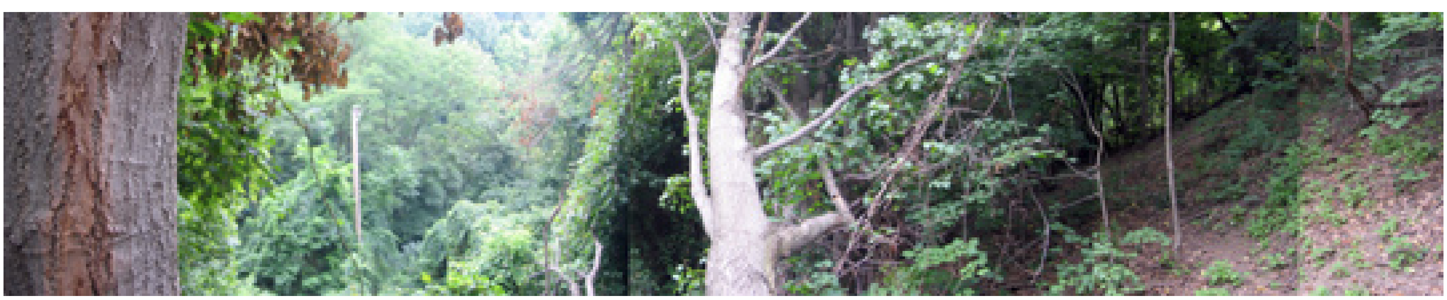
An Ecological and Physical Investigation of Pittsburgh's Hillsides

ECOLOGICAL REPORT

Prepared in cooperation with Allgheny Land Trust for the City of Pittburgh Hillsides Committee

August 31, 2004



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First Edition

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"No city of equal size in America or perhaps the world, is compelled to adapt its growth to such difficult complications of high ridges, deep valleys and precipitous slopes as Pittsburgh."

Frederick Law Olmstead Jr.,

CONTENTS

Summary

Project Description

Provide research, analysis and tools that will inform a hillsides zoning ordinance for the city of Pittsburgh. The specific focus of this section of the report is the ecological systems of said hillsides, expressed below in terms of geology, soils, botany and forest cover.

Purpose

To provide analysis of both quantitative and empirical data that can inform rational decision making on steep slope properties at the level of zoning policy, regulation and enforcement, as well as land use guidance, guidelines and recommendations which may follow zoning use approval.

Methodology

The bulk of this work is based upon quantitative analysis of pre-existing computer mapping data, described in terms of GIS or Geographic Information Systems. The primary sources of this data are the city of Pittsburgh, and Allegheny County. The GIS analysis is used to inform the following narratives on ecological context and cultural need, as well as sections on decision making and recommendations. Specific City of Pittsburgh data sets focused upon existing hillside infrastructure (roads, sewers, buildings) and the United States Department of Agriculture data on soil stability (for roads, buildings and erosion) are used for the land-use decision recommendations. Soil and infrastructure data is then integrated in an interactive database where city parcels can be queried for their relationship to the mapped information. Two additional metrics have been added, first the parcels relationship to underground coal, and secondly the parcels relationship to existing forest cover.

Participants

The Hillsides study team is managed by the Allegheny Land Trust, (ALT). Perkins Eastman Architects (PE) takes the lead on cultural forms and systems, precedents, recommendations for regulation and enforcement, as well as the final report. 3 Rivers 2nd Nature, in the STUDIO for Creative Inquiry, at Carnegie Mellon University (3R2N) takes the lead on natural forms and systems, prototypical site selection, botany and geology field work as well as GIS analysis.

The Hillsides study team is directed by Tim Collins. Priya Lakshmi, MS was the 3R2N research associate working on the GIS mapping. Lena Andrews, policy analyst for Carneige Mellon University's Center for Economic Development, did the work on Access Database. Consultants to the 3R2N team include Susan Kalisz, Ph.D., University of Pittsburgh, Henry Prellwitz, Ph.D, Allegheny Geoquest, and Kostoula Vallianos, MEM, Vallianos Consulting. The final design and review team included project co-director Reiko Goto, research associate and planning coordinator Jonathan Kline. Final design of th maps and report by research asssociate John Oduroe. with graphic support from research associate Noel Hefele.

I. Project Purpose and Goals

Our purpose here, is to provide analysis of both quantitative and empirical data that can inform rational decision making on steep slope properties at the level of zoning policy, regulation and enforcement. The focus in this section is upon 25% slopes or steeper, this is an angle at which many soils become unfit for urban development. Specific goals include contextual analysis at the watershed scale, open space needs analysis at the neighborhood scale and decisions analysis at the parcel scale. Beyond this a plant material and geology baseline has been established through site specific field work on three steep slope properties which can inform land use guidelines and recommendations.

These materials have been developed with the express intention of reflecting the analysis and outcomes of Cyril Fox' study of the authority and jurisprudence of land-use controls. Following the Fox report, we were seeking an analytical methodology that would "identify potential danger from landslide and other development problems" as well as examine the cities current stock of "adequate public services and infrastructure" at each of these parcels. Finally we were seeking to minimize any "perception of arbitrary decision making" – through the rigorous application of accepted material data sets supported by the City of Pittsburgh, Allegheny County and the United State Agricultural Service.

Bio Regional Values

Pittsburgh is located in an ecologically diverse and environmentally important area of the United States. It is part of the Class I Appalachian Mixed Mesophytic Forest Ecoregion, which has been identified as globally outstanding and requiring immediate protection and restoration. This region harbors the most diverse temperate forests in North America. (Ricketts et al. 1999). Southwestern Pennsylvania is also considered a "hot spot" or area of immediate conservation concern for a number of neotropical migratory bird species (Rosenberg and Wells 2004).

Local Field Values

Surprisingly, of our small but diverse list of Pittsburgh hillsides sites sampled - the majority of trees identified were native species. The hillsides of Pittsburgh appear to function as refugia for the native species of the region. At one of the three sites studied we found a tulip tree over three meters in circumference— while the average tulip tree circumference was over one meter. We also found evidence of bear (scat) at this site. (Kalisz 2004)

DISCLAIMER

The following recommendations are conceptual in nature; based on analysis of pre-existing City of Pittsburgh GIS data themes, and United States Department of Agriculture Soil Survey Data provided to us in GIS form, by Allegheny County. This data, is a viable tool to inform decision making. The data has not been field verified by the authors of this report. Everything that follows, are recommendations to inform land-use decision making. In the case of both soils and underground infrastructure onsite analysis and testing by licensed professionals are the only definitive means of assessing infrastructure viability and soil stability on a parcel by parcel basis.

1.2 Overview of General Methodology (with concept-matrix)

The bulk of this work is based upon quantitative analysis of pre-existing computer mapping data, described in terms of GIS or Geographic Information Systems. This work intends to inform the development of Pittsburgh City Zoning regulation. Extending this work is a limited field study of three selected sites. The field work intends to inform development guidelines and recommendations.

The primary sources of this data are the city of Pittsburgh, and Allegheny County. The first level of general GIS analysis occurs at the watershed scale, addressing the ecological condition of our City's hillsides. This study addresses geomorphology, watersheds, steep slopes, forest cover and lost streams, defined as surface drainage networks replaced by underground stormwater infrastructure. The Second analysis occurs at the neighborhood scale and is intended to explore the idea of "need" for open space. This study examines household income, tax values, population density, vacant parcels and parks on a neighborhood by neighborhood basis. Both sections are an attempt to establish a discursive outline for a rational discussion of the potential value and relative need for hillside open space, preservation and restoration. This is presented as a narrative to provide context for the decisions that follow.

The third level of analysis is based upon existing city infrastructure data. Here we examine the geo-spatial area defined by >25% slopes for the current existence of – buildings, roads and sewers. When infrastructure is present, adjacent or nearby an argument can be made for development. The common geo-spatial unit used is a standard GIS polygon from the Allegheny County 25% slope theme. The fourth level of analysis is based upon United States Department of Agriculture soil survey units. Again, we examine the geo-spatial area defined by >25% slopes for the existence of soils that meet the standard USDA definitions of severe and moderate threat to roads and building as well as the potential threat from erosion. When a severe or moderate threat due to soil/slope relationships is present, the relative cost of development may be prohibitive. The common geo-spatial unit used is the USDA soils polygons. (See section 4.2 Understanding the Soil Survey for Plannng for more info.)

In the fifth level of analysis the specific City of Pittsburgh data sets focused upon existing hillside infrastructure (roads, sewers, buildings) and the United States Department of Agriculture data on soil stability (for roads, buildings and erosion) are used for a comparative land-use decision recommendation. Soil and infrastructure data is integrated in an interactive database where city parcels can be queried for their relationship to the mapped infrastructure and soils information. Included in this tool are two additional maps, one based on geology data for coal seams that lie just below the surface, the other is based upon a forest cover analysis. The additional data sets are included in terms of additional analysis – a yes/no query that pushes final decision towards development or preservation based upon real data. See the specific methodology for parcel classification in section 1.3 below.

Field studies in botany and geology address three specific sites but dissimilar sites. The map location of the field studies and the protocol can be found in section 1.4 below, the results can be found in section IV. Natural Systems - Field Studies.

Hillside Ecological Analysis- the Concept Matrix

The matrix is intended to take us to a point where each parcel in the city can be analyzed and sorted into areas for preservation, conservation or development. We primarily rely upon City of Pittsburgh Infrastructure maps and the United States Department of Agriculture Allegheny County Soil Survey, to arrive at the following standardized defnitions:

Preservation: land deemed environmentally unfit for development due to erosive soils, and a lack of available infrastructure.

Conservation: land with sensitive but not exclusionary soil characteristics for safe building practices, with some of the infrastructure necessary to support development.

Development: land with both the soill characteristics for safe building practices and available infrastructure to support development.

Analysis Matrix & List of Maps:			**10-Sep-04**
Scope/Scale	**Ref Map**	**Intention**	**Rating Scheme**
CITY WIDE CONTEXT			
Watershed Scale		**Narrative of Ecolgical Context**	
	1.1 Topography / Geomorphology	nature in the city	context
	1.2 River Valley View Corridor		context
	1.3 Watershed Delineation for City of Pittsburgh		context
	1.4 Watersheds with Lost Streams		context
	1.5 Watesheds with Slopes greather than 25%		context
	1.6 Watersheds with Woodlands and Parks		context
	1.7 Watersheds with woodland and interior patches		context
	1.8 Current Land Conservation Tactics		context
	1.9 Watersheds with sites for potential field study		
CITY WIDE CONTEXT			
Neighborhood Scale		**Narrative of Cultural Need**	
	2.1 Mean House hold Income	for access and open space	Natural Breaks based
	2.2 Average Tax value		Natural Breaks based
	2.3 Population Density		Natural Breaks based
	2.4 Number of vacant parcels		Natural Breaks based
	2.5 Parks by neighborhood		Natural Breaks based
	2.6 Cumulative Value: Need		Natural Breaks based
CITY WIDE CONTEXT		**DECISION**	
Slope Polygon Scale		**INFRASTRUCTURE**	2-6 Rating Scheme
	3.1 25% Slope + Buildings	Support for Development	Onsite - 30' - 100'
	3.2 25% Slope + Streets		Onsite - 30' - 100'
	3.3 25% Slope + Sewers		Onsite - 30' - 100'
	3.4 Cumulative Value - Infrastructure		
CITY WIDE CONTEXT		**DECISION**	
Soil Polygons		**GEOLOGIC HAZARD**	1-3 Rating Scheme
	4.1 Erosion Hazard	Constraints on Development	slight - moderate - severe
	4.2 Stability for Dwellings		slight - moderate - severe
	4.3 Stability for Roads		slight - moderate - severe
	4.4 Cumulative Geological Hazard		
	4.5 Coal Overburden		
CITY WIDE CONTEXT		**DECISION**	
Parcels		**ACCESS DATABASE**	
Slope Polygons	Infrastructure	If/then Argument for Development	sewers/roads/bldgs
Soil Polygons	Geologic Hazards	If/then Argument for Preservation	USDASCS Standards
Woodland Polygon	Forest Cover	Yes/No Push Preservation	Adjacent patch/corridor
USCS	Coal Seam	Yes/No Push Preservation	USDASCS Standards
	5.1 Parcels w/out woodlands or coal		
	5.2 Parcels with woodlands or coal		
	5.3 Parcels w coal only		
	5.4 Parcels w woodlands only		
	DECISION TITLES	**DECISION NARRATIVES**	NUMERICAL VALUES
RATING	5 Preservation	For Woodland/ vacant	
	4 Conserved	for building in park	
	3 Restoration	for vacant land/ woodland	
	2 Eco Development	for vacant parcels	
	1 Development	for already built	

1.3 Specific Methodology for (>25% Slope) Parcel Classification for Zoning Decisions.

The parcel score is based on six categories:

Soils are double weighted for public safety at 2, 4, or 6
Dwellings: 2, 4, or 6 based on soil type – higher value means better soil for dwellings.
Roads: 2, 4, or 6 based on soil type – higher value means better soil for roads.
Erosion: 2, 4, or 6 based on soil type – higher value means less erosion.

Infrastructure: 1, 2, or 3.
Roads:
1 = Parcel is outside of the 300 foot road buffer.
2 = Parcel touches the 300 foot road buffer but does not touch the 100 foot road buffer.
3 = Parcel touches road or 100 foot road buffer.
Sewers:
1 = Parcel is outside of the 300 foot sewer buffer.
2 = Parcel touches the 300 foot sewer buffer but does not touch the 100 foot sewer buffer.
3 = Parcel touches sewer or 100 sewer buffer.
Buildings:
1 = Parcel does not have a building on it nor does it have adjacent buildings.
2 = Parcel has adjacent buildings, but does not have a building on it.
3 = Parcel has a building on it.

These six categories were combined to reach a cumulative score of 9 – 27. Higher numbers indicate parcels that are better suited for development. The ten foot building buffer picked up the majority

Based on this score, parcels were divided into three categories.
1 = Preservation = 9-14
2 = Conservation = 15-20
3 = Development = 21-27

Because the soil categories (2-6) have twice the weight of the infrastructure categories (1-3), the soil categories are the primary determinants of the final score.

Examples:
• A parcel receives a score of 2 in each soil category, meaning that the parcel is situated on soil that is least suitable for development. This parcel will not fall into the Development category, even if the parcel receives a 3 for each infrastructure category.
• A parcel receives a score of 6 in each soil category, meaning that the parcel is situated on soil that is most suitable for development. The parcel will fall into the Development category, even if the parcel receives a 1 for each infrastructure category.
• A parcel receives a score of 4 in each soil category, or an average score of 4 for all three categories, meaning that the parcel is situated on soil that is somewhat suitable for development. This parcel

could then fall into either the Conservation or Development category, depending on the infrastructure scores.

After the initial classification, we identified which parcels are located in woodland areas, and which parcels are located on coal seams. If a parcel is not located in a woodland area or on a coal seam, then it retains its original ranking based on the values above. If it is located in a woodland area or a coal seam, it moves one category lower (closer to preservation). If the parcel is located on a coal seam and in a woodland area, it moves two categories lower (closer to preservation). Preservation is the lowest possible category.

1.4 Specific Field Study Protocols to Produce Data that can Infrom Land Use Guidelines.

Botany:

Primary Themes:

Create a baseline data set of woody plant diversity in the Pittsburgh landscape.

Ascertain forest structure and quantify amount of disturbance.

Method:

Determine area and size

Mark transect(s) through survey area (number and length are site-specific and determined by size and access)

List all woody species

Mark out 10meter by 10meter plot at every 50meters

Identify every woody plant in plot and relative abundance

Measure diameter at breast height of every tree

Identify important native herbs

Analysis:

Determine % invasives

Determine forest continuity

Determine species structure and DCNR's Native Plant Community types where possible

1. Vegetated
   a. modified if information is available to distinguish woody from herbaceous
   b. if there is any estimate of disturbance or proximity to a road cut, etc. that would be valuable, as disturbance is typically correlated with invasive plants
   c. distance from a major road or highway, which are significant barriers to wildlife
2. Connectivity to vegetated areas downslope from "natural" areas or parks would be especially significant
3. Area and width of the corridor -- the larger the area, the better

4. Aspect and Steepness will determine
   a. if species can live there and

b. which species we might find

5. Distance to “interior forest” defined as the forest area approximately 100 m from the edge of forest patch (Moyer 2003

Geology:

Primary Theme:

To identify site typologies that would indicate geologic instability.

Create a baseline data set of geologically diverse conditions.

Secondary Theme:

To Show cause and effect relationships between soils and vegetation.

For Each Site:

1. Consult existing GIS maps, Slopes, Erosion Hazard and Coal Seam

2. If Slope maps shows susceptible areas, look for evidence such as unstable vertical cliffs, landslide, soil creep and rockfall, slow, medium and mass wasting. indicated by tree-trunk changes, landslides/soil slumps etc.

3. If erosion maps show susceptible areas, look for physical characteristics of an eroding soil, such as gullying, lack of vegetation.

4. If coal, look for evidence, such as subsidence, AMD etc.

II. Context

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Kostoula Vallianos, MEM, Natural Resources Planner
Priya Lakshmi, Research Associate, STUDIO for Creative Inquiry, CMU

Applied Ecology

The emergent area of knowledge known as restoration ecology is a logical response to the post-industrial era. Preservation and conservation emerged in the years around the turn of the 20th century in response to the tools and economies of the industrial era and growth and development in the American West. Preservation began with the aesthetic/scientific interests of botanist and gardeners in the subject of trees. Organized groups at that time helped to establish Arbor Day and promoted a plan for national forest preserves. This interest in nature was fueled by the writings of the naturalist/authors Emerson, Thoreau and Muir. A popular movement, preservation was soon balanced by a more practical and scientific voice. The project of conservation has been described by Samuel Hays (1959: 123) as "efficiency in the development and use of all natural resources." Established during Theodore Roosevelt's presidency, conservation was defined by Gifford Pinchot and others as a rational approach to land management. Conservation theory was rooted in an engineering approach to applied knowledge. The ultimate goal was to properly inventory all natural resources prior to a planned development intended to achieve efficient use and minimize waste. This is still the focus of conservation biologists worldwide who inventory natural communities and their movements and then manage habitat so that select species (either migratory or indigenous) will prosper despite impacts from humans. Conservation and preservation are programs that are driven by a reaction to human disturbance of natural systems. Conservation projects today involve large habitat areas, nesting areas and numerous migration areas where landscapes are managed to the best advantage of a single species or groups of similar species.

Preservation and conservation were a reaction to the perception of encroaching physical limits within the United States. Preservationists believed that wilderness was in a state of grace, beyond the limits of human habitation. Nature was something to be preserved and contained for future generations. Conservationists believed that wilderness was a resource bounty to be managed and controlled for long-term economic benefits. Both of these philosophical and political positions placed nature (in the form of wilderness and land-resource) well beyond the limits of cities or towns.

"Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed." (www.ser.org) Restoration ecology is a new way of thinking. It links citizens and experts, as well as cities and wilderness, in a broad program of ecological awareness and action. It is a community of disciplines synthesizing a continuum of diverse knowledge and practices. On one end lie the arts and humanities, in the middle are the design professions, at the other end, science and engineering. Restoration ecology has been touted as a new relationship to nature, one in which the old reductionist paradigm is reversed. Scientists are charged with re-assembling a working nature from the pieces discovered over the last 200 years, while taking it apart. While the machine metaphor was useful in the disassembly and analysis of nature, it is less useful when reassembling nature. The aesthetic roots of restoration ecology can be found in the urban-nature design projects of Frederick Law Olmsted (particularly the Fens of Boston, 1881). The roots of its' science can be found in Aldo Leopold's work restoring the lands of the University of Wisconsin-Madison Arboretum in 1934 (Jordan, 1984).

It can be argued that this "discipline" was established in the early 1980's, in part by the efforts of William Jordan III, a botanist and journalist who was employed at the Madison Arboretum and saw the potential of Leopold's ideas in a contemporary setting. During the 50th anniversary of the Madison Arboretum, he published a seminal text declaring the import of this area. This was followed by a symposium on restoration ecology, which brought together some of the key thinkers worldwide. This resulted in an edited text, "Restoration Ecology: A Synthetic Approach to Ecological Research." (Jordan, 1987). In Jordan's original document, restoration ecology was interpreted as a mixture of cultural and scientific efforts, "….active as a shaper of the landscape, yet attentive to nature and receptive to its subtlest secrets and most intricate relationships. The restorationist is in this sense like an artist and a scientist, impelled to look closer, drawn into lively curiosity and the most intricate relationships" (Jordan, 1984: 24). After Leopold, Jordan is clear that restoration is about restoring a "whole natural community, not taking nature apart and simplifying it, but putting it back together again, bit by bit, plant by plant", "….the ecologist version of healing. " (Jordan, 1984: 23) Jordan commented on the import of restoring whole communities in this text, but he also recognized the import of restoring (reclaiming) industrial sites. Referencing the noted biologist Anthony Bradshaw's pioneering work on coal mining sites in England, Jordan sees the Arboretum as a research laboratory for work that will be in increasing demand in the future, due to the fact that the industrial revolution has provided humanity with the tools to affect nature on a grand scale. The work that first found its symbolic and intellectual focus as a result of the anniversary of the Madison Arboretum occurs around the world today. Today there are academic, private industry, non-profit and federal government models of restoration practices. (Pittsburgh's first major restoration project is underway in Frick Park.) There are two journals attending the area, "Restoration Ecology: The Journal of the Society for Ecological Restoration" published by Blackwell Science, and "Ecological Restoration, published by the University of Wisconsin-Madison Arboretum". Each year, the disciplines of anthropology, art, biology, botany, ecology, engineering, philosophy and poetry participate with government regulators, first peoples, citizen activists, policy makers and spiritual leaders at the annual Society for Ecological Restoration conferences. (http://www.ser.org)

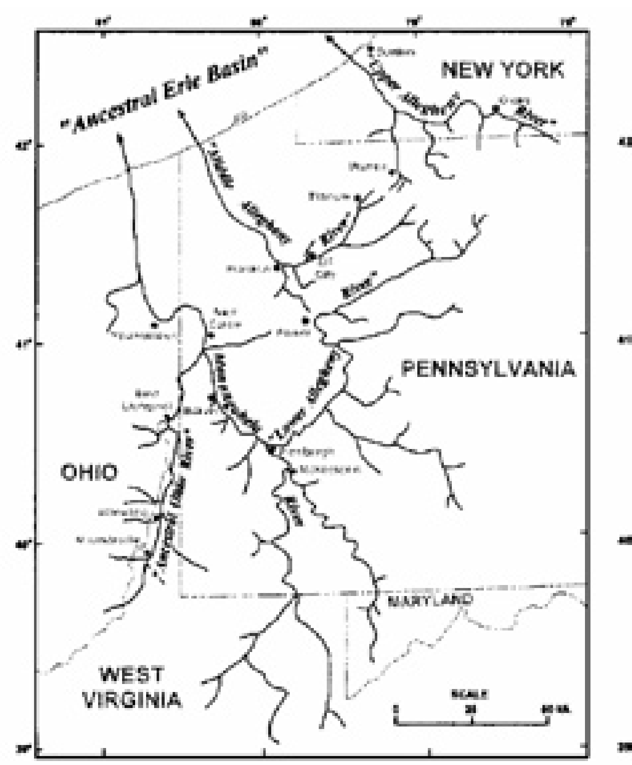
Restoration ecology attempts to both define and reconstruct nature while staying aware (and respectful) of the complexities of natural process, its ethical context and the social and political potential of its performative aspects. Restoration ecology is an important new arena of thinking and acting. It provides us with experience and knowledge that can transform the human relationship to nature. (See appendix I, for more information.)

Restoration ecology, land preservation and species conservation are important tools for, rust-belt cities like Pittsburgh that struggle to recover social, political and economic vitality. Nature was subsumed and ignored during the height of the industrial economy; part of the challenge to recovery involves a restoration of the visible aesthetic vitality, the quality and relationship between the built and natural environment that make places like Pittsburgh unique and interesting places to live and conduct business.

2.1 Watershed Scale

Map 1.1 Topography Geomorphology

History: The Ohio River is formed by the confluence of the Monongahela and Allegheny Rivers, and shares characteristics of both. It is slowly eroding and downcutting the flat-lying sedimentary beds of shale, sandstone, limestone, claystone, and coal deposited during the Pennsylvanian Period of geological time (about 310 million years ago). The history of the Ohio River as we know it today probably began back at the beginning of the Cenozoic Era, about 60 million years ago (Wagner, 1970). During this time, Western Pennsylvania was a broad, flat plain similar to those now seen in the midwestern United States. There was probably very little topographic relief, and there was little elevation difference between the tops of any hills and the water levels of the Ohio. The topographic relief in Pittsburgh is now nearly 700 feet, as the level of the water in the Ohio at the Point is 710 feet above sea level, and the tops of the highest hills are almost 1400 feet above sea level. If one looks out at the Pittsburgh landscape from a high point (such as the USX Tower downtown) one can see that all the hilltops are level, and represent the remnants of this old plain.



The Ohio River has not always flowed south, emptying into the Mississippi River. The Ohio River originally flowed northwards up the Beaver River and French Creek valleys to Lake Erie.

Today if one looks closely at a current map you can see a remnant oxbow of the ancient river at the center of the city, along the rivers edge we see broad flat floodplains that rise steeply into the hillsides which are the primary topic of this report. On a slightly smaller scale, you can see the stream valleys that attenuate the landscape further, streams that once channeled water to the Monongahela, Ohio and Allegheny Rivers. Today, urban surface flow is mostly captured in combined sewer conduits for treatment.

The significant broad flat historic floodplain bordering the rivers has been the site of housing and commerce since the earliest days of human civilization. From this floodplain steep hills rise leading to the ancient plateau described in the previous section on history.

Map 1.2 River Valley View Corridor

The valley view corridor is a simple GIS map, it has a faint topography layer in grey, with a hillsides analysis color-ramped from red to yellow to green illustrating hillside areas that are visible from up 45 separate points in the region (mapped in red) to hillsides that are only visible from a single vantage point which are mapped in dark green. Valley View Corridor is determined by a series of quarter mile points along the centerline of the river at 25 feet above the pool elevation.

With visibility comes an opportunity to create a message. The south side slopes vary from the homes that dot the hillsides, centered upon 18th street to the vertical cliffs of Mount Washington, which feature two restored Pittsburgh Incline railways or funiculars.

Map 1.3 Watershed Delineation for City of Pittsburgh

Watersheds describe the hydrological flow of water over the surface of a landscape. At each point in the landscape – once a saturation point has been reached - water runs downhill. This map describes the areas in an ideal world, where water flows from the high point to a cohesive low point before draining to a stream then to a river below. This map reveals two things that are important first the areas outside the city in black clearly indicate the lack of overlap between our natural hydrologic boundaries and our municipal boundaries. Secondly, you may notice that there are a number of landforms that drain directly from singular hillsides directly to the rivers, in contrast to interior valleys that drain multiple hillsides. It should be noted that much of this hydro-logic is interrupted by combined sewage and stormwater systems throughout the city.

We took the time to delineate the lost watersheds of Pittsburgh so that we might have a ¬hydro-logical land form as the baseline for this eco-logical discussion about the city of Pittsburgh.

Map 1.4 Watersheds with lost streams

A number of streams have been “lost” (i.e. buried or placed in culverts) in the City of Pittsburgh. This map illustrates lost streams and existing streams in addition to the location of woodland patches in the City. The lost streams were generated using GIS analysis (Pinkham 2002). The woodland and interior patches were defined in the same manner as described in for the Woodland and Interior Patch Map. The existing streams were buffered by 100m, a minimum width recommended for neotropical migrants and area sensitive species (Fischer and Fischenich 2000). In addition, 100-meter buffers are sufficient to cover the 100-year FEMA floodplain and some upland area. This buffer is not recommended for streams in Pittsburgh, but merely serves as a way to evaluate the amount and contiguousness of woodland vegetation near the streams.

Riparian vegetation improves water quality and serves as wildlife corridors and habitats. Riparian buffers (i.e. strips of vegetation along either side of a waterway) have been shown to improve stream bank stabilization, reduce sediment, remove chemicals, moderate the temperature of the waterway, and reduce particulate matter (National Council for Air and Stream Improvement 2000). Riparian buffers provide habitat for a large variety of plant and animal species. They have also been documented to be habitat components that promote faunal movement, gene flow, and provide habitats for animals either outright or during disturbance in adjacent habitats (Fischer and Fischenich 2000).

Very few streams still exist within the City limits. Nearly all the existing streams have some woodland near them; though it is important to note that the woodland within the 100 meter buffer along most streams is sparse. The stream valleys are some of the flattest areas in the City and were likely the first areas developed. Saw Mill Run is one of the few streams that is contiguous within the City limits and has a fair amount of woodland area surrounding it. Maintaining woodland areas near existing streams particularly on steep slopes could improve water quality, reduce slope erosion and hillside instability, while providing added green space (Forman 1997).

Map 1.5 Watersheds with 25% + slope

This map depicts 25% slopes in relationship to parks, woodlands and watersheds. It is at a 25% slope that the bulk of our regional soils exhibit what the USDA Soil Conservation Service describes as moderate to severe soil limitations. Moderate is defined as "soil properties that are favorable (to development) but can be overcome or modified by special planning and design. Severe defines "soil properties that are so unfavorable and so difficult to correct or overcome that major soil reclamation, special designs or intensive maintenance are required." (USDA, 1973:53) Note that may of our parks are organized around steep slope environments.

Map 1.6 Watersheds with Woodlands and Parks

This map illustrates parks and woodland areas. By comparing this map with the previous slope map we can see the vast majority of steep slopes are located on woodland areas. In many instances steep slopes could serve as corridors between existing parks and woodland patches. A corridor consists of a strip of a particular type that differs from adjacent land on both sides and connects patches that would otherwise be isolated (Forman 1997). In many instances corridors are discussed in terms of the movement of a particular species in a landscape. The main function of the steep slope corridors suggested above would be to create linked parklands in the City of Pittsburgh for recreational, aesthetic, hazard reduction, and potentially ecological functions. Several areas in the City limits could be connected through this method. For example, from Saw Mill Run to Mount Washington, to the Southside and through the Hays Site, there are steep slopes that create a corridor along the southern side of the Monongahela River. North of the Monongahela River, Schenley Park can be connected to Frick Park using steep slopes south of Schenley Park and woodland areas and steep slopes surrounding Nine Mile Run.

Map 1.7 Watersheds with Woodlands and Interior Patches

The City of Pittsburgh is a fragmented urban landscape containing few woodland patches relative to the rest of Allegheny County. Nearly all the forested land in Allegheny County was previously cut, put to some human use, then reverted back to woodland. This map shows the location, size, interior forest areas, and clustering of woodland patches in the City. Because habitat quality cannot be verified at this time, this data can only provide insight based on the amount of interior forest, and size and shape of the patches.

Woodland patches were classified into 2 size classes: 250 acres and larger, and less than 250 acres. These categories were based on avian studies. Studies have shown that the number of individuals and diversity of neotropical migrants dramatically drops in forest patches smaller than 250 acres or approximately 100 ha. (Robbins et al. 1989 and Askins 2000). Interior or core forest was defined as the forest area approximately 100 m from the edge of forest patch (Moyer 2003). Interior forest habitat is critical in maintaining populations of many organisms by providing stable and valuable sources of food, and cover. The forest edge differs from forest interior in its micro-climate, vegetation, and species present (Moyer 2003, Meffe et. al. 1997, and Turner 2003). The more edge a forest patch has the less likely an interior species will be found within it and more likely wildlife generalist will be present. Larger woodland patches have less edge area and more interior habitat proportionally to smaller patches. Complex and linear shapes consist of more edge and less interior habitat; while simple circular shapes contain the least amount of edge and the most interior habitat (Turner et al. 2003). Generally species richness increases and interior habitat increases with patch size. In this map the largest woodland patches would likely be most valuable because of their size (i.e. they are least fragmented and largest), generally contain the most interior habitat and less edge proportionally to the smaller patches.

Woodland patches in Pittsburgh are concentrated around stream hillsides and steep slopes. These areas tend to be difficult to develop, which is likely the reason they remained woodlands. Frick Park and woodland areas of the Hays Site contain the largest woodland patches and most interior forest in the City. The large proportion of woodland in the City is located in and around the Hays Site. The remaining woodland patches in the City limits are linear and complex in shape, containing mostly edge and little if any interior forest. These woodland areas while not as potentially valuable ecologically as the large patches, they are valuable in reduction of erosion and slope instability and as potential corridors between larger patches.

Map 1.8 Watersheds with Current Land Conservation Tactics

Current land conservation tactics are based upon the Pittsburgh Public Greenway Plan.

Map 1.9 Watersheds with sites for potential field study

During the study phase of the project five sites were, reccomended by the science team for possible inclusion in the field study. Three of the five occurred in watersheds without significant parks or open space. Below you can see the initial review of these sites. Discussion with the Hillsides planning committee and a subsequent assembly of a smaller group from the committee resulted in the choice of three sites. The decision was primarily based upon two factors, onsite soil diversity and potential for biodiversity of plants. The resultant record provides a baseline of potential soils and plant conditions relevant to issues of zoning and land use guidance on steep slope properties.

Sue Kalisz, Ph.D.

INSERT SECTION 1.X MAPS HERE

1. Hayes: on the Monongahela watershed, largest contiguous forest, with interior areas. Floodplain forest and steep hillside forest indicates landscape diversity and likely biodiversity of plants, mam-

mals, birds and insects. Recovering/remnant forest cover.

Best example of a recovering/remnant biological system for city baseline.
Most likely to succeed as a preservation, restoration site.

2. Sawmill Run: Large, urban stream. Has the heterogeneity of habitat found throughout the city, from steep wooded hillsides to developed hillsides. Geology/topography relationship to the stream valley indicates a wide range of native, exotic and invasive species. Small floodplain little bit of everything.

Best example of an urbanized system, a counterpoint to Hayes.
(Proposed greenway development.)

3. Brilliant: Allegheny site, industrial but less so than Monongahela. Indicative of that kind of watershed, parallels the Hays site, both are south side of the river, an intermediate site. Similar in aspect, different topography/limestone outcrops. Real mix of native-wildflower in the understory, exotics, invasives, more intact connections to highland park.

Alternatives:
4. Hill: recovering forest.

5. Swisshelm: Steep slopes, 1.75mi floodplain forest and the connection to Frick.

Henry Prellwitz Ph.D., Allegheny GeoQuest

	Hayes Hillsides	Sawmill Run	Brilliant Hills	Swisshelm Park	Hill District
Soils	10 types	5 Types	3 types	3 types	4 types
Soil Diversity	Highly Diverse	Median	low	low	low
Coal	half underlay	all underlay	no underlay	minimum	all underlay
stream Valley	young valley	y valley, floodplain	Remnant Eroded Plateau	Remnant Eroded Plateau	Remnant Eroded Plateau
	V-shape	V-shape	w young valleys	w young valleys	
				Fossil Riverbed	
Slopes	all sites bordered on 1-2 sides by 30% + Slopes.			all sites bordered on 1-2 sides by 30% + Slopes.	

Section References

Askins, R. 2000 Restoring North America's birds: lessons from landscape ecology. Harrisburg,VA: Donnely & Sons. p. 100-129.

Fischer, R. A. and Fischenich, J. C. 2000 Design Recommendations for Riparian Corridors and Vegetated Buffer Strips U.S. Army Engineer Research and Development Center. Vicksburgh, MS.

Forman. R. T. 1997. Landscape Mosaics: The Ecology of Landscapes and Regions. Cambridge, UK: Cambridge Press. p. 145-162, 214

Hays, S., Conservation and the Gospel of Efficiency, Harvard University Press, Boston Mass. (1959) P. 123

Jordan, W. R. III, A Perspective of the Arboretum at 50, in Our First Fifty Years: The University of Wisconsin, Madison Arboretum. 1934-1984. http:///libtext.library.wisc.edu/Arboretum/, Currently only accessible through http://wiscino.doit.wisc.edu/arboretum then click on the link to Historic Arboretum Documents. ©Board of Regents of the University of Wisconsin. (1984) P. 23-24

Eds., Jordan, W.R. III, Gilpin, M.E., Aber, J.D., Restoration Ecology: A Synthetic Approach to Ecological Research, Cambridge University Press, Cambridge, U.K., (1987)

Meffe, G.K, and C.R. Carroll. 1997. Principles of Conservation Biology. Sunderland, MA: Sinauer Associates. 2nd Edition. p.294-297

Moyer, B. 2003 Pennsylvania's Wildlife and Wild Places: Our Heritage in Peril. Pennsylvania Department of Conservation and Natural Resources.

National Council for Air and Stream Improvement. 2000. Riparian Vegetation Effectiveness. Technical Bulletin No. 799. February.

Pinkham, R. 2002. Stream Restoration and Daylighting – Phase 1. Pittsburgh: Carnegie Mellon University, Studio for Creative Inquiry.

Ricketts T.H., Dinnerstein E., Olson D.M., Colby J. L. et al. 1999. Terrestrial Ecoregions of North America. Washington D.C.: Island Press. p. 96-97.

Robbins, C.S., D. K. Dawson, and B. A. Dowell. 1989. Habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildlife Monographs 103 p.6-33

Rosenberg K.V. and J. V. Wells. Global Perspectives on Neotropical Migratory Bird Conservation in the Northeast: Long-Term Responsibility VS. Immediate Concern. Ithaca, NY: Cornell University. Accessed 3/27/2004. Available at: http//birds.cornell.edu/pifcapemay/rosenberg_wells.htm.

Turner M.G, Gardner R.H., and R. O'Neil. 2003 Landscape Ecology in Theory and Practice. New York: Springer. p.229-235, 272-274.

2.2 Neighborhood Scale

The following maps are provided as a point of reference when considering the social need for parks and open space. In this series of analysis we were trying to gain a spatial understanding of the economic and social conditions in each city neighborhood as well as the relative accessibility to city parks and open spaces.

Data sets used in Section 2 of the Hillsides slope analysis were :
A. Pittsburgh 2000 Census information obtained at the city block Level from www.pasda.org . This data set was summarized geometrically and statistically to represent the city neighborhood level.
B. Property Tax Value Data obtained from the City of Pittsburgh. This data was joined spatially to Land Parcel/Lot block data also obtained from the City of Pittsburgh.

Map 2.1 Per Capita House Hold Income
Using U.S. Census data, we analyzed per capita income within each city neighborhood. This analysis with the parks theme overlay gives us a general sense of the relationship between parks/lack of parks and relative income.

Map 2.2 Average Parcel Value by Neighborhood
This is another means of getting to the relationship between economic values and city neighborhoods. Here we analyze the current assessed tax values of city parcels on an acre by acre basis then translate that into average neighborhood property tax values. This analysis with the parks theme overlay gives us a general sense of parks/lack of parks in relationship to the current tax value of the existing housing stock.

Map 2.3 Population Density
Population density by neighborhood in relationship to parks gives us a general sense of the potential need for open space. It could be argued that if a neighborhood has high population density and minimum park space nearby - there is a need for open space.

Map 2. 4 Number of Vacant Parcels
This is a neighborhood by neighborhood analysis of open and abandoned City properties. It tells us that there may be potential within the existing city property grid for either infill housing, or a shift away from development toward open space.

Map 2.5 Parks by Neighborhood
In an attempt to make the relationship between parks and neighborhoods more clear, we analyzed each city neighborhood for its spatial relationship to existing city parks. We are seeking to highlight the areas of the city that are underserved with this map.

Map 2.6 Cumulative Value I: Need
These values represent neighborhoods in need of open space. Values were calculated by weighing and combining the rankings of each neighborhood based on Per Capita Income (map 2.1), Average Tax Value (map 2.2) and Population Density (map 2.3). Neighborhoods with low per capita income, low Average Tax Values, and high population density were given higher need rankings.

INSERT SECTION 2.X MAPS HERE

III. Decisions

Tim Collins STUDIO for Creative Inquiry, CMU
Priya Lakshmi, Research Associate, STUDIO for Creative Inquiry, CMU
Lena Andrews, Policy Analyst, CMU Center for Economic Development

3.1 Slope Polygon Scale
SOURCE: The Slope polygon of 25% and above has been sourced from the SPC. Each polygon encloses all continuous slopes of 25% and higher.

Process of Generation: Land is represented in a map via contour lines. The accuracy of these contour lines is to a precision of 10 feet at the data obtained from the city of Pittsburgh. To calculate slope, this contour information is converted to a format called "GRID" within the GIS system and more importantly the scale of precision of the conversion is set. The GRID representation of slope is simplified by grouping together certain ranges of slopes for example from 0-15% and representing such a group as a polygon. This polygon representation of slope data is therefore dependent on three critical parameters, the level of detail of the original contour data, the scale of conversion to the grid format and the range of grouping it represents.

Slope, Infrastructure and Zoning
Using a standard GIS polygon from the slope theme, we can map the location of buildings, streets and sewers that occur in slopes of 25% or more. This analysis gives us an understanding of the infrastructure that is currently available to support development.
All infrastructure data is as-supplied by the City of Pittsburgh GIS services.

Map 3.1 25% Slope + Buildings
We wanted to understand where there has been building development on steep slopes and where there has not. If there has already been development in an area, it may indicate that infrastructure is in place and soils conditions are not prohibitive to development.

Map 3.2 25% Slope + Streets
We wanted to understand where streets had been graded, paved and maintained on steep slopes.

Map 3.3 25% Slope + Sewers
We wanted to understand where sewer services were currently available.

Map 3.4 Cumulative Value Infrastructure
The cumulative map takes data on buildings, streets and sewers and integrates it on a single map illustrating areas on slopes of 25% or higher where development has occurred in the past, and is most likely to occur in the future.

INSERT SECTION 3.X MAPS HERE

3.2 Soil Polygon Scale

SOURCE: Soil Polygons are from the AGIS dataset of Soil Polygons of Allegheny County. The soil polygons are based on the Soil Survey of Allegheny County Pennsylvania. by the United States Department of Agriculture, Soil Conservation Service. Data is at a scale of 1:24,000 at an accuracy of +-5'.

We followed the section in the Soil Survey on the "Use of Soils for Town and County Planning" to develop a geo-referenced database that could be used to illustrate conditions that are either favorable or unfavorable (in terms of public safety) for development. (USDA, 1973: 52)

Soil limitations for development are indicated by the ratings such as slight, moderate and severe. Slight means that soil properties generally are favorable for the rated use or, in other words, that limitations are minor and easily overcome. Moderate means that some soil properties are favorable, those that are not can be overcome or modified by special planning and design. Severe means that soil properties are so unfavorable to development and so difficult to correct or overcome that major soil reclamation, special design or intensive maintenance are required.

Each rating, is applied to dwellings, roads and erosion in the following manner

Ratings for Erosion are based on "erosion indexes derived from certain variable of the Universal Soil Loss Equation (Wischmeier and Smith, 1978) and the Wind Erosion Equation (Woodruff and Siddoway, 1965). The indexes are the quotient of tons of soils loss by erosion predicted for bare ground divided by the sustainable soil lost (T factor)." (USDA Soil Survey Manual, 1993: 302)

Ratings are for dwellings with basements or other buildings that are no more than three stories high and have no more than an 8-foot excavation. Buildings larger than this, or buildings with more than an 8-foot foundation excavation are excluded from this rating scheme.

Ratings for roads and streets are based on load supporting capacity, stability of the subgrade, and the workability and quantity of cut and fill material available. Roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Map 4.1 Erosion Hazard
In this map we have analyzed existing soil survey data for the soils that are rated for severe erosion hazard.

Map 4.2 Soil Stability for Dwellings
In this map we have analyzed existing soil survey data for the soils that are rated severe, or moderate for the development of dwellings that are no more than three stories high with no more than an 8-foot excavation.

INSERT SECTION 4.X MAPS HERE

Map 4.3 Stability for Roads
In this map we have analyzed the soil survey for soils that are rated severe or moderate for load sup-

port capacity, subgrade stability and workability and quantity of available cut and fill material.

Map 4.4 Cumulative Geological Hazard

We have integrated the ratings for severe and moderate impacts for erosion, dwellings and roads.

Map 4.5 Coal Overburden

The Pittsburgh City map containing the outcrop lines and overburden areas that are fifty feet above the Pittsburgh Coal seam. It has been produced to be used as a guide in locating any geological hazards connected with past coal mining activity. Potential hazards that are usually associated with coal mining include mine subsidence (cave-in), waste coal pile landslides, waste coal pile fires, and AMD (acid mine drainage).

The Pittsburgh Coal is about 8 feet thick, and was extensively mined in the City limits from the late Eighteenth century to the 1940's. The other economically important coal seam (the Upper Freeport) occurs in Pittsburgh, but is below the elevation of the three rivers, and has no impact on the land surface. The Pittsburgh Coal is found in the higher hills (Squirrel Hill, Herron Hill, etc.) and at slightly lower elevations in the South Hills. This coal bed (along with the other sedimentary beds that are the bedrock in the City of Pittsburgh) do not lie flat, or have a consistent thickness. All of the rocks in the City have a slight inclination down to the south, at about 40 feet per mile, or 2 degrees angle. Other geological structures, including folds, further confuse the geometry of the Pittsburgh Coal.

The Coal Overburden Map was compiled using data from Dodge (1985). This data includes the outcrop lines of the Pittsburgh Coal, and the local geological structures. Since the elevation values in one coal "polygon" change over distance, a single elevation was assigned to a particular area underlain by the coal bed. This value is very accurate at the center of the land area underlain by the coal, and has increasing error towards the edges of the polygon. The map assumes a perfectly flat coal bed, while such is not the case in reality. The polygon areas do serve as a guide for analysis to a particular land parcel, and will alert planners to any potential dangers from past mining activity. After viewing this map, if more detail is needed, the maps in Dodge (1985) can be consulted.

3.3 Parcel by Parcel Scale

With the clear understanding that this exercise is intended to inform Pittsburgh City Zoning, we realized that the geo-referenced data sets would need to be effectively queried at the level of individual city parcels. Working with Lena Andrews, policy analyst to the Carnegie Mellon Center for Economic Development we were able to develop a Microsoft Access Database Tool we call the "parcel identifier." This tool allows the casual user, or city planner to query the infrastructure and soils databases for each city parcel using the lot and block numbers. The results of that query are recommendations for preservation, conservation or development based upon material conditions that either support, mitigate, or deny development. In addition – we added two "push" categories that affect the score and inform the user of potential threats to development due to the underlying coal seam, or potential benefits to preservation in terms of adjacent woodlands.

The relative affects of the "parcel identifier" data base are then mapped and charted for the number of parcels in each category, see maps 5.1 – 5.4 in the section that follows. For this study, we provide the following definitions:

> Preservation: land deemed environmentally unfit for development.
> Conservation: land with sensitive but not exclusionary environmental characteristics, with some of the infrastructure necessary to support development.
> Development: land with both the environmental characteristics for safe building practices and available infrastructure.

The Decision systems
Soils are double weighted for public safety at 2, 4, or 6
Dwellings: 2, 4, or 6 based on soil type – higher value means better soil for dwellings.
Roads: 2, 4, or 6 based on soil type – higher value means better soil for roads.
Erosion: 2, 4, or 6 based on soil type – higher value means less erosion.

Infrastructure: 1, 2, or 3.
Roads:
1 = Parcel is outside of the 300 foot road buffer.
2 = Parcel touches the 300 foot road buffer but does not touch the 100 foot road buffer.
3 = Parcel touches road or 100 foot road buffer.
Sewers:
1 = Parcel is outside of the 300 foot sewer buffer.
2 = Parcel touches the 300 foot sewer buffer but does not touch the 100 foot sewer buffer.
3 = Parcel touches sewer or 100 sewer buffer.
Buildings:
1 = Parcel does not have a building on it nor does it have adjacent buildings.
2 = Parcel has adjacent buildings, but does not have a building on it.
3 = Parcel has a building on it.

These six categories were combined to reach a cumulative score of 9 – 27. Higher numbers indicate parcels that are better suited for development, lower number indicate preservation.

Based on this score, parcels were divided into three categories.
1 = Preservation = 9-14
2 = Conservation = 15-20
3 = Development = 21-27

Because of public safety concerns, the soil categories (2-6) have twice the weight of the infrastructure categories (1-3), the soil categories are therefor the primary determinants of the final score.

Examples:
- A parcel receives a score of 2 in each soil category, meaning that the parcel is situated on soil that is least suitable for development. This parcel will not fall into the Development category, even if the parcel receives a 3 for each infrastructure category.
- A parcel receives a score of 6 in each soil category, meaning that the parcel is situated on soil that is most suitable for development. The parcel will fall into the Development category, even if the parcel receives a 1 for each infrastructure category.
- A parcel receives a score of 4 in each soil category, or an average score of 4 for all three categories, meaning that the parcel is situated on soil that is somewhat suitable for development. This parcel could then fall into either the Conservation or Development category, depending on the infrastructure scores.

After the initial classification, we identified which parcels are located in woodland areas, and which parcels are located on coal seams. If a parcel is not located in a woodland area or on a coal seam, then it retains its original ranking based on the values above. If it is located in a woodland area or a coal seam, it moves one category lower (closer to preservation). If the parcel is located on a coal seam and in a woodland area, it moves two categories lower (closer to preservation). Preservation is the lowest possible category.

The relative affects of the "parcel -identifier" database are mapped and charted for the number of parcels in each category. The maps below provide the committee with an understanding of the affects of the analysis on each category. The 11x17 maps as included in this report are a good representation of the general condition. To see the true detail, the maps need to be printed out at 18x24 or larger.

Map 5.1 Parcels Without Woodlands or Coal
This map is the cleanest presentation of the relationship between existing infrastructure and soil conditions as analyzed by the "parcel identifier." Using just soils and infrastructure we have a very simple, clear and concise tool to inform decisions on zoning.

At 11x17 it is hard to read the true resolution of this map – but it proves a good general idea of the areas that may or may not be best candidates for preservation, conservation and development.

Preservation	3494 parcels (30%)
Conservation	3951 parcels (34%)
Development	4310 parcels (36%)

Map 5.2 Parcels with Woodlands and Coal

With the addition of the woodland and coal "push" categories the categories either increase or decrease by the following number of parcels/percentage:

Preservation	5992 parcels (51%)
Conservation	2860 parcels (24%)
Development	2903 parcels (25%)

Map 5.3 Parcels with Coal Only

If we were to only include the Coal underlay as a push factor the categories increase or decrease by the following number of parcels/percentage:

Preservation	3806 parcels (33%)
Conservation	3937 parcels (33%)
Development	4012 parcels (34%)

Map 5.4 Parcels with Woodlands Only

If we were to only include the woodlands condition as a push factor the categories increase or decrease by the following number of parcels/percentage:

Preservation	5782 parcels (49%)
Conservation	2897 parcels (25%)
Development	3076 parcels (26%)

INSERT SECTION 5.X MAPS HERE

IV. Natural Systems - Field Studies

Geology: Henry Prellwitz, Ph.D., Allegheny GeoQuest
Botany: Sue Kalisz, Ph.D., Biology University of Pittsburgh
Jessica Dunn, Research Ecologist

Introduction

Pittsburgh is located in an ecologically diverse and environmentally important area of the United States. It is part of the Class I Appalachian Mixed Mesophytic Forest Ecoregions, which has been identified as globally outstanding and requires immediate protection and restoration. This region harbors the most diverse temperate forests in North America. (Ricketts et al. 1999). Southwestern Pennsylvania is also considered a "hot spot" or an area of immediate conservation concern for a number of neotropical migratory bird species (Rosenberg and Wells 2004).

Surprisingly of our small but diverse list of sites, the three Pittsburgh hillsides sampled - the majority of trees identified belong to native species. The hillsides of Pittsburgh appear to function as refugia for the native species of the region.

4.1 Geology, Soils

Introduction

The City of Pittsburgh has seen most of its past development on the flattest areas including floodplains (recent and fossil), and hilltops, which are usually flat topped. The flat hilltops are remnants of an ancient plateau that has been subsequently eroded. Many of the hillsides in Pittsburgh, due to their steepness, remain undeveloped. The purpose of this section of the report is to pinpoint geological hazards that could hinder development from an engineering standpoint, and then use the information from the slope stability, soils, and coal overburden maps to perform a field reconnaissance that confirms or negates the existence of any possible hazards. Suggestions for further testing are outlined at the end of this report.

Methods

The Pittsburgh Hillsides Project Committee selected three areas for field studies. The Pittsburgh Watershed/Woodlands Maps, compiled by Kostoula Vallianos, were used as a basis for site selection, using the following criteria: size of green space, amount of development, and site steepness (> 25% slope). The field traverses were conducted on July 22 and 23, 2004 at three selected sites within Allegheny county. The geological hazards GIS maps were first consulted, to alert the presence of any hazards; these potential hazards were then confirmed in the field.

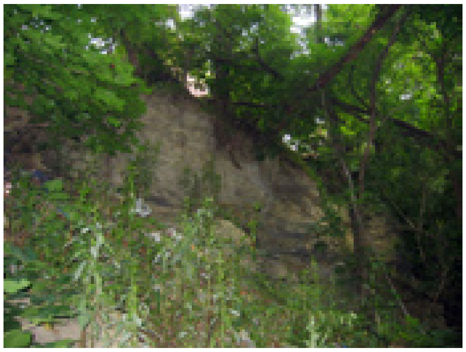


figure 1

Site A Field Reconnaissance

The traverses conducted on Site A cover territory that is very urban in character. Except for some small bedrock outcrops, all of the hillsides have been disturbed, and do not have natural soil cover. Large scale development and past strip mining activities have obliterated the natural soils and hillside profiles.

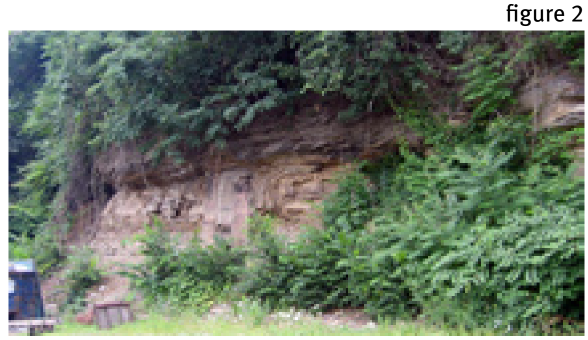
The first traverse started from a residental street, northward up a flight of abandoned cement steps, to a flat area on the hilltop. This flat hilltop was the original level of the Pittsburgh Coal, which has long since been mined out. The traverse turned east, along an old drainage ditch, ending at a 15 foot high cliff, which is a bedrock outcrop of sandstone and shale (figure 1).

The hillside has a 45 degree (100%) slope (average) and consists of clay, construction rubble, and assorted garbage. The rubble includes local rock fragments, bricks, cement, and other debris. No sign of past landslide activity was observed. The rock outcrop near the top of the hill appeared stable, but could pose a rockfall hazard if disturbed. Near the bottom of the outcrop there is a 1.5 foot thick bed of limestone. No evidence of coal mining (waste piles or subsidence) was seen, as the traverse was below the elevation of the Pittsburgh Coal. Elevations for this traverse were 970' to 1060' above sea level.

The second traverse was along a residential street. This traverse showed little geology, as this area has deep vegetation cover. One small outcrop was found (about a 1 foot high siltstone exposure) and a longer 10' high exposure of siltstone that could be followed for 50 feet. The hillside has slopes from 15 degrees (27%) to 45 degrees (100%). These slopes are all a result of man-made activity, with no original natural materials. Compositions of soils are similar to those found on the first traverse. Elevations ranged from 970' to 1000' above sea level. The slopes here appear to be stable, with no evidence of sliding or creeping.

The third traverse on Site A, is from the bottom the hill to the flat top of the hill. The elevation change is from 920' to 1040' above sea level. The top of the hill is the site of a long-ago abandoned strip mine in the Pittsburgh Coal, and was later developed. The bottom of the hillside has an average 45 degree slope (100%), and nearer the top, an average 20 degree (36%) slope. All of the slopes appear stable, with no evidence of slide or creep.

figure 2



The slope materials are similar to traverses 1 and 2, and consist of "urban rubble", with no naturally placed materials. At the bottom of the traverse there is a high (25 foot) outcrop of bedrock (figure 2). This outcrop is made up of sandstone, siltstone, claystone, and limestone. This vertical cliff could have a potential rockfall hazard. The outcrop appears artificial, being an excavation into the hillside. Figure 3 is a closer view of this outcrop, showing the cross-bedded sandstone.


figure 3

The fourth traverse revealed some small rock outcrops consisting of shale and siltstone. Elevation change for this traverse is from 900' to 1040' above sea level. The flat topped Hilltop is the same as seen in Traverse 3, as was the abandoned Pittsburgh Coal strip mine. The soil material is similar to the first three traverses, and is urban rubble. No evidence of the old coal mine operations could be seen (waste piles, subsidence, etc.). The hillside slope ranges from 35 degrees (70%) to 15 degrees (27%).

The fifth (and last) traverse is along an abandoned street right-of-way. This traverse starts from the barrier at the end of the usable portion of the street and extends eastward. The elevations range from 885' to 960' above sea level. This street was abandoned due to severe slope failure (figure 4). This failure is not due to coal mining activity, as the Pittsburgh Coal is well above this locality. Above the street remains is an outcrop of sandstone and siltstone about 20' high (figure 5). This exposure could be a potential rockfall hazard. The hillside slopes range from vertical to 35 degrees (70%), and consist of urban rubble with a mix of more natural rubble, mostly as fall material from the cliffs above the street right-of-way. This site would be a poor location for development, unless the hillside slopes could be stabilized.

All of the soils in the Site A hillsides are classified by the U.S. Department of Agriculture (1981) as "UCE", or Urban land – Culleoka Complex, Steep. The Urban Land soil designation consists of land so altered by excavation and earth moving that the original soils cannot be identified. Culleoka Complex soils are well-drained upland types that result from the weathering of shales and sandstones. The soils observed in the field traverses have an Urban component of over 95%, as there has not been a great enough time period to form a large amount of Culleoka soil. As bedrock weathering progresses over time, the Culleoka portion will increase, if the slopes are not disturbed.

figure 4


Site B1 & Site B2 Road Corridor Field Reconnaissance
Two traverses were walked in the area of a highway road corridor. The first is a residential road, and the second is below a residential development. These two traverses represent a more suburban setting, with the soils and hillside profiles less disturbed than those in Site A.

The first traverse begins in a parking lot on the east side of a major roadway, across from a residential Avenue. This traverse skirted the hillside, and proceeded northward into the westward side of a small valley. The lowest point of the traverse is a small westward flowing stream, under a Port Authority (PAT) right-of-way. Elevations ranged from 880' to 1020' above sea level. The southern portion of this hillside has slopes from 40 degrees (85%) to almost level, with almost all natural soils. A few places have been disturbed by minor excavation. A small bed of limestone was seen on the less steep portions of the hill. As the traverse proceeded northward (and upward in elevation) into the small valley, evidence of coal mining was observed. Several small coal mine waste piles (figure 6) were noted. According to the coal mine overburden map (map 4.5) this elevation is where the Pittsburgh Coal occurs. A small housing development to the west was probably the site of the old mine that generated the observed "gob" piles. The hillside slopes in this vicinity contained less natural material, and more man-made or man-placed soil. Along with the gob piles, there was also an abandoned garbage dump, with numerous old tires, washing machines, and hot water tanks. This valley has a more urban character than the southern portion of the hillside. The coal waste piles can be a source of slide-prone material, and acid mine drainage (AMD). At the bottom of the southern face of the hillside, on return to the starting point, the traverse paralled the small westward flowing stream. About 10 feet above water level, the north bank has slumped into the creek (figure 7). The slumped material does not appear natural, and looks like man-placed fill. This site has very poor soil, from an engineering standpoint.

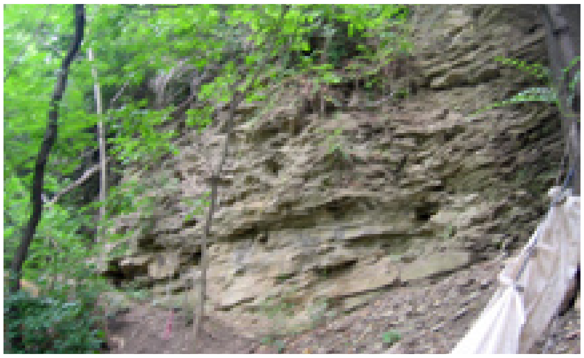


figure 5

figure 6

The second traverse, conducted across a residential development, covers an area that was disturbed to a small extent many years ago. The elevations of the traverse were from 980' to 1080' above sea level. There was no evidence at this site of any past coal mining activity. No coal mine waste piles or subsidence was evident here. The slopes of this hillside ranged from 10 degrees (18%) to 45 degrees (100%). Even though the soils looked disturbed, the materials observed were over 95% naturally occurring. Very little rubble of man-made origin was seen. There was no evidence of slope failure, and no bedrock outcrops were encountered. All of the soils found in these hillsides are classified by the U.S. Department of Agriculture (1981) as "GSF",

figure 7

or Gilpin, Weikert, and Culleoka Shaley silt loams, very steep. This mixture of soils should also include an Urban component; this can be a large percentage of the total. This soil has been reworked, and dumped upon. The soils at the residential development site have been reworked many years ago, and are returning to a more natural state as the weathering process continues.

Site C Field Reconnaissance

Four traverses were walked at Site C: 1) from the starting point across the hilltop to Ravine I, and down to a main access roadway, 2) from the main access road up the old haulage road back to staring point 3) at a railroad right-of-way southwards into a small ravine (Ravine 2) with a 25 foot high waterfall, and 4) from the starting point across the hilltops into the same ravine as Traverse 3. The topographic relief for these traverses is from 740' to 1150' above sea level.

Traverse 1 begins at the uphill end of Ravine 1, downhill to road, and finishes at the lower end (mouth) of Ravine 1. With the exception of man-made materials in the abandoned roadbed (slag, mine waste, bricks, etc.) the soils and rubble were all naturally occurring. This valley has seen little disturbance for many years, except for an old quarry at the bottom of the ravine where it intersects with the main access road. This quarry (figure 8) is in the Morgantown Sandstone, and was probably utilized for building foundation stone. The quarry is on the mineral resource map of Johnson (1929). About halfway down the ravine are some small siltstone outcrops. The slopes are steep (from 20 to 80 degrees or 36% to >100%) but appear stable. There seems to have been no recent landslide activity here.

Traverse 2 also begins at the main access road, and uphill to the top of the site. One outcrop, near a stream, occurs along the side of this abandoned haul road, and is probably not natural. All of the soils on this traverse are natural, until one approaches the top of the site. Site C is covered with a layer of slag on the hilltops. There is no evidence of slope failure anywhere along Traverse 2.

Traverse 3 begins on an old Railroad right-of-way, southward into Ravine 2, containing a small waterfall. The exposed bedrock that forms the waterfall (figure 9) is the Birmingham Siltstone and Shale. The exposed vertical cliff, about 25 feet high, could present a rockfall hazard, if developed. Above the waterfall, all of the soils appear natural and undisturbed in recent times. Much loose soil and fill has been dumped at the mouth of the ravine near the railroad line, and is probably very unstable. This dumping activity is very recent, and no evidence of slide or slump can be seen. Many of the soil piles have been badly eroded and gullied. The sides of the ravine are steep, ranging from 45 to 90 degrees, all greater than 100% slopes. Figure 10 is a close-up view of the BirminghamShale.

figure 8

Traverse 4 goes overland to the head of Ravine 3, but not down to the waterfall elevation. At about elevation 1040' above sea level, much evidence of mining in the Pittsburgh


figure 9

Coal is present: many abandoned waste coal piles ("gob") and areas that appear to be caved-in mine entrances. Mining was active here during the 1920's (Johnson, 1929). The Johnson report (1929) shows many coal mine adits (entrances) at this site. Some of these waste piles show signs of minor downhill movement, or creep. Except for coal mining disturbance, most of the ravine sides have naturally occurring soils and rubble. The slopes in Ravine 3 are steep, from 30 to over 60 degrees (58% to >100%).

Most of the soils in the traversed ravines are classed by the USDA (1981) as GQF, or Gilpin-Upshure complex, very steep. This soil is common in Allegheny County on the steep sides of small stream valleys. It is a product of the weathering of shale, siltstone, and sandstone. Many areas of the four traverses showed high sand content in these soils, due to weathering from sandstones. Where coal mining has disturbed the surface, an Urban component could be added.

Conclusions

The traverses walked on the three major site areas illustrates the importance of field checking maps of geological hazards and soil types before any decisions are made as to the suitability of hillside land for development. An "order of operations" for hillside land selection on a geological basis could be as follows:

Step 1 – Consult the GIS maps generated for this report, including coal mine overburden, soil maps for dwelling construction suitability on slopes, soil maps for street and sewer construction on slopes, and the erosion potential map.

Step 2 – Consult geological references and pinpoint the exact elevation of the Pittsburgh Coal, if the selected parcel is located on or above the coal elevation on the Overburden Map.


figure 10

Step 3 – Field check any potential geological or soil hazards on selected hillside. Record any suspicious looking waste piles and dumps. Check for erosion and landslide evidence, such as gullying, bent tree trunks, and general natural earth movement due to gravity, especially after a prolonged and heavy rainfall.

Step 4 – If the hillside site appears favorable, then test borings and a thorough geotechnical engineering study is warranted, to determine the load carrying capacity and stability of the soils and bedrock for development.

4.2 Understanding the Soil Survey for Planning

Introduction: Use and importance of the Allegheny County Soil Survey

The focus of the GIS mapping and the terrestrial portions of this report have been soils, for two reasons, the first being that soils are the first and uppermost layer of natural materials encountered when excavating for foundations, streets, and sewers. The second reason for a soils focus versus bedrock studies is that soils are generally more susceptible to downslope movement due to gravity.

The land in the City of Pittsburgh is covered by soils, except in very steep areas of bedrock outcrop. Since soils are the first natural materials that are penetrated by excavation activity, and often are the bottom foundation for structures and streets, determination of their mechanical and engineering properties is paramount for successful infrastructure improvements and other development. While the weathering of bedrock produces soil, and determines their physical properties, few structures and streets in Pittsburgh are built directly on bedrock. Soils provide mechanical support for the majority of buildings, excepting large skyscrapers and streets built in tunnels.

With the exception of rockfalls along highway roadcuts, and coal mine subsidence, soils are the main offenders in natural downslope movement and failure. Most of the landslides, slumps, and areas of slow downward creep involve the soil layers, instead of bedrock failure. Compared to other United States cities, Pittsburgh has an acute landslide problem, mainly due to steep slopes and slide prone soil mechanical properties

The Soil Survey of Allegheny County, Pennsylvania (USDA, 1981) has been published as a guide for those in the agriculture industry and urban planners. The Survey contains both agricultural and engineering information pertaining to natural soils. The soils in the Pittsburgh area form as a result of bedrock disintegration through natural and human weathering processes, and reflects the composition of the parent rocks from which it is derived. A few soil types in the Allegheny and Ohio River valleys contain soil that was introduced from sources further north, due to outwash from the glaciers. The great majority of Allegheny County soils are from local sources.

Soil Classification

Soils are classified using many variables; the main factors are the grain sizes of the particles that make up the soil, the natural thickness of the soil, the water holding capabilities, and the topography on which the soil occurs.

Soil texture is the weight percent of certain grain size groups, all less than 2 mm. in diameter. The USDA Soil Survey Manual gives the particle size ranges as:

Very coarse sand	2.0 – 1.0 mm
Coarse sand	1.0 – 0.5 mm
Medium sand	0.5 – 0.25 mm
Fine sand	0.25 – 0.10 mm
Very fine sand	0.10 – 0.05 mm

Silt	0.05 – 0.002 mm
Clay	‹0.002 mm

Using the USDA Soil Texture triangle, a classification can be utilized with three variables: sand, silt, and clay. Each endpoint of the composition triangle represents 100% of the respective component (figure 11, USDA, 1993) If a soil has 40% sand, 40% silt, and 20% clay, the composition triangle indicates a loam. In this diagram, all the different sizes of sand, from 2.0 mm. to 0.05 mm. are included as one component.

Soils are divided into Series, usually named for the locality in which they were first studied. Each series can be further subdivided into Phases, which are different slope environments for a series. Sometimes, more than one series can be combined to form a soil complex. On the soil survey maps, one can find symbols for series, phases, and complexes.

Table 2, on pages 38 to 42 in the Allegheny County Soil Survey (USDA, 1981), is a tabulation of soil properties useful to engineers. The USDA textures refer to the texture triangular diagram in the Soil Survey Handbook (USDA 1993). Also on this table are the series names and map symbols.

Table 5, on pages 54 to 61 (USDA, 1981) is probably the most useful for planners. Each series and phase is listed, with its map symbol, and six columns describing the soils suitability for certain applications, including dwellings with basements, roads and streets, etc. Soil limitations are ranked and slight, moderate, or severe, and the reason for this ranking. These ranks are a result of laboratory tests that have determined the competency of a particular soil. The variables for competency are grain size percentages, porosity (ratio of pore space to solid material) permeability (water transmittability), slope, and compaction tests. For example, a very sandy soil, with large grains, is a good aquifer, but on a slope is susceptible to erosion. A soil with a large clay content will not conduct water well, but has good compaction characteristics, due to its low porosity. All of these variables are taken into account in tables 2 and 5 classification and suitability charts. If one is planning to develop a land parcel, one must conduct test borings and geotechnical engineering studies to quantify the amount of load a particular soil can bear, its slope stability, and ability to drain water.

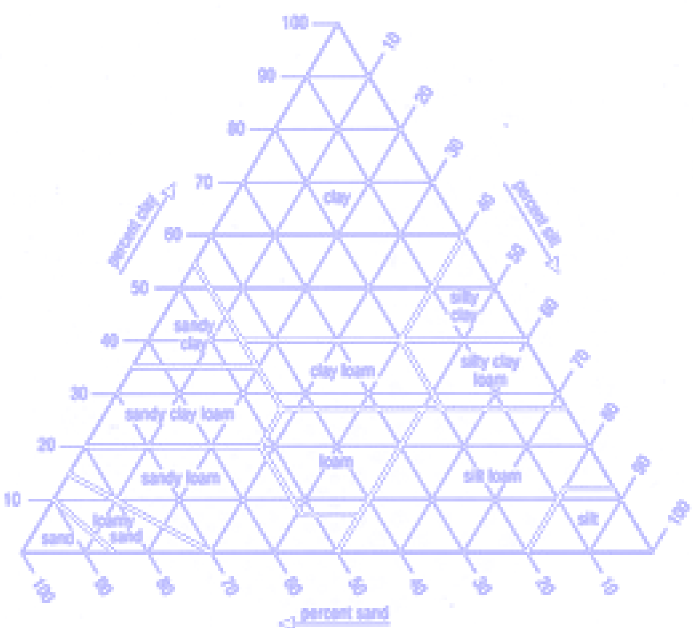


figure 11. USDA Soil Texture triangle

Table 8 (USDA, 1981) on pages 70 to 73 lists the soil series and phase, with its ability to support plant life. Categories are good, fair, poor, and very poor. This table is particularly useful for forest area conservation and preservation.

Example

A practical way to explain the use and application of the Allegheny County Soil Survey (USDA, 1981) is to provide a hypothetical example. You, the developer, want to build a residential and retail complex at the west end of the Carrie Furnace site in Rankin, PA. The flat floodplain land between the CSX railroad and the Monongahela River is level land, suitable for retail use, and the hillside behind the CSX railroad would offer a spectacular view for residential use. After looking at the Allegheny County Soil Survey Map, one sees the floodplain labeled URB, and the hillside GQF.

The text of the Soil Survey indicates that URB is the Urban land - Rainsboro Complex. Since this is a complex, and not a single soil, two descriptions will have to be consulted. The slopes for URB are 0 – 8 percent grade, which fits a river floodplain well. The description shows the URB complex to be 75% urban soil, 15 % Rainsboro soil, and 10 % "other" soils. The Rainsboro soils (see text description) are silty loams, and occur on old river terraces. The USDA Soil composition triangle (USDA, 1993) shows that a "silty loam" would have 60% silt, 20% sand, and 20% clay sized particles. The Urban soils have been disturbed and contaminated enough that no particle size classification applies. In the URB area, extensive test borings, grain size analysis, and engineering studies would have to be performed by geotechnical personnel to determine load bearing characteristics.

The GQF portions on the map are on a steep hillside. The GQF soils, in the Survey text, name this as the Gilpin – Upshure Complex, very steep. Slopes are 25 to 80 percent grade. The description also indicates that the complex has 50% Gilpin soils, 15% Upshur soils, and 35% "other" soils. The surface is silt loam, and deeper soil is silt clay loam. Silt clay loam has about 60% silt, 10% sand, and 30% clay. If one actually walks into this hillside area, the grades are steep, and in some places, there are vertical rock outcrops. Test borings and grain size analysis will confirm or disprove these labels. The soils in the Pittsburgh area are variable, and the Soil Survey map is used as a guide.

After reading the descriptions, the tables in the Allegheny County Soil Survey (USDA, 1981) can be consulted. For this example, Table 5 (Soil Limitations for Town and Country Planning) will be referenced. For URB, the table indicates that the properties of urban land are too variable to be rated. Since 15% of this complex is Rainsboro, that portion of the table can be consulted, and ratings for Dwellings with Basements show a moderate limitation, due to a seasonal high water table. The Gilpin soil lists the limitations as severe, because of slope. Bedrock depth for the Gilpin soils is only about three feet down, making excavation more difficult. The bedrock would provide the most secure foundation on a steep slope, however. The Upshur portion of the complex is rated at very severe, due to slope and proneness to landslides. After reviewing these limitations in Table 5, the reasons for non-development of this hillside are apparent.

Other factors, along with soil analysis, have to be taken into account before developing land in an urban setting, including environmental assessments to check for
any toxicity.

References

Cortiss, S.E., Alexander, T.B., Edmunds, W.E., and Craft, J.L., 1975, Greater Pittsburgh Region maps of mined-out areas and thicknesses of rock over the Pittsburgh Coal. Pennsylvania Geological Survey (4th Series) Map # 45

Dodge, C.H., 1985, Coal Resources of Allegheny County, Pennsylvania – Part I, Coal crop lines, mined-out areas, and structure contours. Pennsylvania Geological Survey, 4th Series, Mineral Resource Report M-89, 112 pp.

Johnson, M.E., 1929, Geology and Mineral Resources of the Pittsburgh 15' Quadrangle, Pennsylvania. Pennsylvania Geological Survey (4th Series) Atlas A-27, 236 pp.*

United States Department of Agriculture, 1981, Soil Survey of Allegheny County, Pennsylvania. 95 pp. and maps.*

United States Department of Agriculture, 1993, Soil Survey Manual, United States Department of Agriculture Handbook #18, 437 pp.

Wagner, W.R., 1970, Geology of the Pittsburgh Area, Pennsylvania Geological Survey, (4th Series), General Geology Report G-59, 145 pp.*

* = out of print

4.3 Vegetation Assessment

Table 2. Allegheny County Soli Survey: Estimated Soil Properties Significant in Engineering

Soil series and map symbols	Depth to— Seasonal high water table	Depth to— Bed-rock[1]	Depth from surface	USDA texture	Engineering classification: Unified	Engineering classification: AASHTO	Coarse fraction larger than 3 inches
	Feet	*Feet*	*Inches*				*Percent*
Allegheny variant: AgB, AgC	>6	>5	0–8	Silt loam	ML or CL	A–4 or A–6	------
			8–35	Silt loam, gravelly loam, gravelly sandy loam.	SM, GC, ML, or CL	A–4 or A–6	0–10
			35–60	Very gravelly loamy sand.	GM, GC, SM, or SC	A–1 or A–2	0–20
Atkins: At	0–½	>5	0–8	Silt loam	ML or CL	A–4 or A–6	------
			8–34	Silt loam, loam	ML or CL	A–4 or A–6	------
			34–60	Loam, silty clay loam	SM, SC, ML, or CL	A–2 or A–4	------
Brinkerton: BrB	0–½	>5	0–8	Silt loam	ML or CL	A–4 or A–6	------
			8–24	Silty clay loam	ML or CL	A–4, A–6, or A–7	------
			24–60	Silty clay loam	SM, SC, ML, or CL	A–4, A–6, or A–7	------
Cavode: CaB, CaC	½–1½	>3½	0–10	Silt loam	ML or CL	A–4 or A–6	------
			10–40	Silty clay loam, silty clay.	ML, CL, or MH	A–4, A–6, or A–7	------
			40–60	Shaly silty clay	ML or CL	A–4 or A–6	0–20
Clarksburg: CkB, CkC	1½–3	>5	0–9	Silt loam	ML	A–4	------
			9–28	Silty clay loam	ML or CL	A–4 or A–6	------
			28–60	Silt loam	ML or CL	A–4 or A–6	------
Clymer: CmB, CmC, CmD	>6	3½–6	0–9	Silt loam	ML	A–4	------
			9–37	Loam, clay loam, channery sandy clay loam.	SM, GM or ML	A–2 or A–4	0–15
			37–55	Very channery loamy sand.	GM, SM, GP, or GM	A–1 or A–2	0–20
			55	Sandstone bedrock			
*Culleoka: CuB, CuC, CuD, CwB, CwC, CwD. For the Weikert part of CwB, CwC, and CwD, see the Weikert series.	>6	1½–3½	0–7	Silt loam	ML	A–4 or A–6	------
			7–27	Silt loam, silty channery clay loam, clay loam.	GM, GC, SM, SC, ML, or CL	A–4 or A–6	0–15
			27–29	Very channery clay loam.	GM or GW	A–1, A–2, or A–4	5–15
			29	Shale and sandstone bedrock.			
Dormont: DoB, DoC, DoD, DoE	1½–3	>4	0–7	Silt loam	ML or CL	A–4 or A–6	------
			7–53	Silt loam, silty clay loam.	ML or CL	A–4 or A–6	------
			53–72	Silty clay	ML or CL	A–6 or A–7	0–30
*Ernest: ErB, ErC, ErD, EvB, EvC, EvD. For the Vandergrift part of EvB, EvC, and EvD, see the Vandergrift series.	1½–3	>5	0–6	Silt loam	ML or CL	A–4	------
			6–28	Silt loam, silty clay loam.	ML or CL	A–4 or A–6	0–20
			28–72	Silt loam	GM, GC, ML, SM, SC, or CL	A–4 or A–6	0–20

Percentage smaller than 3 inches passing sieve—				Permeability	Available water capacity [2]	Reaction	Compaction data		Shrink-swell potential	Corrosion potential	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				Optimum moisture	Maximum dry density		Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Percent*	*Pounds per cubic foot*			
95–100	95–100	85–100	70–90	2.0–6.0	0.18–0.24	4.5–5.5			Low	Low	High.
80–100	60–100	55–100	45–75	0.6–2.0	0.12–0.18	4.5–5.5	10–15	100–125	Low	Low	High.
40–80	30–60	25–50	15–30	0.6–6.0	0.08–0.12	4.5–5.5	5–10	105–130	Low	Low	High.
90–100	80–100	80–100	75–95	0.6–2.0	0.18–0.22	4.5–6.0			Low	High	High.
90–100	80–100	80–100	60–95	0.6–2.0	0.14–0.18	4.5–5.5	12–18	100–110	Low	High	High.
80–100	60–100	45–100	30–85	0.6–6.0	0.08–0.16	4.5–5.5	8–14	108–120	Low	High	High.
95–100	85–95	80–95	75–95	0.2–6.0	0.18–0.24	5.1–6.0			Low	High	Moderate.
95–100	85–100	80–100	65–95	0.2–0.6	0.14–0.18	5.1–6.0	16–22	95–112	Moderate	High	Moderate.
70–100	60–100	55–95	40–90	0.06–0.2	0.08–0.12	5.1–6.0	12–17	100–120	Moderate	High	Moderate.
90–100	85–100	80–95	75–95	0.6–2.0	0.18–0.24	5.1–6.0			Low	High	Moderate.
80–100	75–100	70–95	65–95	0.06–0.2	0.10–0.14	4.5–5.5	15–18	95–110	Moderate	High	High.
80–100	75–95	70–95	65–90	0.06–0.2	0.08–0.12	4.5–5.5	12–15	110–120	Moderate	High	High.
95–100	85–95	70–90	55–85	0.6–6.0	0.18–0.24	5.1–6.0			Low	Moderate	Moderate.
80–100	70–95	60–90	55–85	0.6–2.0	0.12–0.16	5.1–6.0	15–18	100–115	Moderate	High	Moderate.
80–100	70–95	60–90	55–85	0.06–0.2	0.08–0.12	5.1–6.0	12–17	115–120	Moderate	Moderate	Moderate.
85–100	75–90	70–85	60–85	2.0–6.0	0.14–0.20	4.5–6.0			Low	Low	High.
60–85	55–85	50–75	30–60	2.0–6.0	0.10–0.14	4.5–5.5	11–16	115–123	Low	Moderate	High.
40–70	20–65	20–40	10–20	2.0–6.0	0.04–0.08	4.5–5.5	10–14	116–122	Low	Low	High.
85–100	35–95	70–95	60–85	0.6–6.0	0.18–0.24	5.1–6.0			Low	Low	Moderate.
50–100	45–95	45–95	40–85	0.6–2.0	0.12–0.18	5.1–6.0	12–17	108–118	Low	Moderate	Moderate.
25–50	20–45	15–40	10–40	0.6–2.0	0.06–0.10	5.1–6.0	10–15	115–125	Low	Low	Moderate.
95–100	90–100	85–95	80–90	0.6–2.0	0.14–0.18	5.1–6.0			Low	High	Moderate.
90–100	60–100	80–95	55–90	0.06–0.2	0.14–0.18	5.1–6.0	12–18	100–115	Moderate	High	Low.
80–100	60–100	75–100	55–100	0.06–0.2	0.08–0.12	5.6–6.0	12–16	95–110	Moderate	High	Low.
90–100	85–100	85–100	70–95	0.6–6.0	0.18–0.24	5.1–6.5			Low	Moderate	High.
90–100	85–100	85–100	70–95	0.6–2.0	0.12–0.16	4.5–5.5	15–19	102–112	Moderate	High	High.
85–95	80–90	50–75	40–70	0.06–0.2	0.08–0.12	4.5–5.5	12–17	114–120	Moderate	Moderate	High.

Table 2. Allegheny County Soli Survey: Estimated Soil Properties Significant in Engineering (cont.)

Soil series and map symbols	Depth to— Seasonal high water table	Depth to— Bed-rock[1]	Depth from surface	USDA texture	Engineering classification: Unified	Engineering classification: AASHTO	Coarse fraction larger than 3 inches
	Feet	*Feet*	*Inches*				*Percent*
*Gilpin: GlB, GlC, GlD, GpB, GpC, GpD, GQF, GrE, GSF. For the Upshur part of GpB, GpC, GpD, and GQF, see the Upshur series. For the Vandergrift part of GrE, see the Vandergrift series. For the Weikert and Culleoka parts of GSF, see the Weikert and Culleoka series.	>6	1½–3½	0–5	Silt loam	ML	A–4	-----
			5–23	Shaly silt loam	GM, SM, ML, or CL	A–4 or A–6	0–10
			23–31	Very shaly loam	GM, SM, or ML	A–1, A–2, or A–4	10–30
			31	Shale bedrock.			
*Guernsey: GuB, GuC, GuD, GvB, GvC, GvD. For the Vandergrift part of GvB, GvC, and GvD, see the Vandergrift series.	1–2	>4	0–7	Silt loam	ML or CL	A–4 or A–6	-----
			7–38	Silty clay loam, silty clay, clay.	ML, CL, or CH	A–4, A–6, or A–7	-----
			38–50	Shaly silt loam	ML, CL, or CH	A–4, A–6, or A–7	0–20
Hazleton: HaB, HaC, HaD, HTE	>6	3½–6	0–6	Loam	GM, SM, or ML	A–2 or A–4	0–20
			6–28	Channery sandy loam	GM, SM, or ML	A–2 or A–4	0–40
			28–60	Very channery loamy sand.	GM or SM	A–1, A–2, or A–4	0–40
			60	Sandstone bedrock.			
Huntington: Hu	>4	>5	0–20	Silt loam	ML	A–4	-----
			20–48	Silt loam	ML	A–4	-----
			48–60	Sandy loam	SM or ML	A–2 or A–4	-----
Library: LbB, LbC, LbD	½–1½	3½–6	0–8	Silty clay loam	ML or CL	A–4 or A–6	-----
			8–25	Silty clay	ML, CL, MH, or CH	A–6 or A–7	-----
			25–54	Shaly silty clay loam, shaly loam.	ML, SM, MH or GC	A–6 or A–7	0–15
Lindside: Ln	1½–3	>5	0–8	Silt loam	ML	A–4	-----
			8–38	Silt loam	ML	A–4	-----
			38–60	Loam	SM or ML	A–2 or A–4	-----
Newark: Ne	0–1	>5	0–9	Silt loam	ML or CL	A–4 or A–6	-----
			9–34	Silty clay loam, silt loam.	ML or CL	A–4 or A–6	-----
			34–60	Loam stratified with silt loam.	ML or CL	A–4 or A–6	-----
Philo: Ph	1½–3	>5	0–9	Silt loam	ML or CL	A–4	-----
			9–34	Silt loam	ML	A–4	-----
			34–60	Loam, sandy loam	SM or ML	A–4	-----
Rainsboro: RaA, RaB, RaC	1½–3	>5	0–13	Silt loam	ML	A–4	-----
			13–26	Silt loam	ML or CL	A–4 or A–6	-----
			26–65	Silt loam, sandy clay loam, loam.	SM or ML	A–4	-----
Rayne: RyB, RyC	>6	3½–5	0–8	Silt loam	ML or CL	A–4	-----
			8–33	Silt loam, silty clay loam.	ML or CL	A–4 or A–6	0–20
			33–46	Shaly loam, very shaly loam.	GM, GC, SM, or SC	A–2 or A–4	0–30
			46	Shale bedrock.			
Upshur: UaB, UaC	>3	4–6	0–6	Silty clay loam	CL or ML	A–4 or A–6	-----
			6–31	Clay, shaly silty clay	CL, MH, or CH	A–6 or A–7	-----
			31–64	Shaly silty clay, very shaly silty clay.	CL, GC, or SC	A–4, A–6, or A–7	0–40

Percentage smaller than 3 inches passing sieve—				Perme-ability	Available water capacity [2]	Reaction	Compaction data		Shrink-swell potential	Corrosion potential	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				Optimum moisture	Maximum dry density		Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Percent*	*Pounds per cubic foot*			
85–100	70–90	65–85	55–85	0.6–6.0	0.18–0.24	4.5–5.5			Low	Low	High.
50–95	45–90	35–80	35–70	0.6–2.0	0.10–0.14	4.5–5.5	13–15	110–120	Low	Moderate	High.
40–70	20–65	20–60	15–55	0.6–2.0	0.06–0.10	4.5–5.5	11–14	114–125	Low	Low	High.
95–100	90–100	90–100	85–100	0.6–2.0	0.14–0.18	5.6–6.5			Moderate	High	Low.
95–100	75–100	85–100	65–100	0.06–0.2	0.10–0.14	5.6–7.3	15–20	95–110	High	High	Low.
80–100	80–100	75–100	65–100	0.06–0.2	0.08–0.12	5.6–7.3	15–20	95–115	High	High	Low.
80–90	75–90	35–65	15–55	2.0–6.0	0.12–0.16	4.5–5.5			Low	Low	High.
50–85	45–80	40–75	20–55	2.0–6.0	0.08–0.12	4.5–5.5	10–15	115–123	Low	Low	High.
45–85	40–80	35–65	15–45	2.0–6.0	0.04–0.08	4.5–5.5	9–13	115–125	Low	Low	High.
95–100	90–100	85–100	65–100	0.6–2.0	0.18–0.24	6.1–7.3			Low	Low	Low.
95–100	90–100	85–100	65–100	0.6–2.0	0.16–0.20	5.6–6.5	12–18	100–110	Low	Low	Low.
85–100	60–100	50–70	30–65	2.0–6.0	0.10–0.14	5.6–6.5	10–16	105–120	Low	Low	Low.
95–100	85–100	85–100	80–100	0.6–2.0	0.14–0.18	5.1–6.5			Moderate	High	Moderate.
95–100	85–100	85–100	80–100	0.06–0.2	0.10–0.14	4.5–7.3	17–24	95–105	High	High	Low.
80–100	45–100	40–100	35–95	0.06–0.2	0.08–0.12	4.5–7.3	13–20	90–117	High	High	Low.
100	95–100	90–100	70–80	0.6–6.0	0.18–0.24	6.1–7.3			Low	Low	Low.
100	95–100	80–95	80–90	0.6–2.0	0.18–0.24	5.6–7.3	12–18	100–110	Low	Moderate	Low.
100	95–100	90–100	30–90	0.6–6.0	0.14–0.20	5.6–7.3	10–16	105–120	Low	Moderate	Low.
90–100	90–100	85–100	75–95	0.6–2.0	0.18–0.22	5.6–7.3			Low	High	Low.
90–100	90–100	85–100	65–90	0.6–2.0	0.18–0.22	5.6–7.3	12–18	100–112	Moderate	High	Low.
90–100	90–100	80–100	60–80	0.6–2.0	0.12–0.18	6.1–7.3	12–18	100–112	Low	High	Low.
65–100	65–100	60–80	55–75	0.6–2.0	0.14–0.18	5.1–6.0			Low	Low	Moderate.
65–100	65–100	60–80	55–75	0.6–2.0	0.14–0.18	4.5–5.5	10–14	110–120	Low	Moderate	High.
60–95	55–95	55–75	45–65	2.0–6.0	0.08–0.10	4.5–5.5	8–12	115–122	Low	Moderate	High.
95–100	95–100	85–100	65–90	0.6–2.0	0.18–0.24	5.1–6.5			Low	Moderate	Moderate.
95–100	95–100	85–100	65–90	0.6–2.0	0.14–0.18	5.1–6.0	12–18	110–116	Moderate	High	Moderate.
80–100	75–100	60–95	45–90	0.06–0.2	0.10–0.12	5.1–6.0	10–16	110–122	Low	Moderate	Moderate.
95–100	90–100	80–95	60–85	0.6–2.0	0.14–0.18	4.5–6.0			Low	Low	High.
85–100	60–100	60–95	55–95	0.6–2.0	0.12–0.16	4.5–5.5	12–16	113–120	Low	Moderate	Moderate.
40–75	25–70	25–60	10–50	2.0–6.0	0.08–0.12	4.5–5.5	11–15	113–125	Low	Low	Moderate.
95–100	90–100	80–95	70–95	0.2–0.6	0.14–0.20	5.1–6.5			Moderate	High	Moderate.
95–100	90–100	80–95	70–95	0.06–0.2	0.10–0.14	5.6–7.8	18–22	100–110	High	High	Low.
60–95	40–95	40–90	35–85	0.06–0.2	0.08–0.12	5.6–7.8	15–18	110–115	High	High	Low.

Table 2. Allegheny County Soli Survey: Estimated Soil Properties Significant in Engineering (cont.)

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Engineering classification		Coarse fraction larger than 3 inches
	Seasonal high water table	Bed-rock [1]			Unified	AASHTO	
	Feet	*Feet*	*Inches*				*Percent*
*Urban land. Properties are too variable to be estimated. For the Culleoka part of UCB, UCD, and UCE, see the Culleoka series. For the Guernsey part of UGB and UGD, see the Guernsey series. For the Rainsboro part of URB, and URC, see the Rainsboro series. For the Wharton part of UWB and UWD see the Wharton series.							
Vandergrift. Mapped only in complexes with Ernest, Gilpin, and Guernsey soils.	1–2	>5	0–8	Silt loam	ML or CL	A–4 or A–6	------
			8–42	Silty clay loam, silty clay.	CL, MH, or CH	A–6 or A–7	0–5
			42–60	Clay, channery silty clay loam.	CL	A–6 or A–7	0–5
Weikert: WEF. Rock outcrop part of WEF not rated.	>6	1–1½	0–6	Shaly silt loam	GM, SM, or ML	A–1, A–2, or A–4	0–10
			6–15	Very shaly silt loam, very shaly loam.	GW, GM, SW, or SM	A–1 or A–2	0–20
			15	Shale bedrock.			
Wharton: WhB, WhC, WhD	1½–3	>4	0–10	Silt loam	ML or CL	A–4 or A–6	------
			10–42	Silt loam, silty clay loam, silty clay.	ML, CL, or MH	A–4, A–6, or A–7	------
			42–60	Silty clay	ML, CL, or MH	A–4, A–6, or A–7	0–20

Percentage smaller than 3 inches passing sieve—				Permeability	Available water capacity [2]	Reaction	Compaction data		Shrink-swell potential	Corrosion potential	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)				Optimum moisture	Maximum dry density		Uncoated steel	Concrete
				Inches per hour	*Inches per inch of soil*	*pH*	*Percent*	*Pounds per cubic foot*			
95–100	90–100	85–100	80–100	0.6–2.0	0.16–0.20	5.1–6.0			Moderate	High	Moderate.
90–100	90–100	80–100	75–100	0.06–0.2	0.10–0.16	5.1–7.3	15–22	100–115	High	High	Low.
80–100	55–95	55–95	50–95	0.06–0.2	0.08–0.12	5.6–7.3	14–20	100–115	High	High	Low.
30–70	25–65	25–60	20–55	2.0–6.0	0.08–0.14	4.5–5.5			Low	Low	High.
10–60	10–55	10–35	5–35	2.0–6.0	0.04–0.08	4.5–6.0	10–15	110–125	Low	Low	High.
95–100	85–100	80–95	70–90	0.6–2.0	0.18–0.24	5.1–6.0			Low	High	Moderate.
85–100	75–100	70–100	65–95	0.06–0.2	0.14–0.18	4.5–5.5	16–22	95–112	Moderate	High	High.
80–100	75–100	55–100	55–100	0.06–0.2	0.08–0.12	4.5–5.5	14–18	109–118	Moderate	High	High.

Table 5. Allegheny County Soli Survey: Soil Limitations for Town and Country Planning

Soil series and map symbols	Septic tank absorption fields [1]	Sewage lagoons [1]
Allegheny variant:		
AgB	Slight: hazard of ground water contamination.	Severe: moderately rapid permeability in substratum.
AgC	Moderate: slope; hazard of ground water contamination.	Severe: moderately rapid permeability in substratum; slope.
Atkins: At	Severe: hazard of flooding; high water table; hazard of ground water contamination.	Severe: hazard of flooding; moderately rapid permeability in substratum.
Brinkerton: BrB	Severe: high water table; slow permeability.	Moderate: slope; hazard of inflow.
Cavode:		
CaB	Severe: slow permeability; seasonal high water table.	Moderate: slope; bedrock at a depth of 3½ or more feet; hazard of inflow.
CaC	Severe: slow permeability; seasonal high water table.	Severe: slope
Clarksburg:		
CkB	Severe: seasonal high water table; slow permeability.	Moderate: slope; hazard of inflow.
CkC	Severe: seasonal high water table; slow permeability.	Severe: slope
Clymer:		
CmB	Moderate: bedrock at a depth of 3½ to 6 feet; hazard of ground water contamination.	Severe: moderately rapid permeability.
CmC	Moderate: bedrock at a depth of 3½ to 6 feet; hazard of ground water contamination; slope.	Severe: moderately rapid permeability; slope.
CmD	Severe: slope; hazard of ground water contamination.	Severe: moderately rapid permeability; slope.
Culleoka:		
CuB, CwB For the Weikert part of CwB, see the Weikert series.	Severe: bedrock at a depth of 1½ to 3½ feet.	Severe: bedrock at a depth of 1½ to 3½ feet.
CuC, CwC For the Weikert part of CwC, see the Weikert series.	Severe: bedrock at a depth of 1½ to 3½ feet.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
CuD, CwD For the Weikert part of CwD, see the Weikert series.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
Culleoka part of GSF	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
Culleoka part of UCE	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
Dormont:		
DoB	Severe: seasonal high water table; slow permeability.	Moderate: slope
DoC	Severe: seasonal high water table; slow permeability.	Severe: slope
DoD	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
DoE	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
Dumps: Du, Dw. Properties are too variable to be rated.		
Ernest:		
ErB	Severe: seasonal high water table; slow permeability.	Moderate: slope
ErC	Severe: seasonal high water table; slow permeability.	Severe: slope

Dwellings with basements	Lawns and landscaping	Roads and streets	Sanitary landfills (trench)[1]
Slight	Slight	Slight	Severe: moderately rapid permeability in substratum.
Moderate: slope	Moderate: slope	Moderate: slope	Severe: moderately rapid permeability in substratum.
Severe: hazard of flooding; high water table.	Severe: hazard of floooding; high water table.	Severe: hazard of flooding; high water table; potential frost action.	Severe: hazard of flooding; high water table; moderately rapid permeability in substratum.
Severe: high water table	Severe: high water table	Severe: high water table; potential frost action.	Severe: high water table.
Severe: seasonal high water table.	Moderate: seasonal high water table.	Moderate: potential frost action; seasonal high water table.	Severe: clayey; seasonal high water table.
Severe: seasonal high water table.	Moderate: seasonal high water table; slope.	Moderate: potential frost action; seasonal high water table; slope.	Severe: clayey; seasonal high water table.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table.
Slight[2]	Slight	Slight[2]	Severe: moderately rapid permeability.
Moderate[2]: slope	Moderate	Moderate[2]: slope	Severe: moderately rapid permeability.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: moderately rapid permeability.
Moderate[2]: bedrock at a depth of 1½ to 3½ feet.	Moderate: bedrock at a depth of 1½ to 3½ feet.	Slight[2]	Moderate: bedrock at a depth of 1½ to 3½ feet.
Moderate[2]: bedrock at a depth of 1½ to 3½ feet; slope.	Moderate: bedrock at a depth of 1½ to 3½ feet; slope.	Moderate[2]: bedrock at a depth of 1½ to 3½ feet; slope.	Moderate: bedrock at a depth of 1½ to 3½ feet.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Moderate: bedrock at a depth of 1½ to 3½ feet; slope.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: slope.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: slope.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table; slope.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table.

Table 5. Allegheny County Soli Survey: Soil Limitations for Town and Country Planning (cont.)

Soil series and map symbols	Septic tank absorption fields [1]	Sewage lagoons [1]
ErD	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
EvB Rating is for both Ernest and Vandergrift parts.	Severe: seasonal high water table; slow permeability.	Moderate: slope
EvC Rating is for both Ernest and Vandergrift parts.	Severe: seasonal high water table; slow permeability.	Severe: slope
EvD Rating is for both Ernest and Vandergrift parts.	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
Gilpin:		
GlB, GpB For the Upshur part of GpB, see UaB in the Upshur series.	Severe: bedrock at a depth of 1½ to 3 feet.	Severe: bedrock at a depth of 1½ to 3 feet.
GlC, GpC For the Upshur part of GpC, see UaC in the Upshur series.	Severe: bedrock at a depth of 1½ to 3½ feet.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
GlD, GpD For the Upshur part of GpD, see the Upshur series.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
GQF For the Upshur part of GQF, see the Upshur series.	Severe: bedrock at a depth of 1½ to 3 feet; slope.	Severe: bedrock at a depth of 1½ to 3 feet; slope.
GrE For the Vandergrift part of GrE, see the Vandergrift series.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
GSF For the Culleoka part of GSF, see the Culleoka series. For the Weikert part of GSF, see the Weikert series.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.	Severe: bedrock at a depth of 1½ to 3½ feet; slope.
Guernsey:		
GuB	Severe: seasonal high water table; slow permeability.	Moderate: slope
GuC	Severe: seasonal high water table; slow permeability.	Severe: slope
GuD	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
GvB Rating is for both Guernsey and Vandergrift parts.	Severe: seasonal high water table; slow permeability.	Moderate: slope
GvC Rating is for both Guernsey and Vandergrift parts.	Severe: seasonal high water table; slow permeability.	Severe: slope
GvD Rating is for both Guernsey and Vandergrift parts.	Severe: seasonal high water table; slow permeability; slope.	Severe: slope
Gullied land: Gx. Properties are too variable to be rated.		
Hazleton:		
HaB	Moderate: bedrock at a depth of 3½ to 6 feet; hazard of ground water contamination.	Severe: moderately rapid permeability.
HaC	Moderate: bedrock at a depth of 3½ to 6 feet; hazard of ground water contamination; slope.	Severe: moderately rapid permeability; slope.
HaD	Severe: slope; hazard of ground water contamination.	Severe: moderately rapid permeability; slope.
HTE	Severe: slope; hazard of ground water contamination.	Severe: moderately rapid permeability; slope.
Huntington: *Hu*	Severe: hazard of flooding	Severe: hazard of flooding; moderately rapid permeability in substratum.
Library:		
LbB	Severe: seasonal high water table; slow permeability.	Moderate: slope; hazard of inflow.

Dwellings with basements	Lawns and landscaping	Roads and streets	Sanitary landfills (trench)[1]
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table.
Moderate[2]: bedrock at a depth of 1½ to 3 feet.	Moderate: bedrock at a depth of 1½ to 3 feet.	Slight[2]	Moderate: bedrock at a depth of 1½ to 3 feet.
Moderate[2]: bedrock at a depth of 1½ to 3½ feet; slope.	Moderate: bedrock at a depth of 1½ to 3½ feet; slope.	Moderate[2]: bedrock at a depth of 1½ to 3½ feet.	Moderate: bedrock at a depth of 1½ to 3½ feet.
Severe[2]: slope	Severe: slope	Severe: slope	Moderate: bedrock at a depth of 1½ to 3½ feet; slope.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: slope.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: slope.
Severe[2]: slope	Severe: slope	Severe[2]: slope	Severe: slope.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table; too clayey.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table; too clayey.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table; too clayey.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table; too clayey.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table; too clayey.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table; too clayey.
Slight[2]	Slight	Slight	Severe: moderately rapid permeability.
Moderate[2]: slope	Moderate: slope	Moderate: slope	Severe: moderately rapid permeability.
Severe[2]: slope	Severe: slope	Severe: slope	Severe: moderately rapid permeability.
Severe[2]: slope	Severe: slope	Severe: slope	Severe: moderately rapid permeability; slope.
Severe: hazard of flooding	Moderate: hazard of flooding	Severe: hazard of flooding	Severe: hazard of flooding; moderately rapid permeability in substratum.
Severe: seasonal high water table.	Moderate: seasonal high water table; too clayey.	Moderate: frost action; seasonal high water table.	Severe: seasonal high water table; too clayey.

Table 5. Allegheny County Soli Survey: Soil Limitations for Town and Country Planning (cont.)

Soil series and map symbols	Septic tank absorption fields [1]	Sewage lagoons [1]
LbC	Severe: seasonal high water table; slow permeability.	Severe: slope
LbD	Severe: seasonal high water table; slow permeability.	Severe: slope
Lindside: Ln	Severe: hazard of flooding; seasonal high water table.	Severe: hazard of flooding; moderately rapid permeability in substratum.
Newark: Ne	Severe: hazard of flooding; high water table.	Severe: hazard of flooding
Philo: Ph	Severe: hazard of flooding	Severe: hazard of flooding; moderately rapid permeability in substratum.
Rainsboro:		
RaA	Severe: seasonal high water table; slow permeability.	Slight
RaB	Severe: seasonal high water table; slow permeability.	Moderate: slope
RaC	Severe: seasonal high water table; slow permeability.	Severe: slope
Rayne:		
RyB	Moderate: bedrock at a depth of 3½ to 5 feet.	Severe: moderately rapid permeability in substratum.
RyC	Moderate: bedrock at a depth of 3½ to 5 feet; slope.	Severe: moderately rapid permeability in substratum; slope.
Strip mines: SmB, SmD, SmF. Properties are too variable to be rated.		
Upshur:		
UaB	Severe: slow permeability	Moderate: slope; bedrock at a depth of 4 to 6 feet.
UaC	Severe: slow permeability	Severe: slope
Upshur part of GpD	Severe: slow permeability; slope.	Severe: slope
Upshur part of GQF	Severe: slow permeability; slope.	Severe: slope
Urban land: UB, UCB, UCD, UCE, UGB, UGD, URB, URC, UWB, UWD. Properties of Urban land are too variable to be rated. For the Culleoka part of UCB and UCD, see CuB and CuD in the Culleoka series. For the Culleoka part of UCE, see the Culleoka series. For the Guernsey part of UGB and UGD, see GuB and GuD in the Guernsey series. For the Rainsboro part of URB and URC, see RaB and RaC in the Rainsboro series. For the Wharton part of UWB and UWD, see WhB and WhD in the Wharton series.		
Vandergrift:		
Vandergrift part of GrE	Severe: slow permeability; seasonal high water table; prone to landslides.	Severe: slope; prone to landslides.
Weikert:		
WEF Properties of the Rock outcrop part are too variable to be rated.	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe: bedrock at a depth of 1 to 1½ feet; slope.

Dwellings with basements	Lawns and landscaping	Roads and streets	Sanitary landfills (trench)[1]
Severe: seasonal high water table.	Moderate: seasonal high water table; too clayey; slope.	Moderate: frost action; seasonal high water table; slope.	Severe: seasonal high water table; too clayey.
Severe: seasonal high water table; slope.	Severe: slope	Severe: slope	Severe: seasonal high water table; too clayey.
Severe: hazard of flooding	Moderate: hazard of flooding.	Severe: hazard of flooding	Severe: hazard of flooding; seasonal high water table; moderately rapid permeability in substratum.
Severe: hazard of flooding; high water table.	Severe: hazard of flooding; high water table.	Severe: hazard of flooding; high water table.	Severe: hazard of flooding; high water table.
Severe: hazard of flooding	Moderate: hazard of flooding.	Severe: hazard of flooding	Severe: hazard of flooding; seasonal high water table; moderately rapid permeability in substratum.
Moderate: seasonal high water table.	Slight	Moderate: frost action	Severe: seasonal high water table.
Moderate: seasonal high water table.	Slight	Moderate: frost action	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: frost action; slope.	Severe: seasonal high water table.
Slight[2]	Slight	Slight	Severe: moderately rapid permeability in substratum.
Moderate[2]: slope	Moderate: slope	Moderate: slope	Severe: moderately rapid permeability in substratum; slope.
Moderate: high shrink-swell.	Moderate: too clayey	Slight	Severe: too clayey.
Moderate: high shrink-swell; slope; prone to landslide.	Moderate: too clayey; slope	Moderate: slope	Severe: too clayey.
Severe: slope; prone to landslide.	Severe: slope	Severe: slope; prone to landslide.	Severe: too clayey; prone to landslide.
Very severe: slope; prone to landslide.	Severe: slope	Very severe: slope; prone to landslide.	Severe: too clayey; slope; prone to landslide.
Severe: slope; prone to landslides.	Severe: slope; prone to landslides.	Severe: slope; prone to landslides.	Severe: slope; prone to landslides.
Severe: slope	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe: slope	Very severe: bedrock at a depth of 1 to 1½ feet; slope.

Table 5. Allegheny County Soli Survey: Soil Limitations for Town and Country Planning (cont.)

Soil series and map symbols	Septic tank absorption fields [1]	Sewage lagoons [1]
Weikert part of CwB	Severe: bedrock at a depth of 1 to 1½ feet.	Severe: bedrock at a depth of 1 to 1½ feet; moderately rapid permeability.
Weikert part of CwC	Severe: bedrock at a depth of 1 to 1½ feet.	Severe: bedrock at a depth of 1 to 1½ feet; moderately rapid permeability.
Weikert part of CwD	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe: bedrock at a depth of 1 to 1½ feet; moderately rapid permeability.
Weikert part of GSF	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe: bedrock at a depth of 1 to 1½ feet; slope.
Wharton:		
WhB	Severe: seasonal high water table; slow permeability.	Moderate: slope; bedrock at a depth of 4 feet or more.
WhC	Severe: seasonal high water table; slow permeability.	Severe: slope
WhD	Severe: seasonal high water table; slow permeability; slope.	Severe: slope

Dwellings with basements	Lawns and landscaping	Roads and streets	Sanitary landfills (trench)[1]
Severe[2]: bedrock at a depth of 1 to 1½ feet.	Severe: bedrock at a depth of 1 to 1½ feet.	Severe[2]: bedrock at a depth of 1 to 1½ feet.	Severe: moderately rapid permeability.
Moderate[2]: bedrock at a depth of 1 to 1½ feet; slope.	Severe: bedrock at a depth of 1 to 1½ feet.	Moderate[2]: bedrock at a depth of 1 to 1½ feet; slope.	Severe: moderately rapid permeability.
Severe[2]: slope	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe[2]: slope	Severe: moderately rapid permeability.
Severe[2]: slope	Severe: bedrock at a depth of 1 to 1½ feet; slope.	Severe[2]: slope	Severe: bedrock at a depth of 1 to 1½ feet; moderately rapid permeability.
Moderate: seasonal high water table.	Slight	Slight	Severe: seasonal high water table.
Moderate: seasonal high water table; slope.	Moderate: slope	Moderate: slope	Severe: seasonal high water table.
Severe: slope	Severe: slope	Severe: slope	Severe: seasonal high water table.

Table 7. Allegheny County Soli Survey: Suitability of the Soils for Elements of Wildlife Habitat

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
Allegheny variant:				
AgB	Good	Good	Good	Good
AgC	Fair	Good	Good	Good
Atkins: At	Poor	Fair	Fair	Fair
Brinkerton: BrB	Poor	Fair	Fair	Good
Cavode:				
CaB	Fair	Good	Good	Good
CaC	Fair	Good	Good	Good
Clarksburg:				
CkB	Good	Good	Good	Good
CkC	Fair	Good	Good	Good
Clymer:				
CmB	Good	Good	Good	Good
CmC	Fair	Good	Good	Good
CmD	Poor	Fair	Good	Good
Culleoka:				
CuB	Good	Good	Good	Good
CuC	Fair	Good	Good	Good
CuD	Poor	Fair	Good	Good
CwB, CwC, CwD	Poor	Poor	Poor	Poor
Dormont:				
DoB	Good	Good	Good	Good
DoC	Fair	Good	Good	Good
DoD	Poor	Fair	Good	Good
DoE	Very poor	Fair	Good	Good
Ernest:				
ErB	Good	Good	Good	Good
ErC	Fair	Good	Good	Good
ErD	Poor	Fair	Good	Good
EvB	Fair	Good	Good	Good
EvC	Fair	Good	Good	Good
EvD	Poor	Fair	Good	Good
Gilpin:				
GIB	Fair	Good	Good	Good
GIC	Fair	Good	Good	Good
GID	Poor	Fair	Good	Good
GpB	Fair	Good	Good	Good
GpC	Fair	Good	Good	Good
GpD	Poor	Fair	Good	Good
GQF	Very poor	Poor	Good	Good
GrE	Very poor	Fair	Good	Good
GSF	Very poor	Poor	Poor	Poor
Guernsey:				
GuB	Good	Good	Good	Good
GuC	Fair	Good	Good	Good
GuD	Poor	Fair	Good	Good
GvB	Fair	Good	Good	Good
GvC	Fair	Good	Good	Good
GvD	Poor	Fair	Good	Good
Hazleton:				
HaB	Good	Good	Good	Good
HaC	Fair	Good	Good	Good
HaD	Poor	Fair	Good	Good
HTE	Very poor	Poor	Good	Good
Huntington: Hu	Good	Good	Good	Good

Elements of wildlife habitat—Continued			Kinds of wildlife		
Coniferous plants	Wetland plants	Shallow water plants	Openland	Woodland	Wetland
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Fair	Good	Good	Fair	Fair	Good.
Good	Poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Poor	Very poor	Very poor	Poor	Poor	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Poor	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Poor	Very poor	Very poor	Poor	Poor	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Poor	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.

Table 7. Allegheny County Soli Survey: Suitability of the Soils for Elements of Wildlife Habitat (cont.)

Soil series and map symbols	Elements of wildlife habitat			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
Library:				
LbB	Fair	Good	Good	Good
LbC	Fair	Good	Good	Good
LbD	Poor	Fair	Good	Good
Lindside: Ln	Good	Good	Good	Good
Newark: Ne	Poor	Fair	Fair	Fair
Philo: Ph	Good	Good	Good	Good
Rainsboro:				
RaA	Good	Good	Good	Good
RaB	Good	Good	Good	Good
RaC	Fair	Good	Good	Good
Rayne:				
RyB	Good	Good	Good	Good
RyC	Fair	Good	Good	Good
Upshur:				
UaB	Good	Good	Good	Good
UaC	Fair	Good	Good	Good
Urban land: UB, UCB, UCD, UCE, UGB, UGD, URB, URC, UWB, UWD. Properties of Urban land are too variable to be rated. For the Culleoka part of UCB, UCD, and UCE, see CuB, CuD, and CwD in the Culleoka series. For the Guernsey part of UGB and UGD, see GuB and GuD in the Guernsey series. For the Rainsboro part of URB and URC, see RaB and RaC in the Rainsboro series. For the Wharton part of UWB and UWD, see WhB and WhD in the Wharton series.				
Weikert: WEF	Very poor	Very poor	Very poor	Poor
Wharton:				
WhB	Good	Good	Good	Good
WhC	Fair	Good	Good	Good
WhD	Poor	Fair	Good	Good

Elements of wildlife habitat—Continued			Kinds of wildlife		
Coniferous plants	Wetland plants	Shallow water plants	Openland	Woodland	Wetland
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Fair	Good	Good	Fair	Fair	Good.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Very poor	Poor	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.

Recent studies have generated interest and increasing awareness of the importance of urban green space. In addition to aesthetic value, studies suggest that green surroundings improve both physical and mental fitness (Ulrich 84, Williams and Harvey 2001). Furthermore, urban green space provides economic and environmental benefits including habitat for a wide range of wildlife (Jim 2003), removal of pollutants from groundwater, especially storm water runoff, and removal of fossil fuel combustion emissions from the air (Nowak 1994, Hyun-Kil 2001).

In the Pittsburgh area, most of the valleys and floodplains in the region have been developed while the steep hillsides, which provide green space in the city and contribute to the beauty of the Pittsburgh landscape are far less developed. These greater than 25% slope hillsides occupy 38% of Pittsburgh's total forest space and 33% of Pittsburgh's total forest and park area. Information about the quality of these areas, the identity of species found on these hillsides and the level of disturbance on the hillsides is needed to make land management decisions. Our goal was to census the woody vegetation in three areas in Pittsburgh that are characterized by steep hillsides. We evaluated the quality of the vegetation by 1) determining the species identity and of the woody vegetation in our sampling area, 2) quantifying the proportion of each species in the sample area, 3) determining the average size of individual tree species for a subset of trees in our sampling area and 4) assessing the proportion of woody species that were native or invasive. 5) When present, we also noted the identity of the herbaceous species in our sampling area, as the association between key woody and herbaceous species is indicative of distinct forest types.

Methods

In collaboration with the Hillsides Planning Committee, (5/18/2004 meeting) three areas representing the range of green hillsides found in Pittsburgh were chosen. These sites were identified using a map of Pittsburgh green space developed by Kostoula Vallianos based on size of the green space and/or proximity to other green spaces, degree of development in the surrounding area, and the steepness of the site (greater than 25% slope). The sampling was conducted in late July, 2004. The three sites are listed as follows:

SITE A - Steep recovering urban forest with disturbed soils.
SITE B1 and SITE B2 - Steep remnant urban forest, mostly natural soils.
SITE C - A large steep grade urban forest on a mix of natural soils, undermined soils and fill. A mix of remnant and recovering forest.

Site A was expected to be representative of the most urban green space. Site B1 and Site B2 and is more neighborhood to suburban in character. Site C is the largest green space we sampled. It contains a great amount of interior forest (defined as the forest area approximately 100 m from the edge of forest patch) as well as varying topography that could potentially support several different types of plant communities, as well as other wildlife that require a larger minimum habitat area.

Data collection: At each site, we identified all woody and the native herbaceous species present within our chosen sites by walking transect through or just below each steep hillside area and recording all species noted. [Note: Because of late sampling date within the growing season, fewer native herbaceous species than expected were observed in the sampled areas. Many herbaceous species of forests senesce by early July in this region.] Within each area, we set up 3-5 10X10 meter plots at each site, which were spaced at least 50 meters apart. Within each plot, we estimated the abundance of each woody species present and took diameter at breast height measurements for all overstory trees. This data allowed us to calculate the percent of overall abundance and to determine if the species present in these areas indicated remnants of the previous intact communities. The species at each site were compared with those listed in the Pennsylvania DCNR's plant communities (Appendix A). We also calculated the overall percent exotic species abundance for each site.

Results

Overall, we found a high diversity of woody species within each of the sites and evidence of four typical forest community types in the three areas sampled. We identified 84 woody species in total: 66 of which were native (=79%), and 13 of which are native hardwood trees (15%) (See Table 1). We also identified many native herbaceous species (See table 2), and the forest communities in some areas indicate the likely presence of a diverse vernal flora, although we surveyed too late in the season to see vernal species. Most sites also supported an abundance of native understory shrubs and small tree species (Table 1), which is important for many species of wildlife, especially songbirds. Large, mature overstory trees were found at all sites. Many trees were greater than two meters in circumference and one tree at Site C exceeded three meters in circumference. The steep hillsides of Pittsburgh indeed sustain a diverse assemblage of tree species with their attending shrubs and understory trees. An overview of forest structure at all three sites is listed in Table 6.

Black Locust (Robinia psuedoacacia)

We identified elements of four hardwood forest native plant communities along the hillsides (See Appendix A for complete descriptions of these forest types):

Dry oak– mixed hardwood forest, typically occurs on slopes with dry soil

Red oak– mixed hardwood forest, occurs in mesic soils and found on lower slopes in our survey

Sugar maple– basswood forest, often occurs on rich soils with rocky slopes and supports a rich vernal flora .

Mixed mesophytic forest, which is typically found on lower slopes, which is unique to the southwestern portion of Pennsylvania, and supports an extremely rich and diverse herbaceous flora.

Site A

Steep recovering urban forest with disturbed soils.

Although the Site A was the most disturbed of the sites sampled, we identified 52 woody species, 35 of which are native, across the four sampled areas (Table 3). The overall percent abundance of native species was 66%. The more abundant native species are associated with disturbed areas, including black locust (Robinia psuedoacacia) and staghorn sumac (Rhus typhina). However, remnants of native forests were found here, with very large red oak (Quercus rubra), black walnut (Juglans nigra), American elm (Ulmus Americana), and basswood (Tilia Americana) occurring. Exotic species represented 34% of the total percent abundance, the highest of the three sites. This is to be expected, as disturbance in an area increases the likelihood of invasive species establishment, the smaller a fragment is, the more likely non-native species are to establish. These are among the smallest green areas in the city and they are traversed by old, abandoned roads, side walks, and staircases that are no longer maintained but are used. Despite the impact to the hillsides, native species still predominate in the Site A. It is also important to note that seedlings and saplings of these common native species were present in the understory, as well as seedlings of other native species not present in the overstory. This suggests that even on this urban hillside that is surrounded by development, there exists the potential to support native trees.

Site B1 & Site B2
Steep remnant urban forest, mostly natural soils.

Jack-in-the-pulpit (*Arisaema triphyllum*)

Both sites appeared intact and supported diverse and distinctive forest community types. Overall, 48 woody species were identified, 36 of which are native. See Table 4 for a list of species found on this hillside. Both sites had low abundance of invasive species and both supported a diverse flora.

The B1 area is forested predominantly by intact dry oak-mixed hardwood forest. The dominant species are sugar maple (Acer saccharinum), black oak (Quercus velutina), red oak (Quercus rubra), bitternut hickory (Carya cordiformis), and white ash (Fraxinus americana). Native species comprise more than 95% of overall abundance. Herbaceous species seen at the time of survey were Jack-in-the-pulpit (Arisaema triphyllum), false Solomon's seal (Smilacena racemosa), mayapple (Podophyllum peltatum), smooth Solomon's seal (Polygonatum biflorum), and enchanter's nightshade (Circaea lutetiana). The presence of these native species indicates the likely occurrence of other associated native species, especially spring ephemeral species, which are not visible in late July, when the survey was conducted.

The B2 area has a very rich and diverse overstory and understory. Very few exotic species are present, comprising only 2% of overall abundance. The DCNR's Red oak – mixed hardwood forest best describes this site (See Appendix A). The overstory is dominated by red oak (*Quercus rubra*), white oak (*Quercus alba*), sugar maple (*Acer saccharum*), black cherry (*Prunus serotina*), tulip tree (*Liriodendron tulipifera*), white ash (*Fraxinus Americana*), and basswood (*Tilia Americana*). Understory species include Hop-hornbeam (*Ostrya virginiana*), Hornbeam (*Carpinus carolinana*), Spicebush (*Lindera benzoin*), Arrowwood (*Viburnum dentatum*), Maple-leaved viburnum (*Viburnum acerifolium*), and Hydrangea (*Hydrangea arborescens*). Herbaceous species present include: Jack-in-the-pulpit

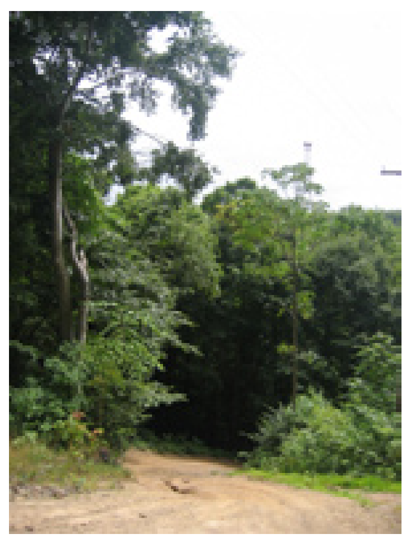
(*Arisaema triphyllum*), wild geranium (*Geranium maculatum*), false Solomon's seal (*Smilacena racemosa*), Mayapple (*Podophyllum peltatum*), smooth Solomon's seal (*Polygonatum biflorum*), and enchanter's nightshade (*Circaea lutetiana*). As indicated by the forest type, this area also likely supports an abundant native herbaceous flora. This area is managed by a private housing development. Grass paths and hiking paths are maintained that run along the top of the ridge and afford views of the forest vegetation growing along the steep hillsides. This tract of land exemplifies how land stewardship can maintain and enhance both the natural and housing value of a site.

Site C

A large steep grade urban forest on a mix of natural soils, undermined soils and fill. A mix of remnant and recovering forest.

Of all three sites, the Site C supports the most diversity in habitat types-- from early successional grass/shrublands to mature forests. It occupies2576 hectares, and has been undeveloped for many years since it was last partially logged and mined. Given the presence of early successional areas, it is surprising that native plants dominate the site. We found that native plants comprise 95% of the overall abundance. We identified 44 woody species on the steep hillsides of the Site C site, 33 of which are native.

Two types of native forest types were identified at the Site C. Some of the steep slopes are best described by the DCNR's Sugar – Maple Basswood forest. This forest type is dominated by sugar maple (*Acer saccharum*), basswood (*Tilia Americana*), red oak (*Quercus rubra*), tulip tree (*Liriodendron tulipifera*), and Yellow Birch (*Betula allegheniensis*). This forest type sometimes overlapped with Mixed Mesophytic forest, a rare and rich forest type found only in the Southwest portion of Pennsylvania. It is dominated by sugar maple (*Acer saccharum*), tulip tree (*Liriodendron tulipifera*), red oak (*Quercus rubra*), black cherry (*Prunus serotina*), and white ash (*Fraxinus Americana*). (insert info for Agnew 2) An abundance of herbaceous species were seen in association with these forest types. Some of these include perfoliated bellwort (*Uvularia perfoliata*), Jack-in-the-pulpit (*Arisaema triphyllum*), mayapple (*Podophyllum peltatum*), tall bellflower (*Campanula americana*), bloodroot (*Sanguinaria canadensis*), and wild geranium (*Geranium maculatum*). The presence of these forest types also indicates the likely presence of other spring ephemeral wildflowers that were not seen at the time of survey. Notable at this site was the largest tree in our sample, a tulip tree over three meters in cirumference—while the average tulip tree circumference was over one meter. We also found evidence of bear (scat) at this site.



Summary/Recommendations

Our methods of sampling provide a rapid assessment of the quality of the vegetation on Pittsburgh's hillsides. These areas were identified using Kostoula Vallianos' Ecological context maps, which classify the woodland and interior forest characteristics of the green space. Our data indicate that there is strong agreement between the map classification and the quality of the site.

Surprisingly, the majority of tree species on the steep hillsides of Pittsburgh we sampled were native species. The hillsides of Pittsburgh appear to function as refugia for the native species of the region. Even Site A, which is the most disturbed, and surrounded by an area that is densely inhabited, native woody species predominate on the hillsides. The well-drained soils and thriving old oaks seen at the site are likely to be found in other south-facing steep hillsides. Site B1 and Site B2 are both relatively intact: Site B1 currently protected and the Site B2 is less intact, but clearly ranks higher in quality than the Site A sites. The Site C is comprised of a variety of forest types on the steep hillsides, with high value for species conservation. There are areas of intact forest where land preservation would ensure the protection of this forest and fauna diversity that probably exists, given the size of the area. This area is likely indicative of other large tracts of land in the Pittsburgh region.

Overall, we found that the forested hillsides of Pittsburgh are surprisingly beautiful, wild areas that potentially offer the residents of Pittsburgh a place for recreation and learning, in addition to the aesthetic and environmental benefits. Land management decisions need to be made that consider the possibilities of conservation and restoration as well as development. In addition – we believe that the information provided in the following tables can be used to develop specific guidelines for steep slope development.

References

Fike, J. 1999. Terrestrial and Palustrine Plant Communities of Pennsylvania. Pennsylvania Natural Diversity Inventory, Harrisburg, PA.

Impacts of urban greenspace on offsetting carbon emissions for middle Korea. Journal of Environmental Management 64:115-126.

Jim, C.Y. and Chen, Sophia S. 2003. Comprehensive greenspace planning based on landscape ecology principles in compact Nanjing, China. Landscape and Urban Planning. 65: 95-166.

Nowak, David J., E. Gregory McPherson, and Rowan A. Rowntree. 1994. Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. USDA Forest Service. 1994. USDA Forest Service Gen. Tech. Report NE-186. Chicago, IL.

Ulrich, Roger S. 1987. View through a Window May Influence Recovery from Surgery. Science 224 (Apr. 27): 420-421.

4.4 Appendix B: Vegetation Assesment Table

Plant Community Types Identified on Steep Hillsides of Pittsburgh.
Native Plant Community Types found on Pittsburgh's slopes based on DCNR's Terrestrial and Palustrine Plant Communities of Pennsylvania

1. Dry oak-mixed hardwood forest

This forest type occurs in areas with dry soils, and is often found on south-facing or southwest-facing slopes. Common trees in this forest type are *Quercis alba* (white oak), *Betula spp.* (birch), *Carya spp.* (hickory), *Celtis occidentalis* (hackberry), *Acer rubrum* (red maple), *Acer saccharum* (sugar maple), *Quercus montana* (chestnut oak), *Quercis velutina* (black oak), *Quercus rubra* (red oak), F*raxinus americana* (white ash), and *Tilia americana* (basswood). This forest type characteristically supports an abundance of understory species, especially *Cornus florida* (flowering dogwood), *Carpinus caroliniana* (hornbeam), *Amelanchier arborea* (shadbush), *Cercis Canadensis* (redbud), and *Ostrya virginiana*. This forest type also supports a relatively plentiful herbaceous flora including *Smilacena racemosa* (false solomon's-seal), *Polygonatum biflorum* (smooth solomon's seal), *Asplenium platyneuron* (ebony spleenwort), *Desmodium spp.* (tick-trefoil), *Hieracium venosum* (rattlesnake weed), *Aralia nudicaulis* (wild sarsaparilla), *Carex pensylvanica* (a sedge), *Carex communis* (a sedge), and *Lysimachia quadrifolia* (whorled loosestrife).

2. Red oak – mixed hardwood forest

This common forest type occurs throughout Pennsylvania in areas with mesic soil conditions. *Quercus rubra* is often the dominant or co-dominant overstory species. Other commonly occurring species are *Acer rubrum* (red maple), *Quercus velutina* (black oak), *Quercus alba* (white oak), *Carya spp.* (hickory), *Betula lenta* (sweet birch), *Betula alleghaniensis* (yellow birch), *Fraxinus americana* (white ash), *Fagus grandifolia* (American beech), and/or *Liriodendron tulipifera* (tuliptree). This forest type includes the understory species *Viburnum recognitum* (northern arrowwood), *Viburnum dentatum* (southern arrowwood), *Viburnum acerifolium* (maple-leaved viburnum), *Amelanchier laevis* (smooth serviceberry), *Ameanchier arborea* (shadbush), *Kalmia latifolia* (mountain laurel), *Carpinus caroliniana* (hornbeam), *Ostrya virginiana* (hop-hornbeam), *Hamamelis virginiana* (witchhazel), and *Lindera benzoin* (spicebush). The herbaceous layer of this forest type is very variable, but some herbaceous species that we found in our survey here are *Smilacena racemosa* (false solomon's seal), *Polygonatum biflorum* (smooth solomon's-seal), *Geranium maculatum*, *Sanguinaria Canadensis* (bloodroot), *Arisaema triphyllum* (jack-in-the-pulpit), and *Dryopterus spp*. (wood ferns).

3. Sugar maple – basswood forest

This forest type is commmonly found on rich rocky slopes, but can also be found in a range of substrate conditions in Western Pennsylvania. *Acer saccharum* (sugar maple) and *Tilia americana* (basswood), are the most common species in this forest, co-occurring with *Quercus rubra* (red oak), *Fraxinus americana* (white ash), *Liriodendron tulipifera* (tuliptree), *Betula alleghanienis* (yellow birch), and *Betula lenta* (sweet birch). Understory species occurring here are *Lindera benzoin* (spicebush), *Hamamelis virginiana* (witch hazel), and in rich areas *Asimina triloba* (pawpaw), and *Staphylea trifolia* (bladdernut). This forest type supports an abundant herbaceous flora including many spring wildflowers, which among many include *Anemone quinquefolia* (wood anemone), *Cimicifuga racemosa* (black cohosh), *Geranium maculatum* (wild geranium), *Caulophllum thalictroides* (blue cohosh), *Sanguinaria canadens*is (bloodroot), *Erythronium americanum* (trout lily), *Arisaema triphyllum* (jack-in-the-pulpit), *Mitella diphylla* (bishop's-cap), and *Asarum canadense* (wild ginger), as well as other herbs including *Smilacena racemosa* (false solomon's-seal), *Dryopteris marginalis* (evergreen wood fern), and *Botrychium virginianum* (rattlesnake fern).

4. Mixed mesophytic forest

In Pennsylvania, this type of forest only occurs in the southwestern portion of the state, and supports a rich and diverse flora, including several species whose northern and eastern limits occur in southwest Pennsylvania. This community type is most often found on lower slopes. Tree species include *Liriodendron tulipifera* (tuliptree), *Acer sachharum* (sugar maple), *Fagus grandifolia* (American beech), *Tilia americana* (basswood), *Quercus rubra* (red oak), *Magnolia acuminata* (cucumber tree), *Prunus serotina* (black cherry), *Fraxinus americana* (white ash), *Juglans nigra* (black walnut), *Carya* ovata (shagbark hickory), *Aesculus glabra* (Ohio Buckeye), and *Aesculus flava* (yellow buckeye). Understoy specis include *Asimina triloba* (pawpaw), *Staphylea trifolia* (bladdernut), *Rhododendron maximum* (rosebay), *Magnolia tripetala* (umbrella magnolia), *Cercis* canadensis (redbud), *Lindera benzoin* (spicebush), *Hydrangea arborsescens* (wild hydrangea), and *Hamamelis virginiana* (witch-hazel). The herbaceous flora in this forest type is among the most diverse in Pennsylvania. Herbaceous species include *Trillium grandiflorum* (white trillium), *Trillium erectum* (purple trillium), *Trillium* sessile (toadshade), *Erythronium americanum* (trout-lily), *Phlox divaricata* (wild blue phlox), *Anemone quinquefolia* (wood anemone), *Dicentra canadensis* (squirrel corn), *Dicentra cucullaria* (dutchman's breeches), *Clintonia umbellulata* (speckled wood-lily), *Cimicifuga racemosa* (black cohosh), *Geranium maculatum* (wild geranium), *Caulophyllum thalictroides* (blue cohosh), *Tiarella cordifolia* (foamflower), *Hepatica nobilis* (liverleaf), *Allium tricoccum* (wild leek), *Sanguinaria canadensis* (bloodroot), *Corydalis flavula* (yellow fumewort), *Botrychium virginianum* (rattlesnake fern), *Claytonia virginica* (spring beauty), *Cardamine concatenata* (cut-leaved toothwort), *Mitella di-*

Table 1. List of woody species

Summary list of all woody species identified in vegetation survey of three sites in the Pittsburgh Steep Hillsides project, 2004. Font color indicates status (black=native, blue=introduced, red=introduced & invasive). Note: Japanese knotweed is herbaceous, but included in this list.

Species	Common Name	Family	Status
Acer negundo	Box Elder	Aceraceae	Native
Acer platanoides	Norway Maple	Aceraceae	Introduced from Europe/Invasive
Acer rubrum	Red Maple	Aceraceae	Native
Acer saccharinum	Silver Maple	Aceraceae	Native
Acer saccharum	Sugar Maple	Aceraceae	Native
Aesculus hippocastanum	Horse Chestnut	Sapindaceae	Native
Ailanthus altissima	Tree of Heaven	Simaroubaceae	Introduced from Asia/Invasive
Amelanchier canadensis	Serviceberry, Shagbush	Rosaceae	Native
Aralia spinosa	Devil's Walking Stick	Vitaceae	Native

Aesculus hippocastanum	Horse Chestnut	Sapindaceae	Native
Ailanthus altissima	Tree of Heaven	Simaroubaceae	Introduced from Asia/Invasive
Amelanchier canadensis	Serviceberry, Shagbush	Rosaceae	Native
Aralia spinosa	Devil's Walking Stick	Vitaceae	Native
Aronia melanocarpa	Black Chokeberry	Rosaceae	Native
Asimina adans	Paw Paw	Annonaceae	Introduced from Southern US
Betula allegheniensis	Yellow Birch	Betulaceae	Native
Betula spp.	Birch	Betulaceae	Native
Carpinus caroliniana	Musclewood	Betulaceae	Native
Carya cordiformis	Bitternut Hickory	Juglandaceae	Native
Carya ovata	Shagbark Hickory	Juglandaceae	Native
Carya tomentosa	Mockernut Hickory	Juglandaceae	Native
Catalpa spp.	Catalpa	Bignoniaceae	Introduced from Southern US
Celastrus orbiculatus	Oriental Bittersweet	Celastraceae	Introduced from Asia/Invasive
Celtis occidentalis	Hackberry	Ulmaceae	Native
Cornus florida	White Flowering Dogwood	Cornaceae	Native
Craetagus spp.	Hawthorne	Rosaceae	Native
Euonymus alatus	Winged Wahoo	Celastraceae	Introduced from Asia
Fagus grandifolia	Beech	Fagaceae	Native
Forsythia cv.	Forsythia	Oleaceae	Introduced from Europe
Fraxinus americana	American Ash	Oleaceae	Native
Fraxinus nigra	Black Ash	Oleaceae	Native
Fraxinus spp.	Ash spp.	Oleaceae	Native
Ginko biloba	Ginko	Class Ginkoopsida	Introduced from Asia
Gleditsia triacanthos	Honey Locust	Fababceae	Native
Hamamaelis virginiana	Witchhazel	Hamaelidaceae	Native
Hibiscus syriacus	Rose of Sharon	Malvaceae	Introduced from Asia
Hydrangea arborescens	Hydrangia	Hydrangeaceae	Native
Juglans nigra	Black Walnut	Juglandaceae	Native
Ligustrum vulgare	Privet	Oleaceae	Introduced from Europe
Lindera benzoin	Spicebush	Lauraceae	Native
Liriodendron tulipifera	Tulip Poplar	Magnoliaceae	Native
Lonicera spp.	Honeysuckle	Caprifoliaceae	Introduced/Invasive
Lonicerna japonica	Japanese Honeysuckle	Caprifoliaceae	Introduced from Asia/Invasive
Lonicerna maccki	Amur honeysuckle	Caprifoliaceae	Introduced from Asia/Invasive
Maclura pomifera	Osage Orange	Moraceae	Introduced from Southern US
Malus coronaria	Crabapple	Rosaceae	Native
Malus pumila	Apple	Rosaceae	Introduced from Asia
Menispermum canadense	Moonseed	Menispermaceae	Native
Morus rubra	Red Mulberry	Moraceae	Native
Morus spp.	Mulberry spp.	Moraceae	Native/Introduced
Ostrya carpinus	Hop-hornbeam	Betulaceae	Native
Parthenocissus quinquefloia	Virginia Creeper	Vitaceae	Native
Pinus resionsa	Red Pine	Pinaceae	**Introduced**
Pinus strobus	White Pine	Pinaceae	Native
Plantanus occidentalis	American Sycamore	Plantanceae	Native
Polygonum cudpidatum	*Japanese Knotweed*	*Polygonaceae*	*Introduced from Asia/Invasive*
Prunus serotina	Black Cherry	Rosaceae	Native
Prunus spp.	Cherry spp.	Rosaceae	Native
Quercus macrocarpa	Burr Oak	Fagaceae	Native
Quercus alba	White Oak	Fagaceae	Native
Quercus prinus	Chestnut oak	Fagaceae	Native
Quercus rubra	Red Oak	Fagaceae	Native
Quercus spp.	Oak spp.	Fagaceae	Native
Rhamnus frangula	*Buckthorn Alder*	*Rhamnaceae*	*Introduced from EurAsia/Invasive*
Rhamnus spp.	Rhamnus spp.	Rhamnaceae	Native/Introduced
Rhus spp.	Sumac	Anacardiaceae	Native

Rhus typhina	Staghorn Sumac	Anacardiaceae	Native
Robinia psuedoacacia	Black Locust	Fabaceae	Introduced from Southern US
Rosa multiflora	Multiflora Rose	Rosaceae	Introduced from Asia/Invasive
Rubus oderatus	Purple-flowering raspberry	Rosaceae	Native
Rubus spp.	Blackberry, Raspberry	Rosaceae	Native
Sambucus canadensis	Elderberry	Caprifoliaceae	Native
Sassafras albidum	Sassafrass	Lauraceae	Native
Smilax spp.	Greenbriar	Similicaceae	Native/Introduced
Solanum dulcamara	Bittersweet Nightshade	Solanaceae	Introduced from Europe/Invasive
Sorbus aucuparia	Moutain Ash	Rosaceae	Introduced from Europe
Syringa vulgaris	Lilac	Oleaceae	Introduced from EurAsia
Tilia americana	Basswood	Tiliaceae	Native
Toxicodendron radicans	Poison Ivy	Anacardiaceae	Native
Tsuga canadensis	Hemlock	Pinaceae	Native
Ulmus americana	American Elm	Ulmaceae	Native
Ulmus spp.	Elm spp.	Ulmaceae	Native/Introduced
Viburnum acerifolium	Maple leaved Viburnum	Adoxaceae	Native
Viburnum dentatum	Arrowwood	Adoxaceae	Native
Vitus spp.	Grapevine	Vitaceae	Native/Introduced

Table 2. List of herbaceous species

List of native herbaceous species identified in woody vegetation survey of Pittsburgh hillsides in July 2004.

Species Name	Common Name	Family Name
Smilacina racemosa	False Solomon's Seal	Liliaceae
Circaea lutetiana	Enchanter's Nightshade	Onagraceae
Arisaema triphyllum	Jack in the Pulpit	Araceae
Geranium maculatum	Wild Geranium	Geraniaceae
Campanula americana	Tall Bellwort	Campanulaceae
Sanguinaria canadensis	Bloodroot	Papaveraceae
Podophyllum peltatum	Mayapple	Berberidaceae
Uvularia perfoliata	Bellwort	Liliaceae
Polygonatum biflorum	Smooth Solomon's Seal	Liliaceae

Table 3. Species Site A

List of species identified in woody vegetation survey. Font color indicates status (Black=native, blue=introduced, red=introduced & invasive).

Species Name	Common Name	Family	Native/Introduced/Invasive
Acer negundo	Box Elder	Aceraceae	Native
Acer platanoides	Norway Maple	Aceraceae	Introduced from Europe/Invasive
Acer rubrum	Red Maple	Aceraceae	Native
Acer saccharinum	Silver Maple	Aceraceae	Native
Acer saccharum	Sugar Maple	Aceraceae	Native

Acer rubrum	Red Maple	Aceraceae	Native
Acer saccharinum	Silver Maple	Aceraceae	Native
Acer saccharum	Sugar Maple	Aceraceae	Native
Aesculus hippocastanum	Horse Chestnut	Sapindaceae	Native
Ailanthus altissima	Tree of Heaven	Simaroubaceae	Introduced from Asia/Invasive
Amelanchier arborea	Shadbush	Rosaceae	Native
Catalpa spp.	Catalpa	Bignoniaceae	Introduced from Southern US
Celatrus orbiculatus	Oriental Bittersweet	Celastraceae	Introduced from Asia/Invasive
Celtis occidentalis	Hackberry	Ulmaceae	Native
Craetagus spp.	Hawthorn	Rosaceae	Native
Creatagus spp.	Hawthorn	Rosaceae	Native
Forsythia cv.	Forsythia	Oleaceae	Introduced from Europe
Fraxinus americana	American Ash	Oleaceae	Native
Fraxinus nigra	Black Ash	Oleaceae	Native
Ginkgo biloba	Ginkgo	Class Ginkoopsida	Introduced from Asia
Gleditsia triacanthos	Honey Locust	Fabaceae	Native
Hibiscus syriacus	Rose of Sharon	Malvaceae	Introduced from Asia
Juglans nigra	Walnut	Juglandaceae	Native
Ligustrum vulgare	Privet	Oleaceae	Introduced from Europe
Lonicerna japonica	Japanese Honeysuckle	Caprifoliaceae	Introduced from Asia/Invasive
Lonicerna maccki	Honeysuckle	Caprifoliaceae	Introduced from Asia/Invasive
Maclura pomifera	Osage Orange	Moraceae	Introduced from Southern US
Malus pumila	Apple	Menispermaceae	Native
Morus rubra	Red Mulberry	Moraceae	Native
Morus spp.	Mulberry spp.	Moraceae	Native/Introduced
Parthenocissus quinquefloia	Virginia Creeper	Vitaceae	Native
Pinus resionsa	Red Pine	Pinaceae	Native
Plantanus occidentalis	American Sycamore	Plantanceae	Native
Poloygonum cudpidatum	Japanese Knotweed	Polygonaceae	Introduced from Asia/Invasive
Prunus serotina	Black Cherry	Rosaceae	Native
Prunus spp.	Cherry spp.	Rosaceae	Native
Quercus macrocarpa	Burr Oak	Fagaceae	Native
Quercus alba	White Oak	Fagaceae	Native
Quercus rubra	Red Oak	Fagaceae	Native
Quercus spp.	Oak, red or black	Fagaceae	Native
Rhamnus frangula	Buckthorn Alder	Rhamnaceae	Introduced from Eurasia/Invasive
Rhus spp.	Sumac	Anacardiaceae	Native
Robinia psuedoacacia	Black Locust	Fabaceae	Introduced from Southern US
Rosa multiflora	Multiflora Rose	Rosaceae	Native
Rubus spp.	Raspberry spp.	Rosaceae	Native
Sambucus canadensis	Elderberry	Caprifoliaceae	Native
Solanum dulcamara	Bittersweet Nightshade	Solanaceae	Introduced from Asia/Invasive
Sorbus spp.	Moutain Ash	Rosaceae	Introduced from Europe
Tilia americana	Basswood	Tiliaceae	Native
Toxicodendron radicans	Poison Ivy	Anacardiaceae	Native
Ulmus americana	American Elm	Ulmaceae	Native
Ulmus spp.	Elm spp.	Ulmaceae	Native/Introduced
Viburnum acerifolium	Maple leaved Viburnum	Adoxaceae	Native
Viburnum dentatum	Arrow-wood	Adoxaceae	Native
Vitus spp.	Grapevine	Vitaceae	Native/Introduced

Table 4. Species Site B1 + Site B2

List of species identified in woody vegetation survey. Font color indicates status (Black=native, blue=introduced, red=introduced & invasive).

Species Name	Common Name	Family	Native/Introduced/Invasive
Acer negundo	Box Elder	Aceraceae	Native
Acer rubrum	Red Maple	Aceraceae	Native
Acer saccharinum	Sugar Maple	Aceraceae	Native
Ailanthus altissima	Tree of Heaven	Simaroubaceae	Introduced from Asia/Native
Aralia spinosa	Devil's Walking Stick	Vitaceae	Native
Aronia melanocarpa	Black Chokeberry	Rosaceae	Native
Asimina triloba	Paw Paw	Annonaceae	Introduced from Southern US
Betula alleghiensis	Yellow Birch	Betulaceae	Native
Carpinus caroliniana	Musclewood	Betulaceae	Native
Carya cordiformis	Bitternut Hickory	Juglandaceae	Native
Carya ovata	Shagbark Hickory	Juglandaceae	Native
Carya tomentosa	Mockernut Hickory	Juglandaceae	Native
Celastrus orbiculatus	Oriental Bittersweet	Celastraceae	Introduced from Asia/Invasive
Celtis occidentalis	Hackberry	Ulmaceae	Native
Craetagus spp.	Hawthorn spp.	Rosaceae	Native
Eunoymus atropurpureus	Winged Wahoo	Celastraceae	Introduced from Asia
Fagus grandifolia	Beech	Fagaceae	Native
Forsythia cv.	Forsythia spp.	Oleaceae	Introduced from Europe
Fraxinus americana	American Ash	Oleaceae	Native
Hamamaelis virginiana	Witch Hazel	Hamaelidaceae	Native
Hydrangea arborescens	Hydrangea	Hydrangeaceae	Native
Juglans nigra	Black Walnut	Juglandaceae	Native
Ligustrum vulgare	Privet	Oleaceae	Introduced from Europe
Lindera benzoin	Spicebush	Lauraceae	Native
Liriodendron tulipifera	Tulip Poplar	Magnoliaceae	Native
Maclura pomifera	Osage Orange	Moraceae	Introduced from Southern US
Menispermum canadense	Moonseed	Menispermaceae	Native
Ostrya carpinus	Hop-hornbean	Betulaceae	Native
Parthenocissus quinquefloia	Virginia Creeper	Vitaceae	Native
Pinus strobus	White Pine	Pinaceae	Native
Polygonum cuspidatum	Japanese Knotweed	Polygonaceae	Introduced from Asia/Invasive
Prunus serotina	Black Cherry	Rosaceae	Native
Prunus spp.	Cherry spp.	Rosaceae	Native
Quercus alba	White Oak	Fagaceae	Native
Quercus rubra	Red Oak	Fagaceae	Native
Quercus spp.	Black/Red Oak	Fagaceae	Native
Robinia psuedoacacia	Black Locust	Fabaceae	Introduced from Southern US
Rosa multiflora	Multiflora Rose	Rosaceae	Introduced from Asia/Invasive
Rubus spp.	Blackberry, Raspberry	Rosaceae	Native
Sambucus canadensis	Elderberry	Caprifoliaceae	Native
Sassafras albidum	Sassafrass	Lauraceae	Native
Smilax sp.	Greenbrier	Similaceae	Native/Introduced
Tilia americana	Basswood	Tiliaceae	Native
Toxicodendron radicans	Poison Ivy	Anacardiaceae	Native
Tsuga canadensis	Hemlock	Pinaceae	Native
Ulmus americana	American Elm	Ulmaceae	Native
Viburnum dentatum	Arrow-wood	Adoxaceae	Native
Vitus sp.	Grapevine	Vitaceae	Native/Introduced

Table 5. Species Site C

List of species identified in woody vegetation survey. Font color indicates status (Black=native, blue=introduced, red=introduced & invasive).

Species Name	Common Name	Family	Native/Introduced/Invasive
Acer negundo	Box Elder	Aceraceae	Native
Acer rubrum	Red Maple	Aceraceae	Native
Acer saccharum	Sugar Maple	Aceraceae	Native
Ailanthus altissima	Tree of Heaven	Simaroubaceae	Introduced from Asia/Invasive
Aralia spinosa	Devil's Walking Stick	Vitaceae	Native
Betula allegheniensis	Yellow Birch	Betulaceae	Native
Betula spp.	Birch	Betulaceae	Native
Carya cordiformsi	Mockernut Hickory	Juglandaceae	Native
Catalpa spp.	Catalpa	Bignoniaceae	Introduced from Southern US
Celastrus orbiculatus	Oriental Bittersweet	Celastraceae	Introduced from Asia/Invasive
Celtis occidentalis	Hackberry	Ulmaceae	Native
Cornus florida	White Flowering Dogwood	Cornaceae	Native
Creatagus spp.	Hawthorn	Rosaceae	Native
Forsythia spp.	Forsythia	Oleaceae	Introduced from Europe
Fraxinus spp.	Ash spp.	Oleaceae	Native
Hamamaelis virginiana	Witchhazel	Hamaelidaceae	Native
Juglans nigra	Black Walnut	Juglandaceae	Native
Ligustrum vulgare	Privet	Oleaceae	Introduced from Europe
Liriodendron tulipifera	Tulip Poplar	Magnoliaceae	Native
Lonicera spp.	Honeysuckle	Caprifoliaceae	Introduced/Invasive
Lonicerna japonica	Japanese Honeysuckle	Caprifoliaceae	Introduced from Asia/Invasive
Malus coronaria	Crabapple	Rosaceae	Native
Menispermum canadense	Moonseed	Menispermaceae	Native
Morus spp.	Mulberry spp.	Moraceae	Introduced from Southern US
Ostrya carpinus	Hop-hornbeam	Betulaceae	Native
Parthenocissus quinquefloia	Virginia Creeper	Vitaceae	Native
Pinus strobus	White Pine	Pinaceae	Native
Polygonum cudpidatum	Japanese Knotweed	Polygonaceae	Introduced from Asia/Invasive
Prunus serotina	Black Cherry	Rosaceae	Native
Quercus alba	White Oak	Fagaceae	Native
Quercus prinus	Chestnut oak	Fagaceae	Native
Rhamnus frangula	Buckthorn Alder	Rhamnaceae	Introduced from EurAsia/Invasive
Rosa multiflora	Multiflora Rose	Rosaceae	Introduced from Asia/Invasive
Robinia psuedoacacia	Black Locust	Fabaceae	Introduced from Southern US
Rubus oderatus	Purple-flowering raspberry	Rosaceae	Native
Rubus spp.	Raspberry, Blackberry	Rosaceae	Native
Sassafras albidum	Sassafrass	Lauraceae	Native
Syringa vulgaris	Lilac	Oleaceae	Introduced from Eurasia/Invasive
Toxicodendron radicans	Poison Ivy	Anacardiaceae	Native
Tsuga canadensis	Hemlock	Pinaceae	Native
Ulmus spp.	Elm spp.	Ulmaceae	Native
Viburnum dentatum	Arrowwood	Adoxaceae	Native
Vitus spp.	Grapevine	Vitaceae	Native/Introduced

Table 6. Abundance and Diameter

Percent abundance and average diameter at breast height (dbh) of woody species in three areas sampled. Diameter at breast height was measured for overstory trees only.

Species	Common Name	% Abundance	Average Dbh (cm)	% Abundance	Average Dbh (cm)	% Abundance	Average Dbh (cm)
Acer platanoides	Norway Maple	-	-	-	-	4.2%	11.9
Acer rubrum	Red Maple	-	-	1.0%	-	-	-
Acer saccharum	Sugar Maple	18.2%	22.6	24.0%	22.9	-	-
Amelanchier sp.	Serviceberry	-	-	2.1%	-	-	-
Betula allegheniensis	Yellow Birch	6.8%	-	1.0%	-	-	-
Carpinus caroliniana	Musclewood	-	-	1.0%	-	-	-
Carya sp.	Hickory	-	-	3.1%	15.6	-	-
Celastrus orbiculaus	Oriental Bittersweet	-	-	-	-	1.1%	-
Celtis occidentalis	Hackberry	-	-	-	-	1.1%	-
Cercis canadensis	Redbud	2.3%	-	1.0%	-	-	-
Craetagus	Hawthorn	-	-	-	-	2.1%	-
Euonymus atropurpureus	Winged Wahoo	-	-	1.0%	-	-	-
Forsythia cv.	Forsythia	-	-	-	-	1.1%	-
Fraxinus americana	American Ash	6.8%	52.9	9.4%	-	2.1%	-
Gleditsia triacanthos	Honey Locust	-	-	-	-	1.1%	-
Juglans nigra	Black Walnut	-	-	-	-	2.1%	23.2
Ligustrum vulgare	Privet	-	-	-	-	1.1%	-
Lindera benzoin	Spicebush	-	-	6.3%	-	-	-
Liriodendron tulipifera	Tulip Poplar	2.3%	102	-	-	-	-
Lonicera sp.	Honeysuckle	-	-	-	-	1.1%	-
Lonicera japonica	Japanese Honeysuckle	-	-	-	-	1.1%	-
Morus rubra	Red Mulberry	-	-	-	-	5.3%	34.1
Ostrya carpinus	Hop-hornbeam	-	-	3.1%	15.4	-	-
Parthenocissus quinquefolia	Virginia creeper	2.3%	-	3.1%	-	2.1%	-
Pinus resinosa	Red pine	-	-	-	-	2.1%	-
Polygonum cuspidatum	Japanese Knotweed	-	-	-	-	19.0%	-
Prunus serotina	Black Cherry	9.1%	39.2	13.5%	25.6	3.2%	-
Quercus alba	White Oak	-	83.4	6.3%	46.5	-	-
Quercus prinus	Chestnut oak	4.5%	-	-	-	-	-
Quercus rubra	Red Oak	15.9%	51.6	8.3%	57.7	1.1%	75.8
Rhamnus frangula	Buckthorn Alder	-	-	-	-	1.1%	-
Rhus typhina	Staghorn Sumac	-	-	-	-	8.4%	-
Robinia psuedoacacia	Black Locust	-	-	-	-	16.6%	22.6
Rosa multiflora	Multiflora Rose	-	-	1.0%	-	-	-
Rubus spp.	Blackberry & Raspberry	2.3%	-	-	-	1.1%	-
Tilia americana	Basswood	4.5%	52.5	1.0%	-	-	24.5
Ulmus americana	American Elm	2.3%	-	3.1%	-	3.2%	47.6
Viburnum spp.	Viburnum	-	-	1.0%	-	1.1%	-
Vitis spp.	Grape	4.5%	-	1.0%	-	9.5%	-

V. Synthesis of Findings

5. 1 Application of data to zoning

The maps and texts in section II Context are strictly intended as narrative background for discussions about the remnant and recovering ecosystems as well as the social-cultural need for open space. The Hillsides ecology team believe that these elements of our report are essential to the moral and ethical discussions that attend zoning discussions but are not part of the legally defensible package that we were charged with developing.

The maps and texts in Section III Decisions are intended as primary material for parcel based zoning decision making. The materials are first developed and grouped to explicate the relative values and intent of the analysis that underlies the data. The “Parcel Identifer” is a data base tool – that is easy to use and actuate. It provides detailed information about the relative dangers, “threats to public safety” that are inherent to parcel soils and the availability or adjacency of infrastructure services that make develoment possible. Both conditions are essentia components to the rational decision making that must attend the development, conservation or preservation of steep hillside properties.

5.2 Application of data to development guidelines

The field work on the three selected sites provide us with baseline knowledge about nature in the city. This information can be used to set development guidelines, for instance:

The following species occur on sites sampled, they could be considered primary native species to be protected at a specific breast height diameter and recommended species for infill landscaping.

Development guidances could be written in such a way that species and vegetative habitats could be protected. The Plant Community Types are identified in Appendix A. The complete list of native specie can be culled from vegetation table 1, table 2 provides a list of herbaceous species.

Occurring on all three sites	Occurring on two of three sites
American Ash	**Sugr Maple**
Black Cherry	**Yellow Birch**
Read Oak	**Redbud**
Basswood	**Virginia Creeper**
	White Oak
	Blackberry Raspberry
	American Elm

VI. Appendix

The SER Primer on Ecological Restoration.
The SER Science & Policy Working Group, May 2002, www.ser.org

James Aronson (France), Andy Clewell (USA), Wally Covington (USA), Jim Harris (UK), Eric Higgs (Canada), Richard J. Hobbs (Australia), Dennis Martinez (Indigenous Peoples), Marc A. Matsil (USA), Carolina Murcia (Colombia), John Rieger (USA), and Keith Winterhalder (Canada).

Section 2. Definition of Ecological Restoration
Ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed.

Section 3. Attributes of Restored Ecosystems
This section addresses the question of what is meant by “recovery” in ecological restoration. An ecosystem has recovered - and is restored - when it contains sufficient
biotic and abiotic resources to continue its development without further assistance or subsidy. It will sustain itself structurally and functionally. It will demonstrate resilience
to normal ranges of environmental stress and disturbance. It will interact with contiguous ecosystems in terms of biotic and abiotic flows and cultural interactions. The nine attributes listed below provide a basis for determining when restoration has been accomplished. The full expression of all of these attributes is not essential to demonstrate restoration. Instead, it is only necessary for these attributes to demonstrate an appropriate trajectory of ecosystem development towards the intended goals or reference. Some attributes are readily measured. Others must be assessed indirectly, including most ecosystem functions, which cannot be ascertained without research efforts that exceed the capabilities and budgets of most restoration projects.

1. The restored ecosystem contains a characteristic assemblage of the species that occur in the reference ecosystem and that provide appropriate community structure.
2. The restored ecosystem consists of indigenous species to the greatest practicable extent. In restored cultural ecosystems, allowances can be made for exotic domesticated species and for non-invasive ruderal and segetal species that presumably co-evolved with them. Ruderals are plants that colonize disturbed sites, whereas segetals typically grow intermixed with crop species.
3. All functional groups necessary for the continued development and/or stability of the restored ecosystem are represented or, if they are not, the missing groups have the potential to colonize by natural means.
4. The physical environment of the restored ecosystem is capable of sustaining reproducing populations of the species necessary for its continued stability or development along the desired trajectory.
5. The restored ecosystem apparently functions normally for its ecological stage of development, and signs of dysfunction are absent.
6. The restored ecosystem is suitably integrated into a larger ecological matrix or landscape, with

which it interacts through abiotic and biotic flows and exchanges.
7. Potential threats to the health and integrity of the restored ecosystem from the surrounding landscape have been eliminated or reduced as much as possible.
8. The restored ecosystem is sufficiently resilient to endure the normal periodic stress events in the local environment that serve to maintain the integrity of the ecosystem.
9. The restored ecosystem is self-sustaining to the same degree as its reference ecosystem, and has the potential to persist indefinitely under existing environmental conditions. Nevertheless, aspects of its biodiversity, structure and functioning may change as part of normal ecosystem development, and may fluctuate in response to
normal periodic stress and occasional disturbance events of greater consequence. As in any intact ecosystem, the species composition and other attributes of a restored ecosystem may evolve as environmental conditions change.

Other attributes gain relevance and should be added to this list if they are identified as goals of the restoration project. For example, one of the goals of restoration might
be to provide specified natural goods and services for social benefit in a sustainable manner. In this respect, the restored ecosystem serves as natural capital for the accrual
of these goods and services. Another goal might be for the restored ecosystem to provide habitat for rare species or to harbor a diverse genepool for selected species. Other possible goals of restoration might include the provision of aesthetic amenities or the accommodation of activities of social consequence, such as the strengthening of a
community through the participation of individuals in a restoration project.

Section 10. Relationship of Restoration to Other Activities
Ecological restoration is one of several activities that strive to alter the biota and physical conditions at a site, and are frequently confused with restoration. These activities include reclamation, rehabilitation, mitigation, ecological engineering and various kinds of resource management, including wildlife, fisheries and range management, agroforestry, and forestry. All of these activities can overlap with and may even qualify as ecological restoration if they satisfy all criteria expressed in Section 3 of this document. Relative to other kinds of activities, restoration generally requires more postinstallation aftercare to satisfy all these criteria.

Rehabilitation shares with restoration a fundamental focus on historical or pre-existing ecosystems as models or references, but the two activities differ in their goals and strategies. Rehabilitation emphasizes the reparation of ecosystem processes, productivity and services, whereas the goals of restoration also include the re-establishment of the pre-existing biotic integrity in terms of species composition and community structure. Nonetheless, restoration, as broadly conceived herein, probably encompasses a large majority of project work that has previously been identified as rehabilitation.

The term reclamation, as commonly used in the context of mined lands in North America and the

UK, has an even broader application than rehabilitation. The main objectives of reclamation include the stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose. Revegetation, which is normally a component of land reclamation, may entail the establishment of only one or few species.
Reclamation projects that are more ecologically based can qualify as rehabilitation or even restoration.

Mitigation is an action that is intended to compensate environmental damage. Mitigation is commonly required in the USA as a condition for the issuance of permits for private development and public works projects that cause damage to wetlands. Some, but perhaps relatively few, mitigation projects satisfy the attributes of restored ecosystems listed in Section 3, and thus qualify as restoration.

The term creation has enjoyed recent usage, particularly with respect to projects that are conducted as mitigation on terrain that is entirely devoid of vegetation. The alternate term fabrication is sometimes employed. Frequently, the process of voiding a site causes sufficient change in the environment to require the installation of a different kind of ecosystem from that which occurred historically. Creation that is conducted as supervised
engineering or landscape architecture cannot qualify as restoration because restoration initiates ecosystem development along a preferred trajectory, and thereafter allows autogenic processes to guide subsequent development with little or no human interference.

Ecological engineering involves manipulation of natural materials, living organisms and the physical chemical environment to achieve specific human goals and solve technical problems. It thus differs from civil engineering, which relies on human-made materials such as steel and concrete. Predictability is a primary consideration in all engineering design, whereas restoration recognizes and accepts unpredictable development and addresses goals that reach beyond strict pragmatism and encompass biodiversity and ecosystem integrity and health. When predictability is not at issue, the scope of many ecological engineering projects could be expanded until they qualify as restoration.

Section 11. Integration of Ecological Restoration into Larger Programs

Ecological restoration is sometimes only one of many elements within a larger public or private sector enterprise, such as development projects and programs for watershed management, ecosystem management and nature conservation. Project managers of these larger undertakings should be aware of the complexities and costs involved in planning and implementing ecological restoration. Cost savings can be realized by careful coordination of restoration activities with other aspects of a large program. For this reason, project managers will benefit by recognizing ecological restoration as an integral component of a program. If this is done, the restorationist can contribute substantively to all aspects of the program that impinge on restoration. Moreover, the restorationist will be in a position to ensure that all ecological restoration is well conceived and fully realized. In this manner, the public good is served.

References

Askins, R. 2000 Restoring North America's birds: lessons from landscape ecology. Harrisburg,VA: Donnely & Sons. p. 100-129.

Fischer, R. A. and Fischenich, J. C. 2000 Design Recommendations for Riparian Corridors and Vegetated Buffer Strips U.S. Army Engineer Research and Development Center. Vicksburgh, MS.

Forman. R. T. 1997. Landscape Mosaics: The Ecology of Landscapes and Regions. Cambridge, UK: Cambridge Press. p. 145-162, 214

Meffe, G.K, and C.R. Carroll. 1997. Principles of Conservation Biology. Sunderland, MA: Sinauer Associates. 2nd Edition. p.294-297

Moyer, B. 2003 Pennsylvania's Wildlife and Wild Places: Our Heritage in Peril. Pennsylvania Department of Conservation and Natural Resources.

National Council for Air and Stream Improvement. 2000. Riparian Vegetation Effectiveness. Technical Bulletin No. 799. February.

Pinkham, R. 2002. Stream Restoration and Daylighting – Phase 1. Pittsburgh: Carnegie Mellon University, Studio for Creative Inquiry.

Ricketts T.H., Dinnerstein E., Olson D.M., Colby J. L. et al. 1999. Terrestrial Ecoregions of North America. Washington D.C.: Island Press. p. 96-97.

Robbins, C.S., D. K. Dawson, and B. A. Dowell. 1989. habitat area requirements of breeding forest birds of the Middle Atlantic States. Wildlife Monographs 103 p.6-33

Rosenberg K.V. and J. V. Wells. Global Perspectives on Neotropical Migratory Bird Conservation in the Northeast: Long-Term Responsibility VS. Immediate Concern. Ithaca, NY: Cornell University. Accessed 3/27/2004. Available at: http//birds.cornell.edu/pifcapemay/rosenberg_wells.htm.

Turner M.G, Gardner R.H., and R. O'Neil. 2003 Landscape Ecology in Theory and Practice. New York: Springer. p.229-235, 272-274.