The 'Forests' of Owings Mills:

Past, Present and Future

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Senior Seminar
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Forward

The Environmental Science and Studies (ESS) Senior Seminar class is taken by students who are completing their academic major and getting ready to graduate. The course consists of a semester long project with the objective being for the students to bring the knowledge, skills, and abilities to the project that they have developed through their academic study and use them to address a specific question or problem. This year the class was asked to address a question presented to us by Mr. Don Outen, a Natural Resource Manager with the Baltimore County Department of Environmental Protection and Resource Management (DEPRM). As Baltimore County implemented development in the designated growth area of Owings Mills, it adopted a policy of protecting 100 feet buffers around local streams. Developers left the buffers as they built infrastructure and housing, but no one knew whether the forest protection the County attempted to provide was *working*; forests had been spared development but would these forests be there in the future? This was the focus of the class project.

Understanding the state and the fate of the forest fragments that were protected from development required that the class look at the history of the region, the development and implementation of Smart Growth policies, the importance of forests for stream protection, and general forest function. In addition, the particular stressors that forest fragments face when surrounded by development needed to be addressed. In order to recommend actions that the County might want to implement, the students had to survey the forests in Owings Mills to assess their current state and understand the soils on which the forests grow.

The students have worked independently. I, and in my absence Dr. Kent Barnes, Department of Geography and Environmental Planning, and Dr. Brian Fath, Department of Biological Sciences, provided limited guidance and help as requested. The students deserve the credit for their success.

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I. Introduction

Population growth can be a serious issue in urban areas, thus managing development is an important part of growth management. When planning urban development, the impact of development on stormwater management, wildlife conservation, and pollution must be considered. A Smart Growth planning model can be used to control many of these issues. Smart Growth can be defined as designating the most suitable areas to accommodate urban growth by mixing residential and commercial development, promoting dense development, and minimizing sprawled infrastructure. Since Smart Growth focuses on protecting natural resources, it provides opportunities to preserve forest parcels. Forests are critical for slowing stormwater run-off, since they reduce erosion, create a refuge for wildlife, and filter pollution before it reaches the streams.

In the northern areas of Baltimore County, some of the land is much the same as it was thirty years ago whereas other areas, such as Owings Mills, have changed dramatically. Northern Baltimore County remains primarily agricultural with sparse residential developments. Development in Northern Baltimore County has been carefully controlled. On Interstate 83 near Shawan Road, a contrast in landscape is readily apparent. To the West, the land is composed of forests and farms, while to the East lay densely developed business parks. This abrupt change in land use is a result of the County's zoning policies, and in particular the Urban-Rural Demarcation Line (URDL). This line was intended to restrict growth into a designated area.

As the population of the County grew throughout the 1950s and 1960s, demand for residential development skyrocketed. There was a clear need for preserving open space and agriculture. In order to keep some parts of the County agricultural, the area north of the URDL was zoned for land preservation and agriculture. Locations south of the URDL were set aside for commercial and high-density residential development. The County would provide infrastructural support, such as water and sewer, strictly for the development zone within the URDL.

Owings Mills is designated as a growth area of Baltimore County. Owings Mills has highly concentrated commercial and residential development as the result of a regulated, planned, and monitored process controlled by Baltimore County. Although dense development is more environmentally sound than sprawl, there are still environmental impacts.

Owings Mills is a high density development that is located near dense and interconnected forested areas. Planners working on the development of Owings Mills decided to practice Smart Growth in Owings Mills. A 100 foot forested stream buffer was implemented restricting development to areas outside the buffer. As a result, the landscape of Owings Mills is very different than that of other urban areas. In Owings Mills we see the occurrence of forest stands, directly next to dense development and housing.

Our study examines the forest parcels to determine if they are functioning properly as forest by providing an adequate buffer to protect the streams. Our findings and recommendations are based on detailed research on forests: what a forest consists of, why forests are important in developed areas, and local threats to the forests. To have a better understanding of how the planners created the ideas for the development of New Town in Owings Mills we needed to learn more about Smart Growth and urban sprawl, the policies associated with development, forests, and Smart Growth, and the economic benefits of building a high density development. The final section of our study focused on four specific forest parcels in Owings Mills. This status report provides details on how the sites were selected, characteristics of the sites (specifically focusing on vegetation and soils), sampling protocols that were used, results of the sampling, and what the data means.

While ecological research verifies that buffers help remove pollutants, there are many additional factors of buffer health and function that must be taken into consideration when assessing the effectiveness of riparian buffer forests. One major consideration is whether or not the forest will remain a healthy and functioning forest that will be able to regenerate. Smart Growth development and riparian buffer protection, in theory, is a good idea, but Baltimore County is now asking about the state of forest fragments that they so carefully protected in Owings Mills. By examining forest composition and soil structure, we attempt to uncover the effectiveness and ultimate sustainability of the forest parcels.

II. Forests of the Owings Mills Area

Forests comprise numerous biomes through out the globe and are composed of different types of physical and biological components. The forests of Owings Mills are deciduous forests of the Piedmont area and the typical characteristics and stressors of these forests will be elaborated upon. Of particular interest to the Owings Mills area are riparian buffers, since the forested buffers are intended to protect the streams they surround.

II. A. Values of Riparian Buffers

Riparian forest buffers are loosely defined as forested areas bordering a body of water or wetland, that are important for removing pollutants from runoff or groundwater (Polyakov et al., 2005). Most scientists agree that the necessary size and width of buffer zones are dependent on the location and characteristics, such as local hydrology, adjacent land use, vegetation type, local geology, and the slope of stream bank of individual streams (Naiman et al., 1997; Polyakov et al., 2005). Riparian buffers provide important functions for maintaining the overall health of the streams or waterways including filtering nutrient and sediment pollution, preventing stream bank erosion, providing habitat for wildlife, controlling local climate and water temperature, and helping to control seasonal flooding (Naiman et al., 1997).

Nutrient pollution, primarily in the form of nitrogen and phosphorus, can have very damaging effects on the health of a stream. Excess nutrients can promote algal blooms and eutrophication. The algal blooms decrease the clarity of the water subsequently preventing sunlight from reaching underwater plant species (Horton, 2003). When the algae complete their life cycle and die, they sink to the bottom, where bacteria consume them (Horton, 2003). Decomposition by bacteria results in decreased dissolved oxygen available to fish, microbial, and macro-invertebrate species within the stream (Horton, 2003). Serious cases of eutrophication can lead to the formation of dead zones, where all the dissolved oxygen in the water is used up, leading to the death of most aquatic species in the area (Horton, 2003).

A stream with a riparian buffer zone is able to maintain more natural inputs of nitrogen and phosphorous within the stream (Polyakov et al., 2005). Most nitrogen enters a riparian zone in the form of nitrate (Polyakov et al., 2005). Riparian zones remove nitrate in two ways: 1) riparian zone vegetation can absorb nitrate directly for its own growth or 2) denitrifying bacteria in the soil use nitrate as an energy source in environments that lack oxygen through a process known as denitrification (Naiman et al., 1997). Denitrification is a reaction that converts nitrate to nitrogen gas and occurs almost exclusively in water-saturated zones where abundant organic matter is present (Naiman et al., 1997). These processes are especially important when large quantities of unwanted nitrogen run-off of agricultural fields or highly fertilized lawns. In the case of phosphorous, the riparian vegetation sequesters the nutrient in their roots or vascular tissue, ultimately controlling its entrance into the stream water (Naiman et al., 1997).

Trapping sediment and controlling erosion are other important functions of riparian forest buffers. Various factors including buffer width, vegetation type, stream bank slope, and sediment particle size affect the efficiency of sediment trapping (Polyakov et al., 2005). Healthy riparian zones are densely populated with vegetation and have an intricate root system that helps to stabilize the stream bank and prevent erosion (Polyakov et al., 2005). In addition, the woody stems and grasses help to physically trap sediment by slowing down the water runoff from the surrounding area, allowing the sediment to settle out (Naiman et al., 1997). Woody debris within the stream channel can help trap sediments by preventing them from being carried further downstream (Naiman et al., 1997). A stream with these riparian characteristics will tend to be deeper and narrower because the banks are stable and sediment is not filling the stream bottom (Naiman et al., 1997).

Streams, whose riparian zones have been cleared, erode easily as a result of the weakened vegetation and root systems by the stream and usually are characterized by wide, shallow streams (Polyakov et al., 2005; Naiman et al.,1997). The weakened buffer zones are incapable of trapping sediments and do not hold the stream banks together (Naiman et al., 1997). The lack of vegetation for shade cover and the shallower stream leads to a dramatic increase in water temperature that results in inhospitable streams for many fish species (Naiman et al., 1997). Increased sediment in the stream water also clogs fishes' gills, covers their food on the stream floor, buries their eggs, and clouds the water, depriving the aquatic plants of light and interrupting photosynthesis (Naiman et al., 1997). As larger pebbles from eroded sediments settle to the stream bottom, the finer sediments are carried downstream where they can build up and create similar problems in fish habitats further downstream (Naiman et al., 1997). Clay particles are often bound to pollutants thus adding an additional environmental burden associated with sedimentation (Polyakov et al., 2005).

Riparian forests provide food and habitat for all trophic levels of the food web, from microbes to top consumers (Naiman et al., 1997). Species richness is generally high in riparian forests, as they provide shelter from predation and access to drinking water (Naiman et al., 1997). Leaf litter that falls into the stream provides food for microbes, such as bacteria and invertebrate larvae, as well as necessary nutrients for biological processes (Naiman et al., 1997). Some macro-invertebrates will also feed on this leaf litter, and these organisms serve as food for fish and other aquatic organisms. A riparian zone also provides many species with shelter. The strong root systems allow for overhangs along the banks for fish take shelter (Naiman et al., 1997). Woody debris serves a similar role, by providing habitat for a variety of species, both inside and out, of the stream (Naiman et al., 1997). Studies have shown that the number and variety of small mammals and birds is greatly increased in areas where debris is available for shelter and perching (Naiman et al., 1997). Decaying woody debris provides a nutrient-rich microenvironment for plant seedlings, offering protection from erosion, drought, and predation by herbivores (Naiman et al., 1997).

Riparian forest buffers play a critical role in maintaining natural riparian climate conditions along streams (Brosofske et al., 1997). The presence, or absence, of a riparian forest can affect the temperatures of the water, soil, and surface air, as well as the relative humidity of the immediate area (Brosofske et al., 1997). Maintaining stable water temperature is especially important for many fish and invertebrate species (Brosofske et al., 1997). Slight fluctuations in water temperature can have drastic effects on the health of these species, particularly species that require cooler temperatures such as trout (Brosofske et al., 1997). Research has shown that soil temperature has a direct effect on water temperature, that is, an inadequate buffer with warmer soil can lead to an increase in water temperature (Brosofske et al., 1997).

Finally, riparian forests weaken the effects of seasonal floods. Riparian buffers slow down run-off that enters the stream, decrease the flow velocity of the stream, and absorb excess water through their root systems (Naiman et al., 1997). Although floods are necessary for the diversity of life in the flood plain and riparian zone, a stream with a healthy riparian zone helps control flooding, keeping it at moderate levels which helps to stimulate growth (Polyakov et al., 2005).

II. B. Determinants of species composition in forests

II. B. 1. The Vertical Organization of Forests

Forests are arranged vertically, from the bedrock up through the canopy (Smith and Smith, 2001). At the lowest level, deep under ground, is the underlying bedrock which is important in the formation of the soil type (USDA NRCS, 1993). The parent material, the bedrock, is broken down into smaller fragments by natural processes and result in changes to the composition, nutrient content, and organic material (Smith and Smith, 2001). The existing rock type gives the particles their chemical composition, which could yield different vegetation depending on the composition (USDA NRCS, 1993). For example, rocks are made up of minerals, which have a definite chemical structure. If these minerals are made up of metals or other nonessential elements, the weathered parent rock, or soil, will have little beneficial value to vegetation (USDA NRCS, 1993). On the other hand, if the minerals contain minor nutrients such as calcium, the soil may be very beneficial to certain vegetation types. Decaying organic material lies on the surface and mixes with the soil, eventually becoming its organic component (Smith and Smith, 2001).

At the surface of the soil one finds the herbaceous layer consisting of plants such as mosses, ferns, and small plants (Smith and Smith, 2001). The shrub layer, made up mostly of small woody plants, grows above the herbaceous layer (Smith and Smith, 2001). Depending upon the nature of the location, native shrubs such as Mountain Laurel (*Kalmia latifolia)* or Spicebush (*Lindera benzoin)* may be found (Smith and Smith, 2001). Invasive species such as Multiflora Rose (*Rosa multiflora)* and Japanese Barberry (*Berberis thunburgii)* are components of the shrub layer in many Maryland forests (Smith and Smith, 2001).

The understory layer consists of small trees which grow between the shrubs and the canopy. Some common tree species of the understory layer in Maryland include Flowering Dogwood (*Cornus florida)* and Sassafras *(Sassafras albidum)*. Some common plants of the canopy layer in Maryland piedmont forests include Oak (*Quercus)* species, Hickory (*Carya)* species, Ash (*Fraxinus*) species, Maple (*Acer*) species, and Tulip Poplar (*Liriodendron tulipfera)* (Smith and Smith, 2001). The plants composing the canopy layer are generally shade intolerant, with the exception of some species such as Red Maple (*Acer rubrum)* (Smith and Smith, 2001).

In many cases, seedlings and saplings of the canopy species lay relatively dormant until a larger canopy tree falls and creates a light gap (Smith and Smith, 2001). When a gap is created, seedlings and saplings often grow rapidly and compete with each other to reach the light-abundant canopy (Smith and Smith, 2001).

II. B. 2. Spatial Distribution of Tree Species

As a source of nutrients, water, oxygen, heat, and mechanical support for vegetation, soil plays a significant role for terrestrial ecosystems (O'Neill and Amacher, 2003). Soil is the loose material which consists of weathered local rock along with some alluvium, which is sediment that arrives through fluvial transport by streams (USDA NRCS, 1995).

A combination of factors influence the tree species found in a particular area including soil particle size, soil depth, the water holding capacity, pH, and the levels of other soil components such as salt, calcium, and heavy metals. Soil characteristics may determine which trees are likely to be found together (USDA Plants, 2007). The relationship between soil characteristics and the presence of a particular tree species is highly complex, and can not be used as a sole predictor of species presence, but given a type of soil characteristics can be used as a rough guide of possible species in an area (USDA Plants, 2007).

Depending plant roots ability to gain access to nutrients and water, certain types of trees prefer soil particles of different sizes (USDA Plants, 2007). Some species of trees are adapted to a broad spectrum of soil particle sizes, ranging from fine to course, including White Ash (*Fraxinus Americana)* and Red Maple (*Acer rubrum)* (USDA Plants, 2007). Sycamore (*Platanus occidentalis),* Tulip Poplar, and White Oak (*Quercus alba)* grow best in medium to coarse soils (USDA Plants, 2007).

Drainage is one of the most important factors for vegetation growth in Maryland. Soils that drain water too quickly, such as those in areas of karst limestone topography, will leave the soils very dry and droughty (USDA NRCS, 1993). On the other hand, in soils that drain water slowly, even a light rain may cause the soil to become saturated and become too wet for some vegetation types (USDA NRCS, 1993). Land in lower elevations may be readily inundated, forming intermittent, or other types, of streams and floodplains, which can greatly affect the soil and plant species that are found. Species such as Skunk Cabbage (*Symplocarpus foetidus)* and

Jewelweed (*Impatiens bidens)* are likely to be found in the wettest areas that are not continually submerged (USDA NRCS, 1993).

The soil characteristics and species composition change within a forest as the distance from water and elevation increases (USDA Plants, 2007). Sycamores require soil with higher moisture content and are more likely to be found in more lowland areas and in closer proximity to water (USDA Plants, 2007). In contrast, White Oaks are much more tolerant of low moisture and drought and would likely be found in more upland environments (USDA Plants, 2007). Red Maples prefer soils that are higher in moisture content (USDA Plants, 2007).

The chemical structure of the soils, such as the amounts of sodium chloride and calcium carbonate present, can be predictors of species found in an area. Salinity is a chemical property that affects vegetation. Sodium chloride (NaCl) salts in soil generally dehydrate vegetation (Kotuby-Amacher et al., 1997). Most freshwater and inland vegetation prefer little or no salt in soils and can usually not tolerate high levels (Kotuby-Amacher et al., 1997). Soils rich in calcium carbonate, species with a higher tolerance for calcium carbonate ($CaCO_3$), will most likely out-compete those with a lower tolerance. Trees such as Black Gum (*Nyssa sylvatica*) and Sycamore are intolerant of calcium carbonate in contrast to species such as Pignut Hickory (*Carya glabra*) and Black Cherry *(Prunus serotina)*, which can tolerate higher concentrations (USDA Plants, 2007).

Nutrient availability is another factor controlling which species are found in a particular area. Tulip Poplar requires soils with significantly higher nutrient levels than White Oak (USDA Plants, 2007). White Oak would most likely dominate upland environments where nutrients are scarcer, while Tulip Poplars would more likely be found in lowland regions (USDA Plants, 2007).

Soil pH is an important characteristic that can predict the type of trees found in an area. For example, the Mockernut Hickory *(Carya tomentosa)* and Red Maple prefer neutral soils with a pH ranging from 6.5 to 7.4 while Black Cherry prefers more acidic soils with a pH range of 4.5 to 5.5; thus the two would not be likely to be found together (USDA Plants, 2007).

In general, plants preferring fine to medium particle size, high moisture and high nutrients content, such as Sycamore and Tulip Poplar, will occupy more lowland areas while plants which prefer medium to course particle size and can tolerate low moisture and nutrients, such as White Oak and Mountain Laurel, will be found in higher elevations (USDA Plants, 2007). Also, if the soil is more acidic and drier, Oak species, Shagbark Hickory (*Carya ovata),* and Mountain Laurel may dominate (USDA, 2007).

II. C. The Stressors of Maryland Forests

A forest stressor is any natural or anthropogenic induced event, or phenomenon, that negatively affects the components of a forest (MDNR, no date). Maryland's forests most significant stressors are changes in land use, forest fragmentation as a result of development, native and introduced insects and plants, and diseases (Alban et al., 1995). Other stressors include deer browsing, forest fires, air pollution, acidic deposition in soils, and abnormal or extreme weather events (Alban et al., 1995). Forest stressors may be categorized into three groups: 1) predisposing stressors, 2) triggering stressors, and 3) mortal stressors (Goudie, 2006).

Predisposing stressors are generally those that cause great damage over long periods of time and result from anthropogenic activities (Goudie, 2006). They pre-dispose the forest to become more susceptible to the negative effects of triggering stressors. Some predisposing stressors may cause more immediate negative effects (Goudie, 2006). Predisposing stressors resulting in less immediate impacts on forests are acid rain, nitrogen deposition, salt runoff, ground-level ozone, non-point source pollution, and heavy metal pollution. Predisposing factors that are generally more immediate in their effects include clear cutting, logging, and forest fragmentation. In addition, predisposing stressors interfere with a tree's ability to naturally recover from mortal stressors including pathogenic fungi on roots and stems as well as insect pests (Goudie, 2006).

Triggering stressors are both the result of human activity and natural occurrences, such as fires, drought, frost, short-term pollution events, storms, and invasive species. Mortal stressors are those that cause death to vegetation either immediately, or within a short period of time (Goudie, 2006).

II. C. 1. Acid Rain and pH

Acid rain is a stressor in Maryland because it contributes to the excessive load of nitrogen that is released into the soils of Maryland forests. Acid deposition refers to other types of precipitation, which tend to be more acidic than acid rain such as snow and fog (Eubanks et al., 2006). Prevailing winds carry the acidic gases released into the atmosphere from the Mid-western regions of the United States to the Northeastern regions of the country (Eubanks et al., 2006). As precipitation occurs in these Northeastern areas, the transported acidic gases, as well as gases released within the Northeastern area, are responsible for acid rain and acid deposition.

Acid rain may impair the survival of Maryland forest vegetation in many ways because it can cause serious problems for vegetation with restricted soil pH tolerance or that require specific soil conditions. Soil changes are induced as acid rain leaches calcium and magnesium from soil, creating more acidic conditions. This is unhealthy for trees because basic elements such as calcium and magnesium are necessary nutrients for proper tree growth. Both calcium (Ca) and magnesium (Mg) can act as soil buffers but their loss can result in acidification of the soil and water of the area (Boyer et al., 2003). Acid rain also harms aquatic organisms in forest streams (Pheiffer, 2007).

Two common tree species in the Owings Mills area are White Oak and Red Maple (Johnson, 1999). White Oaks grow, reproduce, and thrive in a soil having a pH of 6.5-7.5 while Red Maples thrive best in soils that have a pH of 4.5-7.5 (Johnson, 1999). Acid rainfall may alter the soil pH out of the optimum pH range which allows normal and healthy tree growth.

Since the Piedmont region in Maryland consists of granite, gneiss, and quartzite-based soils, some of the vegetation in Maryland may be highly affected by acid rain (DNR, 2007). According to the Baltimore Ecosystem Study, tree growth is highly dependent on the type of bedrock in a specific locality (2007). Tulip Poplars and Red Maples are the dominant trees on schists and gneisses, which are the major rock types in our areas of study in Owings Mills (Baltimore Ecosystem Study, 2007). Tulip Poplars can tolerate a pH level of 4.5 to 7.5. When interactions of acid rain and the components of the soil allow pH to be lower than 4.5, plants can be injured (USDA, 2007). In order for Red Maples to grow healthily, pH must be slightly lower than 7 (Slaughnessy, 2007).

II. C. 2. Sodium Chloride Salts

Salt, which takes the form of sodium chloride, is another predisposing stressor that has the ability to affect vegetation in Maryland. Salt is placed onto roadway surfaces to melt snow and ice. Excess salt runs off into streams and storm-water retention ponds and can eventually infiltrate groundwater. Salinity of fresh water has salinity less than 0.5% and seawater has salinity of about 3.5 % (Garrison, 2004). Increased exposure to salt can have a dehydrating effect on plants (TRB, no date). Salt disrupts normal vegetation growth, damages foliage, limbs, and roots, prevents plants from flourishing, and may lead to death (TRB, no date). American Linden (*Tilia americana*), Black Walnut (*Juglans nigra*), Sugar Maple (*Acer saccharum*), and Red Maple are Maryland trees that are most susceptible to damage by salt (TRB, no date).

Chloride ions cause more harm to vegetation than sodium ions. Chloride is absorbed through the roots of vegetation. After reaching plant tissues, chloride remains present for a significant amount of time (TRB, no date). As a result of excess chloride in plant tissue, osmotic stress may be induced which leads to vegetation dehydration. Maryland trees that are affected the most by salt are American Linden, Black Walnut, Sugar Maple, and Red Maple (TRB, no date). Trees with a higher tolerance of salt are Oaks, Birch, White Ash, Scotch Broom (*Cytisus scoparius)*, and Jack Pine (*Pinus banksiana)* (TRB, no date).

II. C. 3. Ground Level Ozone

Ground-level ozone is another predisposing stressor that can impact Maryland's forests. Ground-level ozone is created when nitrogen oxides and volatile organic compounds react with sunlight (Boyer et al., 2003). This reaction occurs at high temperatures and results in the formation of ozone (Boyer et al., 2003). Though there is no empirical data for our study area that can suggest this, positive correlations have been made from Maryland tree assessments that suggest that ozone may damage and harm Maryland trees (Bernabo et al., 1986). Empirical data in other areas suggest that a correlation exists between ground level ozone and the harmful physiological changes that plants undergo as a response (Boyer et al., 2003). Significant amounts of ozone may result in foliar stripling, necrotic spotting, and premature loss of foliage (Boyer et al., 2003).

II. C. 4. Non-point Source Pollution and Heavy Metals

Non-point source pollution (NPS) is pollution from a number of different sources, that can not necessarily be pin-pointed, such as runoff from impervious surfaces, yards, and roof tops (EPA, 2006). Urban NPS pollution, especially nutrient pollution in the form of nitrogen, phosphorous, and heavy metals, is a predisposing stressor that can seriously impact the trees and landscape in Maryland. Excessive nutrients are harmful to streams (Polyakov et al, 2005). A stream with a functioning riparian buffer is able to maintain more natural inputs of nitrogen and phosphorous within the stream (Polyakov et al, 2005).

Trace metals, such as zinc (Zn), copper (Cu), lead (Pb), chromium (Cr), and nickel (Ni) are absorbed by plant roots and are stored in plant tissues (Sebastiani, 2004). These elements interfere with a plant's ability to photosynthesize at varying degrees of severity for different plants. In addition, heavy metals negatively alter soil microbial activity and fertility (Sebastiani, 2004). Most of these metals come from tire wear on road- ways and roof runoff and enter a forest system during a rainfall (NSPS, 2003). The typical concentrations of some trace metals in soils are as follows: zinc at 108ppm, lead at 37ppm, copper at 19ppm, chromium at 45ppm, and nickel at 26ppm (USDA NRSC, 2007). By sheer volume, zinc alone can be considered one of the most influential pollutants in Maryland (see Figure IV 8 in section IV below).

II. C. 5. Forest Fragmentation and Edge Effects

A predisposing anthropological stressor that presents a large threat to Maryland forests is fragmentation. Much of the Eastern temperate forest region, and nearly all of the Baltimore County area, is second or third-growth forest as a result of clear cutting forests for timber, agriculture, or development (Gurevitch et al., 2002). It takes an estimated 200 to 500 years for a forest to fully recover from a clear-cutting disturbance (Smith and Smith, 2001). When forests are cleared, isolated fragments remain. Fragmentation leads to decreased species richness and forests that are functionally different than contiguous forests (Armstrong, 2004).

Construction equipment disturbs the soil, often destroying the nutrient rich topsoil that provides habitat for earthworms and fungi (Raines, 2007). These organisms condition the soil and make it possible for future forests to grow (Raines, 2007). Urbanization around fragmented areas may contribute to the stress that is endured by forest vegetation in many ways. Impervious surface runoff causes erosion and carries pollutants such as nutrients and heavy metals (Science Daily, 2007).

Forest edges are another potential impact of fragmentation. A forest edge is an area where two separate types of landscapes intersect, such as between forest and meadow, forest and stream, or forest and a backyard. (OLC, 1996). It is common to see intersection of forest and private property in new growth forests, forest fragments, parcels, and urban forests, like in Owings Mills. There are two types of forest edges, inherent and induced, which are defined by how the edges were created (OLC, 1996). An inherent forest edge is created by natural conditions and the evolution of plant communities, whereas an induced forest edge is created by human interactions like development, logging, planting crops, and grazing livestock (Patton, 1992). In each case, an intersection of two landscapes produces an area that is different from the original landscape, which in turn has a series of effects on the surrounding environment (Patton, 1992). These effects are known as edge effects, and they can have both positive and negative effects on the long-term characteristics of both habitats and sustainability of both habitats (OLC, 1996).

Negative edge effects, resulting from clear-cutting have many impacts on Maryland forests. Interior forest habitats have been estimated to take hundreds of years to regenerate into a mature, interior type forest (Raines, 2007). As these interior habitats are destroyed, animals may be unable to move across forest edges as a result of the extreme temperatures and humidity (OLC, 1996). These same induced edges do not provide enough protection against wind for the surrounding trees. During periods of high wind, trees can be blown down like a domino effect (Little, 1995). Edge effects that result in future tree deaths are known as residual tree death (Little, 1995). Current research estimates predict that for every twenty-five acres of clear-cut forest, another sixty acres of forest will die from residual tree death (Little, 1995).

With fragmentation and loss of riparian buffers, erosion becomes a triggering factor that have devastating effects on both stream and forest health (USDA, 2007). Erosion is a huge problem in all of our sites in Owings Mills, and may occur as a result of fragmentation. Erosion affects soil depth and composition and the ultimate water-holding capacity, fertility, and productivity of the vegetation (McQuarrie, 2007). Though erosion is a naturally occurring process, it is intensified by human activities such as construction and runoff from impervious surfaces (Science Daily, 2007). Erosion leads to sedimentation in streams, which blocks sunlight and hinders oxygen flow, both detrimental conditions for aquatic organisms (Butler, 2007).

As a result of fragmentation and loss of native predators, increased deer populations and their browsing have had detrimental effects on the forests (Patton, 1992). Deer prevent forests from regenerating themselves, because they can eliminate seedlings and saplings in an area (MDNR, no date). Their daily consumption of leaves, buds, and twigs contributes to defoliation and the destruction of the shrub and seedling strata (Liang and Seagle, 2002).

II. C. 6. Invasive Species

Invasive species are a significant threat to forest longevity and the ecological services they provide (MISC, 2003). General effects of invasive species vary from minor ecosystem disruption to complete disruption of natural food webs, plant and animal life, and interference with both biological and abiotic ecosystem cycles (MISC, 2003). One effect of invasive plants of particular interest to our project, is the ability for invasive understory, such as Japanese stiltgrass (*Microstegium vimineum*), to interfere with forest succession. A severe case of invasive understory can potentially bring normal forest succession to a halt by reducing or eliminating any new or potential trees from reaching mature height (MISC, 2003).

Some exotic species that have been introduced to Maryland may be categorized as triggering stressors. There have been many species that have been introduced into Maryland forests including Multiflora rose (*Rosa multiflora*), Mile-a-minute (*Persicaria perfoliata*), Bittersweet (*Celastrus orbiculatus*), and Japanese stiltgrass. These plants have the potential to out-compete native species (Smith and Smith, 2001).

Stiltgrass invasion inhibits native plant growth in many ways since it is highly adaptive and can tolerate a wide range of light availability, making it a difficult pest to eradicate (Swearingen and Adams, 2007). It can also leave thick covers of die-back every season that decompose slowly, dropping the soil pH and leads to higher rates of nitrification (Ehrenfeld et al., 2001).

Gypsy moths (*Lymantria dispar*) are another introduced species that are a triggering stressor in Maryland. Gypsy moths are a huge problem in Maryland forests. Gypsy moth larvae have defoliated trees, mostly Oaks, throughout the Eastern forest states (Leibhold, 2003). When larvae density is high, complete defoliation of forests can occur which can kill trees (Leibhold, 2003). Efforts to eradicate this species have been extensive and include spraying infested forests with pesticides and the introduction of numerous insect parasitoids from Eurasia (Leibhold, 2003).

Invasive organisms' especially novel pathogens can be categorized as mortal stressors (Goudie, 2006). Sudden Oak Death (*Phytophthora ramorum*) is a recent problem in U.S. forests and may be a consequence of a newly introduced organism (Cooke, 2007). Multiple strains of this pathogen are present but they all produce similar symptoms for Oaks. The pathogen was originally introduced from the western coast of the United States. This fungal pathogen is well adapted to Oak and various Maple species in Maryland. Upon infection, trees begin to "bleed" from the trunk and their crowns begin to die back leading to a rapid death of the entire tree (MISC, 2007). These pathogens may, or may not, be present in our sites in Owings Mills.

Chestnut Blight (*Cryphonectria parasitica)* is a fungal pathogen that parasitizes the American Chestnut (*Castanea dentata*). Though Chestnut Blight is a stressor in Maryland, it is not a stressor in our sites since American Chestnuts are not present in our sites. Chestnut Blight was accidentally introduced into Maryland in the late nineteenth century and destroyed the local populations in the State (Anagnostakis, 2000). Spread by insects, mammals, and birds that come in contact with it, the fungus affects the tree's cambium, the layer under the bark responsible for yearly growth, eventually taking over the entire cambium and killing the tree or branch (Anagnostakis, 2000). While the above-ground part of the tree dies, the roots continue to live and will re-sprout, though trees rarely reach maturity (Anagnostakis 2000). The Chestnut was a fairly dominant tree in Maryland forests, but the effects of "Chestnut Blight" have nearly eliminated the trees from Maryland forests and Oak species have replaced them (Gurevitch et al., 2002).

Forest stressors can be caused by anthropogenic or natural causes and can have greater effects on weakened forest systems. The forest fragments in Owings Mills may be more susceptible to certain factors because of their fragmentation.

III. Creating and Fostering Communities that Preserve Forests

Anthropogenic effects of development can be devastating for forests, thus Baltimore County has attempted to minimize these effects by curbing sprawl and promoting Smart Growth development. Smart Growth has many environmental and economic benefits for the Baltimore County area.

III. A. Impacts of Urban Sprawl

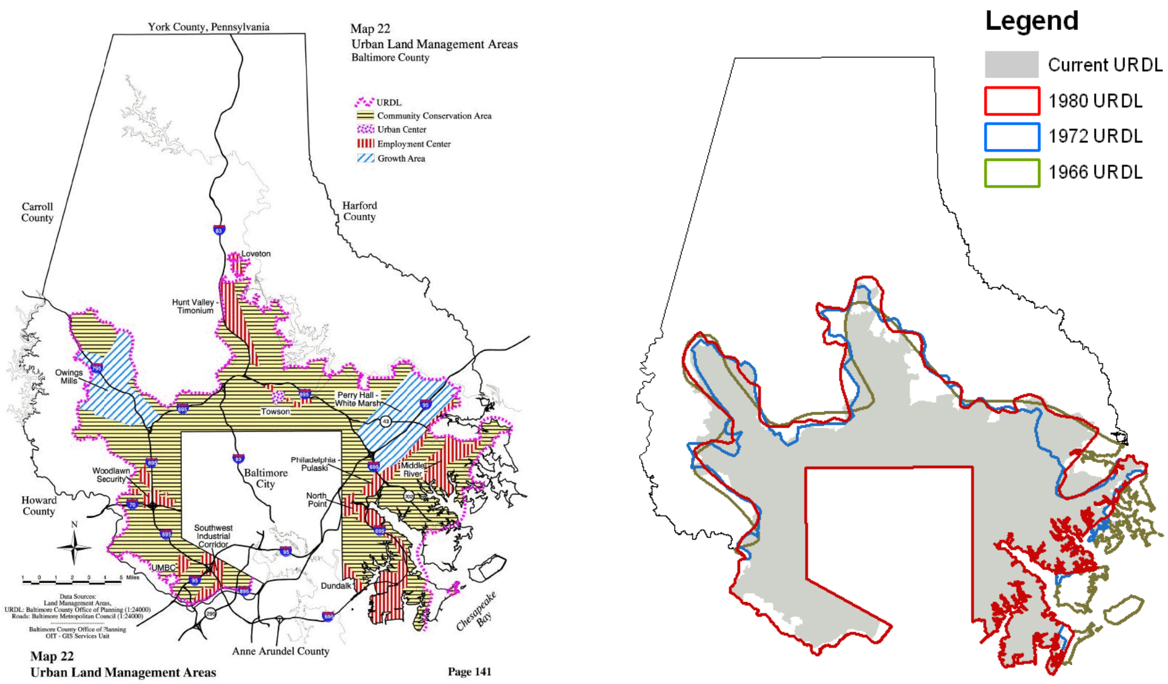
Since the beginning of the 1970's, urban sprawl has destroyed agricultural lands, natural habitats, and recreational areas and has become a critical issue for developed countries (Berlin, 2002). The term sprawl generally refers to development that decreases population density and increases vehicle use (Berlin, 2002). Sprawl can be considered as random development that is characterized by little forethought or consideration of the benefits of connecting components of a community such as housing, employment, schools, and hospitals (Schmidt, 1998). The full impact of sprawl can be understood with the consideration of several factors such as leapfrog development, commercial strip development, single-use development, poor accessibility and automobile dependency, fragmented open space between scattered developments, lack of functional open space, high edge contrast, lack of nearby conveniences, and an increase of expenditures on infrastructure (Berlin, 2002).

Housing characteristics, land-use patterns, transportation choices, and poorly executed or ignored architectural or urban-design decisions, cause ecosystems to fail and communities to collapse (Schmidt, 1998). The negative health impacts associated with sprawl are also of growing concern. These impacts, which are exacerbated by automobile dependence, include poor air quality and its impact on respiratory health, as well as limited physical activity from driving to work, home, school, and shopping which can lead to obesity (Jackson and Kochtitzky, 2001). Sprawl also has deleterious effect on both human and non-humans; it destroys natural habitats and increases costs associated with building new infrastructures (Berlin, 2002).

Destroying natural habitats poses a threat to biodiversity and increases the risk of flooding, causing a demand for more money to be spent on infrastructure such as dams, dikes, and bridges to ensure public safety and accessibility, which in turn, leads to greater losses of natural habitat (Berlin, 2002). In fact, natural habitats and agricultural lands in the U.S. are being converted to sprawl development at a rate faster than the growth of the population (Mookherjee *et al*., 2006). This suggests that more government expenditures are used for building, maintaining, and providing new infrastructures and services to these areas, increasing the burdens put on taxpayers to generate tax revenues (Berlin, 2002). While initially infrastructure costs are not that significant, they are increasingly burdensome on the public as population size starts increasing (Mookherjee *et al*., 2006).

Baltimore County's population underwent a 129% increase from the years 1950 to 1970 (PPFI, 1998). Out of concern for the potential impacts of this increase in population, the Valleys Planning Council created the *Plan for the Valleys* in 1963, which laid out a possible plan for development with conservation in mind. As a result of this report, the Urban Rural Demarcation Line (URDL; see Figure III. 1) was created in 1967 to define the extent of the growth allowed within the Baltimore County (PPFI, 1998). The URDL was originally demarcated on the ability to supply water and sewers to new developments (PPFI, 1998). These first steps were followed by Baltimore County's own *1980 Guideplan*, published in 1969. In 1984 *Plan for Owings Mills* was adopted, selecting the area as an urban growth area (PPFI, 1998). This decision was heavily influenced by its location within the URDL and its proximity to the first ever suburban terminal for the Baltimore Metro light rail system (PPFI, 1998).

However, over the years that have followed the designation of Owings Mills as an urban growth area, forested land in this region has decreased (Gwynn's Falls Watershed Association, 1999). During a 17 year period from 1973-1990, this area saw a 7.4% decrease in forested land and a 9.6% increase in commercial, residential, and industrial developments (Gwynn's Falls Watershed Association, 1999). More recent statistics show a higher rate of deforestation than in the past (Gwynn's Falls Watershed Association, 1999). In the four years following 1990, the Owings Mills area lost an additional 10.4% of forest and gained 14.9% developed acreage (Gwynn's Falls Watershed Association, 1999). By 1994, the Red Run area forest cover was reduced from 55.9% to 38.1% while developed land had increased from 11.2% to 39.5% (Gwynn's Falls Watershed Association, 1999).



A **B**

Figure III. 1: Urban Rural Demarcation Line. A) Urban Rural Demarcation Line: area outside the pink line is intended to remain as agricultural land. B) Map B represents the changes that have occurred to the URDL since its inception in 1967. The current URDL is colored gray while the original line is green. Image A from http://www.neighborspacebaltimorecounty.org/urdlccamap.gif. Image B from D. Outen's presentation, August 2007.

III. B. Policies

In the face of a booming suburban population, Baltimore County realized that planned development policies were necessary to reduce the growing impacts of suburban sprawl (Gwynn's Falls Watershed Association, 1999). Smart Growth policies and environmental laws have shaped the Owings Mills area into a mixed-use, densely populated area interspersed with forested sections (Jack Dillon, personal communication October 2007).

III. B. 1. Smart Growth Policies

Baltimore County addressed the growing impacts of suburban sprawl by implementing Smart Growth policies in the area. Smart Growth development emphasizes designating urban growth boundaries to stop people from settling in new, undeveloped areas, in an attempt to curb sprawl (Burchell et al, 2000). In contrast, sprawled development converts open space or rural land into built-up or urbanized land disregarding environmental degradation (Beck et al, 2003). Smart Growth policies promote high-density residential and mixed-use development while preserving as much green space as possible (Burchell et al, 2000). High-density residential developments support one housing unit per acre and mixed development combines business and residential installations in an area (DNR, 2003). Smart Growth policies aim to revitalize underused land, mix residential and business needs, and maintain as much of the natural environment as possible (MDP, no date).

Smart Growth received its name in the 1990s, but Baltimore County has practiced some degree of growth management since 1975, when a planned government program attempted to control the amount, type, location, design, and rate of growth (Godschalk, 2000). Since that time, in response to increasing environmental degradation, urban sprawl, inadequate infrastructure, lack of affordable housing, and other related issues, the term has evolved. It now refers to “a commitment to balance protection of land, air, and water with urban development” (Godschalk, 2000).

When Governor Parris Glendening came into office in 1992, he worked to increase the State’s role in local land use issues (Frece, 2006). The Maryland Economic Growth, Resource Protection, and Planning Act of 1992 (Planning Act of 1992) set the stage for Smart Growth (Frece, 2006). The Planning Act of 1992 provided critical guidance for development and Smart Growth initiatives but was terminated in 2003 due to cited ineffectiveness (MDP, no date).

The Planning Act of 1992 defined seven goals for conservation and development standards : 1) concentrate development in appropriate areas, 2) protect sensitive areas, 3) direct growth away from rural areas to preserve them and development towards existing infrastructure, 4) serve as stewards of the Chesapeake Bay and respect the land, 5) conserve natural resources, 6) encourage economic growth and restructure regulatory mechanisms, and 7) use funding mechanisms to achieve these goals (MDP, no date). According to the Planning Act of 1992, sensitive areas include streams and buffers, one hundred year floodplains, threatened and endangered species habitats, and steep slopes (MDP, no date). The Planning Act of 1992 implemented improvements to Local Comprehensive Plans by jurisdictions that delineate environmental regulations and development plans (MDP, no date). Improvements to the Planning Act of 1992's guidelines under the Land Use-Local Government Planning bill in 2006 (House Bill 1141) have expanded sensitive areas to also include agricultural and forested lands and wetlands (Summers, 2006).

In 1997, Glendening's Smart Growth and Neighborhood Conservation Initiative was introduced and adopted by the state of Maryland (Frece, 2006). This law led to the creation of Priority Funding Areas (PFAs) designed to manage development; PFAs subsequently became the most successful land use policy up until that time (Frece, 2006). The key to the success of the Smart Growth law was its use of incentives to change people's behavior rather than obligatory regulations (Frece, 2006). State funding went only to developments within the PFAs with the aspiration that financial incentives to developers would curb development outside the PFAs (Frece, 2006).

At the County level, the environmental and Smart Growth laws have been used by Owings Mills to develop its Master Plans (DEPRM, 2006). These are important and accessible tools for promoting environmental protection in Baltimore County. While they are not legally binding, Master Plans offer critical guidance in the planning, development, and environmental conservation of an area (personal communication Jack Dillon, October 2007). The current plan, *Master Plan 2010,* for Owings Mills, builds upon previous Master Plans for the area of the 1980s and 1990s and incorporates pertinent environmental, economic, and social issues related to Smart Growth and Baltimore County's environmental goals (DEPRM, 2006). The 2010 Master Plan also seeks to provide adequate infrastructure and meet the needs of its growing population while restoring degraded areas and preserving as many existing natural resources as possible (DEPRM, 2006).

A goal of the 2010 Plan is to maintain the URDL (see Figure III. 1) that was established in 1967 (Office of Planning, 2006). The URDL separates Baltimore County into two development areas where development can occur in the area inside the URDL whereas the area beyond the URDL is left mostly as farmland and is intended to remain as such (DEPRM, 2006). Land within the URDL receives public sewer and water infrastructure, thus is best fit for urban development

(Office of Planning, 2006). Baltimore County aims to preserve 80,000 acres of farmland from development pressure (Office of Planning, 2006). As of November 2007, more than 53,000 acres of agricultural land have been preserved in the entirety of Baltimore County (Jones, 2007).

Incorporated into the 2010 Master Plan, is the protection of sensitive areas as addressed in the Planning Act of 1992. With DEPRM's management, Baltimore County strives to protect its stream buffers, maintain its forest cover, and restore its streams (Don Outen, personal communication August, 2007). The County recognizes the negative stream bank changes brought on by development and aims to protect these areas or restore them to functioning riparian buffers and streams (Don Outen, personal communication August, 2007). Smart Growth policies are not single handedly responsible for the protection of natural resources in the State of Maryland, several other environmental policies are also to be credited.

III. B. 2. Environmental Policies

In order to protect the State's unique resources such as forested areas, wetlands, and floodplains and to protect the health of the Chesapeake Bay, several environmental laws particular to the state of Maryland have been enacted including the Forest Conservation Act and various Chesapeake Bay protection laws. These laws and the Smart Growth program attempt to maximize green space, foster appropriate development, and protect the natural environment.

The Forest Conservation Act (FCA) of 1991 specifically addresses the methods of preserving forests in Maryland and the reasons for doing so. The FCA requires identification and protection of forest stands and the creation of areas for new trees to be planted (Howell, 1997). The Maryland DNR Forest Service manages the FCA while it is implemented at the County level (DNR, 2003). Therefore, Baltimore County has the responsibility of forest management under the FCA.

The FCA details two planning requirements: 1) the Forest Stand Delineation (FSD) must be identified and 2) a Forest Conservation Plan (FCP) must be proposed (DNR, 2003). The FSD is a way of evaluating and identifying vegetation on a site that is proposed for development and assists in picking the most appropriate areas to focus conservation activities in lieu of development (DNR, 2003; Howell, 1997). The FCP requires local governments to develop forest conservation programs "[…]which meet or [are] more stringent than the requirements and standards [of the FCA…]" (DNR, 2003). These plans provide the state with the amount of land that is protected and replanted with trees, as well as protection during and after development has occurred (Howell, 1997).

Maryland's unique environment along the nation's largest estuary, the Chesapeake Bay, requires it to take special care in protecting its waterways (Windows to the Universe Team, 2002). Under restrictions set by the Chesapeake Bay Agreements of 1987 and 2000 and Baltimore County Code Article IX, Baltimore County is required to prevent erosion and nutrient pollution by maintaining healthy riparian buffers and restrict development in watershed or hundred-year floodplain areas (DEPRM, 2002).

Baltimore County Code Article IX entitled, Protection of Water Quality, Streams, Wetlands, and Floodplains, includes legislation that incorporates requirements of the Chesapeake Bay protection regulations as well as Federal water quality standards (DEPRM, 2002). In particular, Section 14-332 of the Baltimore County Code is dedicated to protecting and enhancing forest buffers because of their connectivity and ultimate importance to the Chesapeake Bay's health (DEPRM, 2002). The Baltimore County Code includes specific language regarding forests and sets development standards (DEPRM, 2002). Forest buffers are defined by Section 14-332, as areas of vegetation and forest with the distinct purpose of protecting a stream by providing shade, a means of erosion control, and a barrier for nutrient runoff (DEPRM, 2002). The 100 feet buffers in Owings Mills are in place to protect the streams that flow into the area's watersheds (Don Outen personal communication, August 2007).

III. C. Economic Benefits of Smart Growth

The Smart Growth program also helps Smart Growth communities save money which leads to an increase in the quality of living for residents in the community. The major concern that most developers face when constructing a community is how to maximize a financial profit in an area where the theoretical maximum number of units that can be placed on the land is not allowed, a place where forest and development are literally separated by about 6 feet of grass, and where commercial development needs to be a walkable distance from residential communities: a place like Owings Mills. Several economic studies can explain the fiscal benefits that Smart Growth development brings to Owings Mills. Forest conservation, walkable communities, and infrastructure cost are all factors that need to be included in analysis to understand the economic benefits of a Smart Growth community on a local level.

A common economic misconception is that a larger tax base, composed of more residents, leads to more revenue a jurisdiction has available to spend; an increase in expensive homes will bring in extra money locally. A continual growth in population can raise the tax base but also increases the stress on the ability to reach a high quality standard of living per person in the community (Albico and Pelley, 1997). When the impact of population growth is not accounted for in community planning, the associated infrastructure cost will grow exponentially. Infrastructure is defined as everything that is publicly owned such as sewer and water authorities, roads, hospitals, and schools; as a community's population increases, so too do its needs. Los Angeles, California is a prime example of failed infrastructure analysis. Los Angeles spent $10 billion in infrastructure cost due to its sprawl style growth (Albico and Pelley, 1997).

In fiscal impact analysis, the cost of public works associated with new development is compared to the projected tax base. These impact reports are an excellent way of determining whether or not a proposed development will be a smart economic investment for future residents and local government. As of 1996, only nine of Maryland's 24 counties, Carroll, Cecil, Charles, Frederick, Howard, Montgomery, Queen Anne's, St. Mary's, and Anne Arundel, as well as the City of Baltimore, had conducted fiscal impact analysis on their local community development (Albico and Pelley, 1997). Often, local governments overlook the price of infrastructure costs, a mistake created by poor planning. The cost of environmentally restoring an area due to lack of a prior economic analysis and proper planning is accounted for in infrastructure cost within a fiscal impact analysis. For example the cost of restoring polluted water is $400 – $1600 dollars per acre (Albico and Pelley, 1997). The Chesapeake Bay restoration effort, which is far from complete, has cost roughly $38 million so far. Maryland counties have begun to realize the value of fiscal impact analysis in saving public funds. The nine counties mentioned above are leading the way.

The lack of infrastructure cost analysis by the 15 other Maryland counties may be part of the reason why so many Smart Growth communities are not able to properly document the benefits of Smart Growth (Wheeler, 2007). If a Smart Growth community does not track its public spending, then it is impossible to gauge whether the Smart Growth program is economically efficient. Cost and benefits drive community decisions; therefore, it is critical that cost and benefits be analyzed to curb sprawl-like growth.

The implementation of public water and sewer works can be quite often a burden on the tax base. Therefore, the benefits of having sewer and water lines must be analyzed in detail in order to develop the best possible development plan; lack of study of a development plan can lead to inefficient sewer placement (Bagi, 2002). The Economic Development Administration, a federal entity under the United States Department of Commerce, worked with several prestigious academic universities to find the key financial differences between the cost associated with the development of water and sewer facilities in dense urban areas versus sparse rural areas. The study was performed at the national level. Funding for development of water and sewer lines was given to 87 communities by the EDA, 54 of which were rural and 33 of which were urban. Eighty-six of the 87 communities had a 10% unemployment rate. On average, 20% of the population in each community was below the poverty level. Per capita average income was $7,088 for all rural and $8,017 for all urban communities (Bagi, 2002).

The results of this study indicate that rural communities benefit less from sewer and water lines whereas dense urban communities benefit more. The key that distinguishes the benefits between a rural and dense population area is the direct impacts versus the indirect impacts of the water and sewer lines. When a line is laid, it usually goes to a specific site, for instance a large industrial park. The study indicated that the overall indirect impact to the dense urban areas was much higher than the overall impact to the sparse rural areas; there was a much greater return on the investment in the urban area even though production cost of the water and sewer lines was higher (Bagi, 2002). In a dense community more people are displaced, inconvenienced, or need to be accommodated near the site where the pipe is laid while in a rural community pipes can be laid easily within the sparse community. The study concluded that most urban projects have larger positive economic impacts than rural areas (Bagi, 2002).

Smart Growth development, such as in Owings Mills, also aims to conserve open space throughout the developed community. Many business oriented people might feel that this is a waste of valuable resources that could benefit the community in other ways (Mankiw, 2006). Yet, economic research speaks otherwise. The Proximate Principle expresses this reality; the market values of properties located near a park or open space reflect the value of the open space. Frequently the value of houses near an open space is significantly higher than that of a space located further away from that amenity (TFPL, 1999).

Consider three, 200 feet zones surrounding a park within a larger development. Zone A is the closest to the open space and outwards until Zone C. According to Crompton, homes in Zone A would be valued 20% higher than the average home cost, Zone B would be around 10% higher, and Zone C would be around 5% higher (TFPL, 1999). This principle rewards the developers and benefits the environment as long as the open land is maintained; it also assumes a property tax is in place which creates revenue for the community. The increase in property value associated with the more valuable homes would increase the tax base providing the community with a larger budget to improve public works.

Land conservation also has benefits beyond improving tax base through increased property value. Smart Growth in Owings Mills calls for the conservation of forested lands near streams. The Trust for Public Land along with the American Water Work Association conducted a survey in 2004 to analyze the value of tree cover in terms of the cost of local water treatment. A direct positive correlation was established between forest cover and the cost of water treatment; the less forest cover there was, the greater the expense of water treatment (TFPL, 2004). For every 10% increase in the forest cover in the source area, treatment and chemical cost of water purification decreased by approximately 20% (TFPL, 2004). It is worth noting that when forest cover reaches 70%, no further gains in water treatment savings would occur by increased forest cover (TFPL, 2007). The benefit of forest cover for water treatment cost demonstrates another economic benefit of forest conservation in Smart Growth communities.

The cost of transportation to local and state government can be greatly reduced by Smart Growth development (Albico and Pelley, 1997). According to U.S. transportation data, the number of household shopping trips jumped from 341 per year in 1990 to 496 per year in 2001 and the overall length of the average trip increased from 5.1 miles to 7.02 miles (Hakim and Peters, 2005). This increase occurred even though the cost of gasoline had been on the rise during those years (Hakim and Peters, 2005). By implementing walkable communities, these costs of living are decreased. The cost of speeding, which is also associated with increased driving, is around $40.4 billion annually nation wide (Hakim and Peters, 2005). The cost arises from enforcement of speed laws and emergency response to crashes caused by speeding (Hakim and Peters, 2005). Local governments in walkable communities will save money, but the additional indirect benefits to these communities, such as healthier lifestyles from increased walking and decreased car accidents, are a priceless benefit.

The analysis of economic data can help communities to decide what to do and what not to do, in terms of development. If done correctly, it often drives society towards the conservation of natural resources. If it is used as part of the decision making process regarding how to develop land properly and wisely, problems such as infrastructure cost exceeding tax revenue gained will be avoided.

IV. The Forests of Owings Mills

The existing forests in Owings Mills are fragments surrounding streams. Our research aimed to determine the composition of these buffers and their sustainability. Tallies of seedlings and saplings were conducted to gauge the appearance of regeneration in the individual sampling sites. Soil analysis, to determine the impacts of trace and heavy metal contamination, was performed to assess how the soils in the area might affect the vegetation present.

IV.A. Site Selection

Small groups of students preliminarily assessed 14 possible sampling sites in Owings Mills in order to identify sampling sites for the forest buffer study. Each group of students used the same set of criteria to evaluate the forest fragments that were visited.

Each student first recorded whether or not each forest fragment “felt” like a healthy, functioning forest, or if it appeared to be a random patch of trees. The students also practiced identifying trees in each forested area and if there were any invasive species present. Next, each location was analyzed to determine if students could perform a modified, point center quarter sampling method in the forest. Students needed to consider whether or not there was too much understory to get around in each forest fragment and if the density of trees in each area was suitable for the study. An additional criterion was based upon the proximity of each forest fragment to surrounding roads and housing developments. Students had determined that in order to determine the effects of Smart Growth on the forests of Owings Mills, it was important to choose forest fragments that were adjacent to housing developments. Finally, the forest fragments were examined to determine whether or not a buffer zone of 100 feet actually existed from the development to the streambed. The width of the buffer zone was crucial, because the study required a width of at least fifty feet from the stream. The groups of students found several locations where the buffer zone was no more than fifty feet wide and deemed them inadequate for sampling.

Once the preliminary assessments had been completed, the class discussed the characteristics of each forest fragment. The class agreed upon conducting the study at four separate sites, which were given names based upon the roads that had been used to gain access to the forests: Manor Forge, Groffs Mill, Runnymeade, and Lyons Gate. The location of these four sites can be seen on the map, Figure IV. 1.

IV.B. Site Characteristics and History

There are a variety of factors that have contributed to the structure of the area's forests. In order to understand the present state of the forest fragments, the soil types and expected forest composition were necessary to be used in the analysis of our results. The history of the area also served as important insight into why some of the forests appeared the way they did.

IV. B. 1 Typical Maryland Piedmont Forests

The Eastern United States, from the Atlantic Ocean to the Mississippi River, comprises the Eastern Deciduous Forest biome (Gurevitch, et al., 2002). This biome is further subdivided into various types of deciduous forest, with Oak-Hickory forest being the predominant type of forest found in the Maryland Piedmont region; this includes the Owings Mills/New Town area where our study has taken place (Gurevitch, et al., 2002). Environmental factors such as moderate rainfall, moderate soil nutrient availability, cold winters, and hot summers all contribute to the species composition found in Oak-Hickory forests (Gurevitch, et al., 2002). Various species of the genera Oak (*Quercus)* and Hickory (*Carya)* dominate Maryland forests, as well as Maple (*Acer)*, Gum (*Nyssa)*, Ash (*Fraxinus)*, Cherry (*Prunus)*, and Beech (*Fagus)* (Gurevitch, et al., 2002). The most common species found in Maryland forests are Oak, Hickory, Tulip Poplar (*Liriodendron tulipifera*), and Red Maple (*Acer rubrum*) (Pywell, 2003).

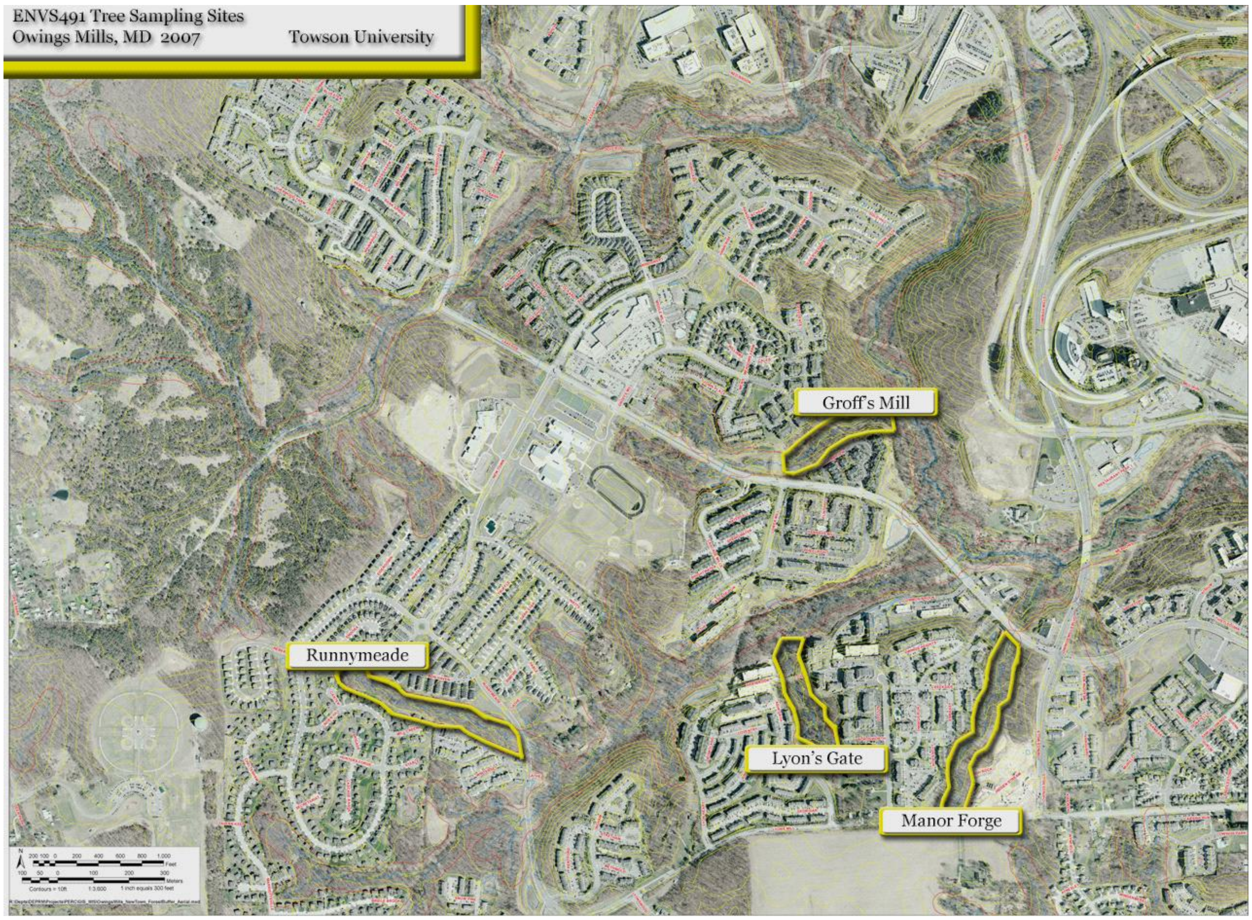


Figure IV. 1: Map of Sampling Sites. Map of the four sampling sites selected by the class to sample trees and soil. Each site represents a fragmented forest, or a forest "finger." Map adapted from DEPRM 2007.

Formerly, American Chestnut (*Castanea dentate)* was a fairly dominant tree in Maryland and elsewhere in the Eastern United States, but the effects of Chestnut Blight have nearly eliminated the trees from the east coast; Oak species have moved into the Chestnut's vacated ecological niche and replaced them (Gurevitch, et al., 2002). Specimens of American Chestnut still exist in Maryland as small branches arising from the stump of a former adult tree, but the

Chestnut Blight prevents these branches from surviving long enough to become reproductive adults, effectively preventing the Chestnut population from recovery (Gurevitch, et al., 2002).

Tulip Poplar is generally considered to be an early to mid-successional tree and its prevalence in Maryland forests is most likely a function of the second growth nature of forests in the state. The climax community that eventually develops in Maryland will usually be composed of a mix of Oaks including White Oak (*Q. alba*), Red Oak (*Q. rubra*), Black Oak (*Q. velutina)*, Chestnut Oak (*Q. montana*) and Hickories, such as, Shagbark Hickory (*C. ovata)*, Mockernut Hickory (*C. tomentosa)*, and Pignut Hickory (*C. glabra*), along with a mix of other less dominant trees (Gurevitch, et al., 2002). Broad generalizations about forests are somewhat difficult to make as no two areas are exactly alike in natural history and environmental factors, resulting in different compositions from site to site. Soil texture, water availability, and degree of disturbance all play a role in determining the exact makeup of any forest stand.

After the arrival of European settlers most of the old-growth forests in the Eastern United States were cut down for fuel, lumber, and to clear land for farming and construction of settlements. Many of the forests in Maryland today are therefore second growth forests which occupy abandoned farm fields that have been recovering naturally over time (Gurevitch, et al., 2002). Consequently, the forests most often seen today are the result of ecological succession occurring naturally with little human intervention. There are many theories concerning forest succession, but most of them center upon the transition from small herbaceous plants to progressively larger and woodier species, until the ecosystem reaches a stable point, called a climax community (Gurevitch, et al., 2002). However, these forests are now being threatened by the encroachment of humans once again in the form of roads and suburban development (Gurevitch, et al., 2002). Roads and development almost inevitably lead to forest fragmentation, where small patches of forest become isolated from one another and are surrounded by roads, houses, office buildings, commercial sites, etc.

Forest fragmentation has serious negative effects on forest ecosystems, resulting in alterations of “forest microclimates as wind, light levels, temperature, and runoff increase at the edges of the forest, while humidity decreases” (Gurevitch, et al., 2002). Not only does this change in conditions negatively impacting species adapted to conditions in the forest interior, but it also opens the door to many invasive species, which generally tend to take advantage of edge conditions (Gurevitch, et al., 2002). In fact, changes in land use are estimated to have a more profound negative effect on ecosystems than climate change or invasive species (Gurevitch, et al., 2002). Tree types in any forest are dependent on many conditions. Anthropogenic factors such as development, which create such conditions as forest edges or polluted soils, along with the natural conditions of an area, such as soil type, can limit the diversity and number of tree species in a given area. Selected tree species and conditions are selected for reference in Table IV. 1.

IV. B. 2 Development History and Soil Types

Development and urbanization in general can greatly impact forests. This can change existing dynamics in an ecosystem, which could potentially have a negative effect on a forests' sustainability. In any ecosystem, soil is an important part in sustaining forests. Local soils can play a significant role in determining plant growth and allows us to understand conditions at each site. The following data were modified from the 1976 USDA Soil Conservation Service Soil Survey of Baltimore County, Maryland. Selected soil characteristics for the soils at each sampling site are available for reference in Table IV. 2.

IV. B. 2a Runnymeade

The Runnymeade site lies to the west of the other three sites. To determine site history, aerial photographs from 1987 to 1989 were used to determine the level of forestation before major development had occurred. Runnymeade was entirely composed of interior forest prior to development and was not bordered by a field at the time of the earlier fly over unlike the other three sites. Based on information from the Real Property Database, development dates were recovered for this site. In 1995, an apartment complex was constructed on the northern edge of the forest. In 2001, a development of single-family homes was constructed to the south of the forest. The construction of the two developments established a 100 feet buffer on each side.

Table IV. 1: Traits of Selected Trees. Modified from the USDA PLANTS database found at http://plants.usda.gov/.

Species	Growth Rate	Longevity	Mature Height (ft)	Soil Preference (Texture, Acidity, and Moisture)
Liriodendron tulipifera	Fast	Moderate	120	Medium to coarse, acidic, moderate Moisture
Quercus alba	Slow	Long	100	Medium to coarse, acidic, moderate Moisture
Quercus velutina	Moderate	Moderate	90	Fine to coarse, acidic, moderate Moisture
Quercus rubra	Moderate	Long	100	Fine to medium, acidic, moderate Moisture
Quercus prinus	Slow	Long	80	Medium to coarse, acidic, moderate moisture
Acer rubrum	Fast	Short	90	Fine to coarse, acidic, moist
Carya alba	Slow	Long	100	Medium to coarse, acidic to basic, moderate moisture
Carya glabra	Slow	Moderate	90	Medium, acidic, moderate moisture
Carya ovata	Fast	Long	90	Medium to coarse, acidic, moderate moisture
Cornus florida	Short	Moderate	40	Medium, acidic, low moisture
Juglans nigra	Fast	Moderate	100	Medium, mildly acidic, moist
Acer negundo	Fast	Short	60	Fine to coarse, moderate water and acidity
Platanus occidentalis	Fast	Long	>100	Medium to coarse, acidic, moist
Prunus serotina	Fast	Moderate	80	Medium to coarse, acidic, moderate moisture
Fraxinus Americana	Moderate	Moderate	90	Fine to coarse, moist, acidic

Due to slope, the Manor series is prone to significant erosion, which was observed at the site. The soil in the Runnymeade site is deep and is well-drained to excessively-drained in some parts (Reybold III and Matthews, 1976). The soil is composed of weathered local rock, which is generally from the Wissahickon group. The Wissahickon group is comprised of mostly schist and quartzite, both having high concentrations of mica. The pH of this soil is moderately to strongly acidic and we would expect to find primarily mixed hardwoods, especially Oaks (Reybold III and Matthews, 1976).

The second soil in this forest site is part of the Glenville series, type GnB (Reybold III and Matthews, 1976). This soil makes up the area around the stream, which has a slope of 3% to 8%. The soil consists of micaceous, acidic, silt loam and is poorly to moderately drained (Reybold III and Matthews, 1976). The water table is generally high in this soil type and native vegetation consists of water tolerable hardwoods. Tulip Poplar, Sweetgum, Ash, Red Oak, and Red Maple grow well in this soil type. There can also be significant erosion present in this soil type (Reybold III and Matthews, 1976).

Table IV. 2: Selected soil characteristics of the soil types at each sampling site. Note the two soils that are not very fertile for hardwoods, the Baile soil and Edgemont soils. Mod refers to moderate and Slight-mod refers to Slightly-Moderate Modified from Reybold III and Matthews, 1976.

Runnymeade	**Erosion Hazard**	**Seed Mortality**	**Hardwood Competition**	**Soil Depth(ft)**	**Water Table(ft)**	**Drainage**
Glenville GnB	Slight	Slight	Moderate	4-10	1-3	Poor
Manor MbC2	Mod	Slight-Moderate	Moderate	3.5-10	>5	Good
Manor Forge						
Manor McD2	Severe	Slight-Moderate	Moderate	3.5-10	>5	Good
Codorus Cu	Slight	Slight	Severe	6-20	1.5-2	Poor
Lyons Gate						
Edgemont EdC2	Slight-Mo	Slight	Slight	3.5-5	>5	Good
Edgemont EgE	Slight-Mo	Slight	Slight	3.5-5	>5	Good
Codorus Cu	Slight	Slight	Severe	6-20	1.5-2	Poor
Groffs Mill						
Manor MdE	Severe	Slight-Moderate	Moderate	3.5-10	>5	Good
Baile BaB	Slight-Mo	Severe	Severe	5-10	0	Poor

IV. B. 2b Manor Forge

The Manor Forge site lies to the east of the other three sites. Based on the 1987-1989 aerial photographs, Manor Forge had a significant amount of disturbance before any development had taken place. In the aerial photograph, there is an agricultural field, along with a sewer line and a road, Owings Mills Blvd, all located where the forest presently lies. Development here was the most recent of the four sites. In 2001, an apartment complex was built to the west of the forest where the agricultural fields had previously been located. In 2005, a development of town homes was built to the east of the forest, establishing a buffer on each side.

This site also has two soil types. The first type is McD2 of the Manor series. This occurs on the sloped areas of the forest. Slopes here range between 15% and 25% and moderate erosion is evident, though this area has fairly low erosion levels because of its high plant densities (Reybold III and Matthews, 1976). The soil is very shallow here and is acidic (Reybold III and Matthews, 1976). Hardwoods grow well in this soil type, especially Oaks. The second soil type is Cu, of the Codorus series. This soil makes up the flood plain area at this site (Reybold III and Matthews, 1976). The slope in the flood plain is almost level ranging up to 3% (Reybold III and Matthews, 1976). Seasonal flooding occurs many times a year at irregular intervals. Mixed hardwoods that are tolerant of excess wetness grow well here (Reybold III and Matthews, 1976). This includes Tulip Poplar, especially on the Codorus soil, red maple, red oak, and Ash (Reybold III and Matthews, 1976).

IV. B. 2c Lyons Gate

The Lyons Gate site lies directly west of Manor Forge and is in the center of the other three sites. Based on the 1987 to 1989 aerial photographs, the forest cover at this site is not as thick as the other three and like Manor Forge, is bordered by an agricultural field to the south. Like the other sites, Lyons Gate is bordered by two developments. A development of single-family homes was built to the east in 1997 and a development of town homes was constructed to the west of the forest in 2001.

This site consists of three soil types, from two series. The first soil type is EdC2 of the Edgemont series. This is a loamy soil with some gravel present at the surface (Reybold III and Matthews, 1976). Slope is normally 8% to 15% and some gullies may be present because of erosion (Reybold III and Matthews, 1976). Although this soil has a high moisture capacity, it is very strongly acidic and becomes very stony in some areas (Reybold III and Matthews, 1976). The second soil type is EgE of the Edgemont series. This soil is similar to EdC2, but has a higher slope of 25% to 45% and consists of very stony loam (Reybold III and Matthews, 1976). These two soils make up the very steep upland area of the forest and small upland vegetation along with some low-density mixed hardwoods grow here because of the large number of quartzite fragments in the soil. The second type is the Cu soil of the Codorus series. This is the same flood plain soil as the Manor Forge site and water tolerant hardwoods grow in this area (Reybold III and Matthews, 1976). Expected trees in this site include Tulip Poplar, Red Oak, and Red Maple (Reybold III and Matthews, 1976).

IV. B. 2d Groffs Mill

The Groffs Mill site lies north of the other three sites. The northwestern section of the forest is an existing edge based on the 1987 to 1989 aerial photographs, but consists of previously contiguous forest. This site has the oldest developments of apartment complexes built in 1993, creating a 100 feet buffer on each side.

This site is composed of two soil types. The first is the MdE soil of the Manor series. This soil lies on a slope of 25% to 50% (Reybold III and Matthews, 1976). Soil depth is generally less than the other Manor soils because of geologic erosion. This soil does provide good protection for streams by supporting a good vegetation cover (Reybold III and Matthews, 1976). This soil is similar to other sites, providing good conditions for mixed hardwoods such as Oaks and Hickories. The second type of soil at this location is the BaB soil of the Baile series. The slope at this area is generally from 3% to 8% (Reybold III and Matthews, 1976). Permeability and drainage are very low so the soil tends to be very wet. Most water generally becomes runoff rather than infiltrating into the soil (Reybold III and Matthews, 1976). Also, idle open areas, such as those that have been disturbed by construction, will generally tend to grow grasses and small plants rather than larger trees (Reybold III and Matthews, 1976). Severe erosion is a problem in this area, mostly because of the low permeability of the soil. Pin Oak and Red Maple grow well in the Baile series soil, depending on a forest’s successional stage, but Baile soils suffer from high seedling mortality (Reybold III and Matthews, 1976). The Manor series soil supports Tulip Poplar, Red Maple, and Oaks well (Reybold III and Matthews, 1976).

IV. C. Sampling Protocol

IV. C. 1. Forest Sampling

The four selected sites were sampled for tree types as well as sapling and seedling types and densities. The point center quarter method was used for our forest sampling for this study. This method is reported as being faster, less complex, and requires fewer people than other forest sampling methods without sacrificing accuracy (Mitchell, 2007). Point center quarter sampling traditionally utilizes a transect line laid out through a forest with each sampling point along the transect at a random distance from each other (Mitchell, 2007). Points that are close enough to each other to sample the same tree twice are then thrown out (Mitchell, 2007).

Therefore, the distance of the transect and the spacing interval of the points will vary depending on how densely forested the sampling area is. At each sample point along the transect, one person determines the cardinal directions, North, West, East, and South, ultimately creating four quadrants, Northwest, Southwest, Southeast, and Northeast (Mitchell, 2007). For each quadrant the distance to the nearest tree larger than 4 centimeters diameter of the trunk at breast height is measured and recorded, along with the Diameter at Breast Height (DBH) and the species of the tree (Mitchell, 2007). Due to difficulties in identification of Black Oaks and Red Oaks, these were lumped into an omnibus "Black Oak" group. One of the main goals of this project was to obtain baseline, descriptive data on the composition of the forest fragments in Owings Mills.

A slightly modified version of the traditional point center quarter method of forest sampling was chosen to survey the mature trees, and 4 meter squared quadrants at each point were utilized to sample seedlings and saplings. Adult trees were defined as any tree with a DBH of greater than 10 centimeters. Saplings were defined as any tree smaller than 10 centimeters DBH and taller than approximately knee height. Any tree shorter than knee height was defined as a seedling. Diameter at breast height was determined using a standard DBH measuring tape. Due to the narrow dimensions of the four buffer forests we sampled, the point center quarter transect was laid out to follow the contours of the main stream channel running through the center of the forest. A constant distance of 50 feet (15.24 meters) from the main stream channel was maintained, and a constant distance of 20 meters was maintained between sampling points along the transect. All transect distances were measured using a standard meter tape. A total of 20 points were sampled at each site, with data collected on four trees per point, yielding a total of 80 trees measured per site. The location of each sample point was recording using a handheld GPS unit and the cardinal directions were determined using a compass. Seedlings and saplings within the 4 meter squared box around the sample point were identified and tallied; no other measurements of the seedlings and saplings were made.

IV. C. 2. Soil Sampling

Each site was also sampled for trace and major elements in the soil. Soil samples were collected from each of the four study sites, Manor Forge, Groffs Mill, Runnymeade, and Lyons Gate. At each location, four core samples were obtained along a transect of the streambed running through each forest fragment and a fifth sample was taken in the closest retention pond; there were a total of five core samples from each study site. Along the transect, one core sample was taken on each side of the stream within the floodplain, and one sample was taken 50 feet from each side of the stream. The core samples taken from each retention pond were located within the wetted perimeter of the pond.

A group of students obtained the samples by driving a core sampler six to eight inches into the ground. If necessary, a hammer was used to drive the core sampler to the required depth. Once the core sampler was removed from the ground, the students removed the soil core from the core sampler and wrapped the ends of the plastic tube in aluminum foil in order to secure the soil core for transport back to Towson University. Once in the lab, the soil samples were separated by removing the soil core from the plastic tube and then thoroughly mixing the soil until it was homogenized. Each of the soil samples were placed in ceramic cups, labeled, and then placed inside a convection oven set to a temperature of 110°F for a period of 4-12 hours to ensure that the sample was dry. Once dry, each soil sample was run through a sieve and any large pebbles or debris was disposed of. Each sample was prepared in two separate methods so that they could be analyzed for trace metals and major elements using the X-Ray Flouresence (XRF).

To prepare the soil to test for trace metals, three and a half grams of sample was weighed out, and then combined with thirty five hundredths of a gram of ultrabind. Next this mixture was poured inside a thirty one millimeter cup, and placed inside a pneumatic press which exerts twenty five tons of pressure for three minutes in order to form a solid soil pellet. To prepare the soil to test for major elements, one gram of soil was weighed out, and combined with five grams of Lithium Borate. The resulting compound was placed inside an oven set to a temperature of 1200°C for twelve minutes until melted. Using gloves and metal tongs, the sample was removed from the oven and quickly poured into a metal die sitting over a Bunsen burner. After a few minutes the Bunsen burner was turned off and the sample was allowed to cool, forming a glass bead. Once all the pellets and glass beads were formed and labeled, they were placed inside the XRF. Using a computer program each sample was x-rayed in order to determine the levels of trace metals in each pellet, and major elements in each glass bead.

IV.D. Results

IV. D. 1 Tree Results

Diversity of tree species for each sample site varied slightly between sites, while overall forest composition, by total basal area, was relatively similar. Common species among all sites include Tulip Poplar, Oaks, Maples, and Hickories. Other species present in low density include Black Cherry, Flowering Dogwood, Sassafras, and Black Gum. Tulip Poplars, Maples, and various Oaks represent the majority of mature tree biomass; with Tulip Poplar accounting for nearly 50% or more of basal area in all four sites (see figures IV. 2 through IV. 5). The original data collected is presented in Appendix 1.

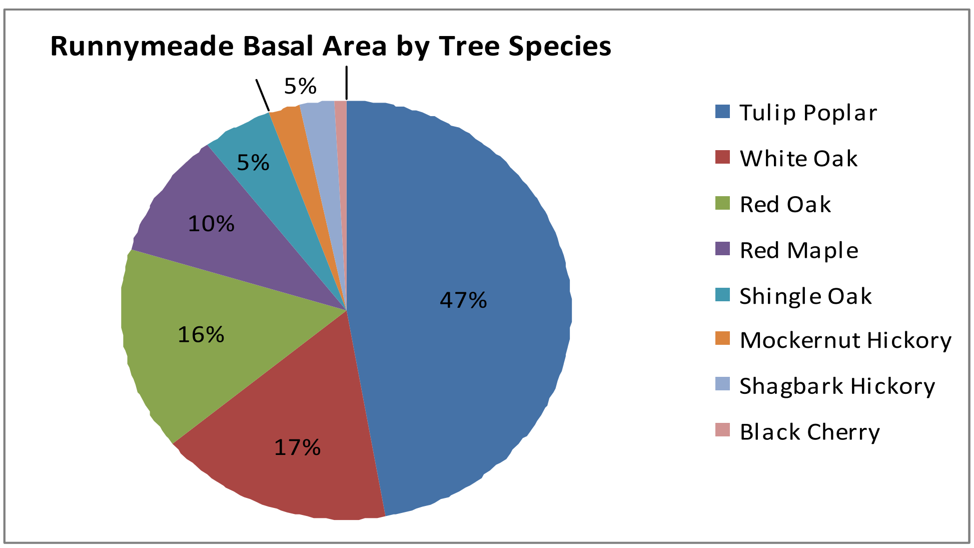


Figure IV. 2: Basal Area: Runnymeade. This site is primarily composed of Tulip Poplar and Oak.

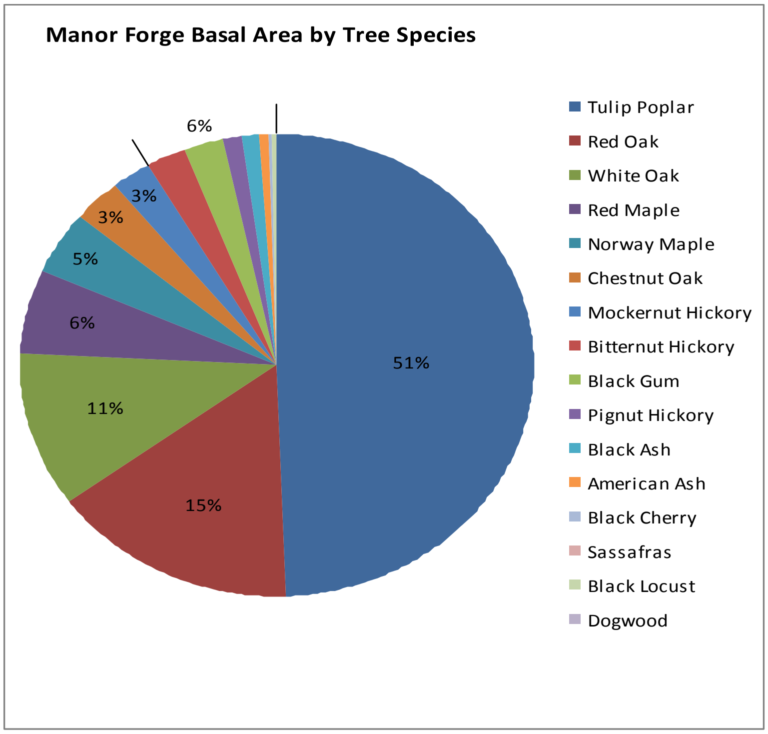


Figure IV. 3: Basal Area: Manor Forge This site area is made up primarily of Tulip Poplar and Oak.

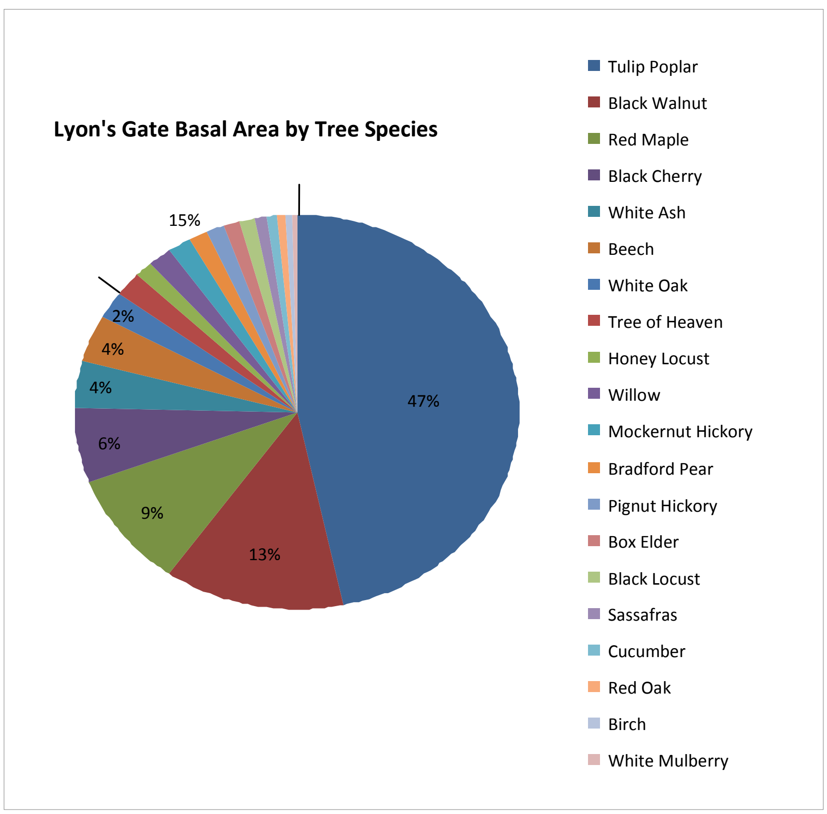


Figure IV. 4: Basal Area: Lyons Gate This site is primarily composed of Tulip Poplar, Walnut, and Maple.

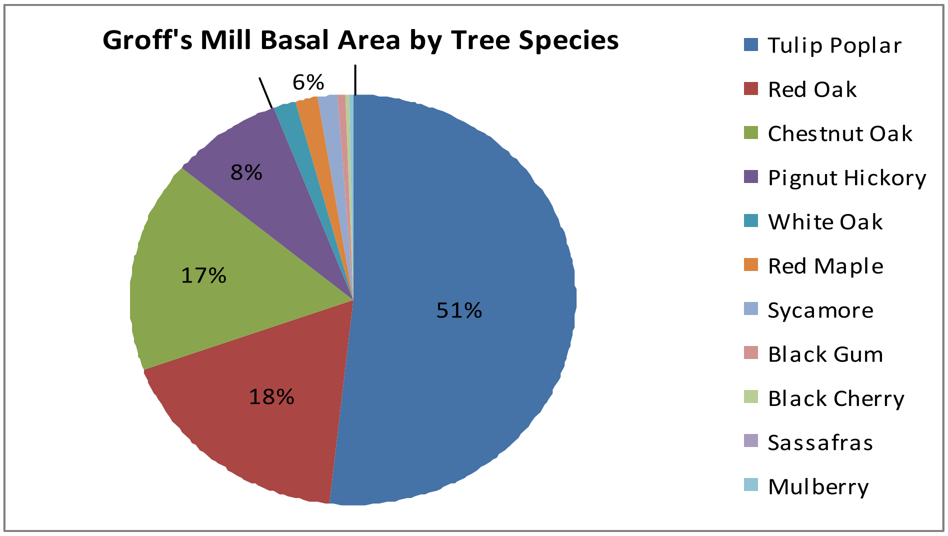


Figure IV. 5: Basal Area: Groffs Mill This site is dominated by Tulip Poplar, Chestnut Oak, and White Oak.

Simpson's Diversity Index (SDI) is used to quantify and compare the diversity of the four sites. Lyons Gate exhibited the highest levels of diversity with twenty species recorded and an SDI of 0.99 (see Table IV. 3). In contrast, Groffs Mill, which is dominated by Tulip Poplar (52% of total basal area), scored comparatively low at 0.666 (see Table IV. 3) with only 12 tree species recorded. Non-native species such as Tree of Heaven, Bradford Pear, and Norway Maple were present in only two of the four sample areas at very low densities, at less than 2.5% of total basal area per species.

Tree density is similar for all sites with the exception of Lyons Gate, which is significantly less dense in regards to mature trees over the sample area. In the Lyons Gate stand, the average distance from sample point to adjacent trees was 7.511 meters and tree density per 100 meters squared is significantly lower than other sites at 1.772 (see Table IV. 3). The remaining sites were comparable to each other; mean distances ranging from 4.5 to 5 meters and densities of 3.9 to 4.6 trees per 100 meters squared.

Diameter at Breast Height measurements indicate a wide range of tree sizes present in each sample site, however, these measurements are closely related to the species of tree sampled. In all sample sites, members of the Oak family tend to have higher DBH measurements, followed by Tulip Poplar and members of the Hickory family. The average DBH measurements for each site are available for reference in Table IV. 4.

The results for seedlings and saplings at each site can be found in Appendix 2. At the Runnymeade site, 14 saplings and 39 seedlings were found. Eight of the saplings sampled were Hornbeam and 11 of the seedlings sampled were White Oak. At Manor Forge, 31 saplings and 12 seedlings were found. Ten of the saplings sampled were Black Cherry and 6 of the seedlings sampled were Red Oak. At Lyons Gate, 16 saplings and no seedlings were found. Of the saplings sampled, there were four of Black Cherry and Box Elder. At Groffs Mill, 53 saplings and 29 seedlings were found. Eleven of the saplings sampled were Red Maple and there were both 11 Chestnut Oak and Red Maple seedlings found when sampling.

Table IV. 3: Point Quarter Analysis of Owings Mills, MD sample sites. Note: site names assigned according to access road

Site	Mean Distance(m)	Mean Area Occupied (m sq.)	Trees per 100m sq.	Simpson's Diversity Index
Groffs Mill	5.063	25.633	3.901	0.666
Runnymeade	4.715	22.232	4.498	0.747
Manor Forge	4.647	21.591	4.632	0.793
Lyons Gate	7.511	56.421	1.772	0.991

Table IV. 4: Average DBH measurements for sampling sites, measured in centimeter (cm)

Site	Min	Max	Average	Std. Dev
Groffs Mill	10.0	72.4	26.7	16.3
Runnymeade	10.0	72.5	30.1	16.4
Manor Forge	10.0	93.4	36.6	21.1
Lyons Gate	13.0	89.5	34.9	17.2

IV. D. 2. Soil Results

Please note that some of the elements were not measured accurately by the X-Ray Refraction instrument.

A standard reference material of known trace metal concentration was run along with the samples as a measure of the instrument's accuracy. The SRM2709 was obtained by Towson University from National Institute of Standards and Technology (NIST) along with a certificate listing the actual value for metal concentration in the sample known as the certified value. Dividing the measured concentration by the certified concentration will give us the percent recovery. An acceptable recovery for XRF analysis is 85-105%. Some elements, sodium (Na), aluminum (Al), phosphorus (P), copper (Cu), and lead (Pb) all fell outside the predetermined accuracy range and therefore results from these elements must be treated with caution (see Tables IV. 5 and IV. 6).

Table IV. 5: Trace metal percent recovery for SRM 2709

Sample	Ti (%)	V (PPM)	Cr (PPM)	Ni (PPM)	Cu (PPM)	Zn (PPM)	Pb (PPM)
SRM 2709	0.35	117.01	122.22	95.63	41.62	97.91	31.82
SRM 2709	0.35	116.56	122.12	94.68	40.67	96.61	28.74
STD	0.34	112.00	130.00	88.00	34.60	106.00	18.90
DEV	0.02	5.00	4.00	5.00	0.700	3.00	0.500
Recovery%	100.00	100.01	97.00	102.80	117.9	95.06	164.02

Table IV. 6: Major element percent recovery for SRM 2709

Sample	Na(%)	Mg(%)	K (%)	Ca (%)	Ti (%)	Al (%)	Si (%)	P (%)
SRM 2709	0.0260	0.0160	2.00	1.92	0.33	8.02	31.31	0.09
Certified Values	0.0119	0.0156	2.00	1.92	0.33	7.56	29.89	0.067
% Return	218.5	102.6	100.00	100.00	100.00	106.1	104.8	134.30

At Groffs Mill, vanadium (V) and copper both had elevated levels near the stream channel in relation to the other trace metals (see Figure IV. 9). Zinc (Zn) and vanadium both decreased at point three along the stream channel in the Lyons Gate transect (see Figure IV. 8). Zinc levels spiked at point four at the Manor Forge site (see Figure IV. 8). Lead also increases at point three along the stream channel of Manor Forge (see Figure IV. 7). At Runnymeade, (see Figure IV. 6), vanadium and nickel (Ni) were found at higher concentrations than at the other sites, especially near the stream channel.

For trace metal analysis, the arithmetic means of the concentrations for each site were compared at the 95% confidence level to determine if they are significantly different from one another. For nickel, Lyons Gate and Manor forge were significantly different from one another but not significantly different from the other sites (see Figure IV. 10). Lyons Gate and Manor Forge were significantly greater in concentration of lead from the Groffs Mill and Manor Forge sites (see Figure IV. 14). The only other significant difference was in copper concentrations between Lyons Gate and Groffs Mill, in which Groffs Mill was greater (see Figure IV. 11).

The cores from each storm water retention pond were next compared to the previously established trace metal concentrations for each site to determine if there was a statistical difference between them. Vanadium, titanium (Ti), and nickel, were not found to be significantly different between stream and pond concentrations at any site. Copper (see Figure IV. 11) and lead (see Figure IV. 14) were elevated in the storm water ponds at Groffs Mill and Runnymeade, however, the concentrations were significantly different for lead at both locations (see Figure IV. 14) and only significantly different at Groffs Mill for copper (see Figure IV. 11). The storm water retention pond at Lyons Gate was significantly greater in concentration of chromium (Cr) compared to its corresponding forest transect (see Figure IV. 12). Groffs Mill showed a significantly greater concentration of zinc in its storm water retention pond compared to site transect. Raw data for trace metals can be found in Appendix 3.

Major element concentrations at each site were compared using the same process as used for trace metals. At Lyons Gate and Manor Forge, the soil is significantly greater in potassium (K) than is found at Groffs Mill and Runnymeade (see Figure IV. 16). The concentration of titanium in the soil at Manor Forge is significantly less than at Runnymeade and Groffs Mill. Lyons Gate, while not significantly different than Manor Forge or Groffs Mill in titanium, is significantly lesser than Runnymeade (see Figure IV.15). All other major elements show no significant difference at the 95% confidence level. Raw data for the major element analysis can be found in Appendix 4.

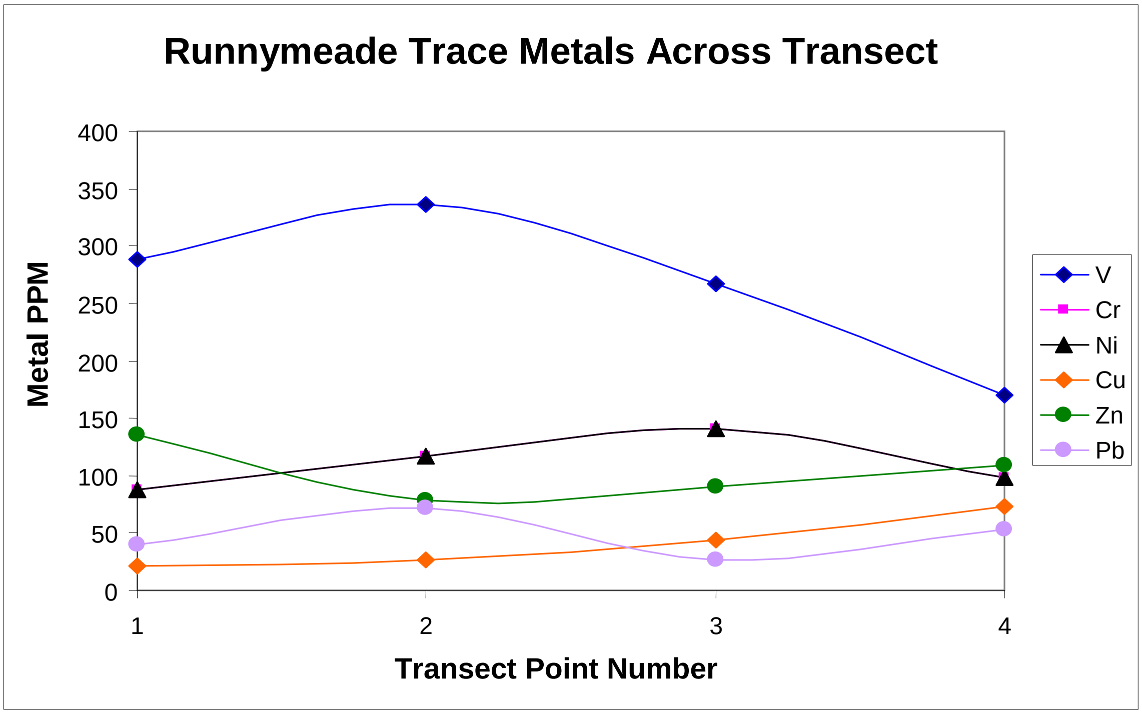


Figure IV. 6: Trace Metal Concentration: Runnymeade Points 2 and 3 are two meters from the stream. Measurements in parts per million (PPM).

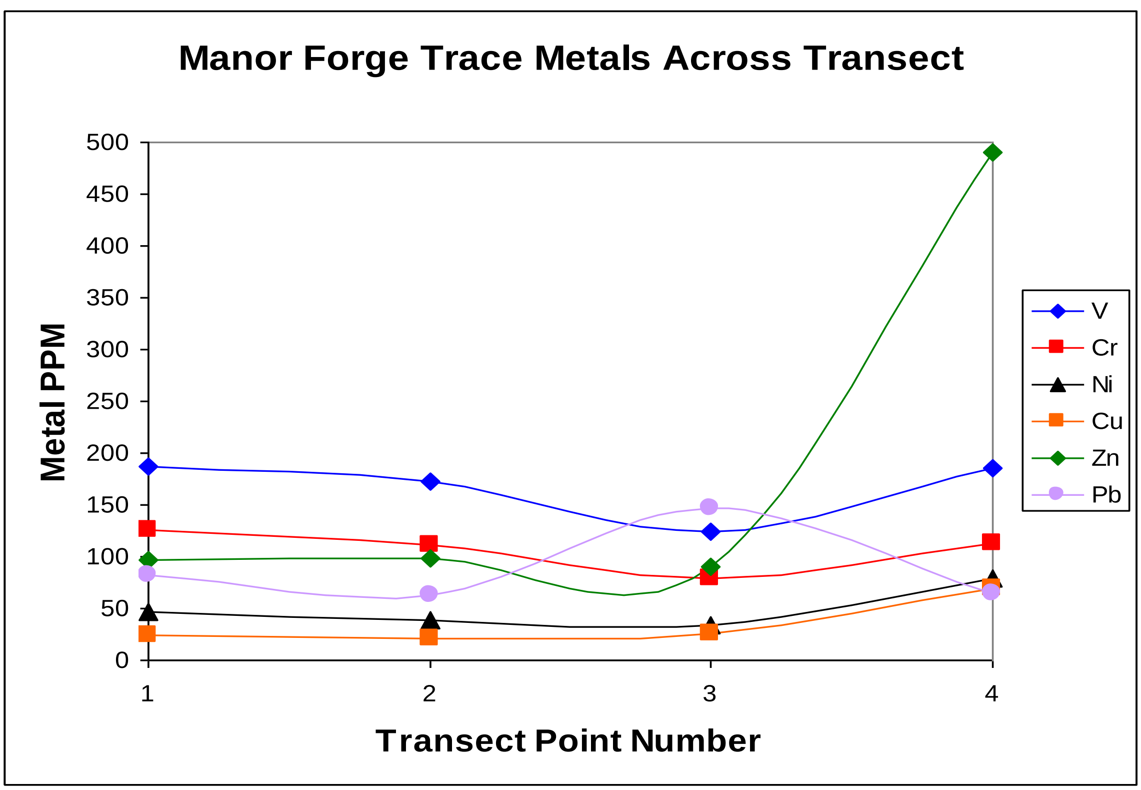


Figure IV. 7: Trace Metal Concentration: Manor Forge Points 2 and 3 are 2 meters from the stream. Measurements in parts per million (PPM).

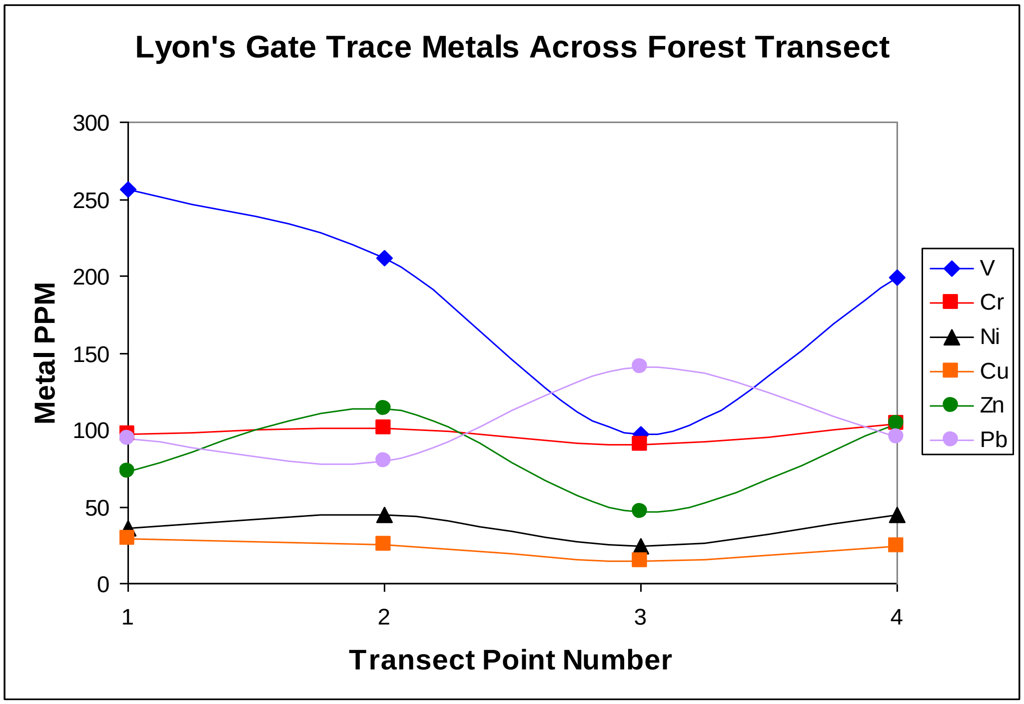


Figure IV. 8: Trace metal concentration: Lyons Gate Points 2 and 3 are 2 meters from the stream. Measurements in parts per million (PPM).

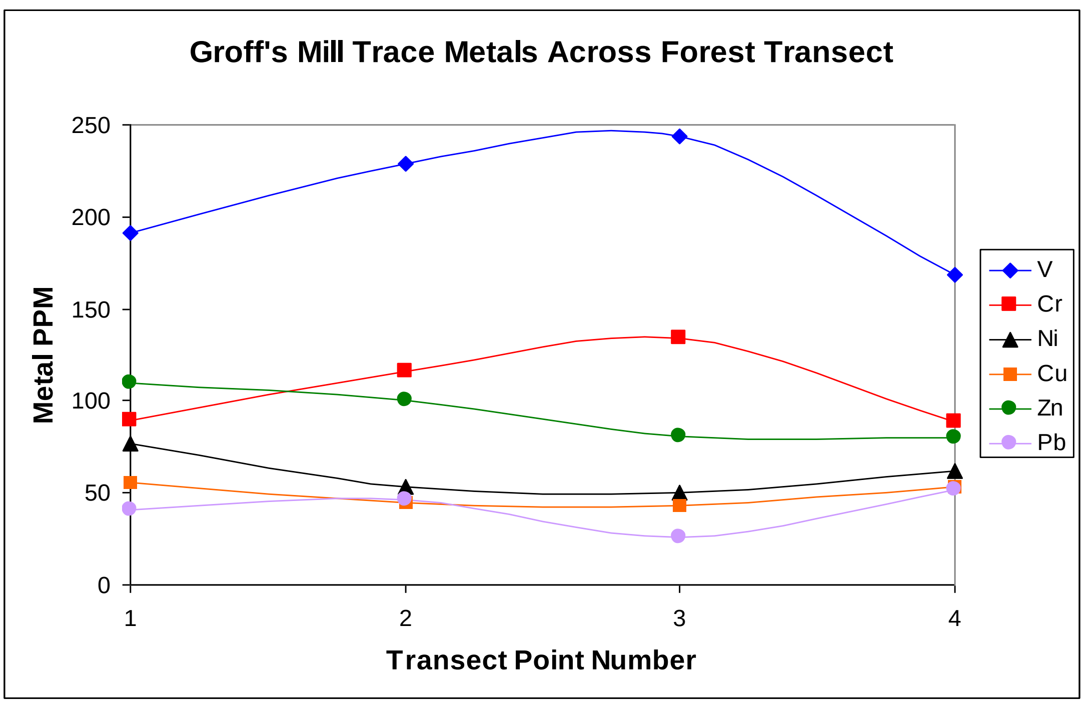


Figure IV. 9: Trace metal concentration: Groffs Mill Points 2 and 3 are 2 meters from the stream. Measurements in parts per million (PPM).

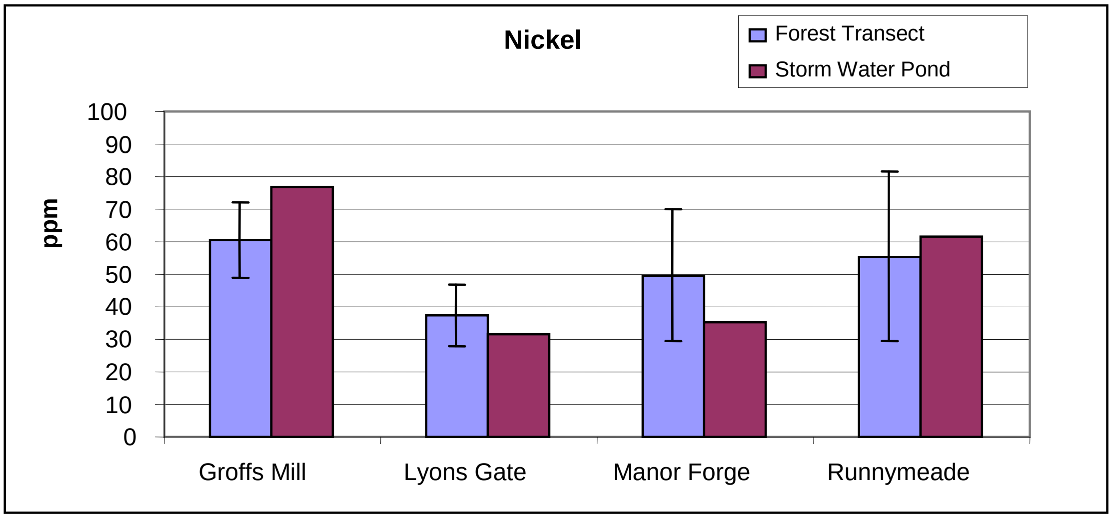


Figure IV. 10: Nickel Concentration Comparison: between sites and their nearest neighboring storm water pond. Forest transect represents the average of four samples taken within each site, while storm water pond samples are representative of a single sample taken in each pond. Error Bars denote the 95% confidence level.

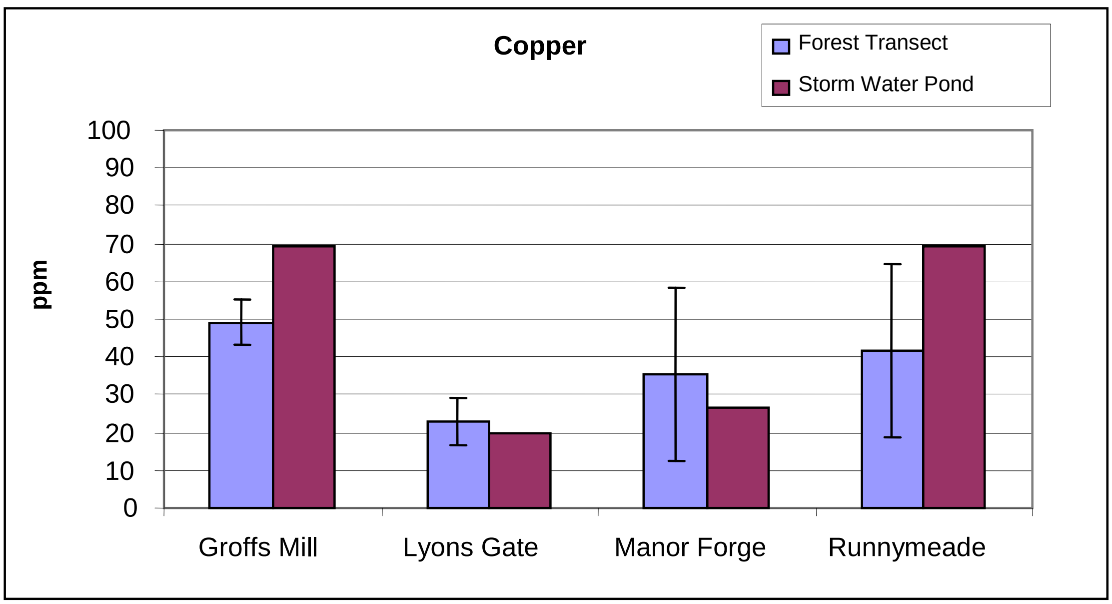


Figure IV. 11: Copper Concentration Comparison: between sites and their nearest neighboring storm water pond. Forest transect represents the average of four samples taken within each site, while storm water pond samples are representative of a single sample taken in each pond. Error Bars denote the 95% confidence level.

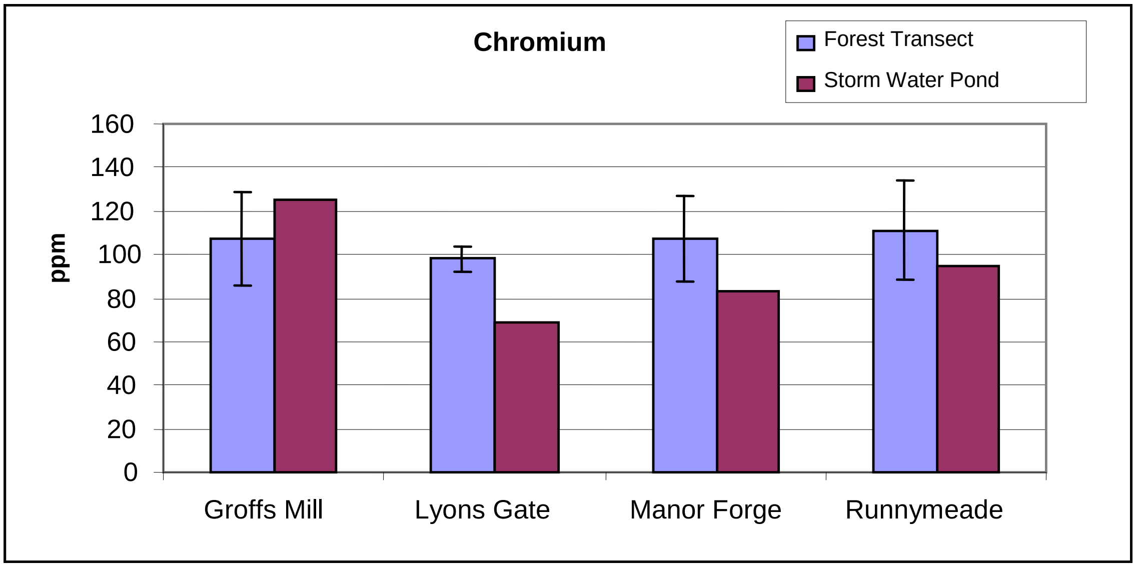


Figure IV. 12: Chromium Concentration Comparison: between sites and their nearest neighboring storm water pond. Forest transect represents the average of four samples taken within each site, while storm water pond samples are representative of a single sample taken in each pond. Error Bars denote the 95% confidence level.

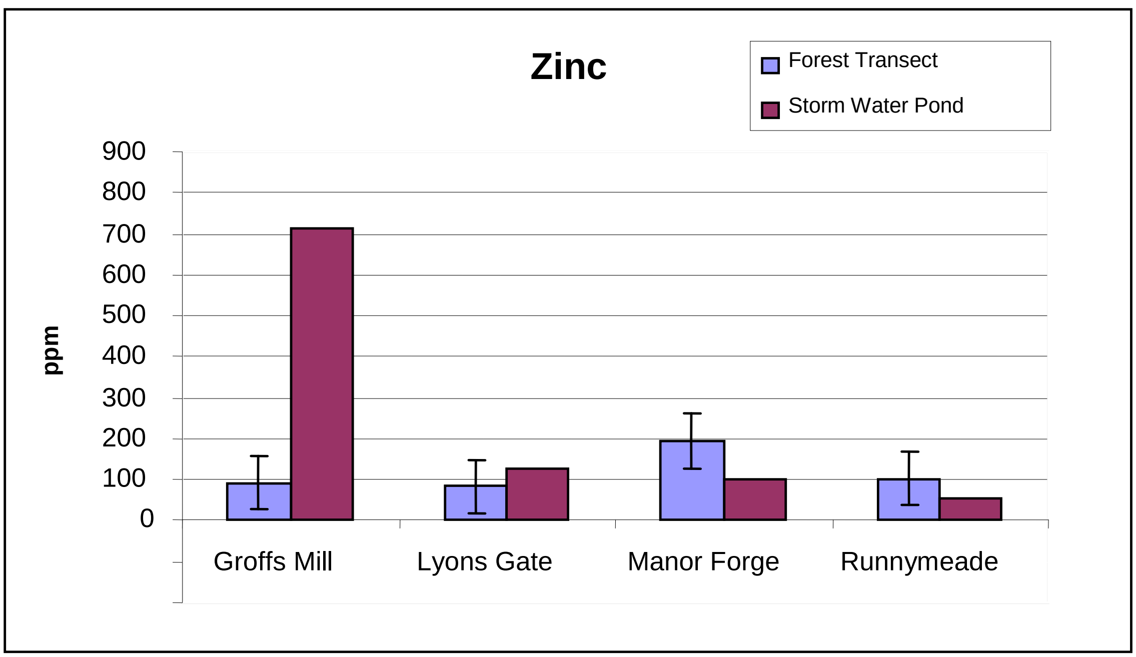


Figure IV. 13: Zinc Concentration Comparison: between sites and their nearest neighboring storm water pond. Forest transect represents the average of four samples taken within each site, while storm water pond samples are representative of a single sample taken in each pond. Error Bars denote the 95% confidence level.

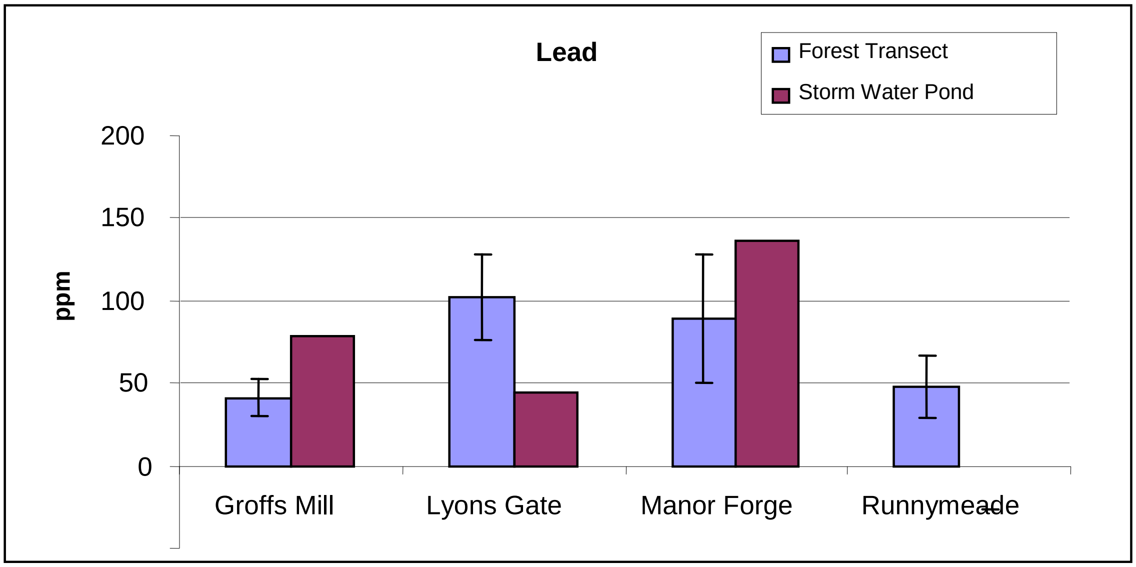


Figure IV. 14: Lead Concentration Comparison: between sites and their nearest neighboring storm water pond. Forest transect represents the average of four samples taken within each site, while storm water pond samples are representative of a single sample taken in each pond. Error Bars denote the 95% confidence level.

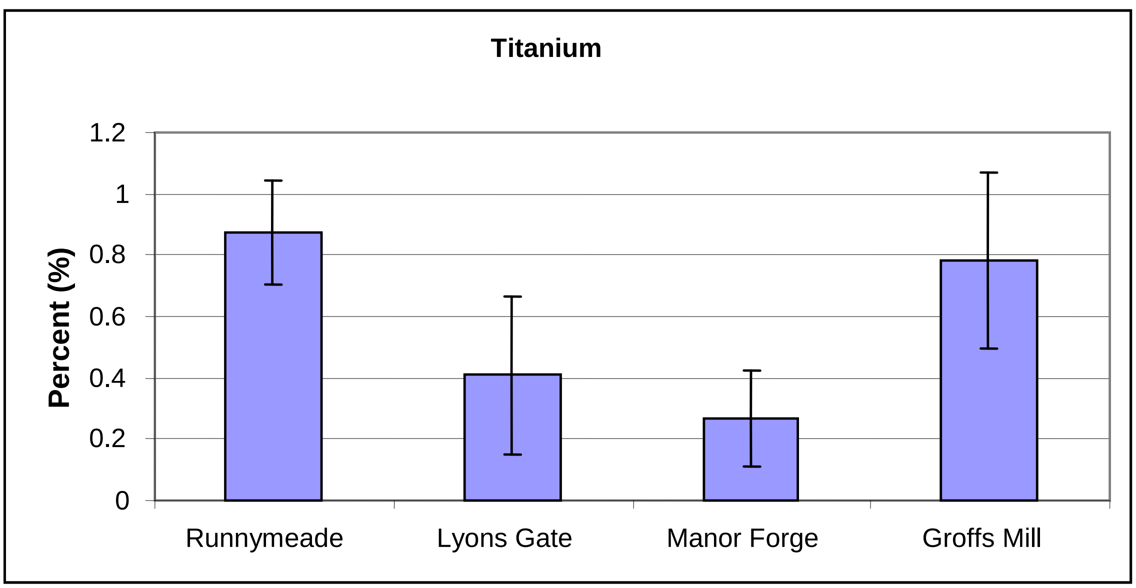


Figure IV. 15: Titanium Concentration Comparison: between the sites sampled. Forest transect represents the average of four samples taken within each site. Error Bars denote the 95% confidence level.

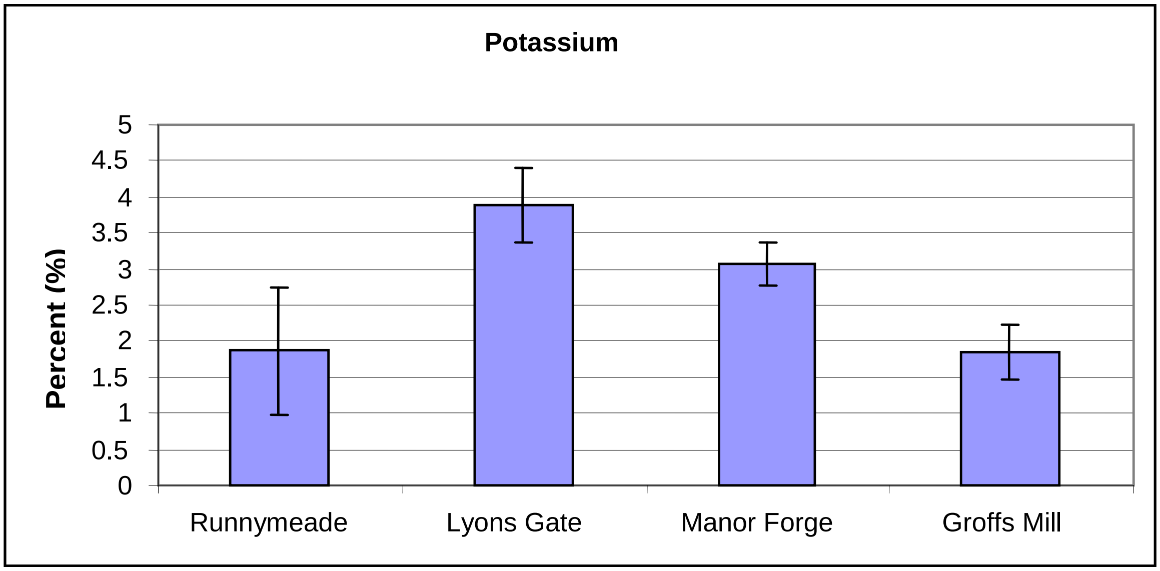


Figure IV. 16: Potassium Concentration Comparison between the sites sampled. Forest transect represents the average of four samples taken within each site. Error Bars denote the 95% confidence level.

IV.E. Discussion

IV. E. 1. Runnymeade

Runnymeade is the western site of the four sampled. According to the 1976 USDA Soil Survey of Baltimore County, Maryland, this forest consists of two soil types. The two soils located here are the Manor series soil on the upland section of the forest and the Glenville series soil located in the flood plain region around the stream. These two soils both grow Tulip Poplar, Sweetgum, Ash, Red Oak, and Red Maple well, but the Glenville soil is somewhat limited to more water tolerant species. We would then expect to find many Sweetgum, Ash, and Red Maple. Most of our tree sampling occurred in the more upland Manor series soil, so one would expect to find all of the trees mentioned above.

We found that this forest does have all of the expected types except for Sweetgum and Ash. One quarter of the 80 trees we sampled were Red Maple, which is likely due to its' water tolerance. The lack of Sweetgum and Ash could be from the noticeably dense canopy cover, as these two species are shade intolerant. The Runnymeade forest also has a high density of trees, being 4.5 trees per square 100 meters, the highest of the four sites. One thing to note is that the northern half of the forest is made up of mostly Tulip Poplar, while the southern half consists of mostly Oaks and Hickories. This suggests either a disturbance has taken place in the northern half or succession has not occurred as in the southern half of the forest.

We also sampled the seedlings and saplings of the forest. From our sampling, we found that Runnymeade has the most seedlings overall with a count of 39, but has the lowest number of saplings with 14. Of these, we found 23 Oak seedlings and only two Oak saplings in our sampling set. This could be due to the high canopy cover which would restrict light that is necessary for sapling growth. The Oak seedlings we found may be waiting for more sunlight in order to grow at a proper rate. Additionally, the northern section, which consists primarily of poplars and also has less seedlings and saplings, is covered by thick underbrush, primarily Multiflora Rose, which could out-compete the seedlings and saplings.

The southern half has more seedlings and saplings and is also more diverse. Along with the Oaks, we found Mockernut Hickory, Shagbark Hickory, and Ironwood. The northern half is predominantly Poplar seedlings and may not survive with the thick underbrush and dense canopy since Poplar seedlings need more light than most other species.

Soil samples of the Runnymeade forest were taken to assess the amount of heavy metals as well as minor nutrients in the soil. Overall, there is nothing out of the ordinary in the soil and minor nutrients, such as zinc and potassium, are around typical levels for this area and not different from the other three sites. In conclusion, we found this forest to be half sustainable. The southern half looks to be very healthy for an urban forest being both diverse and numerous in both adult and juvenile tree species. The northern half of this forest, on the other hand, seems to be trapped in early succession. It consists of mostly Poplar with few seedlings and saplings, most of which are Poplar. The northern half does not appear to be sustainable, possibly because of smothering underbrush, dense canopy cover, and possibly an unknown disturbance.

IV. E. 2. Manor Forge

The next site to be discussed is Manor Forge. This site consists of two soils according to the 1976 USDA Soil Survey of Baltimore County, Maryland. Based on the Codorus flood plain soil and Manor upland soil at this site, one would expect to find a lot of Tulip Poplar, especially in the flood plain, and Oaks more upland. One would also expect to find Red Maple and Ash species here. The trees observed were expected. This forest site consists mostly of Poplar, Red Maple, Oak, Hickories, and Sweetgum. This forest has the highest density of trees with 4.6 per square 100 meters. Also, the trees here are the largest, with a mean basal area of 1400 square centimeters. This is particularly good to see considering that there was a farm, pipeline, and road intersecting this forest in the 1987 Aerial photograph of the area. Seedlings at this site are the second lowest in number, but are mostly Red Maple and Oak. The saplings are the second highest in number of the sites and noticeably diverse. There are saplings of almost every typical Maryland tree species and canopy level here, such as Hickory, Black Cherry, Oak, and Poplar.

In analyzing the soil in this forest, there were a few anomalies to note. Firstly, potassium was significantly higher than Groffs Mill and Runnymeade and virtually identical to Lyons Gate. This is possibly due to the proximity of farm fields located within the watersheds of Lyons Gate and Manor Forge. This could have a positive effect on this forest, but as mentioned earlier, has negative effects in terms of the Chesapeake Bay and its tributaries. Additionally, trace metals in this forest were highly variable, particularly in zinc and copper, two of the most prevalent anthropogenic metals in urban areas.

Though the mean for the forest was not significantly different in comparison to the other three sites, two samples were particularly high in zinc and copper as seen in Figure IV. 7, with one sample having 491ppm and 70ppm respectively. Overall, this forest site seems to be healthy and seems sustainable for the most part. There are numerous and diverse seedlings and saplings and the soil here appears to be good for the trees found at this location. The only minor setback to this forest would be the high metal content in some locations, which could be either a natural characteristic or an anthropogenic source of contaminant.

IV. E. 3. Lyons Gate

Lyons Gate's forest site lies due west of the Manor Forge site. It consists of Codorus flood plain soil and Edgemont upland soils. One would expect to find Tulip Poplar, Red Oak, and Red Maple, mostly in the flood plain area. The Edgemont soil is a very stony loam and has a high slope and acidity with low moisture. One would expect smaller upland trees in this area. We found that the site consists of mostly Poplar, but less than the other sites. Other noteworthy tree species are Red Maple, Black Cherry, and Black Walnut. This forest also has a large amount of smaller upland trees, likely because we sampled on the edge of the two soils, so we found both flood plain and upland species. The density here was very low compared with the other areas with 1.8 trees per square 100 meters. Although it does have a low density of trees, diversity was very high and was 0.99 on the Simpson's diversity index. This forest also looked fairly sparse in the 1987 aerial photograph and was directly adjacent to a farm, suggesting that it is continuing along the same path in succession and density.

The seedlings and saplings at this site will allow insight to whether this forest will be sustainable. First of all, a total of zero seedlings were found at this site. Only 16 saplings, the second lowest amount, were found upon sampling. These consist primarily of Black Cherry, Box Elder, Hickory, Dogwood, and other smaller upland trees. The Black Cherry, especially, will flourish in this stony acidic soil. The only large trees found at this site were Red Maple, Beech, and Sassafras. Again, this is likely due to sampling in or close to the Edgemont soil. If one sampled closer to the stream, some different species may have been found.

In addition to the soil type, the density may have been affected by the abundance of shrub level vegetation which could out-compete seedlings or fledgling saplings. The analysis of the soil again reinforced that this soil is not chemically different than the other three sites and is not atypical to soils in the area. Like Manor Forge, Lyons Gate also has a high Potassium level (see Figure IV. 16) which could be good for the forest itself. Overall, given the soil conditions in this forest, the forest has been sustainable to date, despite possible disturbances in the past. The low number of saplings and zero seedlings in this forest suggests that at least the upland area of the forest may not be sustainable due to an unknown disturbance, growth of non-native species, or presence of underbrush. With the low number of seedlings and saplings, this site could be overrun by underbrush and possibly lose its function as a forest.

IV. E. 4. Groffs Mill

Lastly, the Groffs Mill forest site lies to the north of the other three sites. This site consists of Baile flood plain soils and Manor series upland soils. Both soil types are highly prone to erosion, especially the flood plain soil. The flood plain was expected to have low numbers of trees, primarily Pin Oak and Maple. The Manor upland soil though is good for Poplar, Red Maple, and Oaks though. We did not find any Pin Oaks and only four Maples. Otherwise, the site consists primarily of Poplar, Oak, and Sweetgum. Most of the trees were above the flood plain as expected since the Baile soil has high seedling mortality, heavy erosion, and is usually inundated with water.

There is significant evidence of erosion near the stream here. There is also noticeable disturbance from a sewer line in the forest. Around the manholes, and in some other areas in the forest, large patches of Stiltgrass are present. According to the 1976 USDA Soil Survey of Baltimore County, Maryland, these areas in this soil type are likely to remain as small grasses, such as the Stiltgrass that is currently present, rather than succession by larger hardwood trees. According to the 1987 aerial photo, a large section of a farm field, sewer line, and a road cut through this forest. Based on this level of disturbance, this forest consists of the expected tree species, especially the western section which is where the farm and sewer line were located. The western section of the forest consists mostly of Poplars, more so than the other three sites.

Although this site has low diversity at 3.9 trees per square 100 meters, it has the highest number of seedlings and saplings. We found 29 seedlings along our sampling transect. These consist of Chestnut Oak, Red Maple, and other Oaks. We also found 53 saplings along our sampling transect. These are mostly Maples and Poplars along with some Hickories and Oaks. These data suggest that Groffs Mill is moving along quite well with succession, having some Poplars and mostly Maples for saplings and primarily Oaks and Maples as seedlings.

The soil analysis of this site also revealed no atypical results or differences between the other sites and typical soils in the area. The fairly high level of aluminum is consistent with the poor drainage of the Baile flood plain soil. Aluminum is generally higher in alluvium, of which most topsoil will be washed away as a result of erosion and soil texture in the flood plain. Overall, this site appears to be the most sustainable of the four, given the number of disturbances in the past. The severe erosion potential should be monitored, though, before it becomes unmanageable and damages the forest or stream ecosystem is destroyed.

IV. F. Sustainability of the Forests

Our estimation of forest sustainability was principally based off of the number, diversity, and species types of seedlings and saplings that will succeed the current generation of trees. An accurate assessment of sustainability, given our time to determine this, proved difficult due to the shear number of factors that can affect forest sustainability. We compared what the forest looked like today to preferences of the soil types located in each forest, possible stressors such as runoff and erosion, and past disturbances that could have altered the succession or structure of the forest. Given this information, the only forest that appears not to be sustainable is the Lyons Gate site. A larger study would be needed to fully assess and determine what these forests will look like in 20 or 30 years from now.

An important feature to consider is the presence of storm water retention ponds in Owings Mills. These ponds have been installed over the past 10 to 15 years to collect storm water from roadways. The objective of these ponds is to lower discharge rates into streams to reduce erosion, but the ponds are also known to collect and store urban pollutants, which can effectively keep these out of the forests. Research on these ponds is still ongoing and such information along with forest data will be beneficial for protecting streams in Owings Mills.

V. Recommendations

This project primarily focused on assessing forest sustainability. In completing it, we researched the history, policies, economic impacts, and environmental benefits of Smart Growth development in the Owings Mills area. As we studied the New Town area of Owings Mills, we became aware of future research and public education opportunities. These recommendations will hopefully help Baltimore County in its efforts to protect the riparian areas in Owings Mills.

V. A. Future Research

Further research is necessary to properly assess and monitor the conditions of the forest fragments in Owings Mills. In order for Baltimore County and the Owings Mills area to continue to responsibly develop the land, more information about the health of the forests, streams, and condition of the soils is essential. Our project can be used as a stepping-stone for future research projects.

V. A. 1. Health Indicators

Yearly and continued monitoring of the forests is necessary to track their regeneration. Continued monitoring that follows standardized data collection methods and examines a broader range of forest health indicators, in addition to the species' composition we assessed, would serve as important tools for assessing the health of the forests. There are various forest health indicators, which can be assessed to determine the health and functioning of the forest fragments in further detail. These indicators include: soil quality, amounts of down woody material, and type of vegetation (USFS, 2003). Forest health indicators are significant because they offer a standard of what a healthy forest should be. Each forest health indicator *individually* provides significant information about a forests' health, but in *combination* with one another these indicators can display a very accurate assessment of a forest's health (Bechtold 2003). Our forest and soil surveys are just individual pieces of the forest function puzzle.

V. A. 1a. Soil Quality

When assessing soil quality, data is collected to evaluate the physical and chemical properties of soil and to determine the extent of erosion and compaction (O'Neill and Amacher, 2003). Information concerning the physical and chemical properties of soil provides specific insight about soil quality and forest health (O'Neill and Amacher, 2003). The physical and chemical qualities of the soil can reveal whether declines in forest productivity can be connected to changes in the availability of soil nutrients and water to plants (O'Neill and Amacher, 2003).

V. A. 1b. Down Woody Material

As an indicator, down woody material can be used to monitor and estimate the biomass of down woody material, provide assessment of wildlife habitat dynamics, and estimate forest floor carbon pools, and monitor changes in critical carbon pools for the US (Woodall, 2003).

V. A. 1c. Vegetation

Vegetation, as a health indicator, is significant in determining forest health for a number of reasons (Schulz 2003). Examination of regional vegetation diversity and structure allows for the determination of forest types most prone to invasion by non-native species, the classification of forest community types for both canopy and understory plant species (Schulz, 2003). The forest community types are interconnected with ecosystem properties such as productivity, response to disturbance, and use by wildlife (Schulz, 2003). By monitoring vegetation, forest communities' resistance and flexibility following disturbances can be examined (Schulz, 2003).

V. A. 1d. Invasive Species

More information is needed about the distribution and potential value of invasive species. While invasive species, such as Stiltgrass, are generally unwanted, they may be serving valuable functions along the buffers, such as controlling erosion and acting as sediment traps. These activities are extremely important, especially if forest fragments cannot function as stream buffers should.

Examination of a regional vegetation diversity and structure allows scientists to determine which forest types are most prone to invasion by non-native species (Schulz, 2003). Assessments of the classification of forest community types for both canopy and understory plant species, which are interconnected with ecosystem properties such as productivity, response to disturbance, and use by wildlife, can be made (Schulz, 2003). Vegetation can also be used to study trends over time in relation to other forest health indicators, examine response of forests to disturbance and stresses such as pollution (Schulz, 2003).

V. A. 1e. Impact of Wildlife

The impact of wildlife such as deer, foxes, birds, and squirrels may affect the health, functioning, and regenerating ability of the forests. For example, deer browsing was evidenced at all of the sites we studied and could greatly affect vegetation growth, seed dispersal, and pollination. Foxes act as predators of squirrels and birds and the abundance of these predators and prey species could ultimately affect the health of the forest. Squirrels and birds are critical seed dispersers and their presence could greatly impact the health of the forest.

V. A. 1f. Impact of human disturbance

The impacts of human disturbance on the forests, especially those of road salt, can greatly alter the soil chemistry and plant growth because of the salt's ability to alter soil composition and impact plant health.

V. B. Promoting Forest Regeneration

Regeneration of a forest is essential for the continuity of forest health. Protecting the land, promoting sapling and seedling growth, and removing invasive plants and trash from the forests can be critical tools for ensuring regeneration.

V. B. 1. Saplings and Seedling Regeneration

Saplings and seedlings are indicative of forest regeneration. One way to improve regeneration is by removing invasive plants. Invasive species such as Japanese Stilt Grass and Multiflora Rose can choke seedlings and saplings and prevent their growth. During our research we observed certain areas that were overrun by invasive species. Removal of invasive species and replacement with native under story vegetation could promote the growth of native tree species. While these invasive species may offer some critical functions, they may be interfering with native plant species regeneration and may be altering the functioning capabilities of the forest. Of course great care would have to be taken to prevent erosion after the invasive plants are removed and before native plantings get established.

V. B. 2. Community Involvement

Elementary or middle school students could become involved with the regeneration of their forests by creating and supporting nurseries, in their school yards, of seedlings of trees that are successionally important for the local forests. The trees could be planted in areas where invasive species were removed in order to prevent erosion, future growth of other invasive species, and boost forest regeneration of native plants.

V. B. 3. Replanting

Using the soil analysis (pH, grain size, moisture, etc.), forest fragments could be enhanced by transplanting saplings that are the correct successional stage, prefer the specific soil conditions, and can control erosion and absorb pollutants effectively. Areas that are choked with invasive species should be cleared of them and saplings planted at random in accordance to the density of the surrounding area. That is, saplings should be planted at least 20 meters apart, if that is the average distance between trees in the area. The replanted areas must be kept clear of invasive species, such as stilt grass. These replanting activities could be important supplements to improve forest regeneration.

V. B. 4. Trash Removal

Many of the sites we visited were littered with construction debris, scrap metal, and trash. Construction materials that had been left years after development, such as silt barriers, were observed to be restricting stream flow in some instances. They can also pose a threat to wildlife that can become entangled in them or ingest them. Trash such as metal scraps, appliances, and other discarded materials tarnish the forests and do not motivate efforts to keep areas clean. Trash could also inhibit vegetation growth and leach harmful chemicals into soils. Community clean-ups could coincide with tree plantings to beautify the forests and to create functional habitats for the vegetation and wildlife of the area.

V. C. Enforcement and Land Use

During our research, we noticed several places where buffers were less than 100 feet from the stream. While these properties may have been built prior to environmental restrictions on the land, efforts should be made to maintain uniform 100 feet buffers through out the New Town area.

V. C. 1. Community Responsibility

Home Owners Associations (HOAs) or apartment complex management should be given responsibility for the health of their 'neighboring' forest and held responsible for heavy fertilizer use, tree loss, erosion, and infringement of the buffers. Homeowners could be encouraged to plant barren areas of their yards with native trees and could use the sapling banks from the schools.

V. C. 2. Conservation Easements

Conservation easements can be powerful tools in protecting natural resources on private property upon consent of the property owner. An easement is a legally binding agreement that restricts specific development, residential or commercial on private property (Schear and Blaine, no date). The easement involves a forfeit of certain property rights by the property owner while making the property owner responsible for the maintenance and enforcement of environmental protections on the land (Schear and Blaine, no date). Federal tax credits are available to land owners who "donate" land as easements and can be a great incentive in promoting landowners to consent to some resignation of their land use. Easements become formal wording in the property deed and are passed on to future homeowners (Schear and Blaine, no date). Easements could be promoted by Baltimore County as a way of maintaining the riparian buffers and managing development.

V. D. Educational Programs

Residents who understand the components and importance of features in their environment will be able to act more responsibly and appropriately towards the natural environment of Owings Mills. Education can occur through pamphlets and community programs aimed at involving the public with forest conservation as well as helping them feel some ownership of their area (Jack Dillon, personal communication October, 2007).

V. D. 1. Information Distribution

Residents of Owings Mills area, both those living in single-family homes or in condominiums, should be made aware of the nearby forest fragments and their importance to them as residents. An educational pamphlet with a described walking trail can present information about the different species of trees that are present in these forests, predominant wildlife, and their essential functions. In addition, residents should be informed about the conditions that may potentially cause stress to the health of the forests and their effects, such as heavy metal pollution, road salt sources, invasive species, and nutrient runoff from fertilizer use. Local high school students or Boy Scout/Girl Scout troops could create these pamphlets or booklets and the managerial staff of the Owings Mills condominiums should be asked to distribute these information sources to the residents. In addition, DEPRM, or other environmental organizations knowledgeable about the surrounding forests, should request that the managerial staff of the Owings Mills condominiums conduct meetings with their employees and residents to inform them about the current state of the forests.

V. D. 2. Creation of Red Run Watershed Association

A Red Run Watershed Association could be created in the community. Such an organization could mirror the activities and organization of other local community organizations, like the Gwynn's Fall Watershed Association (GFWA). The GFWA participates in education and community activities related to the watershed as well as restore streams and advocated stream health (Gwynn's Fall Watershed Association, 2004). More information on the GFWA can be found online at http://www.Gwynn's Falls Watershed Associationfalls.net/home/.

V. D. 3. BayScape

Residents need to be aware that riparian buffers need to be 100 feet on either side of the stream. These residents should be informed of their impact on the buffers and aware of the consequences of infiltrating these buffers. Individual homeowners and landscape managers could be educated about the various landscape options that promote native plant species and reduce the need for excessive watering and fertilizer use. Programs such as BayScape offer resources for homeowners. If homeowners understand the purpose and functioning abilities of riparian buffers, they may be more cautious of their habits. More information on BayScape can be found at http://www.fws.gov/chesapeakebay/ bayscapes.htm.

V. D. 4. Promoting Ownership and Forest stewardship

Activities that help residents to develop a sense of ownership of the forests will help improve and maintain the forest buffers. The local elementary school could design an "Adopt a

Forest" program where a fifth grade, or appropriate grade level, science class is assigned a forest fragment to keep clean. The forest could serve as an extension of the classroom and students could learn of the importance of forests, the Chesapeake Bay, and wildlife in the area. This program could also incorporate the seedling nurseries. Students will feel pride for "their" forest. Similarly community groups, such as the proposed Red Run Watershed Association, could organize periodic forest clean-ups. Another way to establish ownership and pride in the area is by designing trails through the woods, linking neighborhoods and making the community feel more close-knit. Closing the gap between the residents and the environment will provide the residents with pride, understanding, and a true sense of stewardship for the forests.

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Appendix 1 Raw Data from Tree Sampling at each Site.

Runnymeade: October 2, 2007

Point No.	GPS Coordinates	Quadrant	Tree species	Distance to tree (m)	DBH (cm)	Saplings	#	Seedlings	#
1	N 39 23.770' W 76 48.867'	NW	Mockernut Hickory	9.2	23.0			Black Oak	1
		NE	Shingle Oak	4.0	16.0				
		SE	Tulip Poplar	3.5	13.7				
		SW	Red Oak	5.3	45.0				
2	N 39 23.756' W 76 48.863'	NW	Red Maple	2.0	24.3	Red Oak	1	White Oak	1
		NE	Tulip Poplar	4.8	37.0			Sassafras	1
		SE	White Oak	9.5	26.2			Black Oak	3
		SW	Red Oak	13.0	54.8				
3	N 39 23.765' W 76 48.874'	NW	Tulip Poplar	7.5	27.0			Black Oak	1
		NE	Red Maple	3.8	13.2			White Oak	1
		SE	Tulip Poplar	4.5	41.4				
		SW	Red Maple	1.5	14.8				
4	N 39 23.765' W 76 48.885'	NW	Red Maple	5.5	13.4			Sassafras	1
		NE	Red Maple	3.0	12.2			Black Cherry	1
		SE	Red Oak	2.3	39.5				
		SW	Red Maple	3.3	24.2				

5	N 39 23.777' W 76 48.904'	NW	Red Maple	4.6	10.4			Black Oak	1
		NE	Tulip Poplar	6.0	18.5			Sassafras	1
		SE	Red Oak	6.2	44.2				
		SW	Mockernut Hickory	8.0	20.1				
6	N 39 23.781' W 76 48.921'	NW	White Oak	2.8	64.2	Mockernut Hickory	1	Red Maple	1
		NE	Red Oak	8.5	52.4				
		SE	White Oak	2.8	33.9				
		SW	Red Oak	9.5	50.2				
7	N 39 23.791' W 76 48.931'	NW	Red Maple	9.0	51.5			Chestnut Oak	2
		NE	Tulip Poplar	1.3	54.8			Hornbeam	3
		SE	Tulip Poplar	7.8	42.1				
		SW	Shingle Oak	9.5	11.2				
8	N 39 23.785' W 76 48.948'	NW	Mockernut Hickory	3.0	23.5	Red Maple	1	White Oak	4
		NE	Tulip Poplar	6.5	63.9	Hornbeam	1		
		SE	Shingle Oak	3.0	38.3				
		SW	Red Maple	10.5	18.0				
9	N 39 23.790' W 76 48.958'	NW	Tulip Poplar	1.3	61.9	White Oak	1	White Oak	1
		NE	Red Maple	0.6	17.0				
		SE	Tulip Poplar	6.0	26.2				

	SW	Red Maple	6.2	14.0				
10 N 39 23.88' W 76 48.965'	NW	Red Maple	2.6	16.0			Mockernut Hickory	1
	NE	Red Oak	5.1	31.5			Shagbark Hickory	1
	SE	Shagbark Hickory	4.6	29.7				
	SW	Red Maple	6.2	18.2				
11 N 39 23.805' W 76 49.971'	NW	White Oak	3.6	13.0	Hornbeam	2	Red Oak	1
	NE	Tulip Poplar	2.0	27.0				
	SE	Tulip Poplar	5.6	17.5				
	SW	Red Maple	3.5	10.6				
12 N 39 23.810' W 76 48.750'	NW	Tulip Poplar	5.5	22.0			Black Oak	1
	NE	Black Cherry	3.4	28.7			White Oak	1
	SE	Red Maple	3.0	10.8				
	SW	Tulip Poplar	8.0	38.2				
13 N 39 23.803' W 76 48.946'	NW	Tulip Poplar	0.6	30.2			Red Oak	2
	NE	Tulip Poplar	4.6	10.7				
	SE	Tulip Poplar	3.3	23.0				
	SW	Tulip Poplar	1.2	18.0				

14	N 39 23.806' W 76 48.929'	NW	Tulip Poplar	5.2	63.0				
		NE	Tulip Poplar	4.0	43.7				
		SE	Tulip Poplar	5.4	41.2				
		SW	Red Maple	2.8	30.0				
15	N 39 23.798' W 76 48.920'	NW	Tulip Poplar	4.7	38.2	Hornbeam	4		
		NE	Shagbark Hickory	5.5	35.2				
		SE	Tulip Poplar	5.3	72.5				
		SW	Tulip Poplar	4.0	24.0				
16	N 39 23.793' W 76 48.907'	NW	White Oak	6.8	58.0	Black Cherry	1	Black Cherry	2
		NE	Tulip Poplar	6.9	20.5	Hornbeam	1	White Oak	2
		SE	White Oak	2.7	51.9				
		SW	Tulip Poplar	5.0	58.0				
17	N 39 23.793' W 76 48.895'	NW	Red Maple	3.0	12.5				
		NE	Tulip Poplar	2.7	23.8				
		SE	Tulip Poplar	1.0	11.0				
		SW	Shingle Oak	7.8	53.3				
18	N 39 23.791' W 76 48.886'	NW	Tulip Poplar	5.1	15.0				
		NE	Tulip Poplar	2.4	38.2				
		SE	Tulip Poplar	2.8	19.8				

		SW	Tulip Poplar	2.6	10.5				
19	N 39 23.778' W 76 48.864'	NW	Shagbark Hickory	3.3	10.0			White Oak	1
		NE	Tulip Poplar	3.7	16.2			Hornbeam	1
		SE	Red Maple	2.6	27.8				
		SW	Red Maple	2.0	10.9				
20	N 39 23.775' W 76 48.885'	NW	White Oak	2.5	28.5	Black Cherry	1	Red Oak	2
		NE	White Oak	7.3	51.7			Black Cherry	1
		SE	Mockernut Hickory	6.0	27.5				
		SW	Red Maple	6.0	29.0				
Totals				377.2	2408.8		14		39

Manor Forge: October 7, 2007

Point No.	GPS Coordinates	Quadrant	Tree species	Distance to tree (m)	DBH (cm)	Saplings	#	Seedlings	#
1	N 39 23.773' W 76 47.937'	NW	Tulip Poplar	3.3	20.4	Mockernut Hickory	2		
		NE	Tulip Poplar	2.1	71.5	Sassafras	1		
		SE	Red Maple	5.7	11.4	Black Cherry	1		
		SW	Red Oak	7.8	53.9				
2	N 39 23.792'	NW	Red Oak	5.5	64.8	Spice Bush	1	Red Oak	1

	W 76 47.930'								
		NE	Red Maple	7.0	19.4				
		SE	Tulip Poplar	4.5	74.7				
		SW	Sassafras	1.8	15.6				
3	N 39 23.791' W 76 47.926'	NW	Tulip Poplar	11.4	20.5			Red Oak	3
		NE	American Ash	3.3	24.4				
		SE	Red Oak	1.7	62.0				
		SW	Dogwood	0.8	12.0				
4	N 39 23.811' W 76 47.936'	NW	Tulip Poplar	5.5	13.3				
		NE	Tulip Poplar	3.3	73.0				
		SE	Tulip Poplar	5.6	76.3				
		SW	Red Maple	6.9	14.6				
5	N 39 23.780' W 76 47.960'	NW	Mockernut Hickory	6.0	24.4			Red Oak	2
		NE	Red Maple	8.7	20.6			Spicebush	1
		SE	Black Gum	8.7	11.1				
		SW	Tulip Poplar	3.5	76.0				
6	N 39 23.826' W 76 47.929'	NW	Tulip Poplar	6.5	44.4	Black Cherry	2	Mockernut Hickory	1
		NE	Mockernut Hickory	2.2	18.0				
		SE	Pignut Hickory	6.0	53.0				

		SW	Mockernut Hickory	2.3	11.3				
7	N 39 23.829' W 76 47.904'	NW	Tulip Poplar	6.1	22.9	Black Cherry	2	Mockernut Hickory	1
		NE	Tulip Poplar	0.4	10.3				
		SE	Mockernut Hickory	4.9	30.5				
		SW	Tulip Poplar	0.8	10.4				
8	N 39 23.855' W 76 47.894'	NW	Tulip Poplar	1.6	25.4	Iron Wood	1		
		NE	Bitternut Hickory	3.9	35.4	Black Cherry	1		
		SE	Black Locust	6.8	12.7				
		SW	Mockernut Hickory	6.5	33.4				
9	N 39 23.857' W 76 47.893'	NW	Tulip Poplar	3.2	62.1	Tulip Poplar	1		
		NE	Bitternut Hickory	8.3	47.0	Black Cherry	2		
		SE	White Oak	6.5	73.3				
		SW	Black Gum	3.2	47.0				
10	N 39 23.869' W 76 47.820'	NW	Black Gum	3.1	12.4	Tulip Poplar	1		
		NE	Tulip Poplar	3.1	32.3				
		SE	Tulip Poplar	2.7	15.6				
		SW	Tulip Poplar	2.7	39.8				

11	N 39 23.897' W 76 47.909'	NW	Tulip Poplar	7.2	25.5	Black Locust	1		
		NE	Black Cherry	4.7	18.6	Black Cherry	1		
		SE	Red Maple	5.6	27.0				
		SW	Black Gum	3.8	11.5				
12	N 39 23.848' W 76 47.880'	NW	Red Maple	11.8	18.2				
		NE	Tulip Poplar	8.1	20.0				
		SE	Tulip Poplar	2.7	93.4				
		SW	Tulip Poplar	3.7	29.2				
13	N 39 23.884' W 76 47.870'	NW	Black Ash	5.7	37.8	Black Cherry	1		
		NE	Tulip Poplar	2.9	14.8	Tulip Poplar	1		
		SE	Red Oak	5.6	39.5				
		SW	Red Oak	2.6	14.9				
14	N 39 23.838' W 76 47.873'	NW	Mockernut Hickory	3.9	24.5	Black Gum	1	White Oak	1
		NE	Red Oak	0.5	53.6			Mockernut Hickory	1
		SE	Tulip Poplar	5.3	56.3				
		SW	Tulip Poplar	5.4	35.3				
15	N 39 23.828' W 76 47.878'	NW	Tulip Poplar	5.2	26.4				
		NE	Tulip Poplar	2.0	38.9				

		SE	Red Maple	7.3	51.4				
		SW	Black Gum	1.5	26.4				
16	N 39 23.802' W 76 47.987'	NW	Tulip Poplar	4.9	68.0	White Oak	2		
		NE	Chestnut Oak	5.8	59.8	Chestnut Oak	7		
		SE	White Oak	3.7	42.9				
		SW	Tulip Poplar	6.3	63.0				
17	N 39 23.794' W 76 47.908'	NW	White Oak	4.9	78.8				
		NE	Norway Maple	7.1	41.2				
		SE	Chestnut Oak	4.4	22.0				
		SW	Tulip Poplar	6.7	42.0				
18	N 39 23.680' W 76 47.992'	NW	Red Maple	2.4	25.2	Tulip Poplar	1	Black Gum	1
		NE	Tulip Poplar	4.5	24.8				
		SE	White Oak	4.1	42.6				
		SW	Red Oak	4.9	77.0				
19	N 39 23.676' W 76 47.989'	NW	Pignut Hickory	5.6	42.4	Tulip Poplar	1		
		NE	Tulip Poplar	4.7	26.9				
		SE	Norway Maple	3.4	15.3				
		SW	Red Maple	4.8	50.1				

20	N 39 23.668' W 76 48.002'	NW	Norway Maple	3.0	58.0				
		NE	Tulip Poplar	3.8	22.3				
		SE	Norway Maple	3.9	34.5				
		SW	Tulip Poplar	3.9	29.8				
Totals				**371.7**	**2926.9**		**31**		**12**

Lyon's Gate: October 1, 2007

Point No.	GPS Coordinates	Quadrant	Tree species	Distance to tree (m)	D.B.H (cm)	Saplings	#	Seedlings	#
1	N 39 29.835' W 76 48.297'	NW	Mockernut Hickory	8.6	43.0				
		NE	Tulip Poplar	1.7	45.0				
		SE	Red Maple	10.6	22.6				
		SW	Black Walnut	7.5	28.0				
2	N 39 23.811' W 76 48.237'	NW	Box Elder	5.0	14.5				
		NE	Tulip Poplar	14.2	89.5				
		SE	Tree of Heaven	11.0	45.7				
		SW	Black Walnut	1.5	34.0				
3	N 39 23.806' W 76 48.284'	NW	Box Elder	2.9	15.2				
		NE	Black Locust	15.4	35.0				
		SE	Tulip Poplar	13.1	44.5				

		SW	Box Elder	5.9	23.0				
4	N 39 23.790' W 76 48.280'	NW	Honey Locust	4.3	26.0				
		NE	Black Walnut	7.5	49.0				
		SE	Red Maple	7.3	22.5				
		SW	Honey Locust	15.3	32.0				
5	N 39 23.776' W 76 48.260'	NW	Tulip Poplar	10.0	36.5	Box Elder	1		
		NE	Red Oak	2.9	27.5				
		SE	Black Cherry	7.9	38.0				
		SW	Black Cherry	2.1	26.5				
6	N 39 23.759' W 76 48.268'	NW	Tulip Poplar	8.5	14.5				
		NE	Bradford Pear	9.0	35.0				
		SE	Tulip Poplar	7.2	33.0				
		SW	Box Elder	7.2	22.5				
7	N 39 23.771' W 76 48.261'	NW	Black Walnut	12.4	68.0	Pignut Hickory	1		
		NE	Red Maple	6.8	88.0	Black Cherry	1		
		SE	Pignut Hickory	12.2	33.5	Box Elder	3		
		SW	Pignut Hickory	8.3	24.5				

8	N 39 23.768’ W 76 48.234’	NW	Tulip Poplar	4.4	44.0	Black Cherry	1		
		NE	White Ash	6.1	46.0	Dogwood	1		
		SE	White Ash	6.3	44.5				
		SW	Tulip Poplar	4.4	51.0				
9	N 39 23.746’ W 76 48.249’	NW	Honey Locust	7.0	16.0	Black Cherry	2		
		NE	Tulip Poplar	5.1	53.5	Sassafras	1		
		SE	Black Cherry	1.3	35.0	Red Maple	1		
		SW	Black Cherry	1.7	20.0				
10	N 39 23.739’ W 76 48.231’	NW	Black Cherry	4.1	30.0				
		NE	Bradford Pear	5.9	23.5				
		SE	Willow	7.8	44.0				
		SW	Red Maple	4.8	25.0				
11	N 39 23.755’ W 76 48.235’	NW	Red Maple	4.6	25.0				
		NE	Black Walnut	8.4	26.0				
		SE	Tulip Poplar	11.6	33.0				
		SW	Tulip Poplar	3.8	19.0				
12	N 39 23.768’ W 76 48.237’	NW	Black Walnut	14.2	62.5				
		NE	Tulip Poplar	11.9	35.5				
		SE	White Mulberry	12.4	17.0				

		SW	Red Maple	13.0	22.1				
13	N 39 23.780’ W 76 48.245’	NW	Tulip Poplar	10.6	33.0				
		NE	Tulip Poplar	7.9	39.0				
		SE	Black Cherry	5.0	35.0				
		SW	Tulip Poplar	9.5	35.5				
14	N 39 23.785’ W 76 48.253’	NW	Red Maple	9.0	15.0	Dogwood	1		
		NE	White Ash	10.5	28.5				
		SE	Red Maple	7.5	16.2				
		SW	Beech	5.4	30.5				
15	N 39 23.796’ W 76 48.258’	NW	Black Cherry	6.8	30.5	Beech	1		
		NE	Black Cherry	8.0	16.4				
		SE	Black Walnut	7.1	35.0				
		SW	Black Cherry	1.9	13.3				
16	N 39 23.808’ W 76 48.258’	NW	Cucumber	10.9	27.0				
		NE	White Oak	3.3	16.5				
		SE	Tulip Poplar	9.5	75.3				
		SW	Tulip Poplar	10.1	40.4				
17	N 39 23.810’	NW	Tulip Poplar	3.9	16.5	Dogwood	1		

	W 76 48.267’								
		NE	Tulip Poplar	4.2	70.0	Pignut Hickory	2		
		SE	Tulip Poplar	14.8	75.8				
		SW	Black Walnut	6.0	33.3				
18	N 39 23.816’ W 76 48.272’	NW	Cucumber	7.1	15.0				
		NE	Tulip Poplar	9.7	69.0				
		SE	Tulip Poplar	3.8	44.0				
		SW	Sassafras	11.8	31.5				
19	N 39 23.840’ W 76 48.290’	NW	Tulip Poplar	5.7	26.5				
		NE	White Oak	6.5	49.0				
		SE	Tulip Poplar	6.7	19.0				
		SW	Birch	6.9	26.0				
20	N 39 23.846’ W 76 48.282’	NW	Red Maple	6.6	18.2				
		NE	Beech	4.2	62.0				
		SE	Tulip Poplar	7.2	27.0				
		SW	Tulip Poplar	7.7	33.0				
Totals				**600.9**	**2792.5**		**17**		**0**

Groff's Mill: October 1, 2007

Point No.	GPS Coordinates	Quadrant	Tree species	Distance to tree	DBH	Saplings		Seedlings	#
1	N 39 24.188' W 76 48.298'	NW	Tulip Poplar	3.1	21.5				
		NE	Tulip Poplar	0.4	13.1	Mulberry	1		
		SE	Tulip Poplar	5.0	12.5	Pignut Hickory	1		
		SW	Tulip Poplar	5.5	19.0	Chestnut Oak	1		
2	N 39 24.195' W 76 48.276'	NW	Tulip Poplar	2.8	20.4	Tulip Poplar	3		
		NE	Tulip Poplar	4.1	11.1	Black Cherry	1		
		SE	Tulip Poplar	9.0	18.5				
		SW	Tulip Poplar	4.0	24.6				
4	N 39 24. 200' W 76 48.271'	NW	Black Cherry	2.2	12.5	Tulip Poplar	2		
		NE	Tulip Poplar	6.4	20.5	Chestnut Oak	1		
		SE	Tulip Poplar	3.1	20.5				
		SW	Sycamore	2.2	31.5				
5	N 39 24.214' W 76 48.251'	NW	Tulip Poplar	3.2	72.4	American Basswood	1		
		NE	Tulip Poplar	4.4	21.3				
		SE	Sassafras	3.7	12.5				

	SW	Tulip Poplar	2.6	27.5				
6 N 39 24.223' W 76 48.251'	NW	Tulip Poplar	0.5	71.5				
	NE	Tulip Poplar	6.7	10.5				
	SE	Tulip Poplar	3.5	42.0				
	SW	Tulip Poplar	1.3	52.5				
7 N 39 24.229' W 76 48.227'	NW	Mulberry	18.0	12.0	Pignut Hickory	2		
	NE	Tulip Poplar	1.6	11.6	Red Maple	1		
	SE	Tulip Poplar	4.1	32.0	Tulip Poplar	1		
	SW	Tulip Poplar	2.5	41.0	Black Cherry	1		
8 N 39 24.231' W 76 48.223'	NW	Tulip Poplar	5.0	10.0	Water Birch	1		
	NE	Tulip Poplar	4.5	12.0				
	SE	Tulip Poplar	2.7	18.0				
	SW	Pignut Hickory	3.5	24.0				
9 N 39 24.239' W 76 48.215'	NW	Pignut Hickory	15.0	26.0	Red Maple	1		
	NE	Tulip Poplar	13.0	12.0				
	SE	Red Maple	4.7	11.0				
	SW	Pignut Hickory	4.7	34.0				

10	N 39 24. 245' W 76 48.203'	NW	Pignut Hickory	4.0	34.1	Pignut Hickory	3		
		NE	White oak	6.0	36.4				
		SE	Chestnut oak	1.3	69.0				
		SW	Pignut Hickory	1.1	34.0				
11	N 39 24. 249' W 76 48.186'	NW	Tulip Poplar	1.6	26.0	Red Maple	1		
		NE	Red Maple	3.2	27.0				
		SE	Red Oak	4.2	21.5				
		SW	Pignut Hickory	3.3	21.0				
12	N 39 24.162' W 76 48.279'	NW	Tulip Poplar	4.3	19.0	Beech	3		
		NE	Chestnut Oak	2.2	12.9	White Oak	2		
		SE	Tulip Poplar	4.9	10.2	Black Cherry	2		
		SW	Tulip Poplar	2.8	27.5				
13	N 39 24.185' W 76 48.272'	NW	Tulip Poplar	3.7	18.8	Tulip Poplar	1		
		NE	Tulip Poplar	3.6	15.0				
		SE	Tulip Poplar	1.0	11.2				
		SW	Tulip Poplar	1.6	15.0				
14	N 39 24.189' W 76 48.257'	NW	Tulip Poplar	4.0	28.8	Chestnut Oak	1		
		NE	Tulip Poplar	2.0	26.0	Red Maple	2		

		SE	Black gum	1.3	11.3	Black Cherry	1		
		SW	Black gum	3.0	11.7	Black Gum	1		
15	N 39 24.191' W 76 48.253'	NW	Red Oak	6.7	53.8	Pignut Hickory	2		
		NE	Pignut Hickory	2.2	11.2	White Oak	1		
		SE	Red Oak	2.8	55.4	Red Maple	1		
		SW	Red Maple	6.6	13.0				
16	N 39 24.191’ W 76 48.245'	NW	Chestnut Oak	5.0	16.1	Tulip Poplar	1	Chestnut Oak	1
		NE	Black gum	9.7	10.6	Chestnut Oak	1		
		SE	Tulip Poplar	5.5	24.6	Red Maple	1		
		SW	Pignut Hickory	3.5	32.7				
17	N 39 24.202' W 76 48.225'	NW	Tulip Poplar	8.9	21.0	Chestnut Oak	1	Red Maple	6
		NE	Black gum	3.5	10.3	Magnolia	1	Black Oak	1
		SE	Tulip Poplar	11.5	57.7	Tulip Poplar	1		
		SW	Red Oak	7.3	49.9				
18	N 39 24.211' W 76 48.224'	NW	Tulip Poplar	6.6	28.7	Chestnut Oak	1	Pignut Hickory	3
		NE	Chestnut oak	11.5	33.5	Pignut Hickory	1	Chestnut Oak	3
		SE	Chestnut oak	1.4	50.5	Red Maple	1	Red Maple	1

		SW	Tulip Poplar	9.5	57.3	Black Gum	1		
19	N 39 24.213', W 76 48.204'	NW	Red Oak	8.0	47.8	Red Maple	2	Black Oak	2
		NE	Red maple	7.0	15.3			Chestnut Oak	5
		SE	Red Oak	10.3	42.6			Red Maple	3
		SW	Chestnut oak	2.3	27.8				
20	N 39 24.222' W 76 48.181'	NW	Tulip Poplar	10.3	16.9	Red Maple	1	White Oak	1
		NE	Tulip Poplar	14.0	14.6			Chestnut Oak	1
		SE	Chestnut oak	5.0	30.3				
		SW	Chestnut oak	2.8	49.1				
21	N 39 24.225' W 76 48.176'	NW	Tulip Poplar	10.0	10.2	Chestnut Oak	1	Chestnut Oak	1
		NE	Tulip Poplar	11.1	11.0			Red Maple	1
		SE	Tulip Poplar	6.6	61.2				
		SW	Red Oak	3.3	29.0				
Totals				**405.0**	**2138.0**		**53**		**29**

Appendix 2: Seedling and sapling count at each sampling site.

Seedlings			**Saplings**		
Site	**Species**	**Number**	**Site**	**Species**	**Number**
Runnymeade	Black Cherry	4	**Runnymeade**	Black Cherry	2
	Black Oak	7		Hornbeam	8
	Chestnut Oak	2		Mockernut Hickory	1
	Hornbeam	4		Red Maple	1
	Mockernut Hickory	1		Red Oak	1
	Red Maple	1		White Oak	1
	Red Oak	5		Total	14
	Sassafras	3			
	Shagbark Hickory	1	**Manor Forge**	Black Cherry	10
	White Oak	11		Black Gum	1
	Total	**39**		Black Locust	1
				Chestnut Oak	7
Manor Forge	Black Gum	1		Ironwood	1
	Mockernut Hickory	3		Mockernut Hickory	2
	Red Oak	6		Sassafras	1
	Spicebush	1		Spicebush	1
	White Oak	1		Tulip Poplar	5
	Total	**12**		White Oak	2
				Total	**31**
Lyon's Gate	**Total**	**0**			
			Lyon's gate	Beech	1
Groff's Mill	Black Oak	3		Black Cherry	4
	Chestnut Oak	11		Box Elder	4
	Pignut Hickory	3		Dogwood	2
	Red Maple	11		Pignut Hickory	3
	White Oak	1		Red Maple	1
	Total	**29**		Sassafras	1
				Total	**16**
			Groff's Mill	American Basswood	1
				Beech	3
				Black Cherry	5

				Black Gum	2
				Chestnut Oak	7
				Magnolia	1
				Mulberry	1
				Pignut Hickory	9
				Red Maple	11
				Tulip Poplar	9
				Waterbirch	1
				White Oak	3
				Total	**53**

Appendix 3: Trace metal data for each sampling site. RP denotes the respective retention pond for each site.

Sample	Ti (%)	V (PPM)	Cr (PPM)	Ni (PPM)	Cu (PPM)	Zn (PPM)	Pb (PPM)
GM 1	0.6556	190.86	89.19	76.82	55.47	109.59	40.39
GM 2	0.7529	228.55	116.03	53.4	44.6	100.66	46.47
GM 3	0.7984	243.44	133.64	49.97	43.43	81.06	25.75
GM 4	0.5642	168.47	88.8	61.63	53.1	80	51.98
RP GM 5	0.5498	168.64	125.39	76.6	69.31	711.82	78.64
1-4 Mean	0.692775	207.83	106.915	60.455	49.15	92.8275	41.1475
St. Dev	0.104379	34.32483	21.90615	11.9569	6.026768	14.66684	11.30382
95% C.I.	0.10229	33.63769	21.46762	11.71754	5.906121	14.37323	11.07753
LG 1	0.957	256.29	96.79	36.28	29.04	72.73	94.45
LG 2	0.7983	211.58	100.78	44.6	25.03	113.48	79.83
LG 3	0.4589	97.15	90.05	24.16	14.1	46.81	140.95
LG 4	0.7644	199.38	104.33	45.04	24.25	104.17	95.4
RP LG 5	0.5247	127.65	69.08	31.34	19.63	126.96	44.69
1-4 Mean	0.74465	191.1	97.9875	37.52	23.105	84.2975	102.6575
St. Dev	0.208178	67.24167	6.122725	9.775889	6.359531	30.47214	26.50437
95% C.I.	0.20401	65.89559	6.000156	9.580189	6.232222	29.86213	25.97379
MF 1	0.729	187.23	126.53	46.92	24.27	97.32	82.01
MF 2	0.6543	172.93	111.78	38.54	20.67	97.73	62.62
MF 3	0.5371	124.29	78.5	33.5	25.66	90.97	146.94
MF 4	0.6548	184.74	112.62	79.58	70.16	490.58	64.33
RP MF 5	0.6361	153.69	83.23	35.44	26.62	98.78	136.03
1-4 Mean	0.6438	167.2975	107.3575	49.635	35.19	194.15	88.975
St. Dev	0.07932	29.34232	20.39275	20.71643	23.40797	197.6442	39.62497
95% C.I.	0.077733	28.75493	19.98451	20.30172	22.93937	193.6877	38.83173
RM 1	1.0607	288.54	87.23	32.03	21.46	135.29	39.46
RM 2	1.254	336.72	117.09	39.25	27.16	78.37	71.2
RM 3	0.88	267.52	140.74	58.39	44.42	90.72	27.23
RM 4	0.5006	169.89	98.81	91.52	73.52	108.56	53.01
RP RM 5	0.581	186.22	95.05	61.35	69.52	54.79	0
1-4 Mean	0.923825	265.6675	110.9675	55.2975	41.64	103.235	47.725
St. Dev	0.320827	70.11507	23.34638	26.58654	23.38779	24.70339	18.86233
95% C.I.	0.314405	68.71147	22.87902	26.05431	22.9196	24.20886	18.48473
SRM 2709 (1)	0.345	117.01	122.22	95.63	41.62	97.91	31.82
SRM 2709 (1)	0.3459	116.56	122.12	94.68	40.67	96.61	28.74
STD	0.342	112	130	88	34.6	106	18.9
DEV	0.024	5	4	5	0.7	3	0.5
Recovery%	100	100.0085	97	102.828	117.9037	95.05825	164.0206
Recovery%	100	100	96.92063	101.8065	115.2125	93.79612	148.1443

Appendix 4: Major element data for each site sampled. RP denotes the retention pond for each site.

Sample	Na(%)	Mg(%)	K (%)	Ca (%)	Ti (%)	Al (%)	Si (%)	P (%)
RM 1	1.51	0.19	1.49	0.36	1.08	3.86	42.86	0.04
RM 2	0.82	0.18	1.27	0.23	1.01	3.55	47.07	0.03
RM 3	0.04	0.13	0.98	0.11	0.7	2.94	27.9	0.04
RM 4	0.65	0.5	2.11	0.07	0.94	9.38	34.52	0.06
RP RM 5	0.38	0.81	3.51	0.5	0.64	11.16	29.38	0.08
Average	0.68	0.362	1.872	0.254	0.874	6.178	36.346	0.05
Standard Dev	0.549773	0.289948	1.005445	0.178129	0.193856	3.802541	8.376018	0.02
95% Confidence	0.481888	0.254146	0.881295	0.156134	0.169919	3.333013	7.341769	0.01753
LG 1	2.61	0.73	4.02	0.49	0.77	6.8	37.1	0.11
LG 2	0.4	0.3	3.56	0.21	0.42	5.25	46.52	0.06
LG 3	0.63	0.03	3.87	0.24	0.11	3.63	48.57	0.01
LG 4	0.72	0.46	3.22	0.25	0.61	6.1	45.41	0.06
RP LG 5	0.66	0.19	4.79	0.21	0.13	4.85	48.28	0.02
Average	1.004	0.342	3.892	0.28	0.408	5.326	45.176	0.052
Standard Dev	0.905941	0.267713	0.588447	0.118743	0.290723	1.212489	4.696725	0.039623
95% Confidence	0.794078	0.234656	0.515787	0.104081	0.254825	1.062774	4.116786	0.034731
MF 1	0.28	0.2	3.17	0.11	0.33	3.67	45.04	0.03
MF 2	0.48	0.26	3.1	0.23	0.26	3.51	48.07	0.03
MF 3	0.28	0.04	3.52	0.1	0.15	2.97	48.1	0.01
MF 4	0.86	0.02	2.99	0.23	0.07	3	50.66	0.01
RP MF 5	0.79	0.72	2.58	1.27	0.53	6.18	36.92	0.09
Average	0.538	0.248	3.072	0.388	0.268	3.866	45.758	0.034
Standard Dev	0.275536	0.283055	0.339072	0.497011	0.177257	1.32971	5.326483	0.032863
95% Confidence	0.241513	0.248104	0.297204	0.435641	0.15537	1.165521	4.668782	0.028805
GM 1	0.34	0.65	2.1	0.25	1.12	8.14	35.75	0.06
GM 2	0.31	0.61	2.45	0.45	1.05	6.9	38.72	0.05
GM 3	0.35	0.27	1.39	0.24	0.66	4.09	44.1	0.03
GM 4	0.52	0.39	1.61	0.2	0.77	8.06	37.85	0.04
RP GM 5	0.25	1.85	1.66	2.45	0.31	3.99	42.75	0.04
Average	0.354	0.754	1.842	0.718	0.782	6.236	39.834	0.044
Standard Dev	0.100648	0.632361	0.426462	0.973072	0.32553	2.064154	3.484183	0.011402
95% Confidence	0.08822	0.554278	0.373804	0.85292	0.285335	1.809277	3.053965	0.009994
Cert Values	0.0119	0.0156	2	1.92	0.33	7.56	29.89	0.067
% return	218.4874	102.5641	100	100	100	106.0847	104.7508	134.3284