yields the following protection prioritization (**Table 6.4**).

Table 6.4 Threat Issues, Habitat Value and Protection Priorities for Reading Horseshoe Habitat Zone

<i>Most Threatened Subwatersheds (>30% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Upper Manatawny	3	-
Pickering	4	-
Swamp Creek	4	-
<i>High Threat Subwatersheds (21-30% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Hay Creek	1	1
French Creek	3	-
Unami Creek	3	-
<i>Medium Threat Subwatersheds (11-20% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Upper Perkionmen	3	-
Schuylkill River 4	3	-
<i>Low Threat Subwatersheds (1-10% population growth projection)</i>	<i>Habitat Value</i>	<i>Stream/Forest Protection Priority</i>
Schuylkill River 5	3	-
Lower Manatawny	4	-

From the above analysis, it seems fair to say that the Kittatinny Habitat Zone in general has the highest habitat value, with the lowest threat from population pressure and expansion, while the Reading Horseshoe Habitat Zone has comparatively lower habitat value but is under significantly more threat from projected population growth.

It should be noted further that Lower Little Schuylkill River and Hay Creek have both the highest habitat value and the highest Stream/Forest Protection Priority, but that Hay Creek is under significant population expansion threat, while Lower Little Schuylkill River appears to be less threatened by population growth.

6.7 Conclusions: The Need for a Watershed Land Protection Collaborative

Should the highest habitat value lands be preserved first, regardless of threat, or should the most threatened landscapes be the focus of protection activities, regardless of habitat value? Who makes the final decisions about what should be protected first, given the analysis provided above?

These are difficult questions to answer. It seems likely that some combination of these strategies will be the most effective in preserving and restoring the watershed's sustainable landscape. Ultimately, these questions need to be resolved by a Watershed Land Protection Collaborative. The conservation community in the watershed, together with representatives from other watershed stakeholders from the development, infrastructure, business, industry/commerce and municipal sectors needs to convene and come to consensus around these questions. Part of the solution lies in the fact that different conservation organizations have different service areas across the watershed. These service areas will determine organizational priorities of each group relative to the sustainable landscape priorities highlighted in this Plan. For example, Berks County Conservancy is unlikely to be directly involved in preserving lands in

Bucks County, even if the most threatened, highest quality natural area in the watershed were to be found there.

A Watershed Land Protection Collaborative needs to be established to decide who will take to lead on protecting which conservation resources. The data presented here serve as inputs to those discussions, but the decisions rest finally in the geopolitical arena. The one essential task of the Watershed Land Protection Collaborative (as recommended by this Plan for implementation) should be to ensure that every sustainable landscape resource has been assigned to a conservation organization, and that conservation priorities that are acceptable to the Collaborative are established. The Collaborative’s goal should be to ensure that the largest amount of the highest value sustainable landscape resources capturing regional diversity are protected over the next 25 years in a connected greenspace network that is ecologically viable now and into the coming decades, or preferably, centuries. See Recommendation **R6.1** for further discussion of this issue.

6.8 Detailed Recommendations for Landscape Sustainability

This section presents detailed recommendations for promoting a sustainable landscape in the Schuylkill River watershed. Each recommendation is listed in a table by its code, the name of the recommendation, a representative list of appropriate groups/agencies that might implement or guide the implementation of each recommendation, the key land use/landscape issues addressed, and the landscape sustainability section(s) and/or map(s) referenced in this chapter, to which each recommendation corresponds. Each table is followed by a detailed description of the recommendation.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.1	Establish a Watershed Land Protection Collaborative (WLPC) to Proactively Protect Greenspace	WLPC composed of watershed nonprofits and government agencies with the resources to pursue land protection	Loss of natural lands Need for greenspace Strategic conservation	Sections 6.5, 6.6, 6.7 Sustainable Landscape Vision map Sensitive Lands map Composite Proposed Greenspace map Watershed Priorities map

Description

More than 200,000 acres of sensitive natural lands have been identified as high priorities for protection in the Schuylkill River watershed. These lands include steep slopes, wetlands and floodplains as primary components and Exceptional Value watersheds, Scenic Rivers, National Historic Landmarks and inactive railroads as secondary components. This acreage is exclusive of contiguous forest blocks >500 acres, and exclusive of additional protection opportunities that may be discovered with further analysis of the primary protection subwatersheds in the Habitat Zones. The 200,000 acre guideline (i.e., 15% of the land area of the watershed) should be considered a functional minimum for promoting a sustainable landscape in the Schuylkill River watershed.

Detailed mapping (see maps listed in the table above) led to the development of a conceptual vision for a proposed greenspace network in the watershed. The map: [Sustainable Landscape Vision](#) identifies proposed habitat zones, greenspace corridors, habitat links to greenspace opportunities outside the immediate boundaries of the watershed, secondary greenspace nodes in the agricultural and urban/suburban zones, as well as the highest priority subwatersheds for protection and restoration. Greenspace components are distributed throughout the watershed, which will help ensure that a connected network of greenspace is preserved, and help maintain the viability of ecosystem processes, water quality, and species movement across the region.

A Watershed Land Protection Collaborative (WLPC) composed of watershed conservation groups working together needs to be established, to promote strategic land conservation and efficient resource use, and to decide who will take to lead on protecting which conservation resources. The data presented in this Chapter serve as inputs to those discussions, but the decisions rest finally in the geopolitical arena. The one essential task of the Watershed Land Protection Collaborative should be to ensure that every sustainable landscape resource has been assigned to a conservation organization, and that conservation priorities that are acceptable to the Collaborative are established. The Collaborative’s goal should be to ensure that the largest amount of the highest value sustainable landscape resources capturing regional diversity are protected over the next 25 years in a connected greenspace network that is ecologically viable now and into the coming centuries.

Watershed-based nonprofits (Land Trusts and Conservancies) should take the lead in proactive land protection. Land Trusts and Conservancies, or indeed any bona-fide conservation entity in the watershed with the eligibility, qualifications and resources to buy land or hold easements, should be encouraged to work collaboratively to promote the common goals and recommendations of land preservation throughout the watershed. PALTA (Pennsylvania Land Trust Association) may be the best vehicle for setting up such a watershed land protection collaborative. Representatives from Forestry, Development, Infrastructure Planning and Commerce/Industry and all municipalities should be invited to participate in implementing the plan’s open space goals and sustainable landscape vision. Perhaps a Steering or Technical Advisory Committee can be appointed to oversee activities and coordination.

An overview of protection options is discussed at the end of the sustainable landscape section of this Plan under **Section 6.9 Sustainable Landscape Protection and Implementation Tools**. Use of *Smart Conservation* (<http://www.smartconservation.org>) or other rapid assessment techniques may help further prioritize which of these sensitive lands to protect first.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.2	Refine Prioritization of Watershed Natural Lands using a Standardized Relative Assessment Tool	Watershed conservation nonprofits, academics, scientific experts, government	Loss of natural lands Need for greenspace Strategic conservation	Sections 6.3.2, 6.4.1 Sensitive Lands map Composite Proposed Greenspace map

Description

Given the 200,000 acres of potential greenspace identified by this Plan, the watershed conservation community should take proactive steps to further prioritize high priority, sensitive lands according to their ecological value and degree of threat. Conservation groups should use established landscape analyses and relative assessment tools to refine land prioritization and to conserve the high priority potential greenspace identified in this Plan.

Natural Lands Trust has pioneered a technique called *Smart Conservation* that may meet the needs of this recommendation. The *Smart Conservation* assessment tool is under development, but preliminary results for setting conservation priorities are promising. NLT has tried to incorporate the best conservation science thinking into these assessments by inviting more than a hundred local experts from over eighty organizations and government agencies to provide input and review of the technique. NLT is also interested in having conservation entities learn how to use the tool, so that they can test it by doing their own assessments for conservation sites throughout southeast Pennsylvania. Conservation groups who have ideas to contribute, or who are interested in being involved with developing the technique should contact NLT for further information. For more information, see <http://www.smartconservation.org>.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.3	Support Outreach and Education Programs Providing Landowners with Land Preservation Options	Conservation organizations who have regular contact with landowners, such as Penn State Cooperative Extension, NRCS and nonprofits/land trusts	Loss of natural lands Need for greenspace Guidance on ecological management	General

Description

Private citizens, who may have little understanding of the land preservation and ecological management options available to them, own the vast majority of lands proposed for preservation in the watershed. A growing list of protection and implementation tools balance land protection with landowner needs (see **Section 6.9** for more information). In order to improve the likelihood of protecting these critical resources, outreach and education efforts should provide landowners with viable options and guidelines for land preservation and ecological management.

Several conservation nonprofits already have developed sophisticated materials to help landowners understand their choices regarding protection of their land. These materials could be used as models for the development of educational materials specifically for use in the Schuylkill River watershed. The distribution of these materials to educate landowners about their conservation choices also will raise awareness of land protection and stewardship needs in the Schuylkill River watershed.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.4	Proactively Protect PA Natural Diversity Inventory (PNDI) Sites	WLPC, nonprofits and agencies with resources to pursue land protection, along with PNDI staff	Loss of natural lands Need for greenspace	Section 6.4.2.1 PNDI Site Types map PNDI Site Scores map Composite Proposed Greenspace map

Description

This is a sub-recommendation of **R6.1**, intended to highlight the special issues of PNDI sites as a critical component of the proposed greenspace network.

Within the proposed greenspace network, the PNDI sites should be one of the highest priorities for protection. These sites represent the most threatened biodiversity in the watershed, and their preservation will help to maintain species and genetic biodiversity across the watershed (see the maps listed in the table above). PNDI sites are spread throughout the watershed, although some of the highest ranked sites are found within Berks County. Protection of PNDI areas should be implemented in order of priority and threat, and to ensure a balanced portfolio of species and community biodiversity.

The PNDI scores establish clear priorities for protection of rare or threatened species in the watershed. Higher scoring sites should be targeted for protection before lower scoring sites, where possible. Sites with the highest scores should be pursued proactively for protection through fee or conservation easement by conservation entities. Watershed-based nonprofits (land trusts and conservancies) should work collaboratively with support from government to target PNDI sites for protection. **Section 6.9** below provides an overview of land protection and implementation options.

While it is important to protect the highest-ranked or most threatened sites first, it is also important to save a representative sample of sites, which reflect the maximum species diversity across the watershed – i.e., to select sites to maximize a species diversity portfolio. This latter task is currently handicapped by the PNDI species coding

system, which has been established to protect the rare species from poaching and disturbance. Watershed conservation entities, working in conjunction with the PNDI staff, should develop a PNDI portfolio targeted at promoting representative biodiversity.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.5	Proactively Protect Identified Greenspace Nodes	WLPC, nonprofits and agencies with resources to pursue land protection	Loss of natural lands Need for greenspace	Section 6.4 Sustainable Landscape Vision map Sensitive Lands map PNDI Site Types map PNDI Site Scores map Composite Proposed Greenspace map

Description

This is a sub-recommendation of **R6.1**, intended to highlight special issues of greenspace nodes as critical components of the proposed greenspace network.

Various government-owned lands already can be considered greenspace nodes within the watershed. However, the overall acreage (4.5% of the watershed) and uneven distribution of these lands suggests that alone they are inadequate to achieve a sustainable landscape. The existing greenspace network needs to be supplemented with the addition of other large area, sensitive natural lands that deserve protection.

Analysis completed for this Plan indicates where sensitive natural lands are throughout the watershed (see the maps noted above). The PNDI and Proposed Greenspace maps document the rationale for, and show the distribution of, proposed greenspace nodes in the watershed. Primary greenspace components include PNDI sites, NWI sites, floodplains, steep slopes, and IBAs. Secondary components represented are Exceptional Value Watersheds, Scenic Rivers, National Historic Landmarks and inactive railroads. Each of these components represents a potential greenspace node or corridor, and identifies greenspace “hotspots” where two or more of components overlap. Protecting these hotspots will efficiently leverage resources; therefore these areas should be among the first targets for conservation action.

Watershed-based nonprofits (land trusts and conservancies) should take the lead in proactive land protection and work collaboratively with public agencies and other watershed stakeholders to implement the sustainable landscape vision. Within the Kittatinny and Reading Horseshoe Habitat Zones, a Strategic Protection Plan (see Recommendation **R6.7**) needs to be developed for each subwatershed before specific greenspace nodes and corridors can be proposed. Use of *Smart Conservation* (<http://www.smartconservation.org>) or other rapid assessment techniques may help prioritize further which potential greenspace nodes to protect first.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.6	Proactively Protect, Restore and Create Identified Greenway Corridors	WLPC, nonprofits and agencies with resources to pursue land protection	Loss of natural lands Need for greenspace Landscape connectivity	Section 6.4 Sustainable Landscape Vision map Sensitive Lands map Composite Proposed Greenspace map

Description

This is a sub-recommendation of **R6.1**, intended to highlight the special issues of greenspace corridors as a critical component of the proposed greenspace network.

Existing and proposed greenspace nodes need to be connected across the watershed by the addition of natural land corridors to ensure biological exchange (e.g., migration, pollination, colonization) and on-going viability of watershed species and populations. In many cases, corridors can serve a dual purpose as riparian buffers, which help protect water quality. If natural land corridors also are considered as recreational opportunities, care should be taken to ensure that the habitat resource is not degraded by excessive or inappropriate human use. Disturbance from recreational use should be carefully monitored and withdrawn if necessary to maintain ecological integrity.

Existing protected lands in the watershed are unconnected, as are the proposed habitat zones and greenspace nodes, unless greenspace corridors are protected. In order to create a sustainable landscape in the watershed, greenspace corridors must play a vital connecting role to ensure biological exchange and habitat resilience throughout the watershed. Analysis completed for this Plan indicates where sensitive natural lands and potential greenspace corridors are located throughout the watershed (see the maps noted above).

Primary components that could serve as greenspace nodes or corridors include PNDI sites, NWI sites, floodplains, steep slopes, and IBAs. Secondary components include Exceptional Value Watersheds, Scenic Rivers, National Historic Landmarks and inactive railroads. Greenspace components that lend themselves to corridor development in particular tend to be the linear elements: floodplains, steep slopes and inactive railroads, along with Scenic Rivers. Greenspace corridors will be important especially within the Agricultural and Urban/Suburban zones, where they can also serve as riparian buffers in deforested landscapes.

Watershed-based nonprofits (land trusts and conservancies) should take the lead in proactive land protection and work collaboratively with public agencies and other watershed stakeholders to implement the sustainable landscape vision. Within the Kittatinny and Reading Horseshoe Habitat Zones, a Strategic Protection Plan (see Recommendation **R6.7**) needs to be developed for each subwatershed before specific greenspace corridors can be proposed. Use of *Smart Conservation* (<http://www.smartconservation.org>) or other rapid assessment techniques may help prioritize further which potential greenspace corridors to protect first.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.7	Develop Strategic Protection Plans for Identified Subwatersheds in Habitat Zones	Any watershed conservation entity, or a consortium, with the expertise and experience necessary to develop the plans	Loss of natural lands Need for greenspace Guidance on ecological management Strategic conservation	Sections 6.5.3.2 and 6.6 Primary Protection Watersheds map Summary Habitat Value map Watershed Priorities map

Description

According to the analysis conducted in this Plan, the Kittatinny and Reading Horseshoe Habitat Zones appear to be some of the highest quality remaining natural areas in the Schuylkill River watershed. Detailed, site-specific Strategic Protection Plans should be developed for each of the fifteen subwatersheds in these Habitat Zones. Since it is unlikely they can all be undertaken at the same time, the Subwatershed Protection Plans should be developed in order of priority by considering habitat value, forest/stream priorities and threat (i.e., projected population growth) as noted in the tables in **Sections 6.5 and 6.6**.

Strategic Protection Plans should focus on collection of GIS data for tax parcels and zoning data as well as further refinement of relative values for natural resources within the subwatershed. Landholdings then can be assessed at a site-specific level to evaluate priorities and appropriate strategies for protection. Use of *Smart Conservation* (<http://www.smartconservation.org>) or other rapid assessment techniques may help further prioritize which potential greenspace nodes to protect first, and within a greenspace node, which parcels are the lynchpins for preservation.

Recommendations from these Plans likely will include traditional (e.g., fee acquisition and easement) as well as non-traditional protection methods, such as: NLT’s Growing Greener - Conservation by Design program; municipality zoning and ordinance reviews/suggested improvements; community-based conservation; and adaptive ecological land management guidelines. Other planning tools may be useful to consider, such as Transfer or Purchase of Development Rights (TDR and PDR). An overview of many of these implementation tools is given in **Section 6.9**. Once these subwatershed protection recommendations have been developed, an estimated budget can be generated to implement them, with suggestions for where the funds can be raised to achieve implementation.

River Conservation Plans already have been developed or are about to be initiated for several of the priority habitat subwatersheds (see **Section 3.6**). Obtaining any available data and GIS resources from these plans is strongly encouraged, so that the Strategic Protection Plans can be jump-started where possible. Potential funding sources include PA DCNR – Community Conservation Partnership planning grants (requires a 50% match) and PA DEP Growing Greener Watershed Protection planning grants (matches encouraged but not required). Other sources of watershed funding may include private foundations, community funds, corporate and individual donors. Any watershed conservation entity with GIS capabilities, conservation planning and knowledge of land protection tools should be encouraged to apply for funding from PA DCNR and/or PA DEP Growing Greener, or private foundations, to develop the recommended plans.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.8	Develop Strategic Restoration Plans for Identified Primary Restoration Subwatersheds	Any watershed conservation entity, or a consortium, with the expertise and experience necessary to develop the plans	Loss of natural lands Need for greenspace Guidance on ecological management Strategic conservation	Sections 6.5.3.3 and 6.6 Primary Restoration Subwatersheds map

Description

According to the analysis conducted in this Plan, certain subwatersheds in the Agricultural and Urban/Suburban Zones would appear to benefit from some level of habitat and riparian restoration, at least in the form of reforestation. Detailed, site-specific Strategic Restoration Plans should be developed to guide future actions by local conservation groups within the five subwatersheds highlighted for restoration in **Section 6.5.3.3**: Tulpehocken; Little North Kill; Skippack; Ontelaunee; and Upper Maiden Creek. Since it is unlikely all the required plans can be developed at the same time, it is recommended that the first five subwatershed Strategic Restoration Plans should be developed in the order of priority.

To be cost-effective, the Strategic Restoration Plans should focus initially on ensuring maximum riparian buffer coverage along the streams in the priority subwatersheds. The riparian buffers should be created, restored or protected with the understanding that they are also designated greenspace corridors. As such, every effort should be made to reinforce these buffers with permanent land protection. This not only will justify the financial investment made for the restoration, but will ensure that another piece of the watershed greenspace network is secured.

Recommendations of these plans may include restoration guidelines as well as land protection options. An overview of many of these implementation tools is given in **Section 6.9**. Once these restoration recommendations have been developed, an estimated budget can be generated to implement them, with suggestions for where the funds can be raised to achieve implementation.

Berks County Conservancy could take the lead in the Agricultural Zone with Schuylkill Riverkeeper taking the lead in the Suburban/Urban Zone. In conjunction with other local conservation partners e.g., Trout Unlimited Chapters, as well as NRCS, USFWS Partners for Wildlife, PA DEP and PA DCNR, the focus should be on fundraising and Strategic Restoration Plan development. Installation of riparian buffers and habitat restoration should be completed by community groups and volunteers, where possible, to leverage resources and provide environmental education

outreach. Land protection should accompany restoration, which can be facilitated by developing partnerships with land trusts or government agencies who are prepared to hold riparian buffer easements.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.9	Develop and Adopt a Strategic Protection Plan for Watershed-wide Agricultural Land Resources	A task force of watershed agricultural conservation groups such as NRCS, PA Dept. of Agriculture and County agencies involved with the agricultural easement programs	Need for greenspace Guidance on ecological management Strategic conservation	General Agricultural Land Cover map

Description

As mentioned in the introductory chapters, the focus of this Plan from inception was on landscape sustainability, water quality and institutional capacity. While agriculture is acknowledged as critical component of the human communities and natural resources in the watershed, and should be a key part of a comprehensive planning process, agriculture has not been addressed specifically in this Plan due to the scale required for the watershed assessment (2,000 square miles) and the limited resources available. A tight focus on the three primary areas of interest was required to meet the goals of the project.

Although not a focus of this Plan, agricultural preservation can serve a supporting role in maintaining landscape sustainability if ecological BMPs and NMPs are implemented and enforced. Agricultural preservation is also a laudable goal in its own right, and has the potential to support a market for tourism. Data should be collected to document where agricultural preservation already has taken place, and to plan where else it should happen, both in its own right and as a support to a sustainable landscape plan for the Schuylkill River watershed.

Agricultural preservation should be addressed through a separate Strategic Protection Plan, ensuring that the goals of agricultural preservation are fully integrated with the goals of this Schuylkill Watershed Conservation Plan. Once agricultural preservation recommendations have been developed, an estimated budget can be generated to implement them, with suggestions for where the funds can be raised to achieve implementation.

Comments collected during the Public Meetings indicated that several, if not all, of the watershed counties now have GIS data of where agricultural easements exist for lands under their jurisdiction. It may be a fairly straightforward process to collect and compile existing agricultural easements as a discrete watershed data layer. Together with soils information, data on the locations of approved agricultural security districts, and targeted tax parcel and zoning data, a plan can be developed to prioritize which lands should be pursued for agricultural easements or other protection.

Government agencies such as NRCS and/or County Planning Agricultural Easement program staff need to work in coordination with watershed conservation groups that facilitate the agricultural easement process, as well as the watershed farming community, to develop a comprehensive plan for the entire watershed. Berks County NRCS and Berks County Conservancy could be encouraged to play a central role in developing this recommendation, establishing a watershed-wide collaboration to develop the Strategic Protection Plan with support as necessary from other County agencies and nonprofits in the Schuylkill River watershed.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.10	Reactively Protect Natural Resources in the Watershed as Opportunity Arises	WLPC, nonprofits and agencies with resources to pursue land protection	Loss of natural lands Need for greenspace	General

Description

Land protection is both a science and an art. Strategic conservation planning can indicate where are the best natural lands for protection, which ones are under greatest threat, and in what order they should be preserved to maximize the impact of a limited funding base. However, in the context of a “willing buyer-willing seller” paradigm, prioritized plans may not always be implemented in the order suggested. Land protection is very opportunistic, and subject to changes in the land market and the ability and interest of landowners to participate. Therefore, it is vitally important to maintain a flexible approach to land protection that allows for taking action as good opportunities arise. This “reactive” mode of land protection should be seen as a safety net to more “proactive” land protection based on strategic conservation planning.

The critical difference between proactive and reactive land protection rests with the issue of outreach. Proactive land protection involves conservation organizations targeting key landowners and offering expertise and resources to help protect their lands. Landowners and priority lands are identified ahead of time through conservation planning. By contrast, reactive land protection spends no energy or resources targeting landowners, but responds as opportunities arise based on landowner initiative.

If an opportunity arises that is not part of a strategic protection plan, a decision about the cost-effectiveness of the proposed deal will need to be made. It sometimes can be very difficult to make these decisions, since it is always hard to estimate what will be the opportunity cost of completing an unsolicited deal. Members of the land trust community are working to develop methods to help make such decisions easier, at least by providing rapid assessment techniques such as *Smart Conservation* (<http://www.smartconservation.org/>) to help evaluate biological value and threat. But it seems unlikely that tools can be developed to help assess opportunity cost. By committing to an unsolicited, out-of-plan land protection deal, a land trust may use resources that might otherwise have been available to complete a proactive, in-plan opportunity arising shortly thereafter.

Land Trusts and conservancies, or indeed any bona-fide conservation entity in the watershed with the eligibility, qualifications and resources to buy land or hold easements, should be encouraged to work collaboratively to achieve the joint goals of land preservation throughout the watershed. PALTA (Pennsylvania Land Trust Association) may be the best vehicle for setting up such a Watershed Land Protection Collaborative (see Recommendation **R6.1**).

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.11	Promote Development of Forest Resource Management Plans on Privately-owned Forest Lands	PA DCNR Bureau of Forestry, Penn State Co-operative Extension, NRCS and other conservation groups	Loss of natural lands Guidance on ecological management	General Forested Land Cover map

Description

The majority of the watershed’s forest resources are found on private lands. Private landowners of key forested properties should be provided guidance on maintaining or restoring these lands to their natural health and viability. Tailored Forest Resource Management Plans should be developed with the goal of achieving both ecological sustainability and economic returns.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.12	Control Invasive Species and Deer Densities to Enhance Forest Regeneration of Native Plants	PA DCNR and PA Game Commission along with interested nonprofits and government agencies	Loss of natural lands Guidance on ecological management	General

Description

Invasive species, including non-native plants and animals such as white-tailed deer, increasingly threaten the stability and biodiversity of ecological communities. Efforts should be made to control invasive species and reduce white-tailed deer densities in the watershed to levels compatible with forest regeneration of native plants. Demonstration projects, particularly at environmental education facilities, should be developed and supported to address these concerns, especially where the human community is engaged in proposed demonstration land management projects. Invasive species management represents an opportunity to improve habitat quality and to provide environmental education for the watershed public.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.13	Develop Watershed-wide Adaptive Ecological Land Management Guidelines for Protected Lands	A task force of watershed conservation entities with the expertise and experience necessary to develop the guidelines	Guidance on ecological management Strategic conservation	Section 6.4.1, General

Description

As mentioned in **Section 3.5** of *Chapter 3.0 Watershed Characterization*, many biological resources in the watershed are becoming out of balance with the ecosystem due to disturbance caused by human activities. Introduced invasive species – plant and animal, aquatic and terrestrial, vertebrate and invertebrate – are changing the natural processes and native habitat of the Schuylkill River watershed. For example, it is quite likely there are more rodents and small mammals in the watershed now than in pre-colonial times, due to the extirpation of large carnivores. The intricate checks-and-balances imposed by the natural trophic pyramid - who feeds on whom, who outcompetes whom – has been altered under human influence.

To address the worst of these imbalances, those that most threaten to destabilize the ecosystem, generic ecological management guidelines should be developed for issues that are common throughout the watershed. As a supplement to the generic guidelines, site-specific Adaptive Ecological Management Plans (or resource management plans) should be developed for all existing greenspace nodes and corridors and on an on-going basis as additional land protection is secured. These plans should focus on a holistic approach to re-establishing ecological balance, rather than on the needs of any one species or natural community. The only notable exception should be PNDI sites, where the needs of the rare species or community may be given priority over the needs of common communities or species. Much of the effort in these plans needs to be directed to controlling invasive exotic plant species that are known to destabilize ecosystems. A list of plant species of primary concern in this region, by no means exhaustive, is given in **Section 3.5** of this Plan.

The conservation entity holding the land protection rights on a property should accept the responsibility for developing site-specific Adaptive Ecological Management Plans, while watershed guidelines should be developed for approval by a consortium of watershed conservation stakeholders, including both government agencies and nonprofits. All Adaptive Ecological Management Plans should meet a pre-determined quality assurance/quality control protocol.

Such watershed “governance” issues need to be implemented through a watershed administration system that is described in Recommendation **R7.1**, **Section 7.5** of *Chapter 7.0 Institutional Assessment*. At the state level, the Ecosystem Management Advisory Commission (EMAC)³ is focusing on similar issues for state-owned lands throughout the Commonwealth, and may be a source of recommendations and innovative solutions for adaptive management.

³ EMAC is an advisory group of ecological experts that is working with PA DCNR’s Bureau of Forestry to address concerns about ecological management and restoration on Bureau of Forestry lands in Pennsylvania.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.14	Establish Community-Based Programs to Implement Adaptive Ecological Management Plans on All Protected Lands by Priority	Watershed nonprofits and government agencies	Guidance on ecological management Strategic conservation	Sections 6.4.1 and 6.5

Description

As noted in Recommendation **R6.13**, to ensure viability of a sustainable landscape, there is a clear need for Adaptive Ecological Management Plans to be implemented on protected lands throughout the watershed. The issue of resources to implement these initiatives is an obvious concern. Given the choice of maintaining lands already protected, or protecting more land, concern over urban/suburban sprawl usually dictates a decision to support additional land protection. Usually it is easier to raise funding for land protection than for ecological land management.

However, ecological land management offers some unique opportunities for community outreach. Engaging the human community in managing local greenspace is an excellent way to increase awareness and understanding of the ecological issues in the watershed. By developing Adaptive Ecological Management Plans that can be implemented by community-based volunteers, neighborhoods can reconnect with the local ecosystems on which they depend. At the same time, community-based ecological management implementation can leverage precious resources to the maximum extent possible. For example, between 1987 and 1997 in the Wissahickon Park, a budget of less than \$30K/yr was used to great effect planting thousands of native canopy trees, restoring forest canopy gaps that otherwise would be invaded by invasive exotic plants. Hundreds, even thousands, of volunteer hours were harnessed annually. If consultants and contractors had undertaken this work, the costs would have been exorbitant, and much less might have been accomplished. To complement community initiatives that “take back the streets,” communities should also be engaged in the race to “take back the forest.” Coordination, equipment, materials and publicity costs will be incurred initially, but can be leveraged many times over.

A watershed-wide program that facilitates community-based implementation of Adaptive Ecological Management Plans should focus on the Urban/Suburban Zone. Ecological management programs should be run out of existing environmental education facilities, where possible. A consortium of conservation entities needs to be convened, ensuring that the groups with the technical knowledge and experience to develop such ecological management guidelines and plans work with groups that have community outreach experience and resources. Such watershed “governance” issues need to be implemented through a watershed administration system that is described in Recommendation **R7.1** in **Section 7.5**.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.15	Develop and Adopt a Strategic Resources Plan for Watershed-wide Land Protection, Restoration and Ecological Management	PA DEP and PWD could spearhead a task force of watershed conservation entities such as PEC, PA Greenspace Alliance and other nonprofits	Strategic conservation	Sections 6.4.1 and 6.5

Description

There is a shortfall between the financial resources available to protect lands in southeast Pennsylvania and the needs recommended just by this project alone. PA DCNR historically has made available between \$4 and \$8 million annually to land trusts for conservation projects across the Commonwealth based on a 1% tax from real estate

transactions. Land trusts can apply these funds to conservation planning and land protection projects. Of that amount, perhaps \$1.5 million is earmarked for southeast Pennsylvania. Therefore, over 20 years, perhaps \$30 million would be available through this program – but these funds must also be used to fund projects in counties that lie outside the Schuylkill River watershed.

A functional minimum of 200,000 acres of designated greenspace nodes and corridors is recommended for protection in the Schuylkill River watershed. To fit the currently-available budget, the average cost of protecting an acre (excluding staff and planning time, just considering purchase price) would need to be less than \$150/acre. This seems quite unrealistic given that this is one of the most rapidly developing regions in the Commonwealth, where suburban lots regularly are sold for tens of thousands of dollars/acre, and even agricultural cornfields regularly change hands for \$5,000/acre (and sometimes up to \$12,000/acre, even with agricultural easements in place). A \$30 million budget can purchase only 6,000 acres at \$5000/acre. This financial resource base is clearly insufficient to implement the sustainable watershed greenspace network proposed by this Plan.

Of course, less financially resource-intensive methods are available for protecting land. To achieve a sustainable watershed in the Schuylkill, many non-traditional protection methods should used to maximally leverage funding. Planning tools, zoning codes and ordinances enacted by watershed municipalities can assist to some degree, although these public policies, and even federal regulations, can change over time depending on the political climate and economic development pressures. Other conservation design tools, such as NLT's Growing Greener program and "Stormwater Utilities" (see **Section 6.9** below for more information), can also help to some extent, and certainly should be encouraged throughout the watershed. However, even with these policies and tools, there still will be a need to permanently protect as much of the 200,000 acres as possible through fee simple purchase or conservation easement.

It may seem like an impossible task, but there are contemporary examples of projects that have similar price tags. There is precedent for land protection programs that have funding of this order of magnitude. For instance, New Jersey recently passed a bond issue making \$100 million available each year for land protection across their state in addition to county and municipal funding programs. In conjunction with all the leverage tools, tax relief incentives and innovative planning techniques that can be brought to bear, this magnitude of funding program would make promoting a sustainable landscape in the Schuylkill River watershed more of a reality.

A funding plan for land protection in the Schuylkill River watershed should be developed, strategizing how to close the apparent funding gap between available financial resources and implementation needs of this plan for the entire watershed. Key stakeholders from the conservation and government communities need to be involved. The Philadelphia Water Department (PWD) and PA DEP could be key players in the development of a watershed-wide Strategic Resources Plan for land protection, ecological restoration and management, for the following reasons:

- The Schuylkill River watershed was one of the highest ranked "Category 1 impacted watersheds" in the Commonwealth, as noted in Table 6 of DEP's *PA Nonpoint Source Management Program: 1999 Update*, and is one of the highest priorities for PA DEP attention in fiscal year 2000.
- The Philadelphia Water Department's Office of Watersheds has initiated a Source Water Protection Program in response to a mandate from the federal government (1996 Safe Drinking Water Act). They are trying to assure potable water supplies to the 1.5 million residents of the Philadelphia region and the more than 3 million people who live and work in the Schuylkill River watershed. They will be developing a plan to protect water quality across the Schuylkill River watershed - the *Schuylkill River Source Water Assessment Partnership* - that should be aligned to the maximum extent possible with the water quality and land protection recommendations from this Plan. Their program and this Plan are likely to have many common goals. Common funding sources should be made available to achieve those goals.
- PWD and PA DEP need to spearhead a coalition of government and nonprofit conservation entities in the watershed to secure the funding necessary to ensure that the common goals and recommendations of land and water quality protection are met.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.16	Develop an Interactive GIS Resource for the Watershed Community	PA DCNR, PA DEP, DVRPC, PASDA, EPA Region 3, NPS and the US ACE, as well as watershed conservation entities conducting GIS	Strategic conservation	Sections 6.4.1, 6.4.3, and 6.4.5

Description

The paper maps produced for this Plan are only of limited utility to the conservation community who will use them, due to scale and resolution issues. Paper copies are also very inflexible tools for analysis. The real utility of GIS data lies in the ability to select different areas of the watershed to view at greater resolution; understand issues by overlaying different data; combine data to determine patterns that refine conservation thinking; and to incorporate data improvements as they become available. Making this GIS data available so the watershed conservation entities can use it as an interactive tool will ensure that the full potential of the data are realized.

At a minimum, the GIS mapping compiled for this project should be used as the foundation for a watershed-wide GIS database. It could be housed within the watershed clearinghouse or resource center described in Recommendations **R7.11** and **R7.12** in **Section 7.5**, or perhaps on the PASDA website, which has been established as the GIS data clearinghouse for the Commonwealth. Precedent exists for this approach since GIS data sets for Spring Creek watershed are already provided on the PASDA website. PA DCNR could take the lead in establishing whether PASDA could house and maintain the Schuylkill River watershed GIS database under their jurisdiction. A fallback alternative would be distribution of all available GIS data to all interested watershed conservation entities on CD-ROM, but this would limit the ability to add to or update the database over time. If the PASDA initiative is not feasible, a consortium of watershed conservation entities should be convened to develop a cost-effective solution.

However, distributing map data in isolation of the GIS software that allows transformation and analysis of these data are of limited utility. Implementation of the Plan could be facilitated greatly by the development of a user-friendly GIS model illustrating the data in the Plan, in addition to any other information that stakeholders may wish to add. As with simple data distribution, just creating the GIS model does not necessarily ensure its use. To ensure Plan implementation and use of the GIS model, all stakeholders must have the capacity to use GIS technology. This means not only transfer of technology to nonprofit and government stakeholders, but also the education of future users as to GIS systems. Furthermore, users of the GIS model need to be educated about the data incorporated into the model so that information is not misinterpreted or misused.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.17	Establish a Funding Base, Schedule and Distribution Protocol for Updating and Upgrading GIS Mapping	PA DCNR, PA DEP, DVRPC, PASDA, EPA Region 3, NPS and the US ACE, as well as watershed conservation entities conducting GIS	Strategic conservation	Sections 6.3.2, 6.4.1, 6.4.3, 6.4.5 and 6.5.1

Description

New GIS data sets are being made available all the time, such as agricultural easements and the PEC privately protected lands mentioned elsewhere. Other standard data, such as soils and geology, can be modified to include missing value-added information that would make these data more targeted, useful and user-friendly for the watershed conservation community. As new watershed projects are completed, their GIS data should be integrated

into the Schuylkill River watershed GIS database or model. Mandatory annual GIS data reviews should assess and address update and upgrade issues.

In addition to these new data, as identified by this Plan, some significant watershed-wide data gaps currently exist that are required for providing the best analysis and conservation resource planning. For example, one of the most significant data gaps is the lack of up-to-date classified digital land cover for the entire watershed. While DVRPC generates land cover data from aerial photography for the PA 5-county region around Philadelphia every 5 years, the other four counties in the watershed are either not completing this task, or are not coordinating with the other counties to ensure that full coverage of the watershed is available in a standardized format. Other examples of conservation data gaps for the watershed that would be invaluable for further planning and assessment purposes are noted below. These data gaps, and other conservation mapping components that were not the focus of this Plan, should be addressed on an on-going basis. Watershed-wide data needs to be compiled in GIS using a standardized system, based on metes and bounds where possible to ensure accuracy. Some of the following data may already have been compiled as partial coverages for the watershed, but, to the best of our knowledge, are unavailable watershed-wide.⁴ Besides the data listed below, there may be other data sets that would be very useful.

Recommended watershed-wide data for acquisition/updating:

- Updated land cover (post 1992-4)
- Nonprofit owned protected lands
- Aquifer recharge areas
- Municipal-owned open space (by type – e.g., active recreation vs. passive recreation vs. natural areas)
- County-owned open space (by type – e.g., active recreation vs. passive recreation vs. natural areas)
- Agricultural easements (both government and nonprofit)
- Historic, cultural, recreational and scenic resources
- Riparian corridor assessments.
- Detailed Ecological Landscape Unit Analysis (to provide a more detailed prediction of habitat type than is available from current land cover assessments).
- Superfund sites, landfills, quarries, NPDES permitted facilities and other point-source pollution generators, etc
- Ecological restoration sites/Community-Based ecological restoration and management sites
- Environmental Education sites
- Complete tax parcels
- Complete zoning

All County Planning agencies in the watershed, along with DVRPC, DRBC, DCNR, DEP, PWD, federal agencies, nonprofits and municipalities who possess GIS capabilities, should work collaboratively to address these data needs. A task force needs to be appointed to ensure that watershed-wide GIS data sets are available (ideally free of charge, or at most on an at-cost per download basis) through a GIS clearinghouse such as PASDA or a yet-to-be-established watershed-specific GIS clearinghouse (see Recommendation **R7.11** in **Section 7.5**). The task force also needs to establish data development priorities and protocols for data standards and development, and to administer grants for data compilation and distribution.

⁴ Note that as of 5/9/01 PWD and their consultant, CDM, have tried to address the need for a consistent and updated watershed-wide GIS land use/land cover map. This will be done by using the 2000 Census data to project updated land cover changes based on population density in the watershed for use in their Schuylkill Source Water Assessment project. As the best working alternative for updated land cover for the entire watershed (since the last Landsat MRLC data was released from 1992-4), DCNR and DEP should provide financial and any other kind of support necessary to ensure that these data are of sufficient quality to release for public use as soon as possible.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.18	Develop Local-Scale Comprehensive Subwatershed River Conservation Plans	Any interested watershed-based conservation entities.	Guidance on ecological management Need for greenspace Strategic conservation	General

Description

Comprehensive subwatershed plans should be completed for areas in the Schuylkill River watershed not currently covered by local-scale River Conservation Plans. Although this Plan established regional priorities, it is too broad a scale for developing detailed local initiatives. Where there is interest, local groups should be prepared to develop local plans that implement some of the generic recommendations developed here, but also factor in critical missing local information.

Several established watershed and conservation groups are interested in conducting site-specific River Conservation Plans for areas underrepresented in the watershed-wide analysis. Other nonprofits and government agencies with the expertise could be used as consultants and resources to help complete these plans where necessary. PA DCNR has recommended that organizations, local nonprofits and municipalities that serve the Schuylkill Headwaters and Little Schuylkill subwatersheds should develop a comprehensive watershed conservation plan for this region. Several local groups, such as the Little Schuylkill Conservation Club, already are engaged in various conservation efforts, such as re-introduction and back-crossing of the American Chestnut, riparian restoration and water quality monitoring. Other groups would benefit from organizational support to generate membership and interests in watershed activities. These local, comprehensive planning efforts should be encouraged and supported by foundations and funding agencies in the watershed.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues</i>	<i>Sections/Maps</i>
R6.19	Support the Schuylkill River Heritage Corridor Management Action Plan	Schuylkill River Greenway Association, in conjunction with other watershed conservation entities	Need for greenspace Strategic conservation	General

Description

As mentioned in the introductory chapters, the focus of this Plan from inception was landscape sustainability, water quality and institutional capacity. While scenic, cultural, historic and recreational resources are critical aspects of the watershed community and part of the comprehensive planning process, they have not been addressed specifically in this Plan. Instead, it is recommended that these aspects of the watershed be addressed under a separate Plan, ensuring that the two efforts are integrated and support each other to the maximum extent possible.

The Schuylkill River Valley National Heritage Area (see **Section 3.6.2** in *Chapter 3* for further discussion) is one opportunity to develop such a scenic, cultural, historic and recreational strategic plan for the watershed. The geographic boundaries of the National Heritage Area are “those portions of Schuylkill, Berks, Chester, Montgomery and Philadelphia that are in the Schuylkill River Watershed.” The National Heritage Area is charged with recognizing the national significance of the contribution of the Schuylkill River Valley to the nation’s political, cultural and industrial development. Its purpose is to enable local communities to conserve their heritage while continuing to pursue economic opportunities and to conserve, interpret and develop the natural, historical, cultural and recreational resources related to the industrial and cultural heritage of the area.

The Schuylkill River Greenway Association is the management entity for this National Heritage Area, and is responsible for developing a Management Action Plan. Many of the resources this plan will focus on have been described and documented in the National Park Service’s 1995 Cultural Landscapes Assessment for the Schuylkill River Heritage Corridor. This Management Action Plan should be supported, and could be expanded if necessary, to address the conservation of the full range of cultural, historic, scenic and recreational resource needs in the watershed. Nonprofits and government agencies across the watershed interested in cultural, historic, scenic and recreational issues should be invited to assist the Schuylkill River Greenway Association with the National Heritage Area project activities. It is recommended that additional PA DCNR funding be made available to match National Heritage Area’s federal funds if necessary, to ensure that these valuable watershed resources are documented appropriately.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.20	Encourage Smart Growth Policies	Municipalities, county planning offices, PA DEP, US EPA, nonprofit watershed groups	Loss of natural lands Need for greenspace	General

Description

In urbanizing areas, it is important that development occurs with as little disturbance as possible to the soil and hydrology of the watershed. Smart growth policies that incorporate urban best management practices can be an effective means for protecting watersheds, and minimizing the development-related impacts of increased stormwater runoff and non-point pollution. Approximately 75% of the municipalities in the Schuylkill River watershed are expected to experience continued growth through the year 2010, with Berks County being the area of the highest potential population increase. Other areas of concern include the expanding suburbs of Philadelphia and Reading, although the expected trend in the watershed is one of out-migration from the suburbs to more rural areas (see **Section 6.6**). Within these areas of projected high growth, county and local governments can help guide the development process to ensure economic and environmental sustainability.

Smart growth policies that help to guide development may include:

- promoting location-efficient development, e.g., encouraging brownfield and infill development, transit-oriented development, and development near existing infrastructure and amenities, through policies that establish redevelopment/revitalization zones, growth management zones, priority funding areas or service districts;
- encouraging mixed land uses and a balance of jobs and housing in regional and site design;
- promoting compact, clustered or conservation-oriented development design that conserves open space and reduces lot size;
- preserving community character through the protection of important local cultural, historic and natural features;
- making necessary changes to zoning and development codes to encourage smart growth; and
- encouraging stakeholder and community collaboration.

See also **Section 6.9** for policies and tools that complement smart growth and assist in land conservation.

A number of programs exist on the federal, state, and local levels to help guide the development of smart growth policies. For more information on smart growth policies being used for watershed protection, see the following resources.

- Pennsylvania Department of Community and Economic Development (http://www.dced.state.pa.us/PA_Exec/DCED/government/land-use.htm)
- The Natural Lands Trust, with the PA Department of Conservation of Natural Resources and the Penn State Cooperative Extension Service, Growing Greener Program: *Conservation by Design* (<http://www.natlands.org/Planning/growgreen2.html>)

- The Brandywine Conservancy’s Municipal Assistance Group (<http://www.brandywineconservancy.org>)
- Chester County *Landscapes Program* (<http://www.chescowedd.org/general.htm#Landscapes>)
- 10,000 Friends of Pennsylvania (<http://www.10000friends.org/Default.htm>)
- PA DEP *Handbook of Best Management Practices for Developing Areas*
- US EPA *Green Communities* program (<http://www.epa.gov/greenkit>)
- US DOE online *Center of Excellence for Sustainable Development* (<http://www.sustainable.doe.gov>)
- Livable Communities program and National Livability Resource Center (<http://www.livablecommunities.gov>)

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.21	Support Brownfield Redevelopment Initiatives	Montgomery County Planning Commission, PEC and any other interested and qualified watershed conservation entities	Loss of natural lands Need for greenspace Strategic conservation	Section 6.9.5

Description

As the complimentary strategy to land preservation, a model redevelopment incentive ordinance including BMPs should be developed for watershed-wide application. Montgomery County Planning Department or PEC could be ideal choices for developing this text, which could subsequently be distributed to municipalities throughout the watershed.

<i>Code</i>	<i>Recommendation</i>	<i>Appropriate Partners</i>	<i>Issues Addressed</i>	<i>Sections/Maps</i>
R6.22	Support Development of Standardized Demographic, Transit, Infrastructure and Land Use “Change Indicators” for the Entire Watershed	DVRPC and interested watershed County Planning Commissions, together with other interested watershed organizations	Loss of natural lands Need for greenspace Strategic conservation	General

Description

In order to adequately characterize levels of threat in the watershed so as to better direct conservation, a collaboration of county planning agencies and other interested organizations could address the need to develop and maintain standardized periodic updates for critical data that will assist in tracking the development pressure and human population impacts throughout the watershed. No agency is currently responsible for such watershed-wide assessment. DVRPC develops some statistics that assess conditions for the lower watershed, but can supply data only for the 5-county region immediately surrounding Philadelphia. Prototypes of such “Change Indicators” are currently under development in Chester County, and these could serve as a model for similar Indicators of Change/Threat to be developed for use in monitoring conditions in each subwatershed of the Schuylkill River watershed. Once developed, these Change Indicators can then be applied to assess conditions on a relative basis for each of the 37 subwatersheds used for analysis in this Plan, with the goal of helping to better direct strategic conservation and land protection activities.

6.9 Sustainable Landscape Protection and Implementation Tools

The following is a brief discussion of and introduction to land protection and implementation tools that could be used to help advance the goals of this project across the watershed. As part of a watershed-wide management structure, these preliminary guidelines could be developed into a more comprehensive and extensive, user-friendly tool-kit for the watershed conservation community.

There are many ways to protect land, with varying levels of protection and restrictions on property and development rights. While government agencies have the power, in certain circumstances, to condemn or “take” land, the tools listed here focus on the “willing buyer – willing seller” paradigm that the nonprofit land trust community operates under, and on local municipal planning tools, such as zoning and ordinance codes.

6.9.1 Fee Simple Purchase

Fee simple purchase is the outright purchase of property for an agreed sum. The fair market value (FMV) of the property is usually established by conducting two appraisals. A sale for less than FMV is referred to as a “Bargain Sale,” with the cash-price difference being an eligible conservation donation with resulting potential tax benefits.⁵

Fee Simple Purchase Recommendations

- To be an effective tool landowners have to understand how sales and gifts of land to land trusts can help them achieve their goals and the goals of this Plan. A watershed-wide program of mailings and small meetings should be developed to educate them. For landowners, the emphasis might be on protecting a defined neighborhood, with local citizens providing leadership in this effort. Neighborhood leaders can help craft the specifics of their neighborhood initiative. Municipal officials should be briefed and provided with concise materials on conservation real-estate options, with examples of their use by municipalities in the watershed.
- Find landowners that have make a gift of land or bargain sale and, if they are willing, have them serve as case studies for other potential donors.
- Start a “conservation buyer” network, perhaps on the web, to facilitate the exchange of lands in the watershed that have been or should be preserved. Conservation buyers are people interested in purchasing land for conservation purposes, or under conservation easement restrictions.

6.9.2 Easements

Conservation easements are voluntary restrictions placed on a property to protect selected resource areas. The easement is either donated or sold to another party, usually a conservation organization or government agency. The owner retains all rights in the property except that which is specifically conveyed. For instance, the owner may convey to a conservation organization the right to subdivide the property, the right to log along the stream, and the right to exceed a certain percentage of paved area on the property. The owner retains the right to live on the property, and sell it to someone else. The

⁵ Note: For further information on the tax benefits of conservation giving to a bona-fide conservation organization – whether in the form of cash donations, gifts of land, or bargain sales – see Small (1992) or Abbin et al. (1995) in **Section 6.11 References**; or go to the Land Trust Alliance web page at <http://www.lta.org>. The tax rules on charitable giving are complex and change frequently, so it is very important that any conservation donors retain their own tax lawyer or accountant as an advisor. Conservation entities receiving the conservation gifts should avoid giving tax advice to limit potential liability.

conservation organization has the right and obligation to enforce the terms of the easement in perpetuity. If the easement is donated, its value may be considered a charitable contribution under the federal income tax code.

Easements have an important place in the protection of natural resources, particularly riparian buffers and stream corridors, because they offer a landowner the ability to protect the natural features of a property, without losing the right of ownership. Easements may be an effective estate-planning tool because they may lower the value of the property and its estate taxes, making it easier to pass to a younger generation. Easements may, but do not have to, specify that the public has a right of entry – that decision is up to the landowner. If the public is given the right to enter, it is often along a clearly defined corridor such as a ridgeline or stream.

Easements can be useful to a municipality as a way to provide a trail through common open space as a condition of subdivision approval, or as a means to ensure proper management of common open space. If a landowner is willing, a municipality could even purchase a trail easement to connect parkland or natural areas within a Township or Borough.

As a conservation and tax-planning tool, easements are not particularly well known to landowners. Municipal open space plans mention them as an inexpensive preservation tool, but landowners need to be educated to turn this suggestion into on-the-ground conservation easements. Municipal officials may not have the same experience with easements as land conservancies, and may not have the time to market them effectively.

Easement recommendations

- To be an effective tool, landowners and municipalities have to understand how easements can help them achieve their goals. A watershed-wide easement program of mailings and small meetings should be developed to educate them both. For landowners, the emphasis might be on protecting a defined neighborhood, with local citizens providing leadership in this effort. These leaders can help craft the specifics of their neighborhood initiative. Municipal officials should be briefed and provided with concise materials on easements, with examples of their use by municipalities in the watershed.
- Find one or more landowners willing to donate conservation easements and, if they are willing, have them serve as a case study for other potential donors.
- The cost of negotiating, drafting, and documenting conservation easements can put them out of the reach of many landowners. Funding to provide easements on a sliding scale to interested donors would greatly improve the chances of the program's success.

6.9.3 Conservation Design for Subdivisions

In recent years, planning efforts have increased at the state and county levels within the watershed. These efforts include allocation of County dollars for open space preservation and planning in Bucks, Chester and Montgomery Counties as well as Keystone and Growing Greener funding initiatives at the state level. Increased preservation and planning does not preclude the critical role of local government. Conserving Pennsylvania's important natural landscapes is a challenge that is largely met by the Commonwealth's municipalities. All too often, municipalities adopt land use regulations that are easy to enforce, but that may encourage land development in an sprawling pattern of house lots, streets and lawns. In developing areas, municipal officials often feel they have no choice but to approve conventional subdivisions that

meet ordinance requirements, despite the fact that such proposals may irrevocably consume important resources and permanently alter their community's special character.

Development pressures, coupled with scarce preservation funds mean that communities wishing to conserve natural resources will have to strategically target preservation dollars and carefully plan for growth.

A practical approach to managing growth and conserving land must be relied upon to protect the conservation network envisioned in this Plan. In 1996, NLT, in collaboration with DCNR and Penn State University, launched Growing Greener-Conservation by Design, a statewide conservation-planning program to educate municipal officials in conservation design techniques. The objective of conservation design is to improve the pattern of residential growth as it presses out into the countryside, so that an interconnected network of conservation lands may be identified, designed around and protected from inappropriate changes. The concept for conservation subdivisions has evolved from NLT's efforts to help municipalities add significant land protection standards to their existing land use ordinances, so that conservation approaches will become "institutionalized" within the local planning framework.

In order to implement conservation design, municipalities must make changes to three documents: the Comprehensive Plan; Zoning Ordinance; and Subdivision/Land Development Ordinance. The principal elements of Conservation by Design involve the following.

- (1) *Supplementing the Comprehensive Plan to include a Township-wide "Map of Potential Conservation Lands,"* including both "Primary Conservation Areas" (wet, flood-prone, steep slopes) and "Secondary Conservation Areas" (otherwise buildable woodlands, farmland, habitat areas, riparian corridors, cultural landscapes and scenic viewsheds, and other noteworthy features that help define the Township's special character). These maps are displayed in such a manner as to identify an interconnected network of conservation lands for protection.

A composite "green infrastructure" map is rendered in three shades of green. The darkest green would be reserved for public lands designated for conservation use, properties with conservation easements, and lands owned by conservation organizations such as land trusts. The medium green would show inherently unbuildable lands (wet, flood-prone, and steep slopes), the category called "Primary Conservation Areas." The third and lightest green would include further resource lands such as woodlands, habitat, and agricultural soils that are not otherwise wet, flood-prone or steep, plus a number of other features of the natural and historic landscape that are noteworthy and desired for protection ("Secondary Conservation Areas"). The map is adopted as a guide, showing developers the natural resources that they will be expected to design around as new development occurs.

- (2) *Updating the Subdivision Ordinance* to include critical elements such as an expanded Sketch Plan section providing standards for an "overlay sheet" based on the Potential Conservation Lands map, an On-site Visit by Township officials, and a four-step design process that establishes an orderly and logical procedure for analyzing each property in terms of its potential for conservation and development in light of the Township-wide Map of Potential Conservation Lands. The Ordinance should clearly outline a four-step process: identifying conservation areas; positioning house sites; locating streets and trails; and drawing in the lot lines.
- (3) *Selectively amending the Zoning Ordinance* to include a "menu of choices" which respect the private property rights of the landowner and require the inclusion of permanent open space and conservation lands into new subdivisions.

In addition to Conservation by Design, communities should consider Transfer of Development Rights (TDR) provisions. Simply stated, TDR preserves land by extinguishing development rights on one parcel and “sending” the density to another parcel. The state enabling legislation hinders broad-scale applications of TDRs for several reasons. First, TDR is voluntary, unlike conservation design, which may be mandated through ordinances. Second, most communities will have to find higher density receiving zones within their municipal boundaries, often an unpalatable solution even when land conservation on a nearby parcel is achieved. The June 2000 revision to the Municipalities Planning Code creates the ability for Townships to engage in joint municipal planning and create inter-municipal sending and receiving zones, which may provide additional opportunities for TDR. Due to the complexity of the technique and difficulty in reaching consensus on receiving zones, TDR will remain an important, but “now and then” tool for land conservation.

For further information, visit Natural Lands Trust’s website (<http://www.natlands.org>) and follow the links for the Growing Greener – Conservation by Design program.

Conservation Design Recommendations

- A number of townships in the watershed are rewriting their zoning ordinances to encourage the use of conservation subdivision design. In Chester County, Wallace, Newlin, West Vincent and London Britain Townships have adopted Growing Greener model ordinances. In Montgomery County, codes were recently adopted by Upper Salford Township. All municipalities throughout the watershed should consider whether such code and zoning reviews would benefit their communities. Numerous models now exist which illustrate the kind of upgrades that can be achieved.
- *Potential Conservation Lands maps* should be prepared at the Township or, ideally, subwatershed level. The “green infrastructure” mapping assists in determining preservation priorities, and guides the location and design of new development.

6.9.4 PA Natural Diversity Inventory Sites

Regulatory protection for PNDI sites or Natural Areas sites seldom is specified in municipal ordinances. In more sophisticated ordinances that offer conservation design provisions, Natural Areas are listed as one of the important areas to be protected in the watershed common greenspace network.

It is interesting to consider that most of the Natural Areas identified in County inventories exist in areas that are either difficult to utilize for agriculture or development (e.g., marshes, or serpentine soils), or in areas long protected by public or institutional ownership. Many of the remaining open spaces, by virtue of their rarity and fragmentation, are becoming important habitat refuges and Natural Areas for the watershed. If additional lands are preserved in the watershed, over time they may mature into important Natural Areas as well.

PNDI Recommendations

- Municipal comprehensive and open space plans should include all PNDI sites and Natural Areas in their Open Space preservation component. The comprehensive plans should discuss the means by which the municipality plans to preserve them. Preservation may occur through:
 - informal agreement with the landowner;
 - part of a general environmental feature overlay zoning district (see Willistown Township’s

- Environmental Protection Ordinance for a model);
 - donation or fee purchase for parkland; and/or
 - conservation easement donation or purchase.
- Owners of Natural Areas should be informed of the special habitat contained on their property and be offered assistance to manage them.
- All natural features identified in comprehensive and open space plans should be included on preliminary and final subdivision and land development plans.
- Municipalities should require permanent protection and management plans for Natural Areas within new subdivisions.

6.9.5 Redevelopment of Urban/Brownfield Sites

While the more developed townships in the lower watershed may be able to make scant use of clustering and conservation subdivision design, they have an opportunity to improve existing conditions when properties are reviewed for redevelopment. They can also amend their environmental ordinances so that any remaining developable properties are required to plan for restoration and set aside streamside riparian buffers.

Redevelopment means renovating “brownfields,” which may involve refurbishing existing structures or demolishing old structures and rebuilding new facilities on previously developed lands. Brownfields development is one of the most important issues in the Schuylkill River Corridor (as identified by Montgomery County Planning Commission’s new Schuylkill River Greenway Stewardship Plan study).

Subdivision typically is not part of a redevelopment process. Generally speaking, the Subdivision and Land Development Ordinance (SLDO) controls vehicular circulation, grading and storm drainage, while the Zoning Ordinance controls building setbacks, buffer requirements, and required number of parking spaces. Ideally, these two policies should be designed to work together, to provide incentives to reduce the amount of pavement near the stream, and to install stormwater devices that pass water through vegetation before it reaches the creek.

New zoning standards (especially for lot coverage and stream setbacks) could be established that might render non-conforming some of the current unsustainable development along the stream system. Any future proposals for expansions or changes in land use could be held to the new standards, unless they take advantage of incentives such as allowing a reduced front yard setback and lowered parking requirements, in return for removal of streamside pavement and installation of a buffer planting. The ordinances must be carefully crafted to allow flexibility, to prevent rendering property unprofitable to renovate. Incentives to utilize Best Management Practices (BMPs) are a good technique because the initial development established a precedent that makes requiring complete adherence to new standards unreasonable.

Urban Redevelopment Recommendation

- A model redevelopment incentive ordinance with BMPs should be developed. Montgomery County Planning Department would be an ideal choice for developing this text, which could subsequently be distributed to municipalities throughout the watershed.
- Market the opportunities presented by brownfields as the urban corollary to land protection and conservation planning efforts to protect the watershed’s natural resources.

6.9.6 Steep Slope Ordinances

Steep slope ordinances limit, and sometimes prohibit, development on slopes considered too steep to be built upon without danger to public health and safety. Steep slopes erode rapidly if exposed, which can cause silting of streams or landslide. It is also difficult to build safe driveways and roads on steep slopes without excessive grading and disturbance to vegetation. Generally two categories of steep slope are defined:

- slopes that fall one foot for every 6.67 linear feet (15%) to one foot for every four linear feet (25%);
- slopes greater than 25%.

Ordinances governing development on slopes in the second category (slopes > 25%) usually are more restrictive, reflecting the greater erodibility and sensitivity of these slopes. These steep slope areas may be handled as overlay zoning districts, similar to floodplain districts.

In the greater than 25% slope areas (often called Very Steep Slopes), structures and septic fields are usually prohibited. In the 15-25% category (Steep Slopes) buildings and septic systems often are allowed as conditional uses. In other cases a maximum percentage of each slope type may be disturbed (e.g., as in Upper Providence). West Whiteland Township, Delaware County, has a steep slope ordinance which could serve as an effective protection model for the watershed. West Whiteland only permits the crossing of slopes greater than 25% by utility lines and driveways when no other alternative exists. On 15 to 25% slopes, the Township permits emergency access roads and, subject to conditional approval, roads and buildings.

Steep Slope Recommendations

- Steep slopes ordinances should be instituted where they do not currently exist. All such ordinances should include standards limiting development and protecting vegetation on slopes adjacent to the floodplain and small tributaries.

6.9.7 Stormwater and Impervious Surface Ordinances

Excellent recommendations for ordinances and sustainable taxation schemes already have been provided in the Wissahickon River Conservation Plan, page V-10 through V-23 (Delta Group et al. 1999). The following is a brief summary of the highlights, but it is highly recommended that the entire section referenced above be read and implemented where possible in municipalities throughout the watershed.

Stormwater management ordinances should be consistent with approaches presented in Pennsylvania Handbook of Best Management Practices for Developing Areas, PACD (1998). By and large, it is smaller storms that cause most stormwater problems in watersheds. Comprehensive ordinances should provide:

- Performance standards;
- Appropriate storm designs (e.g., detention of the 1- and 2-yr storms);
- Improvement in groundwater recharge, including:
 - Retain first ¾ inch of rainfall on-site (rain barrels);

- Preserve the same volume of infiltrated rainfall as in pre-development condition (based on annual rainfall); and
- Lists of recommended stormwater management BMPs.

Also, the following are encouraged:

- Reassessment of stormwater management objectives by municipalities;
- Retrofitting grandfathered properties with up-to-date stormwater management levels as they are redeveloped;
- Requirements for the management of roof runoff; and
- Requirements for agricultural lands.

Watershed municipalities should adopt policies and ordinances that incorporate provisions to reward developers and homeowners for using low-impact site design principles, for example, relaxing some permitting requirements or shortening review cycles.

Finally, tangible financial incentives are justified where voluntary measures will substantially reduce infrastructure costs that would otherwise be incurred by municipalities for water treatment, maintenance, repairs or improvements to publicly owned facilities. Stormwater Utilities, a mechanism to fund stormwater facilities and services, are being implemented with greater frequency in the United States. Tax payments can be made to the municipality on the basis on some index of stormwater impact created by the property – such as total impervious area or contiguous impervious area. The revenues from these taxes should be used to fund watershed studies, GIS databases, public works projects (e.g., tertiary treatment sewage treatment plants), and direct subsidies to landowners who install BMPs.

Montgomery County is developing a model stormwater management ordinance, which should be made available for all municipalities in the watershed to review and adopt. In addition, the Stormwater Act 167 allows for improved coordination between municipalities so that stormwater issues can be addressed on a watershed basis.

6.9.8 Private Land Stewardship

Private land stewardship, the which individual property owners care for their land, has a strong influence on the stream system and is one of the fundamental issues that must be addressed in crafting a viable strategic conservation and protection plan for the watershed. Each landowner in the watershed can play an important role in making the landscape in the Schuylkill River watershed as sustainable as possible, regardless of the size of their property.

The strongest response by citizens and municipal officials to the watershed issues in the public survey was to the importance of protecting and enhancing natural habitats. This included equal concern for protection of special habitats, for stabilization of streambanks, and for loss of riparian (streamside) forests. See Recommendation **R5.7** in *Chapter 5.0 Water Quality* for further discussion on this subject.

6.9.9 Management of Public Lands

Management techniques in existing park lands vary according to the use of the land. Woodlands and meadows are found in many of the watershed's open spaces that allow passive recreation. Speaking

strictly from a water quality and wildlife perspective, these are excellent approaches to management of streamside lands. They require little labor to maintain and they provide buffers for sensitive riparian habitats. Large expanses of mowed grass are, from the same perspective, less beneficial to the natural environment, in that grass requires regular maintenance and does not provide the same buffering and habitat qualities as wooded buffers or even native meadows. Even less desirable are the well-used parking areas along stream banks that can be found in municipal and county parks throughout the watershed. For further discussion on public lands management, see Recommendations **R6.13** and **R6.14**.

Public Land Management Recommendations

- Install riparian buffers at least 75 feet-wide, and ideally 100 feet-wide along all watercourses, where feasible.
- Correct or mitigate erosion problems on trails next to streams.
- Provide parking areas at least 75 feet, and ideally 100 feet, from streams. Move existing parking and provide new parking away from streambanks to reduce the potential for non-point source pollution.

6.10 Additional Watershed Resources and Assessments

In addition to those GIS data sets used in this Plan to determine protection and restoration priorities in the Schuylkill River watershed, the following GIS maps have been compiled as supporting documentation for the plan. These maps are available in the online Reference Documents for viewing and downloading from the project website: <http://www.schuylkillplan.org>. As noted in Recommendations **R6.16** and **R6.17**, the resolution and usefulness of these data sets in PDF and paper is seriously limited. The real utility of these maps and the other GIS data generated for this Plan would be to distribute these data through a centralized database or interactive model to all interested watershed conservation organizations, who then can use them as interactive GIS resources to generate their own targeted conservation assessments. Distribution would ideally be via the web, or if necessary, via CD-Rom.

Aquatics Habitat Value
Plants Habitat Value
Mammals Habitat Value
Birds Habitat Value
Invertebrates Habitat Value
Herpetofauna Habitat Value

Stream Order
National Wetland Inventory (NWI) Types
Slope Classes
Soils
Surficial Geology
Geologic Provinces

PA House Districts
PA Senate Districts
Census Tracts
USGS Quadrangles

Further comments regarding additional data and analysis that could improve future assessments follow.

6.10.1 Watershed-Wide Simplified Geology, Soils and Potential Analysis

6.10.1.1 Surficial Geology

Surficial geology and soils GIS data sets were downloaded and compiled from the PASDA website at <http://www.pasda.psu.edu>. These two abiotic components potentially are valuable to round out the GIS data set for the watershed, but are of limited value to the watershed-wide analysis in their current state. These data provide multiple listings of geology and soils by name, rather than generalized characteristics by soil or geologic type, which would better inform the GIS analysis. For example, the surficial geology data layer is very complex and provides approximately 84 different named geological formations.

To make these data sets more useful for future GIS analysis, a significant amount of work needs to occur to transform and re-attribute the data. This “value-added” procedure should simplify the data while also ensuring that the most relevant characteristics of the data are available for analytical purposes. For example, the surficial geology data layer could be simplified to show the major geological types of importance to defining ecological assessment: e.g., approximately 9 geological types defined on the basis of the three primary rock types (e.g., sedimentary, metamorphic and igneous) and the three-pH classes of “acidic,” “alkaline,” and “circumneutral.” General characteristics of the geology then can be used more directly as part of the sustainable landscape analysis.

6.10.1.2 Soils

Soil maps have been available in report format for many years from the USDA Natural Resources Conservation Service (NRCS) for each county within the Schuylkill River watershed. These reports and their map components are now being generated digitally. However, not many of these soil maps are currently available within the watershed, and some of the digital maps are based on soil surveys from 40 or 50 years ago. (Tim Craul, *pers. comm.*).

A watershed-wide GIS soils coverage is available from PASDA at a general level, but is not very user-friendly since it again provides soil association names rather than “value-added” characteristics. These data could be made more useful for assessment purposes by modification to show primary soil characteristics. For example, grouping soils by their hydric properties would allow identification of sensitive wetland areas, while attaching standard NRCS soil classes would be useful for determining agricultural preservation priorities. Although not a primary component of a sustainable landscape assessment, which focuses primarily on natural lands, agricultural land preservation can play a secondary or supporting role, particularly if ecological land management policies can be implemented adequately.

As with the simplified watershed-wide geology map, a “value-added” soils map also could be used with the other maps generated in this Plan to help explain the land cover patterns within the watershed and to predict where key habitat types or land cover would most likely or most appropriately be located.

Not surprisingly, soil categories tend to align with surficial geology patterns, since soil type primarily is determined by geology and topography. Climatic factors, while a component of soil development, do not vary enough across the Schuylkill River watershed to have much effect on soil patterns. However, variations in microclimate, particularly in combination with topography and hydrology, can have a very strong influence on local soil type development, and certainly influence local habitat type and quality.

6.10.1.3 Combining Abiotic Environmental Factors to Develop Predictive Analysis Models

Simplified geology and/or soil characteristics data layers can be used in conjunction with any or all of the GIS data layers generated through this Plan to increase understanding of the habitat and land cover patterns that are revealed in the watershed. They may help predict the location of certain more valuable habitats. For example, sedimentary circumneutral or alkaline geology typically supports good agricultural production if slopes are not very steep and soil depth is good, as is true of the agricultural belt that runs through the middle of the watershed to the SW and NE of Reading. Meanwhile, circumneutral or alkaline igneous rocks, such as the diabase ridge that runs through Montgomery and Bucks counties, typically have steeper slopes and shallower soils and have been used little for agriculture. However, these areas are known to support healthy native plant populations due to reduced levels of human-induced disturbance, as well as the fact that base minerals in the rocks provide many of the macro- and trace nutrients essential to healthy plant growth. The thinner soils this geology typically supports also may decrease nitrogen enrichment (especially due to atmospheric nitrogen pollution loading), and perhaps also phosphorous accumulations, potentially giving a competitive advantage to native plant species over non-native invasive plant species which are postulated to thrive in nitrogen and phosphorous enriched environments.

6.10.2 Emerging New Techniques

New techniques that could supplement this preliminary analysis are emerging, as the full potential of GIS analysis is starting to be recognized by multi-disciplinary groups across the country. Some of these techniques may help to bring a higher level of detail and precision in landscape-scale analysis. Since the inception of this project, several techniques have been initiated elsewhere in the nation that, with adaptation to this region, could assist with further prioritization of natural area preservation or restoration priorities. One example is the Contiguous Block/Ecological Landscape Unit Analysis under development by The Nature Conservancy. A brief description of that new technique follows.

6.10.2.1 Ecological Landscape Unit and Block Analysis

The Nature Conservancy (TNC) has developed a technique within GIS to analyze ecoregions using abiotic factors to predict ecological landscape components, known as Ecological Landscape Units (ELUs). Details are available at <http://www.fws.gov/r5gis>, by following the links to data download page then to *The Nature Conservancy Connecticut River Watershed report*. Using factors such as geology, slope and elevation within an ecoregion, the model can predict where different ecosystem components, such as acid ridge tops and alkaline bogs, would be found:

“Potential natural vegetation is determined directly by environmental gradients such as nutrient availability, moisture and temperature. These environmental gradients are driven by more broad determinants such as geology, climate and topography. Therefore, in order to produce predictive maps the gradients thought to drive vegetation must be mapped or modeled themselves. From the compiled data...we derived several information layers to assist in developing predictive vegetation models at the community alliance level. Primarily we used three key layers: lithography, elevation and landform.”

These ELUs can help define ecological habitats and land cover, at a level of detail greater than can be derived from Landsat Thematic Mapper MRLC land cover classes. For example, MRLC imagery will define woodlands by three or four major types: coniferous; broadleaf; mixed; forested wetland; etc. However, using the ELU technique, greater detail can be predicted in the forest cover type, perhaps even allowing for identification down to the vegetation community level.

The Block Analysis technique then can be implemented as a filter on the ELU data to select blocks of contiguous habitat of each ecological unit. For example, perhaps the best (in terms of size and quality) acid ridges consisting of scrub oak could be picked out for priority protection in a portfolio of natural habitats across the region. TNC has used this technique to identify landscape blocks of between 15,000 and 25,000 acres as part of their national ecoregional analysis. NLT is currently investigating ways to regionalize TNC's model to highlight ELUs of smaller scale, between 500 and 15,000 acres, since few landscapes in SE PA meet TNC's contiguous habitat size criteria.

Development of this technique was not possible within the scope of this Plan. However, it is strongly recommended that GIS analyses such as these be pursued in later implementation phases of the Schuylkill River conservation planning process to further refine and prioritize conservation efforts.

6.10.2.2 Soil Erodibility Index

Various soil erodibility indices have been developed, based on land cover vegetation class, slope, hydrology and soil type. These indices are useful for identifying areas of high erosion and high erosion mitigation potential for water quality management. One such index is the Agricultural Relative Runoff Sensitivity Index (ARRSI) developed by Lawson (1996), which is a simple algebraic combination of:

- soil erodibility (K) value derived from USGS SSURGO dataset for that soil series;
- slope, derived from a Digital Elevation Model;
- Topographic Relative Moisture Index (TRMI) (Parker 1982) or Topographic Convergence Index (TCI) (Bevin and Kirkby 1979; Wolock 1993), a measure of accumulative hydrologic flow;
- land cover vegetation class, ranked according to the amount of runoff expected (e.g., water has value of 0, agriculture/urban = 1 and dense forest = 4); and
- Euclidean distance from streams.

These layers are combined and weighted with the constant factors a, b, and c, where $a+b+c = 1$.

$\text{ARRSI} = a (\text{soil erodibility} * \text{slope}) + b (\text{TRMI or TCI}) + c (\text{ranked land cover} * \text{distance from stream})$

The advantage of this index is that it serves as a "value added" slope/sensitivity measure. It combines soil erodibility and slope steepness in modeling soil erosion potential, and weights the runoff areas by the type of intercepting vegetation, while including the actual hydrologic flowpaths as represented by the TRMI or TCI models.

A soil erodibility index could be overlaid with water quality information to show areas of high erodibility and pollution (mitigation priorities); areas of high erodibility but low pollution (future areas of concern/sensitive lands); and areas with low scores for erodibility and pollution (stable or conserved areas).

6.10.2.3 Preservation of Lands with High Recharge & Stormwater Retention Potential

There is an opportunity to integrate some of the water quality and sustainable landscape recommendations through future analysis. For example, Recommendation **R5.18 Monitor and Regulate Existing and Future Groundwater Withdrawals**, could be partially addresses if sites with high groundwater recharge potential were permanently protected from development. In the same way, areas with high stormwater retention

potential, such as wetlands, could also provide a valuable water quality resource. Further analysis of these overlapping issues in the future would benefit future conservation planning in the watershed.

6.10.2.4 The Need for Improved Land Cover Data

Although GIS mapping has improved tremendously over the last decade, finding up-to-date data to perform analyses on the scale of the Schuylkill River watershed is still difficult to achieve cost-effectively. Because land cover is a critical component of many water quality, development and landscape sustainability analyses, finding up-to-date, higher quality land cover data set for the watershed should be a funding and program priority. As the availability and affordability of digital aerial photography and GPS-referenced aerial videography gradually improves, and as desktop computer capacity to process the large size of these files increases, better land cover data will be available to make future landscape scale assessments easier to conduct.

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