The Last Plant Standing—Ecosystem assessment and Response to Human Disturbance in the Gordon Natural Area, West Chester University, Chester County, Pennsylvania

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Abstract-

Forests regeneration in southeast Pennsylvania is reaching a critical stage. Today, forests compose mostly even-aged second, third, or even fourth growth woodlots. Primary forests of long-lived individuals are extremely rare. Dynamic suburban land-use trends threaten forest coverage by converting forests into residential developments depleted of natural forests. Forests are only one ecosystem component taking a hit from human disturbance. Biotic (invasive species, forests, and deer) and abiotic (soil, trails, and streams) respond to the human presence in the landscape. While focusing on one of the few remaining natural forests in central Chester County, we aim to describe and document the natural patterns and processes of its ecosystem and responses to human disturbance. Our findings will aid in management policy and decisions of the Gordon Natural Area.

I. Introduction

Ecosystem response to changing environmental conditions and dynamic disturbance regimes is defining many research endeavors concerned with natural resource preservation and management. The impact of global climate change and loss of habitat from urbanization looms large in the perception of those concerned with natural resource management. Urbanization stands in direct conflict with a natural resource manager. While staring the enemy of sprawl in the eye, one believes in only one winner and loser. A biased knowledge of how natural resources and humans interact and respond to one another is formed, that does not really respond to the need of a comprehensive outlook in managing human behavior and ecosystem health. Human behavior and ecosystem health are not two conflicting sides of a coin. In fact, both play a role in the other. Human behavior directly affects ecosystem health, and ecosystem health directly affects human behavior. This idea surely has been manifested in the 350 year history of environmental change in the eastern United States (Whitney, 1994). While it is true that environmental degradation has won the day in the history of environmental change in the eastern United States and fueled the colonial settlement and exploitation, industrial revolution, urban transformation, and megalopolis historical periods, environmental health has developed some of its own proponents and ecological restoration has begun in some places and at various times.

important context for your work

To help aid ecological restoration it is therefore important to measure and discern the responses ecosystems exhibit when pressured by natural disturbance and human disturbance. Knowledge of ecosystem response is critical in planning, implementing, and managing ecological restoration. With this knowledge at hand, we aim to identify the ecological patterns and processes associated with the Gordon Natural Area's vegetation and gauge and, if possible, measure the ecosystem response of human induced change.

II. Study Area (For Study Area Maps see Appendix)

The Robert B. Gordon Natural Area for Environmental Studies (GNAES) is located in West Goshen Township, Chester County, in southeastern Pennsylvania. The GNAES covers approximately 121 acres of woodland, floodplain and wetlands and is situated on West Chester University's South Campus. In 1973, the West Chester University's Board of Trustees officially dedicated the GNAES for research and education (Hertel 2003).

The GNAES is located in the upland Piedmont physiographic province. This province is a "highly eroded plateau underlain by relatively soft parent rock, situated between the harder ridges of the Appalachians proper and the alluvial deposits of the coastal plain" (Matlack 1997). The soils of West Goshen Township belong to the

Chester, Manor and Conowingo series of the soils classification. These soils are mostly due to the weathering of crystalline gneisses and schists, granites, granodiorites and serpentine (Gordon 1941). One exceptional soil series present in the Gordon not formed from metamorphic bedrock is the Wehadkee. The Wehadkee is a fine clay soil deposited by alluvial processes (HP?)

Chester County, Pennsylvania has a climate that can be described as humid-continental. Winter weather is caused by cold continental air masses approaching from the west and northwest (Canada). Weather in the summer is caused by warm, humid bodies of air moving north along the Atlantic coast. This area receives approximately 120cm of precipitation each year and has monthly mean temperatures ranging from -1 to 26 degrees C (Matlack 1997).

Before European settlement, Chester County was covered by a deciduous hardwood forest dominated by oaks, hickories and American chestnut (Matlack 1997). During the colonial period, forests were clear cut to make way for agriculture uses. Forests also provided fuelwood to support the cities of Wilmington and Philadelphia. By 1800, much of the forests that dominated Chester County were no longer (Matlack 1997). The Gordon Natural Area is considered a 2nd, 3rd, or 4th growth forest. The original species that once made up the forest have given way to invasive species that now have become a problem. Forest type of this region defined by Braun (1972), Keever (1973), and Overlease (1987) is Oak-Chestnut, possibly being replaced by Oak-Hickory.

The GNAES is drained by a tributary of Plum Run. The tributary is a first-order stream within the Brandywine Watershed. Intermittent streams, seeps, and smaller tributaries of the Gordon Natural area also constitute the area's hydrology.

III. Methods

Forest Stand Composition and Dynamics

To develop stand dominance by species composition frequency and age-class dynamics for the Gordon Natural Area we placed 8 transects in the study area. Each transect was placed by a location that would capture relict land-use patterns. Each transect was not randomly distributed. Total transect area amounted to 0.2 hectares. Each transect was 50 m in length and 5 m in width with the transect as the midpoint of the 5 m width. Thus, each transect was divided into two parts. A data collection team was assigned to each part of the transect. Each team collected the species, diameter at breast height (dbh), and age class (overstory, intermediate, overtopped) of every woody species > 10 cm. The species type of saplings (10 cm < dbh > 2 cm) was collected. Seedling layer was difficult to identify due to leaf senescence and deer browsing. The shrub layer and site conditions (slope, topographic position, soil type, soil moisture, and site history) were also identified for each transect. Two trees from 3 transects were cored to determine age and measured for height (m).

Transects were placed in order to detect differences in species composition based on relict land-uses. From the historical records (Aerial photography) 4 different land-use classes were used (See below in next section). Species composition and results were grouped into these classes and were also grouped by two other environmental variables: topographic position and soil series type.

Analysis of Historical Human Use within the Gordon Natural Area

To determine the site history of the Gordon Natural Area the local and regional historic records were investigated. We contacted the Chester County Historical Society

(West Chester, PA), Chester County Archives (West Chester, PA), Chester County Planning Commission (West Chester, PA), Pennsylvania Historic and Museum Commission (Harrisburg, PA, Pennsylvania Historical Society (Philadelphia, PA), and Special Collections Library of West Chester University for any resources pertaining to the Gordon Natural Area. Specific investigation of known resources included historic photographs, deed records (1680 – present), warrantee maps (original survey maps 1680 – 1740), and aerial photographs (1937 – present). Results of the investigation of known resources offered some success. Historic photographs of the Gordon Natural Area were not produced. The deed records are available and located in the Chester County Archives. Warrantee maps are located at the Pennsylvania Historical Society and PHMC. Aerial photographs are available from the Chester County Planning Commission. Unknown resources deemed useful for project were the Chester County Roads Docket available at the Chester County Archives. The Roads Docket includes a survey of roads laid in Chester County from 1680 to 1880. Not every road was surveyed in Chester County before it was laid out and not all of the surveyed records survive in the archives. However, two road surveys were available for interpretation in the Gordon Natural Area: New Street (1837) and a road running east of the New Street and Tigue Road (currently a powerline right-away) (1861). Land-use patterns were recorded from these surveys.

The aerial photographs provided the opportunity to perform analysis of land-use and vegetation types through repeat photography. A photograph from 1937 became the benchmark of land-use patterns and vegetation. Beginning in 1970, photographs were taken at 5-year intervals. Photographs also are available between 1937 and 1970. From the photographs, 4 land-use classes were developed: woodland (not significantly disturbed)-pre-1880, farm abandonment 1890, farm abandonment 1950, and farm abandonment 1970 (Matlack, 1997).

Deer Browsing

The methods used to obtain information about the effects of deer browse in the Gordon Natural Area include a review of the literature, general field observation, and discussion with Dr. Gerald Hertel and Dr. Joan M. Welch. Since the literature promotes the use of long-term observation of fenced plots to identify the effects of deer browsing, we could not include a complete study of deer browsing due to the short conclusion of our joint research effort.

Trail Assessment and Use

Trail and sign identification was conducted through use of a Trimble Global Positioning System. Sign points were collected by gathering 140 points, capturing one point every two seconds, trail polyline points were collected every five seconds. Data collection took place December 1, 2004 between the hours of 12:30 pm and 2:00 pm. under partly cloudy skies, with the assistance of Dr. Joan Welch.

Sign points were identified as either an entrance sign or trail head sign. Sign condition was recorded noting damage and weathering. Trail polylines were collected using segments which were delineated based upon continuous features or changes in features, for example; noticeable change in width, erosion, trail split, or presence of bridge structure. Width measurements were taken for each segment along with segment characteristics; rocky, exposed roots, erosion, and bike travel etc. Only data for authorized trails was collected.

Once data was collected, Pathfinder GPS software was utilized to transfer rover files from the hand held unit to a desktop computer. Differential correction was done by obtaining the necessary SSF files from Chester County GIS covering the hours of 12-3. Once data layers were differentially corrected, data was exported to the ESRI Shape file format with the coordinate system being specified as State Plane 1983 (meters) Pennsylvania South. Newly created Shape files were inserted into ArcGIS 9 for use.

Photographs of features such as man made structures, multiple lane or split trails and both entrance and trail head signs were taken and scanned for use documenting areas of concern or interest and serving as a presentation aid.

Stream Response to Human Disturbance

Water is an essential part of life. This is not only true for humans, but also for nature. In order to fully understand a natural area it is critical to understand how water flows within that area. What impacts does it have on the surrounding forest? How does human interaction with the stream affect the forest and the stream itself? These are questions that have to be answered when considering the management of a natural area. In order to answer those questions it is necessary to have a foundation of information including the location of the stream and what enters the stream and where. In order to create a foundation of information for the stream network in the Gordon Natural Area (GNA), an initial map layer needed to be produced. This initial layer was to include the centerline of the main stream as well as its tributaries. In addition, a point layer was to be created that would include any instance of visible runoff including both human and natural causes.

The creation of these layers was performed through the use of a Global Positioning System (GPS) obtained from the Geography and Planning Department of West Chester University. All the information was obtained on three separate visits to the GNA by walking the stream and creating line features within the GPS for the stream centerlines. The evidence of runoff points were collected in a separate point feature layer and classified by human or natural run off processes within the GPS. Using Pathfinder software the data was then exported to ArcMap in the form of shapefiles.

Invasive Species

On November 13, 2004 a field survey was conducted. The objective was to locate and determine a general presence of invasive species within the Gordon Natural Area. A data sheet was created prior to going into the field. An example can be found as Figure 1. For each of the transects, invasive species were identified and given the label of abundant, moderate, or rare. Five transects were chosen based on predetermined environmental issues. More specifically, transects were chosen by these four elements, slope, visual presence, orientation from edge, and old land uses such as farming and orchards. The method followed was chosen from an on-line source *Weed Mapping and Database Development Guidelines for the National Park Service, Intermountain Region (IMR)* (Benjamin, 2001). It was approximated that the Gordon Area was 66 acres in size. Each transect was 250 square meters for a total of 1250 square meters measured. In order to compare acres to meters a conversion was necessary. The metric equivalent of acres was 26.709294 hectares. The next step to the method was to assign each species with a percent of ground cover within the 26.709294 hectares. Figure 2 described the percentages in terms of 10% being rare, 30% moderate, and 60% abundant presence of invasive species within the Gordon Natural Area. When 26.709294 was divided by the percent from the table an amount of infestation within the Gordon Area was approximated.

IV. Results

Historical analysis

An investigation of the site history of the 66-acres woodland portion of the Gordon Natural Area produced various findings. Archival records for this exact location commence in 1682 with the original deeds and warrantee maps of property dispersed by William Penn. The original patent for a 5000 acres parcel was deeded to Arthur Cook in 1684 (in East Bradford Township). Cook's eastern boundary formed the boundary to the Welsh Tract (the boundary of West Goshen and East Bradford Townships). John Willis was also granted a parcel adjoining the Gordon Natural Area's southwest corner and bordered the Welsh Tract. John Willis later bought land from Cook's original patent and was the earliest settler in the area in direct proximity to the Gordon Natural Area. Arthur Cook never arrived in the New World and his heirs divided the land he claimed in the New World. John Willis was deeded his original patent for 150 acres in 1712. It can be assumed that John Willis settled his land prior to the patent was delivered.

The majority of the Gordon Natural Area actually fell within the Welsh Tract. The Welsh Tract was a sizeable portion of land (approx. 40,000 acres) William Penn granted a group of Welsh Quakers. The terms of agreement was that the Quakers were going to settle the land and improve it expeditiously and establish an organized community and act a lightning rod in the formation of colonial infrastructure and regional settlement. This never materialized and settlement continued haphazardly through the will of individual settlers. No central settlement pattern or infrastructure was developed. Settlers already in the New World staked claimed within the Welsh Tract and Penn abandoned the terms of agreement of the Welsh Tract.

A possible historic relict of the Welsh Tract exists in the Gordon Natural Area. A straight line of old-growth trees (Oak, Tulip Poplar, and Beech) delineating the West Goshen Township/East Bradford boundary could represent the original trees used to survey the original boundary of the Welsh Tract in 1684. Dendrochronology will be employed to precisely determine the age of these trees. The collection of tree-ring cores will be performed at a later date.

General field observations reveal clues to relict land-uses. Stand structure and form reveal prior growth environment and rates. A tree that grew without competing for canopy space grows more horizontally and produces multiple main stem leaders and its branches stretch outward and even toward the forest floor. A tree with this shape that still persists in a forest dates the establishment of the individual stems surrounding it currently. These observations helped locate the eight transects into the four relict land-use classes we classified in the Gordon Natural Area.

Forest Stand Composition and Dynamics

The data collected from our eight transects revealed some unanticipated results. The greatest discrepancy existed between our results and the label of community type Oak-Hickory by Braun (1972). The dominant species of our frequency table are Beech / Tree of Heaven / Box Elder (Figure 1 and Table 1). We found it true that species location can be correlated to relict land-use and can inflate the dominance of a few species with many individuals successfully germinated on recently disturbed sites. The complete absence of Oak and Hickory in the Gordon Natural Area is not valid, yet the presence of Oak and Hickory is dependent on the disturbance history and land-use history of each site. The dominance of Beech is perhaps inflated by the number of root suckers each individual beech tree produces. Beech can therefore be more localized in dominance, rather than the widespread dominance it garners in our general frequency chart and table (Figure 1 and Table 1). To determine stand dominance, an alternative method, we would calculate the basal area of the sample stems.

A second main concern is the lack of saplings and understory candidates for canopy regeneration. An unusual decline in age class structure was observed in our frequency table (Figure 1). Sapling and understory dominants were beech, box elder, and tree of heaven. Deer browsing can be attributed in reducing understory species, but the lack of understory candidates is surprising.

These two main conclusions are what the data reveal, but it could be said that the sample size is too small to capture robust results and our results are skewed to areas of the forest that capture the presence of invasive species like Tree of Heaven, Box Elder, and Norway Maple. Yet, we believe a greater sample size would not terribly affect the dominance of Beech in species composition and stand dynamics. The dominating presence of Beech in three of the four relict land-use classes places it quite robustly as the last tree standing and regenerating. More results are broken down by relict land-use, topographic position, and soil type / moisture gradient.

Relict Land-use

The distribution of transect equally among the four classes to capture an equal share of species composition in each and to off-set unequal density of stems in some areas was achieved with some success (Table 2a). The land-use class underrepresented was 'farm abandonment 1880.' Only 52 individuals were sampled in this class (Table 2b). The class with the most individuals sampled was the 'site not intensely modified' with 113 individuals (Table 2b). Diversity of each class was measured by '# of species.'

In the class of no intense disturbance, we found the greatest resemblance to an Oak-Hickory forest of this region (Table 2b). A dominant shrub presence (spicebush) supports to signal a healthy forest (Overlease 1987). The diversity of species in this class is also representative of forests in this region. Beech still dominates this age class.

The second age class is poorly represented, but note the dominance of Beech again (Table 2a). Beech is not known as a pioneering species in successional dynamics. Perhaps, the abandonment of farm or pasture in 1880 granted Beech time to colonize the area after the pioneering species settled the site.

The third age class is dominated by a representative understory species of the Oak-Hickory type of the region: Hornbeam (Table 2a). Hornbeam's presence is good news. It demonstrates that forest composition and regeneration can come back after heavy land-use and abandonment. Hornbeam produces nuts are dispersed mainly by birds and slightly by wind. In this case wind-dispersal could have aided Hornbeam's dominance in this age class and location.

The fourth age-class is a product of recent abandonment and the germination of wind-dispersed seeds. Box elder, tree of heaven, and black locust dominate this site as well as a plethora of invasive herbaceous species and vines. The relict land-use of agriculture prepared a well-suited location for colonization.

The separation of results into these four main classes could cause one to support the premise of successional climax. The oldest land-use class represents some components of a climax forest of our region and youngest land-use class is dominated by pioneering species. Is only time needed for healthy forest regeneration? Wait long enough and the oak, hickory, tulip poplar, and beech will begin colonizing sites. In this case we believe this is a false theory. The regeneration of these mid-successional to late successional species is failing and forest composition is a response to the presence of human disturbance. The failure of oak is tied to human disturbance and presence.

Topographic position

Separation of results by topographic position was not evenly distributed and is not as robust as land-use class. Transect locations were dominated by upland sites. (Table 3a). Upland sites are the dominant topographic class in the Gordon Natural Area, however. An interesting result of this separation was the presence of Hornbeam in the area was correlated to Topographic position rather than relict land-use (Table 3b). The time of germination was not important, but the environmental variables favorable to Hornbeam germination and recruitment. Alluvial soils and a 'cove' site are important in regulating moisture conditions favorable for Hornbeam. The dominance of Beech across the topographic gradient stresses it dominance in the Gordon Natural Area (Table 3b). Invasive woody species present in the Gordon dominate the Upland portions of the area, perhaps due to lower moisture and the competitive advantage of a favorable microclimate.

Soil Series Type and Moisture Gradient

Soil series type was most equally represented in transect location (Table 4a and 4b). The Glenelg / Neshaminy soil types are upland soils derived from gneissic bedrock. The Wehadkee is an alluvial soil. The Glenville soil type is an upland soil derived from gneissic bedrock, but does not occupy a significant amount in the Gordon Natural Area. The two dominant soil series types in the Gordon Natural Area are the Glenelg and Wehadkee. The Glenelg is a coarse-textured well-drained soil, while the Wehadkee is a poorly drained clay soil derived from alluvial processes. The main result of the separation of results by soil series type is the presence of Hornbeam in the Wehadkee series type and absence in the Glenelg series type. Hornbeam favors moister soils, yet not saturated soils. Species composition is evenly distributed between the two soil series types. No great difference is noticed. It is surprising the amount of diversity captured in the Wehadkee series type. One might expect it to be dominated by floodplain species and invasive species.

Deer Browsing

The make up of the understory of the Gordon Natural Area would indicate that deer browse is present. The data collected from the eight transects indicates that the natural frequency (reverse j-shape) of tree species has been altered. The DBH Class Frequency chart (Figure 1) shows a sharp decline from the number of species that have a diameter of 1-10 cm to the number of species that have a diameter of 21-30 cm. In a healthy forest a decline is natural, but much more gradual. This great decline may be caused by deer browse which would prevent saplings and seedling from reaching maturity.

Through general observations one can see the effects of deer browse. Many of the stems within the browse zone (from ground level to 1.8 meters above ground) have been grazed. The stems that have not been browsed are the stems of the invasive plants and the species that the deer do not prefer. By browsing young seedlings, woody shrubs and herbaceous plants, deer have the ability to alter the vegetation composition and regeneration of the Gordon Natural Area.

The effects of deer browse on forest composition are compounded by the emergence of ferns in the understory. Ferns can interfere with the germination, growth, and survival of desirable tree seedlings (Alverson 218). Deer browse not only affects trees but herbaceous plants as well. Recent studies have shown deer browse selectively on rare lilies, orchids and dicots. Many of the herbaceous plants found in the understory do not grow tall enough to escape deer browse and are thus subject to repeated grazing (Alverson 220). This repeated grazing can eventually obliterate certain herbaceous species from the understory.

Recent studies have shown that the browsing habits of white-tailed deer have altered the growth of the woody species that make up our local forests. Research performed by Jacquelyn Arnold and Joan M. Welch of West Chester University's Department of Geography and Planning shows that the white-tailed deer selectively browse certain woody species. The area studied was located in Warwick County Park in northern Chester County, Pennsylvania. The goal of the research was to document and investigate the effects of deer browse in order to guide forest management plans (Arnold 2). The study consisted of six randomly selected plots within the interior forest habitat. All the species within the plots were counted and it was determined whether or not the stems had been browsed. A chi-squared analysis was employed to test for a significant relationship between stems browsed and preference of deer towards certain woody species (Arnold 3). To determine preference the researchers counted the total number of stems available and the total number of stems that had been browsed. The chi-square test compared the counted number of stems browsed to an expected number of stems browsed.

The results showed that deer do not browse woody plants in proportion to their availability; instead deer browse selectively (Arnold 3). It was determined that six species were browsed less than expected: beech, blueberry, maple leaf viburnum, multiflora rose, raspberry, and smooth alder. There were also six species that were browsed more than was expected: black cherry, mockernut hickory, mountain laurel, red maple, and sour gum (Arnold 4).

Trail Assessment and Use

Areas of high bike travel can be seen even with a substantial amount of leaf litter present on the trails. Trampling effect areas easily notable on areas of higher slope, such areas are noted with erosion comments and often times are associated with gullies due to heavy rainfall throughout the summer and fall months (Weaver and Dale 1978). Trail width varies throughout the natural area leading one to think some trails are more readily used than others, and or experience different types of use.

Exposed tree roots are seen throughout the trail system. Although severity differs most roots impose upon the safety of the trail. Biker made structures can be noticed in three areas all along the same trail, and are in some cases in areas of low lying trail height which is causing pools of water to form. Differences in soil properties can also be noted as walking the trails. Although this feature was not recorded as a comment, future trips will help aid in the location of fragile soils which is necessary when delineating proper trail routes based upon use (Bryan 1977, Lei 2004). The authorized trail system can be clearly seen and will aid in preservation and awareness of the Gordon Natural Area.

Stream Response to Human Disturbance

The data collected and converted to shapefiles allows a Geographic Information System (GIS) user to access the data and view it in ArcMap. The three viewable layers include a layer of the main stream, a layer of tributaries, and also a layer consisting of all runoff points. These layers will now form a basis for continuing studies within the GNA.

Invasive Species

In all five transects there was a presence of invasive species. The five transects chosen were an overall reflection of the presence of invasives within the 66-acre area. In Table 5 a table has been created to show which invasive species were identified in the field survey. It can be said by using the table as an example that invasive species exist within the Gordon Area. Study Map C outlined the invasive tracts. The most common invasive species that were found throughout the five transects were Multiflora rose (*Rosa multiflora*), Bush honeysuckle (*Lonicera*), and Wineberry (*Rubus phoenicolasius*). The more sun exposure, such as transect 1 and 2, the more diagonal the lines became in the forest. Furthermore, instead of looking at the forest as vertical lines with negative space between the tree trunks, the invasives replaced this negative space with green vines pulling the trees toward the ground. These invasive vines were, Japanese honeysuckle (*Lonicera japonica*), Oriental bittersweet (*Celastrus oribiculatus*), and Porcelainberry (*Ampelopsis brevipedunculata*). Transects 3 and 4, which were chosen by their orientation to the edge and divided by the road, consisted mainly invasive shrubs. Japanese honeysuckle (*Lonicera japonica*) was the abundant vine and Multiflora rose (*Rosa multiflora*), Privets (*Ligustrum* species), Winged burning bush (*Euonymus alata*), and Wineberry (*Rubus phoenicolasius*) were the most abundant invasives within these 2 transects. Transect 5 was located in the understory of the Gordon Area. The abundant invasive tree was the Norway maple (*Acer platanoides*).

V. Discussion

Forest Stand Composition and Dynamics

Forest regeneration and response to intense human land-use produces patterns and processes distinctive to human presence. Forest growth can never be natural or defined by an equilibrium or natural state. Forest growth is dynamic. Our results illustrate forest response to human presence and disturbance. In this region, many tree species benefit from human presence, like Tree of Heaven, Box Elder, Norway Maple, Tulip Poplar, Black Cherry, Black Locust, and possibly Beech according to our data. Others decline with human presence: Oak, Chestnut, Hickory, and Hemlock. Are there new community assemblages forming that are associated with humans disturbance, rather than environmental conditions and species interactions? It seems one could attempt to make this claim. In our study, Beech was not the natural dominant of forest regions, but is a new dominant based on the patterns and processes of human disturbance. Beech's shade-tolerance and ability to sprout from root suckers allows it to persist despite adverse growing conditions and in our study area it is found across environmental gradients. If it was historically a minor component of an Oak-Chestnut regime and in the understory and Oak and Chestnut are removed from the forest, Beech stands to gain tremendously from the presence of humans and has the capability of sustaining its dominance in a forest. Shade-tolerant invasive species can also create a niche within a Beech forest. Norway Maple is such a species currently gaining a minor share of forest dominance. Shade-intolerant invasive species, like Tree of Heaven and Box-Elder, should not persist and regenerate unless disturbance frequency is short and at a large-scale.

Forest management focus should include the removal of Norway maple and maintenance of the primary forest sites in the Gordon Natural Area. These sites hold the potential seed source of the disappearing Oak and Hickory. Management policy should be directed to ensure Oak regeneration, which might include the introduction of fire and deer enclosures. Deer browsing is having a serious effect on the understory recruitment in the Gordon Natural Area. Human encroachment should be as limited as possible, which would might include intense management of forest edges where invasive species gain a foothold.

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Deer Browsing

The problems related with deer browse should not be taken lightly. There are ways to curb the effects of deer browse. One such measure is to build large enclosures that keep the deer from interfering with the regeneration of desired species. The Gordon Natural Area has recently built deer enclosures however it is too early to determine their effectiveness. Another measure would be to hold controlled deer hunts in the Gordon Natural Area. This would decrease the density of the deer population allowing for natural growth and regeneration to occur.

Trail Assessment and Use

Trail management is definitely an issue that will need to be discussed in the future. Areas of the trail are overwhelmed by erosion and exposed root systems. Human activity has taken its toll on this natural area. There is a network of unauthorized trails which will also need to be located and collected. This will be done at a more suitable time of year. Future management plans may need to include the re-routing of certain trails where a high rate of erosion is noted. These plans may include the Chester County Parks and Recreation trails specialist (G. Hertel).

The limitation of technology is most certainly an aspect of field work which can not be overlooked. After numerous attempts at collection of reliable data, the information needed was collected using older equipment. Newer is not always better. One can also not take time for granted. The earlier field work is started the easier it is to refine your work in a timely fashion.

Stream Response to Human Disturbance

This portion of the study is limited to initial information gathering. However, this beginning step is crucial to the continuing study of the GNA. With these layers serving as a base for comparison there are many avenues of opportunity to study within the GNA concerning the stream network.

Both human and natural affects of runoff represent one portion of future study. With the runoff points already mapped future researchers will be able to locate these points and address the over all flow of water throughout the GNA. In addition, any possible contamination will be able to be recognized through those flow patterns. These points can also be used to identify flood patterns within the GNA, and how those patterns effect the rest of the forest (Ghersa 2002).

The stream network also acts as a disturbance for the invasion of exotic plant life (Parendes 2000). Through initial observations there was evidence to support the theory that streams are also corridors for invasive plant life to enter a forest. These initial observations along with the conclusions discovered by Parendes and Ghersa (Parendes 2000, Ghersa 2002) lead to a possible study within the GNA in relation stream corridors and the presence of Invasive plant life. There are a number of ways that these basic layers can be used in future studies to better understand what is happening in the GNA, as well as predicting management policies for the GNA.

Invasive Species

Eleven invasive species have been identified within the Gordon Area. It is important to note that areas in the United States that are considered preserved areas, areas that are protected from development are being threatened by invasive species. An on-line source that addressed the threat of invasive species in the Northeast explains on page 1 that, "In most parts of the Northeast, all Site Conservation Plans include invasive species as a primary threat". (Zaremba, 2003) Moreover, Zaremba stated on the same page that, "The US Fish and Wildlife Service identifies non-native species as the second most common threat to species protected under the federal Endangered Species Act." (Zaremba, 2003) Robert Faust wrote an article in 2001 titled *Invasive Species and Areawide Pest Management: What We Have Learned.* Faust refers to the Invasive Species Council on what defines invasive species, "…invasive species as any plant, animal, or organism that is not native to the ecosystem under consideration and whose introduction is likely to cause harm to human health, the environment, or the economy". (P 1) Invasive species has become a world issue.

The introduction of an invasive species into an ecosystem is extremely disruptive. A suggestion on how to control and manage the threat of invasive species is spot-burning. This method is adapted from Jack McGowan-Stinski, Land Steward, The Nature Conservancy, Michigan Chapter.

> Spot-burning means burning individual plants or groups of plants (or a small area) using propane torch or similar device. These torches can also be used to ignite brush piles. Two advantages to spot burning are: 1) the torches can be used in areas where there is little or no fine fuel to carry a prescribed burn; the primary fuel source is propane, and 2) these torches can be used during wet conditions to kill invasives. (P 1)

What is unique about this method is the control over the flame. It seems to be an accurate way of managing the spread of invasive species. The field study was aimed to identify and describe the presence of invasive species within the Gordon Area. Like any preserved area the identification of these invasives is a start to be able to control the spread and presence of them. The natural environment and health of the ecosystem is in danger and hopefully with more research they will no longer be abundant within the Gordon Natural Area. If the goal is to preserve and conserve then this problem needs to be addressed and the initial information provided by this study has purpose to provide a basis for further investigation. In conclusion and ending on a positive note, the Pennsylvania Constitution, Article 1, Section 27 states: "The people have a right to clean air, pure water, and the preservation of the natural scenic, historic, and aesthetic values of the environment". Let us work together to control the invasive species within the Gordon Natural Area.

Works Cited

Forests and Study Area

Braun, E. Lucy. 1972. Deciduous Forests of Eastern North America. Hafner Publishing Company: New York.

Gordon, Robert B. 1941. The natural vegetation of West Goshen Township, Chester County, Pa. Proceedings of the Pennsylvania Academy of Science. 15:194-199

Hertel, Gerald. 2003. An ecological treasure: the Robert B. Gordon Natural Area for Environmental Studies & associated forested area: 121 acres of forest, floodplain, wetland & streams. (unpublished).

Keever, Catherine. 1973. Distribution of major forest species in southeastern Pennsylvania. Ecological Monographs 43 (3): 303-327.

Matlack, Glenn. 1997. Four Centuries of forest clearance and regeneration in the hinterland of a large city. Journal of Biogeography, 24 (1): 281-295.

Matlack, Glenn R. 1997. Land use and forest habitat distribution in the hinterland of a large city. Journal of Biogeography. 24:297-307.

Overlease, William R. 1987. 150 Years of Vegetation Change in Chester County, Pennsylvania. Bartonia 53 (1): 1-12.

Whitney, Gordon G. 1994. From Coastal Wilderness to Fruited Plain: a history of environmental change in temperate North America 1500 to the Present. Cambridge: Cambridge University Press.

great references

Deer Browsing

Alverson, William and D.M. Waller. 1997. The white-tailed deer: a keystone herbivore. Wildlife Society Bulletin. 25(2):217-226.

Arnold, Jacquelyn and Joan M. Welch. 1996. Deer Browse in the Interior Forest of

Warwick County Park. *Middle States Geographer* 29:139-146

ok

Trail Assessment and Use

Bryan, Rorke B. 1977. The Influence of Soil Properties on Degradation of Mountain Hiking Trails at Grovelsjon. *Geografiska Annaler. Series A, Physical Geography.* 59 (½): 49-65.

Hertel, G. West Chester University of Pennsylvania Department of Biology.

Lei, Simon A. 2004. Soil compaction from human trampling, biking and off-road motor vehicle activity in a blackbrush (Coleogyne ramosissima) shrubland. *Western North American Naturalist.* 64 (1): 125-130.

good

Weaver, T., and Dale, D. 1978. Trampling Effects of Hikers, Motorcycles and Horses in Meadows and Forests. *The Journal of Applied Ecology*. 15 (2): 451-457.

Stream Response to Human Disturbance

Ghersa, Claudio M.; de la Fuente, Elba; Suarez, Susan; Leon, Rolando J.C. 2002. *Invasions of Riparian Corridors in Southwestern France by Exotic Plant Species.* Agriculture Ecosystems and Environment Vol. 88 (3): 271-278

Parendes, Laurie A.; Jones, Julia A. 2000. *Role of Light Availability and Dispersal in Exotic Plant Invasion along Roads and Streams in the H. J. Andrews Experimental Forest, Oregon.* Conservation Biology Vol. 14 (1): 64-75

interesting

what about discharge + runoff point sources?

Invasive Species

Baker, Beth. "National Management Plan Maps Strategy for Controlling Invasive Species." Bioscience Feb. 2001: 92

"Chapter 3- Prescribed Fire." Oct. 2004. Online. EBSCO HOST. 19 Oct. 2004.Availablehttp://tncweeds.ucdavis.edu/products/handbook/05.PrescribedFire.doc

Faust, Robert. "Invasive Species and Areawide Pest Management: What We Have Learned." Agricultural Research Nov. 2001: 2.

Lodge, David M. and Kristin Shrader-Frechette. "Nonindigenous Species: Ecological Explanation, Environmental Ethics, and Public Policy." Conservation Biology Feb. 2003: 31-38.

"Recommendations for Invasive Species Programs in the Northeast and Caribbean Division of the Nature Conservancy." Oct. 2004. Online. EBSCO HOST. 19 Oct. 2004. Available http://tncweeds.ucdavis.edu/products/library/neassessment.doc

Schnoor, Jerald L. "Top 10 Stupid Environmental Policies." Environmental Science and Technology July 2004: 239A

Schweiger, Larry J. "A Global Trade Agreement Must Address Invasive Species." National Wildlife Oct/Nov. 2004: 9

"Spot Burning." Oct. 2004. Online. EBSCO HOST. 19 Oct. 2004. Available http://tncweeds.ucdavis.edu/products/handbook/23.Spotburn.doc

good

United States. Department of the Interior. Problem of Invasive Species.
FDHC Congressional Testimony, April 29, 2003.

U.S. National Park Service, U.S. Fish and Wildlife Service. "Plant Invaders of Mid-Atlantic Natural Areas."

"Weed Mapping and Database Development Guidelines for the National Park Service, Intermountain Region (IMR)" Nov. 2001. Online. GOOGLE. 12 Nov. 2004. Available www.science.nature.nps.gov/im/monitor/invasives.htm#Generalguidelines

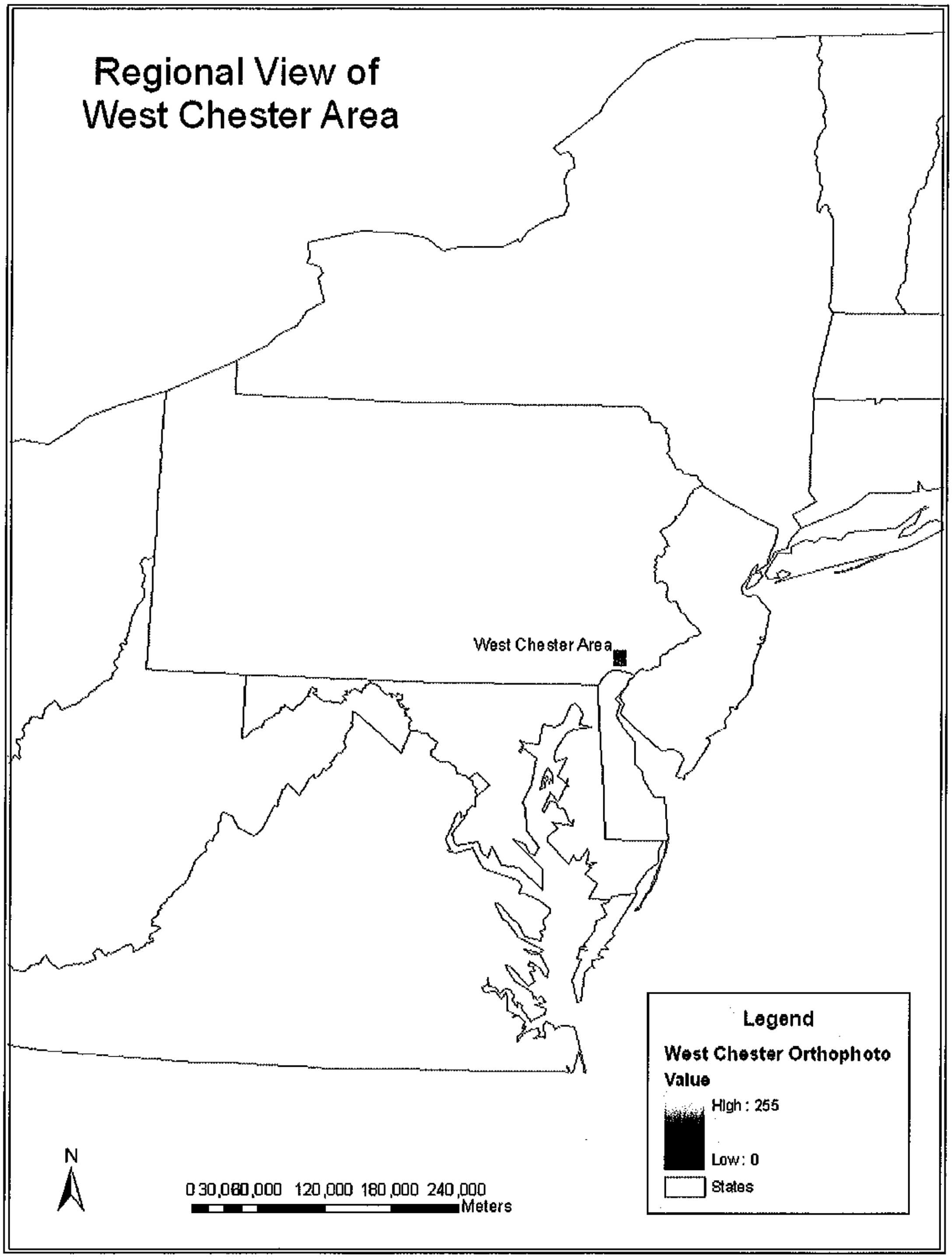
organization: 6/6
grammar: 6/7
analysis/content 5.5/7
Total 17.5/20

A challenging project with many components! This document will serve as a great baseline (& the GIS database, too) for continuing research on the Gordon Natural Area.

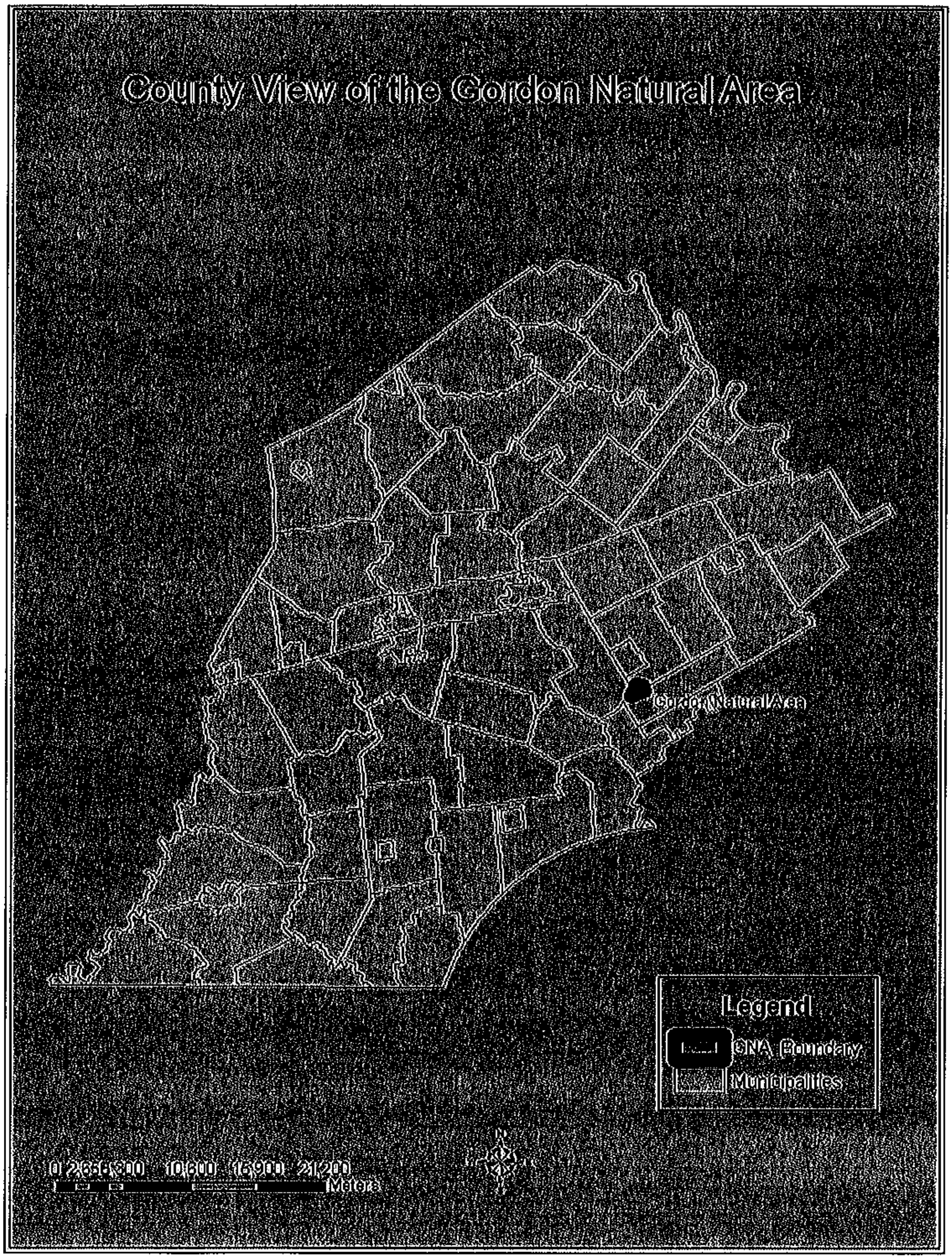
Appendix

Study Area Maps

A.



B.



County View of the Gordon Natural Area
Gordon Natural Area
Legend
GNA Boundary
Municipalities
0 2,650 5,300 10,600 15,900 21,200
Meters
N

C.

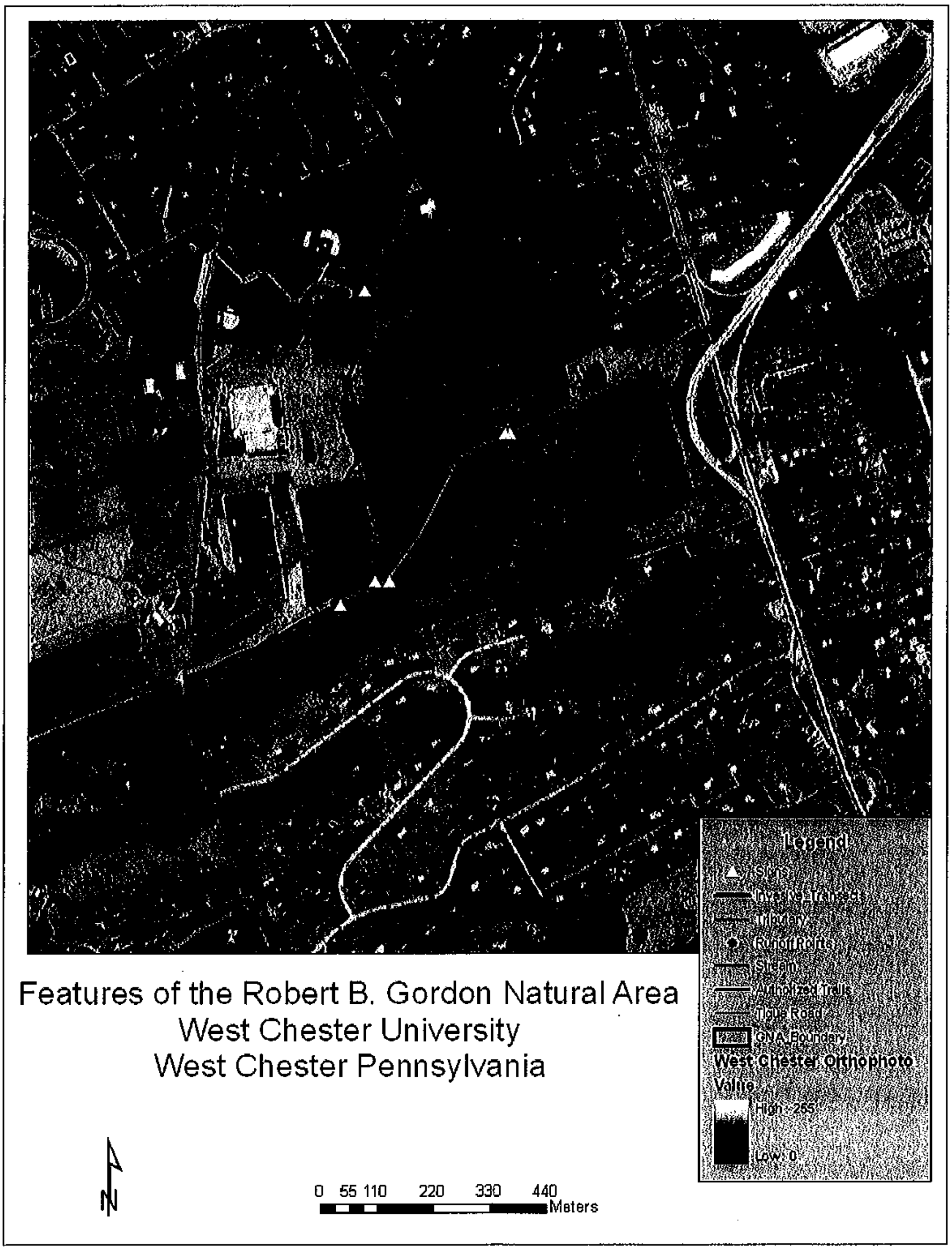

Legend
Signs
Tributary
Stream
GNA_Boundary
West Chester Orthophoto
Value
Low : 0
Features of the Robert B. Gordon Natural Area
West Chester University
West Chester Pennsylvania
N
0 55 110 220 330 440
Meters

Figure 1. Species Frequency by Age Class (n=268)

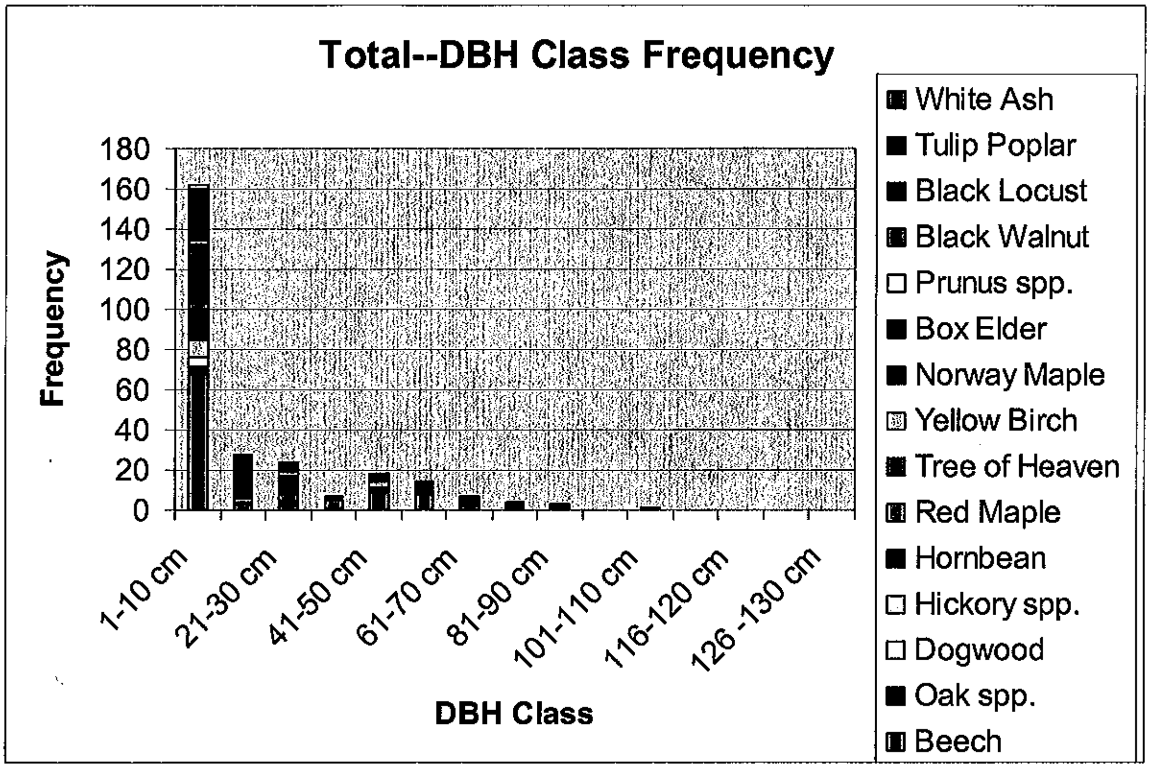


Table 1. Species composition by percent

Species	Count	Percent
Beech	94	35.07%
Tree of Heaven	34	12.69%
Box Elder	29	10.82%
Hornbean	21	7.84%
Hickory spp.	16	5.97%
Oak spp.	15	5.60%
Norway Maple	15	5.60%
Red Maple	11	4.10%
Tulip Poplar	10	3.73%
Prunus spp.	6	2.24%
Black Locust	6	2.24%
Dogwood	5	1.87%
Yellow Birch	2	0.75%
Black Walnut	2	0.75%
White Ash	2	0.75%
	268	100.00%

Table 2a. Transect location within pattern of land-use abandonment on landscape

Transect	Site not intensely modified	1880 Abandoment	1950 Abandonment	1970 to present Abandoment
1	X			
2		X	X	
3	X			X
4			X	X
5			X	
6				X
7	X	X		
8	X			

*Transects were located across land-use class boundaries.

Table 2b. Results of Species Frequency and Diversity Index within Assigned Land-Use Classes

Species	Site not intensely modified	1880 Abandoment	1950 Abandonment	1970 to present Abandoment
Beech	51 (45%)	33 (62%)	18 (23%)	
Black Locust				6 (10%)
Box Elder	1		4	23 (37%)
Dogwood	3	1	1	
Hawthorne	1			
Hickory spp.	8 (7%)	1	4	3
Hornbeam		1	20 (25%)	
Norway Maple	10 (9%)	2	2	
Oak spp.	9 (8%)		5	
Prunus spp.	3		2	
Red Maple	1		8 (10%)	1
Spicebush (shrub)	19 (17%)	9 (8%)	2	
Tree of Heaven			8 (10%)	25 (40%)
Tulip Poplar	1	4	1	3
White Ash	1		1	
Yellow Birch		2		
Witch Hazel	2			
Total Number	113	52	77	61
# of Species	12	8	13	6

Table 3a. Transect Location within Slope Orientation and Topographic Gradient

	North-Facing / Floodplain	North-Facing / Cove	Upland
Transect			
1			**X**
2	**X**		**X**
3			**X**
4		**X**	**X**
5	**X**		
6			**X**
7			**X**
8	**X**		**X**

*Transects crossed topographic class boundaries.

Table 3b. Results of Species Frequency and Diversity Index within Assigned Topographic Classes

	North-Facing / Floodplain	North-Facing / Cove (Low Slope)	Upland
Species			
Beech	33 (41%)		69 (34%)
Black Locust			6
Box Elder	2	3	23 (11%)
Dogwood		2	3
Hawthorne			1
Hickory spp.	1		15 (7%)
Hornbeam	3	15 (60%)	2
Norway Maple	1	2	11
Oak spp.	5	2	8
Prunus spp.	3		3
Red Maple	5	1	5
Spicebush	16 (20%)		14
Tree of Heaven	9		28 (14%)
Tulip Poplar	1	1	7
White Ash	1		1
Yellow Birch			2
Witch Hazel			2
Total	80	25	201
Species Diversity	12	7	17

Table 4a. Transecct Location within Soil Moisture Gradient and Type

	Glenelg / Neshaminy (well to moderately drained — coarse textured) = B	**Glenville** (moderately drained — medium textured) = C	**Wehadkee** (poorly drained — fine textured) = D
Transect			
1	**X**		
2	**X**		**X**
3	**X**		
4	**X**		**X**
5			**X**
6	**X**		
7	**X**		
8	**X**		**X**

*Transect crossed soil series type boundaries.

Table 4b. Results of Species Frequency and Diversity Index within Assigned Soil Classes

	Glenelg / Neshaminy (well to moderately drained — coarse textured) = B	**Glenville** (moderately drained — medium textured) = C	**Wehadkee** (poorly drained — fine textured) = D
Species			
Beech	66 (39%)		36 (26%)
Black Locust	1		5
Box Elder	22 (13%)		6
Dogwood	3		2
Hawthorne	1		
Hickory spp.	11 (7%)		5
Hornbeam			20 (15%)
Norway Maple	10 (6%)		4
Oak spp.	8		7
Prunus spp.	2		3
Red Maple	1		9
Spicebush	14 (8%)		16 (11%)
Tree of Heaven	22 (13%)		11 (8%)
Tulip Poplar	2		7
White Ash	1		1
Yellow Birch			2
Witch Hazel	2		
Total	166		134
Species Diversity	15		15

Table 5. Invasive Species

Name	Multiflora	Wineberry	Bush honey	Oriental_B	Porcelain_	Vine_Honey
Transect 1	0.3	0	0	0	0	0
Transect 2	0.3	0.6	0.6	0	0	0
Transect 3	0.6	0.6	0.6	0.3	0	0
Transect 4	0.6	0	0.1	0.3	0	0.6
Transect 5	0.3	0.6	0.3	0.6	0.1	0.3

	Japanese_S	Norway_Map	Tree_of_He	Japanese_B	Privet	Winged_Ero
Transect 1	0	0.6	0	0	0	0
Transect 2	0	0	0	0	0.6	0.1
Transect 3	0	0	0	0	0.3	0.1
Transect 4	0	0	0	0.3	0	0
Transect 5	0.3	0.1	0.3	0	0	0

Figure 2. Data Sheet for Invasive Species

IDENTIFY INVASIVE SPECIES	ASPECT (N,S,E,W)	CANOPY COVERAGE (x,y,z coordinate)	DISTANCE FROM EDGE (meter)	ORIENTATION FROM EDGE (Meters)	ABUNDANT,MODERATE, RARE	MEASUREMENT OF SPECIES	ESTIMATE % OF COVERAGE	LATITUDE/LONGITUDE (GPS coordinates)	TOPOGRAPHIC CONDITION DESCRIPTION
SHRUB									
Multiflora Rose									
VINE									
Oriental Bittersweet									
HERB									
TREES									
Norway									

DATE:

TRANSECT LOCATION:

Table 1. Results of Species Frequency and Diversity Index within Assigned Land-Use Classes

Species	Site not intensely modified	1880 Abandoment	1950 Abandonment	1970 to present Abandoment
Beech	51 (45%)	33 (62%)	18 (23%)	
Black Locust				6 (10%)
Box Elder	1		4	23 (37%)
Dogwood	3	1	1	
Hawthorne	1			
Hickory spp.	8 (7%)	1	4	3
Hornbeam		1	20 (25%)	
Norway Maple	10 (9%)	2	2	
Oak spp.	9 (8%)		5	
Prunus spp.	3		2	
Red Maple	1		8 (10%)	1
Spicebush (shrub)	19 (17%)	9 (8%)	2	
Tree of Heaven			8 (10%)	25 (40%)
Tulip Poplar	1	4	1	3
White Ash	1		1	
Yellow Birch		2		
Witch Hazel	2			
Total Number	113	52	77	61
Diversity Index (Number of Species)	12	8	13	6

Table 2. Results of Species Frequency and Diversity Index within Assigned Topographic Classes

Species	North-Facing / Floodplain	North-Facing / Cove (Low Slope)	Upland
Beech	33 (41%)		69 (34%)
Black Locust			6
Box Elder	2	3	23 (11%)
Dogwood		2	3
Hawthorne			1
Hickory spp.	1		15 (7%)
Hornbeam	3	15 (60%)	2
Norway Maple	1	2	11
Oak spp.	5	2	8
Prunus spp.	3		3
Red Maple	5	1	5
Spicebush	16 (20%)		14
Tree of Heaven	9		28 (14%)
Tulip Poplar	1	1	7
White Ash	1		1
Yellow Birch			2
Witch Hazel			2
Total	80	25	201
Species Diversity	12	7	17

Table 3. Results of Species Frequency and Diversity Index within Assigned Soil Classes

Species	**Glenelg / Neshaminy** (well to moderately drained —coarse textured) = B	**Glenville** (moderately drained — medium textured) = C	**Wehadkee** (poorly drained — fine textured) = D
Beech	66 (39%)		36 (26%)
Black Locust	1		5
Box Elder	22 (13%)		6
Dogwood	3		2
Hawthorne	1		
Hickory spp.	11 (7%)		5
Hornbeam			20 (15%)
Norway Maple	10 (6%)		4
Oak spp.	8		7
Prunus spp.	2		3
Red Maple	1		9
Spicebush	14 (8%)		16 (11%)
Tree of Heaven	22 (13%)		11 (8%)
Tulip Poplar	2		7
White Ash	1		1
Yellow Birch			2
Witch Hazel	2		
Total	166		134
Species Diversity	15		15